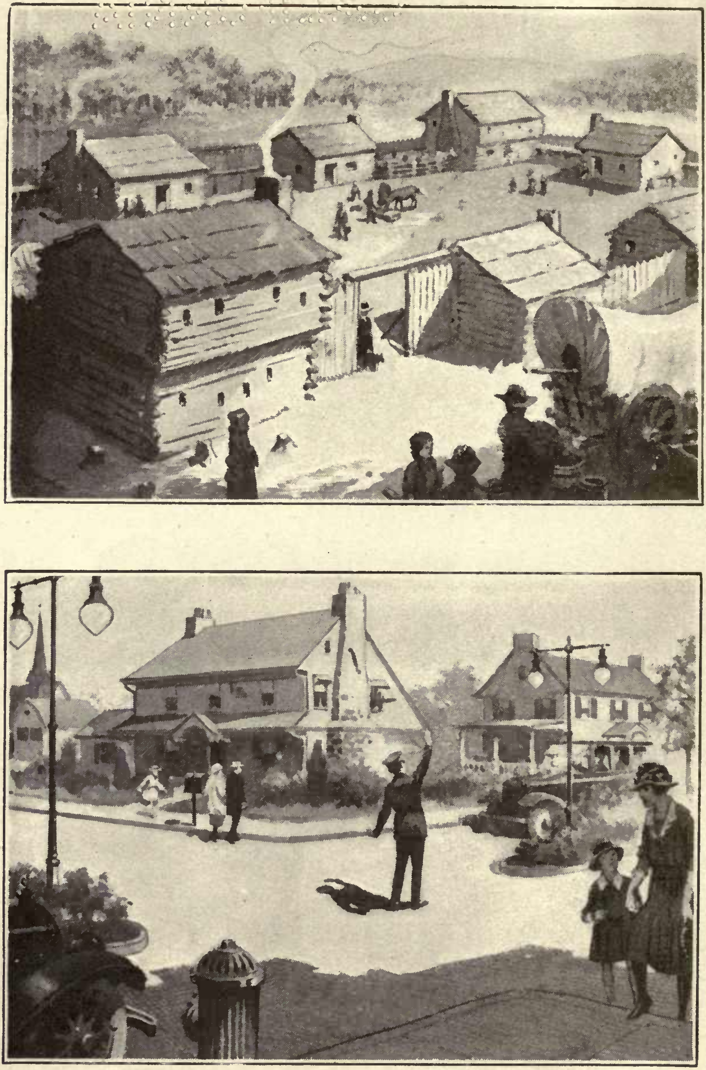
CIVIC SCIENCE IN THE COMMUNITY

HUNTER AND WHITMAN



Our modern community, with all its beauty, comforts, and conveniences, has gradually been evolved from the early settlement of our hardy forefathers through the application of science and invention.

CIVIC SCIENCE IN THE COMMUNITY

BY

GEORGE W. HUNTER, Ph.D.
PROFESSOR OF BIOLOGY, KNOX COLLEGE, GALESBURG, ILLINOIS
FORMERLY HEAD OF DEPARTMENT OF BIOLOGY, DEWITT
CLINTON HIGH SCHOOL, NEW YORK

AND

WALTER G. WHITMAN, A.M.
EDITOR, GENERAL SCIENCE QUARTERLY
PHYSICAL SCIENCE DEPARTMENT, STATE NORMAL SCHOOL
SALEM, MASSACHUSETTS

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FOREWORD TO THE TEACHER

Man's place in relation to science. — Living things, man included, live in an environment which is made up of certain definite factors, and with these factors living things react and interact. Some of these factors are materials — things; other factors are forces. The ultimate result of the complex we call life is the interaction of the materials and forces with the living things on the earth. Man, however, is supreme among animals because of all the animals he alone can control the factors of his environment. He has control of fire and water and electricity. His home has evolved from the cave of primitive man to the complex housing systems of the present age. His communal life has brought with it new problems — the disposal of wastes, the safeguarding of water and milk supplies, the need of community sanitation and hygiene. His higher civilization demands use of machines, the need of which his forefathers neither knew nor felt; of transportation and communication; of more varied and practical education as well.

Children's interests in science. — In the midst of such a life as this our children are growing up. Science beckons to them from every side. In every device used at home for comfort and better living, science speaks. The telephone and telegraph, the trolley and the automobile, the airplane and submarine, have all become part and parcel of their daily lives. Many of the common things of science which directly affect the lives of children are equally interesting to both sexes. But in any scheme of modern education we must take individual differences into consideration. We no longer educate in the mass. Sex, age, environment, capability, heredity, all are important factors which must be recognized by the modern teacher as having a place in educational practice as well as theory.

The project method. — Since we must allow for individual differences in our scheme of education, it goes without saying that mass education, which does not account the child as a personality, can no longer be admitted as a part of our scheme. We must take cognizance of all the factors mentioned in the last paragraph; environment, age, and sex act more uniformly and thus may be taken into account in the forming of classes or groups. But individual capability and endowments, heredity's part in the game of life, are much more difficult factors with which to deal. Recent developments in educational psychology show that one method of attack, however, has certain elements which may be used successfully with any group of children not too young to think to a conclusion. Problem solving of one sort or another is common to all the activities of life. It is the one great factor which goes toward making for success or failure in life. It should be part of the mental attitude of every educated person. Problem or project, call it what you will, represents the method by which things worth while in life are achieved. It offers the pupil a method for accomplishing those things in life which mark off greatness from mediocrity — the leader from the led.

Methods in science adapted for children. — We hear a good deal nowadays about the logical versus the psychological approach. No teacher, and the word is used in its truest sense, can teach except from the viewpoint of the child. Approached from this angle, the psychological becomes logical. We must have a plan, but we must remember that a plan may sometimes be changed to advantage. Above all we must be human. If we but remember how we looked at things with the eyes of thirteen instead of those of forty-three we will have no difficulty in solving the method of lesson attack. We must remember, too, that concepts *grow* and are not always brought to maturity in one lesson. The cyclic treatment of topics, which has been followed in Civic Science, is a far more natural method of acquiring information than a dogmatic statement, made perhaps with proof but dimly comprehended and soon forgotten.

The textbook in introductory science. — Any book in introductory science should be based on the facts we have just mentioned. It must contain an adequate amount of the basic material from which the interpretation of the common things of interest in life may be gained, and it must also be adapted to start the individual boy or girl whose interest has been awakened along the line of the project in which this developing interest would naturally flow. Most of all a textbook should interpret to the child the part played by the various natural factors in his environment. It should conceive the child as the center, and all the world of the child revolving around this center. In this conception boys and girls would first become aware of the vital part played by air, water, light, heat, and food on them as individuals within their homes. After the child has learned the meaning of these central factors in the home the next step would logically be the application of the forces of nature by man in communal life. In short, Civic Science plans to lead the child in a manner which is both logical and psychological from the simple factors which make up his environment as a living thing to the complex combinations and interactions which have arisen through what we call civilization. It is the interpretation of this complex that Civic Science undertakes with the belief that children, if given a rational point of view, will have enough varied interests to build on the outline which follows. They will thus work toward the solution of those things in science which seem most worth while to them as individuals and most worthy of them as future citizens.

Purpose of this work. — This volume is intended to round out some of the science information previously acquired by the pupil, to add new information regarding his relations to his fellows, and through its point of attack to teach good citizenship, good morals, and straight thinking.

Acknowledgments. — For an incentive to undertake this work, the authors are indebted to those educators who have written much on the subject of science for young people, particularly, Thomas M. Balliet, Thomas H. Briggs, John Dewey, Charles W. Eliot, David Snedden, George R. Twiss, and John F. Woodhull. To the many science teachers who have been active in developing general science from its early beginnings to its present state, the authors make full acknowledgment for much help and inspiration. Acknowledgment for illustrative material is made in the text. The drawings were nearly all made by Mr. F. M. Wheat, of the George Washington High School, New York. The following teachers have carefully read the entire proof and made many valuable suggestions: Mr. M. C. Leonard, Vice-principal, Dickinson High School, Jersey City; Miss A. P. Hazen, Head of the Department of Biology, Eastern District High School, Brooklyn; and Mr. George C. Wood, Head of the Department of Biology, Commercial High School, Brooklyn; and also Miss Lydia Holtman, Knox College, Galesburg, Ill.

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PART I. ADVANTAGES OFFERED BY THE COMMUNITY

CHAPTER I

THE IDEAL COMMUNITY

Problems. — 1. *To find out what the factors of my environment are.*

2. *To see what natural advantages my home community has.*

3. *To find out what man has added to nature to make my community a good place to live in.*

4. *To learn how I can help make my community a better place to live in.*

5. *To understand the need of wise laws and regulations in the community.*

Experiments. — 1. To learn what constitute the primary factors of our environment.

Project I. — A STUDY OF THE ADVANTAGES AND DISADVANTAGES OF MY COMMUNITY.

What particular advantages does my community enjoy because of favorable factors of the environment?

What disadvantages make the community unattractive to newcomers? Are there any remedies?

Project II. — TO MAKE AN EXTENSIVE SURVEY OF ONE FACTOR OF MY ENVIRONMENT.

Study some one favorable or unfavorable factor of the environment and report whether full advantage is being taken of a favorable factor; or if all that is possible is being done to change an unfavorable factor.

Project III. — To make a survey of my home block, locating all good and bad factors so as to try to make it an ideal place in which to live.

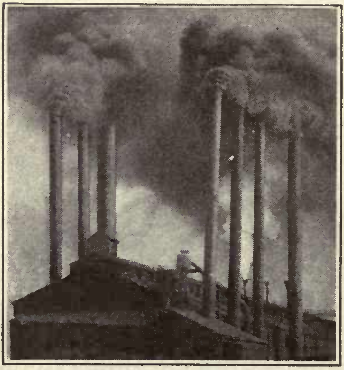
What is most important for a community? — If each member of the class were asked to name the most important thing to have in the community where he or she is to live, we should be likely to hear a great many differ-

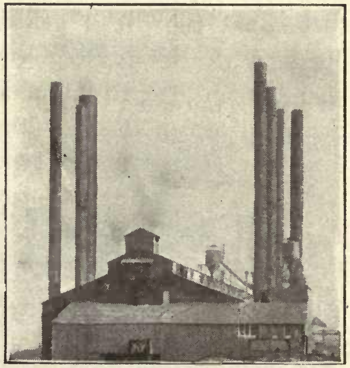
Only ruins mark the place where the thickly populated Greek city of Paestum once existed in southern Italy. Blocking of the mouth of the Silarus with silt caused overflowing of the banks and the resulting marshes became the homes of countless malarial mosquitoes.

ent answers. One boy would say: "A nice house to live in"; another, "Plenty of room around the house, so that I can play"; still another, "Vacant lots to play ball in." A studious girl might say: "A good school." Some one might say: "A healthful place to live in," and this perhaps is the best answer of all, for of all the important things which go to make life worth while, good health is certainly the most important. Many a city of ancient Greece, once adorned with beautiful buildings and charming surroundings, and important commercially, had its inhabitants bitten to death by the malarial mosquito. To-day those cities do not exist except as interesting heaps of ruins. Many cities of our South and Central American neighbors, as well as our own southern cities, were very unfavorable places to live in before it was discovered how to combat the dread yellow fever. Location, favorable opportunities for trading, good government — all of these would mean little to the inhabitants of a community without good health to enjoy them, and good health depends upon the coöperation of every one in the community as well as the care that those placed in control exercise. As one writer has well put it: "Health is a civic obligation." Perhaps the best indication of the health of a city is the physical condition of its school children, for this shows that not only does the community try to take care of its young citizens but that they in their turn are trying to do their share toward promoting good health in their town.

Purpose of this book. — Among the chief purposes of this book are: first, to show boys and girls what the essential factors are which make a community a good place in which to live; second, to try to make them realize that they, as the future leading citizens of the community, must be awake to their opportunities and responsibilities. Boys and girls have cleaned up towns and made them fit places in which to live; boys and girls have helped to make the fly less of a menace to health; they have helped free our towns from mosquitoes because they were well informed and well read. This book above all else should show the boys and the girls of the average community how they can work together to make it a better and a safer place in which to live.

The factors of environment. — We have already learned what the factors of the environment are. We have found that air, heat, light, water, food, and the soil are the necessities which living things must have in order to exist. Each of these factors plays an important part in





How the air in one community was improved when a smoke consumer was installed in the furnace of a near-by industrial plant.

the life of every individual. They play an equally important part in the relation of one person to another in a community.

Experiment. — To learn what constitute the primary factors of our environment.

Materials: Some wild or domestic animal.

Method and Observations: What is a factor in arithmetic or algebra? How might this term be used in speaking of our surroundings, remembering that environment is that which surrounds us and gives us certain materials necessary for our life? Bearing this in mind, determine the factors in the environment of a common plant; of a cat or dog; of yourself. Can you suggest experimental ways to prove whether or not all these factors are necessary? Now compare all the factors common to all environments to see which are the common factors.

Conclusion: What are the primary factors in environment of plants and animals?

Air. — We are all familiar with the term "pure air," but we do not realize always what pure air is. The boy or girl who lives in a big city where much soft coal is used does not breathe pure air. City air contains, besides dust and bacteria, a considerable quantity of carbon, of which we all become aware in our frequent attempts to keep our outer clothing clean. Many factories and industrial plants produce noxious gases which make living near them unpleasant if not harmful. Even country towns are not always entirely free from impure air.

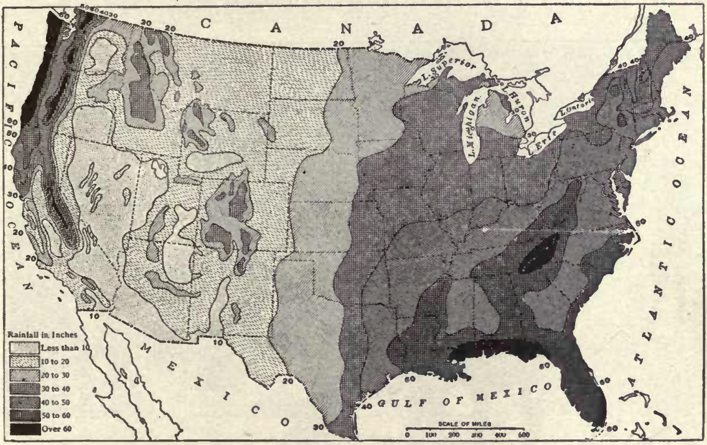
Heat and temperature. — It is not mere chance that most people live in temperate climates, nor is it chance that most of the world's activity is found in the temperate zone. Climate plays a most important part in life. Recent science has shown that the most efficient work can be done at a temperature which we call moderate; that is, between 60 and 70 degrees Fahrenheit. As a matter of fact, most great scientists, men and women prominent in the world of art, literature, or business, have made their name in temperate climates, and we are fortunate to live in this land where we are not exposed to extremes of temperature. Our ideal community, then, should have a moderate temperature without great extremes.

Weather. — Favorable weather conditions are important factors in our community life. Weather conditions are due to changes in the atmosphere, and these changes are frequently local. We may have excessive rains or excessive dryness. A body of water is warmed more slowly than an equal body of land and consequently, at night, a breeze may come in from the water to the land. This accounts for the cool evening breeze which so frequently makes life bearable in a hot city near a large body of water, as in Chicago or New York. Another weather factor is the kind of prevailing wind we have. Westerly winds prevail in the wind belt in which the United States is situated. One part of the United States, however, is subject to tornadoes, and we all know there is a storm belt which, in a general way, moves from west to east across

Along the lake front, Chicago.

the continent, passing off the Atlantic coast to the northeast. Very strong winds might be of importance to our community, especially if much damage were done by storms to crops or buildings.

Because of the prevailing westerly winds, the rainfall in the western part of the United States, for example, on the west slope of the Cascade Mountains, is much greater than it is farther inland. This is simply because the wind, loaded with moisture from the ocean, becomes cooler, condenses upon striking the sides of the mountains, and then gives up part of its moisture as rain. This explains, in part, the desert conditions in the southwestern part of the United States, for there the winds have to pass over two or more mountain ranges before they reach the interior, and by that time hardly any moisture remains in the air, consequently little or no rainfall occurs. Locate your community on the rainfall map and decide



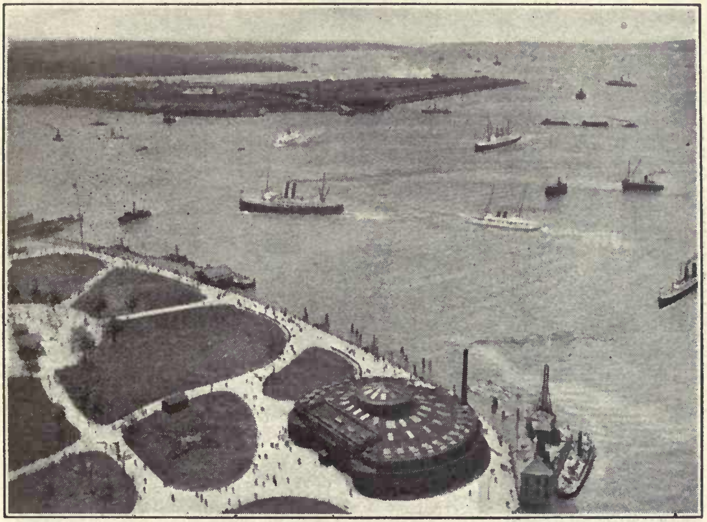
Rainfall map of the United States.

whether it is favorably located as to conditions of rainfall. Local conditions, such as forests, wooded hills, small ponds, also help to equalize climate and contribute to rainfall. Can you see why? Snow, too, would have to be considered in our ideal community life. Snow gives us winter sports, skiing, coasting, and tobogganing. It keeps the soil in good condition. In lumbering regions it is of much use, as the logs may be sledded out easily to places where they can be sawed into usable lumber. On the other hand too much snow hinders transportation on streets and railroads.

Light. — Light is of great importance to health. We live in a temperate zone where light is abundant, and although our winter days are shorter than those of summer, we do not have, as the Eskimo does, a long winter night several months in length. In addition, we have artificial lighting. One of the factors we must judge our community by is its lighting system. Is the system up-to-date? Is it sufficient for the needs of the community?

Fine winter sport.

Presence of water routes. — Navigable bodies of water are also of very great importance in determining the economic standing of a community. Our geography has shown us that most, if not all, important cities are on navigable rivers or other bodies of water, and that frequently they are at the ends of important lines of communication by rail. Examples of such are New York, with its great harbor at the mouth of a large navigable river, Boston and Rio Janeiro, each on a splendid harbor, Detroit, St. Louis, and New Orleans on fine rivers, Albany and Pittsburgh near the head of navigation on rivers. The problems of transportation and communication are of the

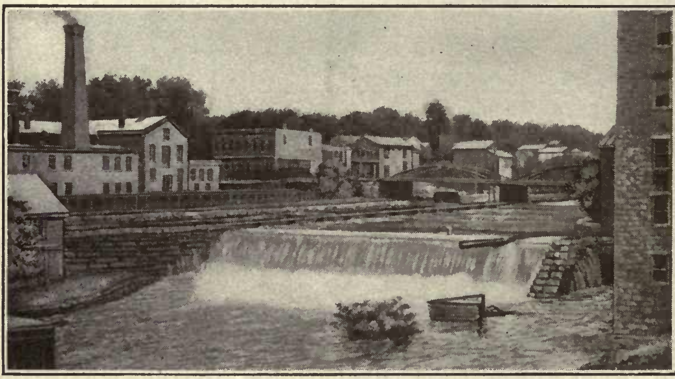


New York harbor from Battery Park

utmost importance to any large city, and many communities owe their importance to the fact that they lie along lines of communication between two or more large terminal cities.

Water power. — Water power on a river is also a factor in the determination of the location of a town or city. Any one who has traveled along the Merrimac River in Massachusetts at once realizes the importance of water power; in the Middle West, Minneapolis is a city using much water power. Frequently, in olden times, a mill to grind wheat or corn might have been placed where water

Shipping along the water front.



Water power in a manufacturing city.

power was located, and as the people of the neighborhood depended upon the products from this mill, a community would gradually develop. Water power has become of great importance in running machines for factories and in producing electricity. Manufacturing communities have developed on sites where water power was available.

The soil. — In a city, soil is not always in evidence. The paved streets and sidewalks, sometimes the open squares themselves, show little signs of the original earth which once was there; but the soil, especially in some communities, is of very great importance in determining the healthfulness of the place. If, for example, a city or town is built upon small hills composed of sand or gravelly soil, drainage will be good and probably little standing

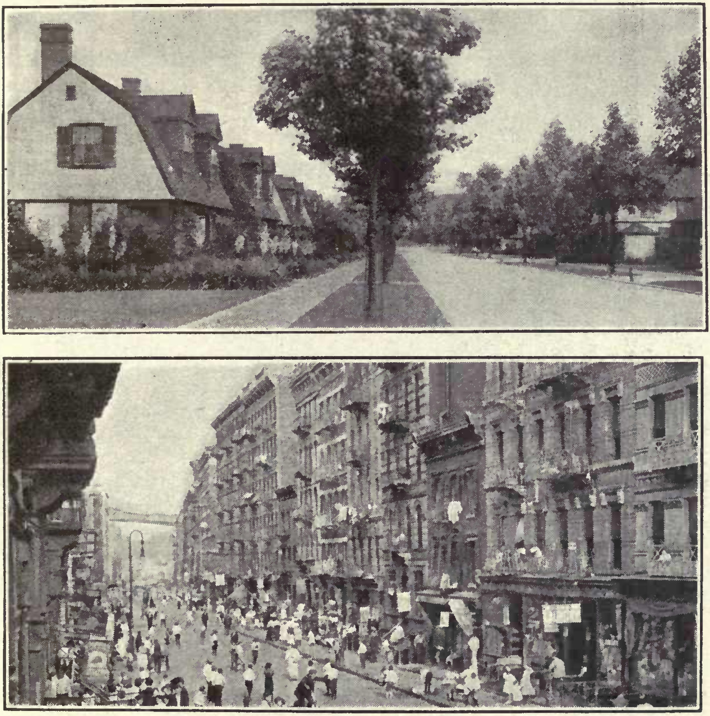
The mosquito menace may be removed by draining and filling a swamp.

water will be found. If, on the other hand, the town has considerable rock underneath it, or much clay or other impervious material, the drainage is not likely to be good and much standing water will be found. If a city or town has much marsh land adjacent to it, the mosquito problem may become very grave and the health of the city be menaced by malaria or yellow fever. Some areas covering limestone are particularly useful for farming districts.

Sewage. — Among the problems confronting every community in these days are those of providing some means for the disposition of wastes in the form of sewage, and of solid wastes such as garbage. Large cities have to spend large amounts of money in properly disposing of these wastes. In some cases, such as we have mentioned above, where the towns have natural slopes and where there is some body of water into which to drain the wastes so that they may be carried off, the disposal of sewage is a comparatively simple matter, but sometimes there are no rivers or oceans to drain into and then the city must get rid of all its waste by means of a disposal plant.

Garbage. — Garbage disposal is also of very great importance for the health of the city. Garbage pails, if left uncovered, are apt to become breeding places of flies, and flies are carriers of disease. One of the problems that a community has to face is properly to dispose of garbage. And we must always remember that coöperation on the part of everybody is necessary if our community is to be free from flies and diseases carried by flies.

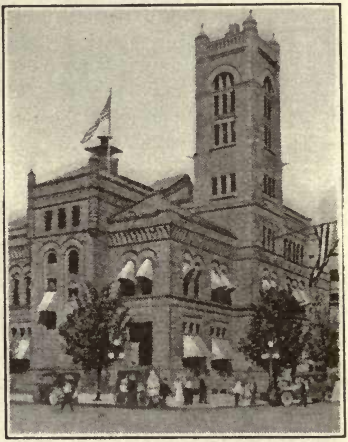
Housing. — In an ideal community, every family lives in a detached house with land for a little garden and a few trees. The house has ample ventilation. Bedrooms have two windows each and the house is provided with a sleeping porch. Unfortunately such conditions do not prevail in a large city. Not only do we have rows upon rows of closely built houses with little or no space for gardens or playgrounds but we have apartments or flats piled one on top of another. If such buildings must exist,



What are the advantages and disadvantages of these two types of houses?

then it is of the utmost importance to the health of that community that ample ventilation in the form of air-shafts and windows be provided. The ideal community has laws regarding such ventilation and has those laws enforced.

Public supplies. — When people come to live together there are certain things which it has been found economical to control in common. Water supplies and milk supplies are of this nature. An ideal community must have an abundant supply of pure water. Los Angeles has provided its inhabitants with over 200 gallons of water a day for each individual, and the new aqueduct of the city of New York brings over 150 gallons daily to each inhabitant. The source of the water must

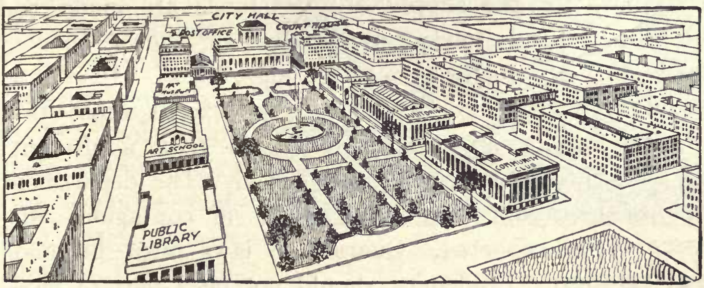


What three things were done for improvement around this public building?

be free from contamination, so that pure water will be delivered to the city. If, as in some cases, it is impossible to get pure water, the water supply of the city should be safeguarded by means of a filter, sometimes made of huge beds of sand through which the water may pass in order to remove impurities. In addition to filtering, most water supplies are treated with certain substances which kill any organisms harmful to health, which may be in them. Milk supplies, although sold by private concerns, should be under public supervision in every community. Milk is one of the most important factors in the health of the babies of a community, and upon the health of the babies depends the health of the future inhabitants of the town.

Improving the environment by the removal of signs.

Community planning. — No city or town should be allowed to grow in a haphazard manner. The streets should be well planned for the future growth of the community; they should be wide enough for all traffic. Parks should be scattered here and there, especially in the poorer sections, for people who do not have home grounds need something to make



A well-planned group of community buildings, in which are shown a City Hall, Court House, Post Office, Art Museum, Auditorium, and Community Club.

up for this lack. Playgrounds, with bathing pools and bathhouses, ought to be a part of our ideal community's equipment. Ugly buildings, billboards, and unkempt vacant lots ought to be prohibited by law and the community should see to it that smoke, dust, and unnecessary noise are reduced to a minimum. Lastly, churches, libraries, and schools, with a community auditorium and stadium or outdoor theater, ought to be included in the plan of our ideal community.

Community government. — Laws are not of much value unless they are enforced. A community government, first of all, should make wise laws which will keep the citizens of the town or city safe and healthy, and then it should enforce these laws. A city, furthermore, must have several departments of activity: lighting the streets, taking care of the water supply, looking after our health, protecting our homes from the menace of fire; making good laws and having a police force to see that these laws are kept. The work of the department of health is of particular importance. This department should not only see to it that all public supplies, such as water and milk, are uncontaminated, but it should also see to it that laws for the supply of pure foods are made and observed. Fresh foods exposed for sale should be covered with screens or placed in glass cases. Inspectors should see that no foods are sold except those that are fit for human consumption and that adulterants of a harmful nature are not allowed. The department of health should require all cases of contagious diseases to be reported. Quarantine laws must be made and enforced. Epidemics should not be a part of modern life, for they usually occur through carelessness. Carelessness must not be allowed in the ideal community. Modern methods for the combating of disease should prevail. The serum treatment of disease should be given free in all cases where it is necessary. Hospitals and sanatoria must be provided for various diseases, and each city or community ought to have at least one hospital, removed from the town, where tuberculosis patients could have the best care.

Schools. — Fully as important as the department of health and perhaps more important are the schools, for a modern school in our ideal community should not only teach but should take care of its children. Not only should hygiene be taught in schools, but there must be school clinics in which to examine and care for the teeth and the eyes, the throats and the noses of school children. In addition to this, boys and girls who go to school can do their share. They can organize sanitary and service squads, the members of which will take the supervision of the lunch room and see that boys and girls observe the rights of others and make the lunch period a time of fun but not of annoyance. They can help in the morning inspection of pupils by acting as health officers in their own individual

The school nurse helps us to keep well.

divisions or classrooms. They can all work together to increase the school spirit for better living and better working conditions in the schools and in the community.

Use of the score card. — At the end of this and other chapters in the book is found a *score card.* The object of this card is to compare our community in various ways with the ideal or perfect one. Of course, if we are honest with ourselves, no matter how much we wish to "boost" our home town, we shall be fair in our scoring. Otherwise there is no value in the exercise. We wish to know how we may make bad conditions better. The score card should show up the weak points of the community and then enable us to improve them. In making out this preliminary score card or survey, copy the score cards in your note book, put your estimate down in the column headed "My Guess Score" — leave the column headed "My Final Score" blank until you have finished your course and then insert the scores obtained from each of the individual score cards made out from time to time. The last estimate will show how far your guess was from being a true estimate.

GENERAL SCORE CARD OF MY ENVIRONMENT

		Perfect Score	My Guess Score	My Final Score
NATURAL RESOURCES, ADAPTATION FOR MAKING A LIVELIHOOD	Soil adapted to cereal crops . . . . (20) Soil adapted to market gardens . . (20) Forests give opportunity for community business . . . . (20) Land suitable for grazing . . . . (20) Land suitable for fruit growing . . (20) Presence of natural waterways . . . (20) Presence of ores for mineral wealth . (20) Natural fuels abundant . . . . . (20) Fish sufficient for industry . . . . (20) Selection from such groups as offered by your community not to exceed 100	100		

GENERAL SCORE CARD OF MY ENVIRONMENT — *Continued*

			Perfect Score	My Guess Score	My Final Score
CLIMATE AND WEATHER	Not great extremes of temperature .	(20)			
	Moisture plentiful	(20)			
	No danger from tornadoes or lightning	(20)			
	Freedom from hail, early frosts, and high winds	(10)			
	No long periods of severe heat or cold	(20)			
	Freedom from floods	(10)	100		
RELATION OF WATER TO PRODUCTION	Water power gives community source of business, many factories, power cheap	(60)			
	All power utilized	(20)			
	Near-by farms well watered	(20)	100		
COMMUNITY WATER SUPPLY	Water from pure source	(20)			
	Water safe, no epidemics	(10)			
	Water supply safeguarded, filtered .	(10)			
	Water desirable, soft, no color or taste	(20)			
	Adequate supply, good pressure . .	(20)			
	Public fountains and baths	(10)			
	Cost moderate	(10)	100		
COMMUNITY CARE OF FOOD	Milk supply inspected	(10)			
	Milk supply pure	(10)			
	Milk graded and pasteurized . . .	(10)			
	Inspection of meats and slaughter houses	(15)			
	Inspection of groceries and stores . .	(15)			
	Inspection of bakeries and products .	(15)			
	Inspection of restaurants and soda fountains, proper care demanded .	(15)			
	Supervision in sale of patent medicines and adulterants	(10)	100		
INSECTS AND CITY CLEANLINESS	No breeding places for mosquitoes. All standing water entirely eliminated or protected by oil or introduction of fish. No mosquitoes present	(50)			
	If culex only is present, score . . .	(30)			
	If anopheles is present, score . . .	(0)			
	No breeding places for flies found, manure heaps frequently moved, no open privies, no rubbish in vacant lots, screening and inspection of markets, no flies	(50)			
	Some flies but not annoying, score .	(30)			
	If flies are present in swarms, score .	(0)	100		
WORK OF BOARD OF HEALTH	Board of Health active, efficient, well provided with equipment, laws enforced on quarantine and disinfection, free antitoxins, and serums. Ample hospital equipment . . .	(35)			
	Law enforcement of all health measures and coöperation with schools, homes, and civic organizations . .	(35)			
	Adequate laws with reference to proper housing conditions are enforced. Factories and stores are sanitary and safe. No fire traps	(30)	100		

GENERAL SCORE CARD OF MY ENVIRONMENT — *Continued*

		PERFECT SCORE	MY GUESS SCORE	MY FINAL SCORE
COMMUNITY SAFEGUARDING OF LIFE AND PROPERTY	Streets well lighted at night . . . (15) No grade crossings . . . . (5) Efficient police system . . . . . . (25) Efficient fire department and fire laws and regulations . . . . (35) Traffic laws and signals . . . . . . (5) Coöperation on the part of State and Civic organizations in protection of life and property . . . . . . (15)	100		
ADVANTAGES FOR EDUCATION, RELIGION, SOCIAL LIFE AND RECREATION	School system complete and adequate, having elementary (5), secondary (5), technical (5), normal school or college (10), special schools for deficients and defectives (10) . . (35) Free library . . . . (10) Churches, active . . . . (15) Social agencies, active . . . . . . (15) Museums, concert and lecture courses free . . . . (10) Public parks, playgrounds, and baths free and adequate . . . . (10) Movies, theaters, and recreational centers . . . . (5)	100		
TRANSPORTATION AND COMMUNICATION	Streets well paved and in good repair, trees abundant . . . . (12) Roads connecting surrounding communities well paved and kept in repair . . . . (15) Adequate trolley, jitney, and steam passenger service . . . . (16) Adequate freight service . . . . . (12) Canal or other water transportation . (12) Air transportation developed . . . (4) Parcel post and mail service adequate (12) Telegraph and telephone . . . . . (8) Fire and police system . . . . . (4) Daily newspapers . . . . (5)	100		
	GRAND TOTAL	1000		

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CHAPTER II

HOW THE COMMUNITY CAME INTO EXISTENCE

Problems. — 1. *To learn something of the earth as a planet and of its early history.*

2. *To learn how the earth became prepared for life.*

3. *To learn what forces are constantly at work changing the earth's surface.*

4. *To learn about the life of early man.*

5. *To learn how community life began.*

Experiments. — 1. To see the effect rotation (centrifugal motion) has upon a body.

2. To see if natural surface waters contain soil sediment.

3. To learn how to identify a few common rocks.

4. To show the expansive force of freezing water.

Project I. — TO FIND EVIDENCE OF EROSION IN OR NEAR MY COMMUNITY.

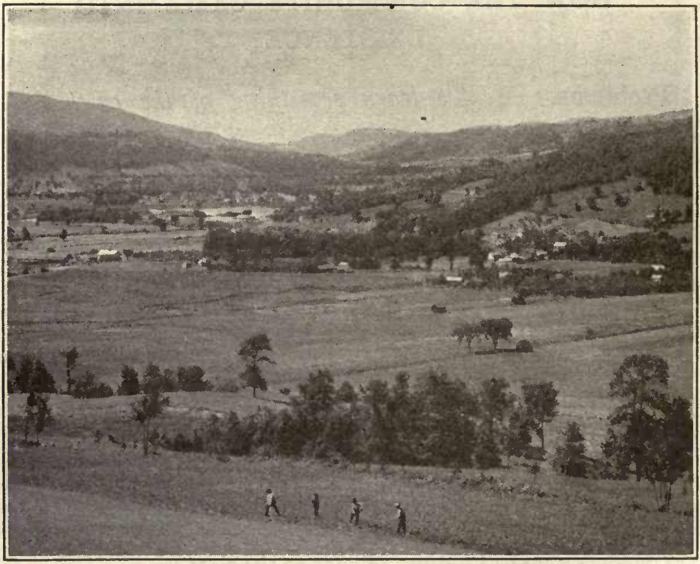
Prepare a report in form to present to the class.

Project II. — TO MAKE A COLLECTION OF LOCAL ROCKS, MINERALS, AND SOILS.

Learn the names and classification of as many as possible. Arrange them in a home-made cabinet properly labeled.

Project III. — TO LEARN THE EARLY HISTORY OF MY COMMUNITY AND TO FOLLOW ITS DEVELOPMENT UP TO THE PRESENT TIME.

How the earth became inhabitable. — Any boy or girl who has climbed to the summit of a hill or a mountain knows the feeling with which we look out over the expanse below. We are alert to pick out this or that familiar landmark, we spy out forests here and fertile fields there, a lake nestling among the hills, a little town or river in the valley, perhaps a big city away off on the shore of some large body of water. We have that feeling of elation which comes to any of us after we have accomplished something worth



We view the mountains, the valley, the river and wonder if they have always existed as we now see them.

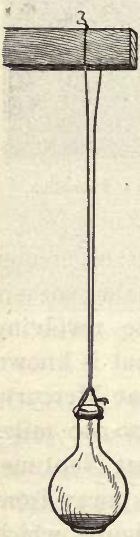
while, and we feel that the world spread out below us is a pretty fine place to live upon, after all. How many of us, do you suppose, think back into the distant past and ask, "How did all these wonders of mountain and plain, hill and valley, river and lake, rock and soil, come into existence? Were they always just as they are now? Or did the earth grow and change, much as living things which we know do?"

The earth a planet. — Scientists who have made a careful study of the earth's history tell us that it was once very different from what it now is. We remember that the earth is pictured in our geography as a nearly round ball, in space, moving about a central rotating body

A nebula from which new bodies like the earth may be in process of formation.

called the sun. Around the sun, with orbits of greater or less diameter, are other planets, some smaller, others much larger, than this earth of ours. These revolving planets, moving around the sun, make up what is known as the solar system. When we remember that Mercury, the planet nearest to the sun, is nearly 36,000,000 miles from that glowing mass, and when we recall that Neptune, the most distant planet, is 2,780,000,000 miles away from the sun, our brains whirl at the stupendous figures which astronomers and mathematicians have given us. Of even greater interest than these enormous figures is the fact that our sun is only one of many, each of which has its own company of planets.

How the earth was formed. — Scientists believe that this earth, and probably other planets as well, have grown gradually from accumulation of solid particles from space, or have been evolved from gaseous bodies into their present form. According to this latter view, the *nebula theory*, the entire solar system was a mass of rapidly whirling gas. From time to time portions of this gas were thrown off by centrifugal action and in time each mass so separated became a planet. One of these bodies formed from a detached fragment of the sun was the earth; thus the entire earth was at one time in the form of hot gases. As these cooled, those substances which form the solid portion of the earth condensed and solidified first, leaving a surrounding atmosphere of less easily condensed gases. In the course of time water must have come from the atmosphere by condensation as the earth's surface cooled off. You are all aware of the condensing of moisture and formation of rain when warm moist air is cooled. In a similar way did the rivers, lakes, and oceans receive their supply of water from the atmosphere.



Experiment. — To see the effect rotation (centrifugal motion) has upon a body.

Materials: A one-liter flask. Colored water. Stout cord.

Method: (1) Pour 50 c.c. colored water into the flask. Tie a cord tightly around the neck and suspend it from a double cord four feet long. This suspension cord must be fastened to the flask so that it lies in a vertical axis running through the center of the neck of the flask. Twist the cord many times by turning the flask. When left free the cord untwists and the flask will be rotated rapidly.

(2) Repeat (1) using a flask with several small holes blown through the walls of the flask at the level of its greatest diameter.

Results and Conclusion: What happens to the colored water in (1)? in (2)?

What effect does an increase in speed of rotation have in case (2)?

Application: Apply results seen here to explain one phase of the action by which the earth was formed according to the nebula theory.

The age of the earth. — Various methods have been worked out by scientists to determine the time it has taken for the earth to assume its present form. One way is to estimate the amount of salt in the ocean as a measure of its age.[1] Assuming that the water was originally condensed from the atmosphere as rain the time it would take for the ocean to get its present content of salt from the earth could be computed with a fair degree of accuracy. The latest estimate based upon this method makes the oceans a little less than 100,000,000 years old. The age of the earth itself must be much greater. Some scientists estimate up to 400,000,000 years. Its present surface form is due to the forces of water, air, heat, and cold, all working to carve out the hills and valleys, and produce the rivers and lakes that we see from our mountain top.

Early beliefs. — The early beliefs concerning the earth seem rather ridiculous to us now. When we remember that as late as the time of Columbus the majority of educated people in Europe believed that the earth was flat, and that the sun moved around it, we can appreciate the advances made later. Copernicus, a native of northern Europe, gave out in 1530 the now famous belief that the sun was the center around which the planets moved. This theory was slow in being accepted, but half a century later Galileo, by the use of his newly invented telescope,

[1] T. C. Chamberlain, "The Evolution of the Earth." *Scientific Monthly*, 1916.

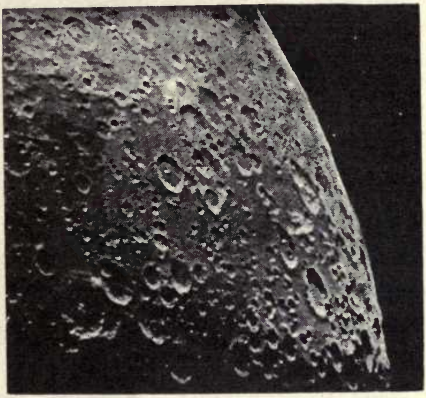
added much to the theory of Copernicus and helped in its establishment. Still later, about 1660, Sir Isaac Newton applied his discovery of the law of gravitation to the movements of the earth and other planets. The familiar story of how Newton saw in the dropping of an apple to the ground the law of gravitation is one which every boy and

In what regions on the earth are these two types of vegetation found?

girl ought to know. He recognized that this pull of the earth upon objects was a universal thing and could be applied as a law to other planets as well. The attraction of the earth for bodies near its surface is called *gravity.* Gravity causes unsupported bodies to fall and is measured in units of weight. Gravitation is the attraction which any one body in the universe has for every other body. The sun, moons, and planets in the solar system are kept in balance by this attraction of gravitation.

Temperature. — The effect of temperature on the living things upon the earth, we are all familiar with in a general way. Geography has taught us something about the various zones of life upon the earth. Temperature is the one greatest factor in determining the kind of life found in a given region. The lack of plant life in the arctic regions and the wealth of vegetation in the tropics are due largely to the factor of temperature.

How the earth became prepared for living things. — It would have been a strange world that would have met our eyes had we been able to view it as it became cool enough to sustain life. Probably its surface, though very irregular and holding bodies of water in its depressions, was not carved into mountain ranges and deep valleys as it is now. It probably looked very much as the surface of the moon appears to-day through the telescope. It was an age of volcanic action and we may imagine that great craters or active volcanoes were almost everywhere present. These volcanoes, vents from the superheated interior of the earth, poured out molten rock or threw off with the heated vapor masses of powdered material that became the first soil of the earth. Bare rocks protruded everywhere in a chaos of wildness, broken only by the dark sullen bodies of water.



A portion of the moon's surface seen through a telescope. Notice the craters of extinct volcanoes.

No life of any kind, plant or animal, could be seen. It was this bleak, lifeless earth that has been transformed into the beautiful vegetation-covered world that we know. How were all these things brought about?


Surface of a lava flow.

Rocks — what are they? — Rock is a common sight to all of us. We see it used for building purposes, for paving, both in the streets and on the sidewalks. Farmers go to some trouble to remove loose rock in the form of stones from their fields and build them into walls And most of us know that if we dig into the earth, sooner or later we shall come to solid rock. The island of Manhattan, for example, is an almost solid mass of rock. If we examine such rock closely, we see it is twisted or contorted as if it had once been soft, and had been squeezed together. This would seem to indicate that rock was once molten or at least soft. The first rock on the earth was of this kind.


Twisted gneiss rock

Erosion by water. — Many of our western peaks and the mountains of Switzerland are huge rock masses which are being slowly worn away by water. If we were to go to the edge of a rapidly flowing stream in Switzerland, we would notice that the water was not clear but had a muddy or milky appearance. A dish of such water, if allowed to stand for a few hours, becomes clear, but shows a large amount of sediment in the bottom of the dish. Where did this material come from? Perhaps a visit to the boisterous stream at a point where it dashes over the rocks will answer our question. The force of the water, tearing loose the strong rocks, rolls them downstream one against another, and finally grinds them into powder. In many a mountain valley to-day we may see this powdered material going down the turbid river. Rock particles are carried until they finally reach the river's mouth, where the current, met by the tide from the ocean, slows up and the water drops its load. Thus *deltas* of new soil are formed. This method of breaking down rock into soil particles is known as *erosion.* Rivers are at the present time doing

A gorge formed by water erosion.

much work in erosion. Not only do they carry away the powdered rock particles near their source, but they are continually wearing away the material from some part of their banks, and depositing it in other places. Our western rivers are yellow with mud carried from the treeless plains through which they flow.

Experiment. — To see if natural surface waters contain a soil sediment.

Materials: Glass jars.

Method: A. Collect water. 1. From a surface puddle after a rain. 2. From a swiftly moving brook or river just after a heavy rain. 3. From any other surface water. Let these stand overnight.

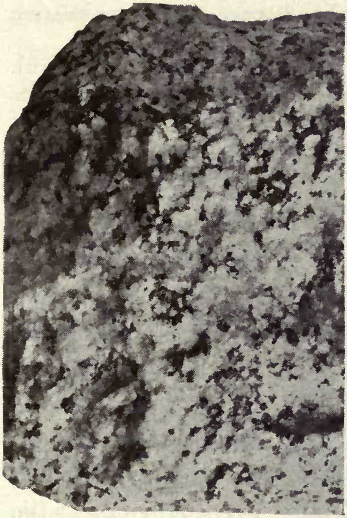
B. Mix soil with clear water by stirring in a glass jar. Allow to stand overnight.

Results and Conclusion: What is the result in each case?

How do you account for sediment found in *A*? What was its probable source?

Kinds of rock. — The Mississippi River carries millions of tons of soil to the Gulf of Mexico every year. Enormous amounts of rock sediment are brought to the oceans by all large rivers. The deposits, in time, become miles in depth and the lower layers are subjected to tremendous pressure and heat. As a result the particles are cemented together into rock. In this way sandstone is formed. Rock like sandstone, which was formed from deposits made under water, is *sedimentary rock*. Because this shows the layers of formation it is also called *stratified rock*. Rock like granite, which was formed by cooling from a molten condition, is *igneous rock*. All the rocks of the earth are in, or have belonged to, one of these two classes. A rock of either class may undergo a change of partial melting and develop new crystals and a different appearance, from twisting, folding, or flowing. It is then called *metamorphic rock*. Gneiss, slate, and marble are examples of metamorphic rock.

Small amounts of rock are produced by deposit from water solution, as for example the stalactite of limestone caves.



Granite, an igneous rock.

Gneiss, a metamorphic rock.

Experiment. — To learn how to identify a few common rocks.

Materials: Large class specimens and if possible small hand specimens of granite, sandstone, limestone, and marble. Dilute hydrochloric acid.

Method: Observe the specimens and note their most characteristic properties of texture, hardness, luster, etc. Test each with a drop of acid.

Results and Conclusion: What properties may serve to distinguish one of these rocks from the others?

Methods of erosion. — It is common knowledge that heat causes substances to expand and occupy more space, while cold, on the other hand, causes them to contract. When water freezes, the ice formed is larger than the water from which it came. Since this is true, it is easy to see that when water gets into cracks of rocks and freezes there, it expands, thus forcing the rocks apart.

Experiment. — To show the expansive force of freezing water.

Materials: A small narrow-neck bottle. Stopper. A freezing mixture of salt and ice.

Method: In freezing weather each pupil may fill a small vial with water. Close it with a stopper and place it out of doors when the thermometer reads below 32° F. In warm weather a bottle full of water is closed with a stopper and packed in alternate layers of crushed ice and salt. After a time, depending on the size of the bottle, examine.

Result and Conclusion: When the water has completely changed to ice what other change do you find accompanied the freezing?

Application: What is the application of this to soil making?

The hot rays of the summer's sun melt the ice on the high mountains during the day. At night the water freezes again, and this process, kept up day after day, eventually cracks the hardest rocks. Running water moves sand and gravel over rocks, wearing them down. A large mass of moving ice, as a glacier, is a powerful agent of erosion. The Alpine glaciers gather rock fragments from the sides and bottoms of the valleys. These fragments become grind-

An Alpine glacier. See the three streams of rock fragments torn from the sides of the valleys. (After Cleland.)

ing tools, moved under tremendous pressure of the ice, and cut away more rock while they in the end are worn to fine particles. Rock thus grinds against rock so that by the time the valley is reached both may be ground to powder. Thus many of the streams issuing from the foot of glaciers are white with the rock dust or sediment carried away by them.

Erosion by wind. — In many parts of the world, the wind plays an important part in soil making. You have all seen a sand blast, and have noticed that the tiny particles of sand, driven by a current of air against the outer surface of a building, will in a very short time change the appearance of its surface. In some parts of the West the wind drives millions of particles of sand against the sandstone cliffs or buttes with such force that they are worn down and hollowed out by this natural "sand blast."

Erosion by wind-driven sand.

Changes in rock material. — We have thus found that rocks which in their original form may have been either molten volcanic matter or formed by slow deposition of material under water, may be broken down to form soil in several different ways. First, water may wear away rocks, and then deposit the ground-up material as inorganic soil. Second, rocks may be cracked up under the alternate action of heat and cold. Third, glaciers, or rivers of ice, may transport the fragments of rocks which are broken off by the action of frost or heat, and grind them into soil. Fourth, the wind may, by driving particles against the rocks, have an eroding effect upon them.

What is soil? — Soil, then, in its original form, is ground-up or powdered rock. The character of the soil depends upon the kind of rock from which it is produced Sand, for example, is rather coarse material containing usually a good deal of silica. Clay, on the other hand, is very finely ground-up rock, and may be of various colors, depending upon the mineral substance with which it is impregnated. Such soil is *inorganic*, and is without living material of any kind. But soil, after plants and animals appeared on the earth, became made, in part at least, of their dead forms. The addition of *organic* matter, derived from dead animals and plants or products of these, to the inorganic soil makes the rich black soil we call loam. After the earth became covered in part with soil, water in the form of rivers or streams began to play an important part in changing its appearance. Rivers cut their way through its surface and to-day in places where the natural protection of living plants has been removed, the forces of erosion are doing their work very swiftly, because water, wind, heat, and cold act more quickly upon unprotected soil and rock.

The coming of life on the earth. — Just how and when life came on the earth we do not know. It must have been a good many millions of years ago. Probably at first the water became the home of tiny one-celled plants and possibly animals as well. And as time went on more and more complex forms of life came into existence. Perhaps some day you will take up the study of that fascinating subject, geology, which treats of the rocks and their formation. In these rocks we frequently find fossils, remains or traces of plants or animals which lived upon the earth in former ages. By means of a study of these fossils which are embedded in different kinds of rocks and at different depths, we have been able to form quite a definite history of the development of life upon the earth. We know that as life on the earth developed, plants and animals became more and more complex, until finally animals of a type found upon the modern earth came into being, and at last man.

Rock bearing fossils

The life of early man. — Think of a world without any modern conveniences, without homes, without even fires. But such was the world of primitive man. He was a wanderer and lived like the wild beasts which preyed upon him and which he killed with his own hands for food. At first these people probably lived in caves, and we can imagine how the discovery of fire must have added to their comfort as well as their safety. They must have been skilled hunters, for piles of bones have been found near their ancient camps. Gradually they must have learned to use implements as well as weapons, made earlier of stone and later of bronze and iron. Then came the discovery that the seeds of certain wild grasses were good to eat. When grains began to be cultivated. and animals were domesticated, we had the beginning of a fixed home.

How a community came to be formed. — In the early days people lived in large families or clans. These people had certain tribal customs and the members of a given clan all lived according to these customs. Often they lived in deadly enmity with people of other clans and, as in the case of our North American Indians, they came to hunt and live together for mutual protection. In the Middle Ages the people of Europe built walled towns, often making them on the hilltops for protection against their hostile neighbors. So the first communities were formed.

A North American Indian.

First settlements in this country. — When the early settlers came to this new world, they, too, were exposed to unfriendly inhabitants, the Indians. But not only did they live together for the sake of protection, but also for other reasons. Towns were settled because of natural advantages which gave the inhabitants opportunity for trade, water power, or agriculture. And the people who settled in these early communities wanted social life as well. So they had churches, schools, and public meeting houses. At first life was very simple and there were few trades or occupations. Each man was his own carpenter, tailor, and shoemaker. But as the settlement grew in numbers some men who were better carpenters took that as their trade, while others became tailors and still others, shoemakers. So gradually, just as life always develops, the modern community with its complex life and its many advantages has come into existence.

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CHAPTER III

RESOURCES OF THE COMMUNITY

Problems. — 1. *To find out what our natural resources are.*

2. *To learn the relation of farming to a community.*

3. *To understand the relationship between forests and industry.*

4. *To see what forms of animal life are valuable natural resources.*

5. *To learn something of our mineral resources.*

6. *To learn something of coal and oil in relation to communal life.*

7. *To learn about manufacturing in relation to communal life.*

8. *To find out the reasons for conservation.*

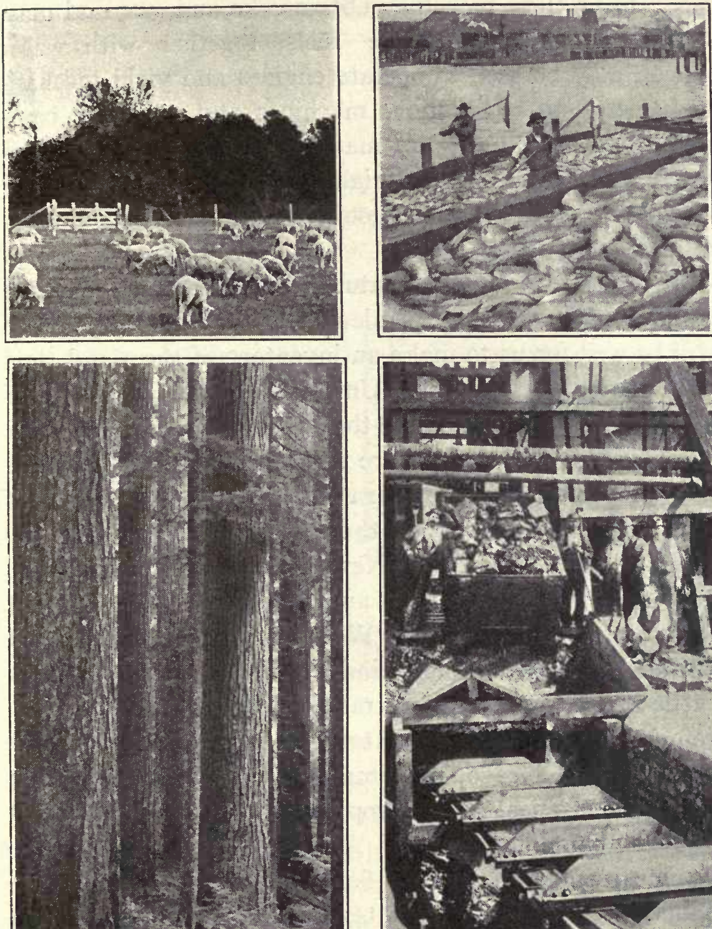
Project I. — A STUDY OF THE NATURAL RESOURCES OF MY COMMUNITY.

a. To make an inventory of the natural resources of my community.

b. To determine whether or not these resources have been utilized by the inhabitants of the community.

c. To find out if resources are conserved.

Natural resources. — Man in his primitive state needed food, shelter, fuel, and clothing. These primary needs, as civilization grew, were supplemented by many others. Indians who inhabited wooded territory had all the wood they needed, and if this became exhausted they moved to



Sheep raising, fishing, lumbering, and mining are among the industries which depend upon our natural resources.

a new supply. Now great manufactories have come into existence, particularly where there is an abundance of different fuels, — wood, hard and soft coal, oil, and natural gas. From these fuels they obtain coke and gas, and may produce electricity. These fuels, together with water power, may be used to operate engines and yield mechanical energy to run various machines and enable a community to enter into very many different kinds of manufacturing. The raw materials near at hand are likely to determine the kind of goods manufactured in a community.

An inventory of our natural resources. — Since our communities are so dependent upon these resources it will be well for us to make an inventory of them and thus we can appreciate why the United States has become such a wealthy nation We have the fertile plains of the Middle West, great forests which are untouched in the Northwest and in parts of our northern states; cotton, cane, citrus fruit and truck farms in the southern states, and the vineyards and orchards of New York and California. All of these indicate a richness and fertility of land. A visit to the farms in the central West shows us that different localities create different kinds of wealth: pigs in Iowa, cattle in Texas and the central West, sheep in the mountain states, the great slaughtering and packing industries in St. Louis, Chicago, and Omaha. Then we have the iron mines of Minnesota, the copper of Michigan, the gold of the mountain states and Alaska, the coal of Pennsylvania and Illinois, the oil fields of West Virginia, Oklahoma, and California, all testifying to the richness of our natural resources. Although the United States has only 6 per cent of the world's population, and only 7 per cent of the land of the globe, yet we produce a large part of the world's supplies as shown by the following table:

THE UNITED STATES PRODUCES OF THE WORLD'S SUPPLY:

Aluminum	60%	Corn	75%	Iron and Steel	40%
Automobiles	85%	Cotton	60%	Lead	40%
Coal	52%	Gold	20%	Silver	40%
Copper	60%	Oil	66%	Wheat	25%

Richness of soil a natural resource. — Those of us who have traveled through some of the fertile lands along river valleys in the Northwest know how lavish nature has been. This country has hardly begun to use fertilizers to help enrich the soils as Europe has. Our wheat crop was almost one billion bushels in 1919 and our corn crop even more. But the yield per acre of these and other cereal crops is not nearly as high as that of Europe where the wornout land is cultivated more carefully and constantly enriched with artificial fertilizers.

The leading corn-producing states. The numbers represent a hundred million bushels produced yearly.

Farming. — The foundation of the wealth of this country is the soil. The average production of all crops for five years prior to 1915 was over six billion dollars a year. This is two or three times as great as the money obtained from any other kind of industry. We find corn our greatest crop, exceeding one billion bushels a year. About half of the corn is raised in the states of Illinois, Iowa, Kansas, Indiana, Ohio, Nebraska, and Missouri. Although much corn is used as food for man, yet the bulk of our corn crop is fed to hogs and cattle. We export our corn "on the hoof," in the form of pork and beef.

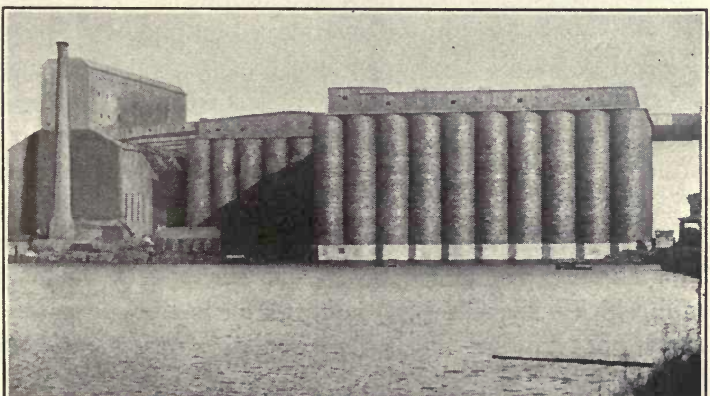
Wheat, which has become a crop of nearly a billion bushels a year, is grown most largely in Kansas, Nebraska, and the Dakotas and Minnesota, with a belt along the Pacific coast centering in Washington and Oregon. It is a northern crop, and thanks to the experiments made by the Department of Agriculture, we are increasing our yield and getting wheats which are more resistant to cold and plant enemies. Other cereal crops, — oats, rice, barley,

Picking strawberries for the market.

buckwheat, and particularly forage crops, such as grass and clover, are of very great importance to our central and western farms. A comparatively new type of farm which is becoming very important in the South is the truck farm. Vegetables can be shipped by rail or water so that we can get them fresh any time of the year. We also find vegetable canning, which was first practiced in 1846, becoming a very important adjunct to the work of the farmer.

Types of farming communities. — Since most farms are of large size, some having several hundred acres, the houses are scattered. Machinery does much of the work and each large farm is often the center of more than one family. Farming communities are well-to-do. The farmers have their own automobiles, and the villages are often settled by retired farmers. Stores keep commodities which are needed for tilling and reaping, also those staple foods which cannot be grown on the farm. Doctors and dentists and other professional men locate in these communities. There are good churches and schools and movies and the post office provides rural delivery. There are no very poor nor very wealthy people, thus a farming community in many respects is ideal.

Industries which grow out of farming. — Perhaps the most important industry is that of milling. As late as 1823 a small government milling plant was established



A grain elevator.

in Minneapolis; to-day the Minnesota mills supply hundreds of thousands of barrels a year. The flour, which was once of a poor quality, is now, because of the introduction of chilled iron and porcelain rollers in place of millstones, of a very high grade. Milling centers are usually near sources of water power and must not only be near the wheat fields but also on lines of railroad or other transportation. Much grain is shipped long distances by boat. Great grain elevators have been built in many terminal places such as Duluth and Buffalo.

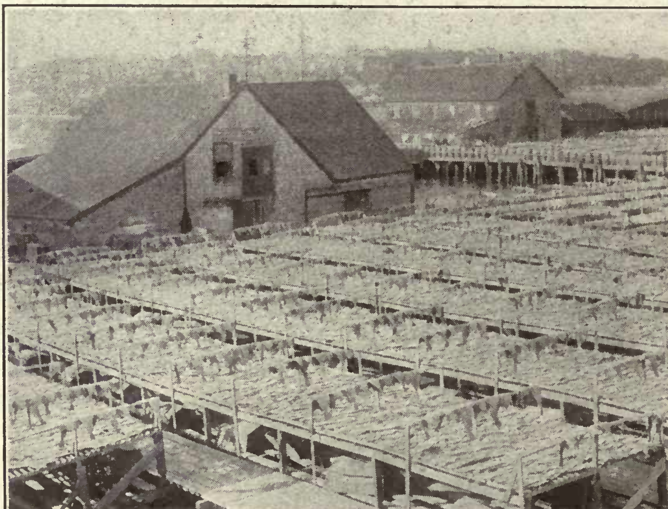
The transportation of fruits and vegetables has already been spoken of, as well as the canning industry. The sugar crop is of much importance, sugar cane being grown in the South and sugar beets in the North. Potatoes are also an important crop, which, thanks to Luther Burbank, have been greatly improved. Nevertheless, Europe obtains many more bushels per acre than we, because of superior methods of cultivation.

Forest industries and their communities. — Ever since early colonial days forests have played an important part. Then they were looked upon as a hindrance because they covered the land which the colonists wished to use for cultivation. Now, however, they have become a source of many kinds of great enterprises. Over six hundred million dollars' worth of sawed lumber is produced every year. Eight hundred thousand wage earners are engaged in lumbering and allied industries, such as the planing mill, which makes interior woodwork for houses, the manufacture of furniture, and the paper pulp industry. Grand Rapids, Michigan, is almost entirely given over to the making of furniture; Chicago, Philadelphia, and St. Louis also manufacture a great deal. Paper making machinery was introduced in 1820 when paper was made out of cotton or linen scraps. When wood pulp was first used in 1867 an immense industry came into existence. At the present time over three hundred million dollars' worth of paper is produced yearly. New York, Massachusetts, Maine, and Wisconsin are the states most prominently interested in paper making.

"Logging," the start of much fine lumber.

Fisheries and fishing communities. — As early as 1731 Massachusetts had six hundred vessels and six thousand hardy men engaged in fishing. At every available harbor along the New England coast small fishing communities have sprung up. These are usually beautifully located. And from the modest wooden houses the mothers and sisters used to watch for the return of their loved ones when the fishing fleet came in. The fishing industry, however, has spread from New England along the southern coast as well as to the far West. The most important fish caught are the cod, mackerel, herring, halibut, and salmon, while lobsters, oysters, and clams are important shore industries. As a result of the fisheries there have grown important fish-drying and fish-canning establishments. Gloucester, Massachusetts, is an example of a town largely given over to this industry.

Wild life as a natural resource. — In the early colonial days birds and other wild animals took a much more important place in the life of people than they do to-day.



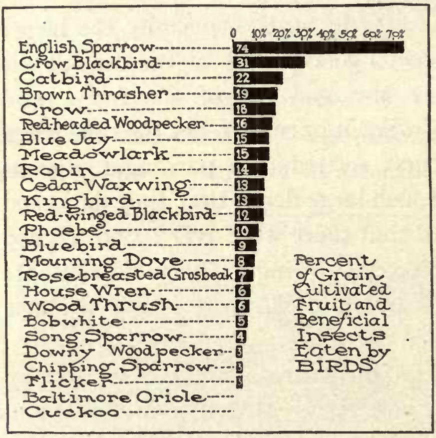
Drying fish on the flakes in Gloucester.

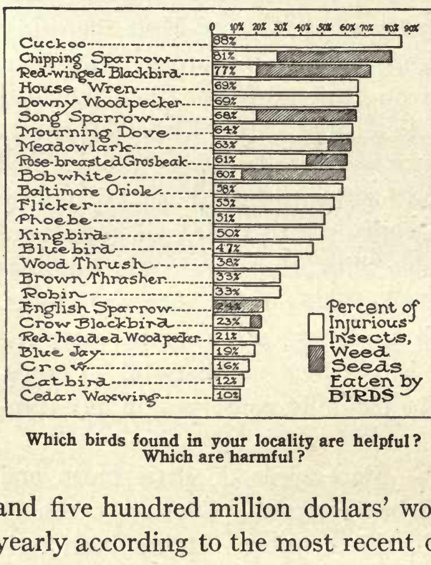
The Indians traded valuable skins for goods which the colonists possessed. At the present time the fur trade is of great importance in Alaska. The fur seals, which have been protected by our Government, produce annually a greater value in fur than we paid to Russia for the whole of Alaska. Animals were used for food. The buffaloes of the plains were once so numerous that the early pioneers, after killing them, cut out the tongue and left the rest of the carcass to rot. To-day the buffalo is almost extinct except for a few privately owned herds.

Destruction of birds. — Wild birds, especially the larger ones, must have furnished a goodly part of the diet of the early colonists. To-day the wild life of the forest and plain is but a fraction of what it once was. At the time when the Ohio Valley was first settled, the passenger pigeons flew over the country in such large flocks that they darkened the sun. It is estimated that there were over 2,000,000,000 birds in a single flock. To-day, owing to the indiscriminate slaughter of these birds by hunters, there is not a single living passenger pigeon in existence.

Value of birds. — Wild birds are a great asset to any community. Not only are they attractive in form and color, but their songs are learned so that they are recognized by any country-bred girl and boy. More than this, they are of very great importance to the farmer. A careful study of the diagrams on page 58 shows that the food of most birds consists to a large extent either of insects injurious to vegetation, or weed seeds. Even the despised crow and robin make up for their meals at our expense by eating harmful insects, and most of their food consists of wild fruits. Many people think that hawks are injurious because the chicken hawk feeds on our barnyard chicks. But three-fourths of all hawks are useful since they feed upon mice or other rodents which are harmful to crops. Birds are an asset to be carefully conserved in any community.

Protection of birds. — Since birds do little harm and much good they should be protected. Cats are probably their greatest enemy in this country. It has been estimated that cats annually destroy 3,500,000 birds in New York State alone, and in the United States east of the Mississippi from 75,000,000 to 100,000,000 birds, mostly young ones, each year. When we add to this, destruction by hunters, small boys, and certain birds, like the English sparrow and the sharp shinned hawk, we can see the need of conservation of this valuable resource.





Which birds found in your locality are helpful? Which are harmful?

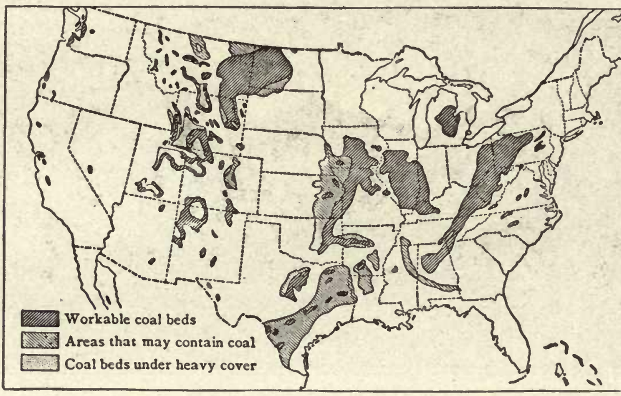
Our mineral resources. — The yearly mineral products of this country are over two billion dollars. Of these minerals, coal and iron occupy the most important place. Over six hundred million dollars' worth of coal and five hundred million dollars' worth of iron are mined yearly according to the most recent census reports. When we add the copper, gold, silver, lead, zinc, and cement products we get a total of about a billion dollars more.

Iron mining. — In early times the iron industry was centered in many small mines in the East, each with its little smelting works. Connecticut iron mines were worked

Iron ore in the Mesaba Range.

before the War of the Revolution and continued in operation for over one hundred and fifty years. At the time of the Civil War over half of the iron produced in this country came from Pennsylvania because both iron and coal were found there. But to-day four-fifths of all iron mined comes from the great deposits of the Lake Superior region. It is estimated that the United States Steel Corporation controls about half the available ore found in this country. Germany's move early in the World War to seize the rich iron mines in northern France indicates the importance of iron. When we learn that over 1,350,000 tons of materials manufactured from iron were thrown into the Verdun area during the war, we can see what a tremendous waste of iron and steel took place during the period of the World War.

Mining communities. — The old picture of a mining camp is a thing of the past. In northern Minnesota "on the Range," where are located the most productive iron mines in the world, the towns are well built and are well



Map showing bituminous coal beds.

planned by the great corporations that own the mines. Their schools are excellent, the housing conditions are good, and both native American and foreign born population have the advantages of schooling and recreation not often found in larger cities. The disadvantage of mining communities is largely due to dirt, smoke, and poisonous fumes, especially in the copper industry.

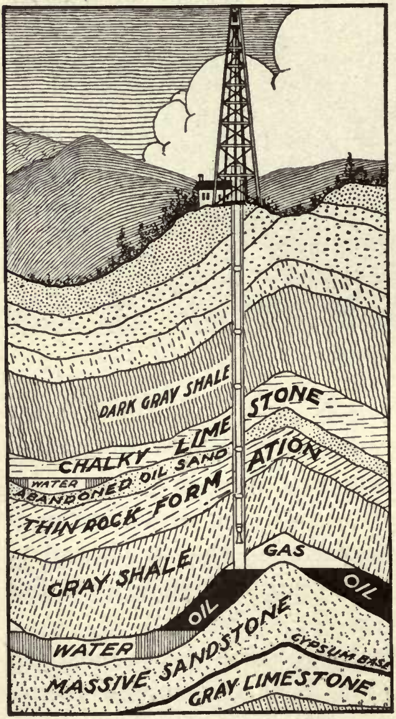
Coal. — Anthracite coal is restricted to an area of about five hundred square miles in Pennsylvania. Bituminous coal, however, comes from different localities (see map on page 60). The largest field exceeds five hundred miles in

In a coal mine.

length, extending from New York to Alabama. Most bituminous mines are found in Pennsylvania, West Virginia, Illinois, and Ohio. Coal was first used in quantity for smelting iron and it was not until the development of railroad and steamship transportation that it jumped to its present enormous use of a yearly output of over five hundred million dollars.

Coal mining towns. — Probably some of the most important civic work to be done is in coal mining towns. Here housing conditions are often poor. There are many foreigners with low living standards, and Americanization work is much needed. Coal mining is unhealthful and somewhat dangerous. Child labor was once quite prevalent among the so-called "breaker boys." The towns are usually dirty and grimy, for coke making and many smelting industries are often associated with the mining of coal.

Oil and its relation to community life. — Although oil was well known to the Seneca Indians it was not thought to be worth anything by the early colonists. It was not until 1859 that oil was drilled for and pumped from a well near Titusville, Pa. This was the beginning of the industry which has advanced by leaps and bounds until to-day great corporations with hundreds of millions of capital, thousands of wells, and tens of thousands of miles of pipe line are distributing oil from the wells by means of these lines, tank cars, and steamers to all parts of the civilized world. The greatest fields to-day are in California, Oklahoma, Pennsylvania, and West Virginia. In most of these localities natural gas is also obtainable, which in many cities supplants coal for lighting and fuel purposes.



Section through a gas or oil well.

Oil-producing communities. — Since the method of oil production requires constant drilling in new as well as old fields it means a fluctuating community existence. In 1865, Pothole City was one of the largest post offices in Pennsylvania. To-day it is nothing but a farm. In many parts of the country oil-boom towns have grown up almost overnight, and have been as quickly abandoned when oil in that locality gave out. It is evident that community life under such conditions is not very favorable.

Manufacturing communities. — We have not mentioned cotton, the great fiber crop, which gives occupation to hundreds of thousands, both in the fields and in the factories where cotton cloth is manufactured. It is interesting to know that there are many cotton mills in Massachusetts far from the source of supply. There are the great steel industries with a production of over one billion dollars' worth yearly, the foundry and machine shop productions with a billion more; men's, women's, and children's clothing with almost as great a production; the automobile industry with five hundred million dollars' yearly production, and the hundred and one other manufacturing industries which this great country of ours contains. All of these industries take our natural resources and turn them over into manufactured products which represent the wealth of the communities, hence it is that in our great manufacturing centers we find wealth in its most lavish form. In large industrial centers are our finest museums and philanthropic institutions. Here we find our best school systems. Here civic development is worked out at its best, but here also we find, due to the high rents, high cost of land, much congestion, overcrowding, and poverty.

Wastefulness in the use of our resources. — When we see the wealth of a great city we are prompted to ask, "Where does it all come from?" We must remember that, in spite of man's ingenuity and progress, wealth depends in the long run upon the natural resources of the country. We are like a man who has a sum of money in the bank the interest of which is supposed to take him through life. He spends part of his capital and in doing this makes his income less At the present time we are spending our capital in this country; especially of our forests, our coal, and our oil supplies.

Conservation. — Theodore Roosevelt wisely preached conservation, and showed his interest by appointing able men to put its principles into practice. Our forests, that great asset of ours, once covered the greater part of the country with the exception of the plains west of the Mississippi valley. To-day, with our life as a nation just beginning, we have used up most of the best wood, and have less than half of the salable timber remaining. Fortunately, we are making forest reservations where timber can be taken only under proper supervision, and we are also replanting forest areas, thanks to the work of the Bureau of Forestry.

Conservation of coal is necessary. In many industries, we may substitute oil, water power, or electricity, but we probably could hardly get along without the by-products which come from coke and gas making. We use more than five tons of coal per person a year. We have waste in imperfect combustion, in the process of coke making, and most of all at the mines. It has been estimated that for every ton of coal mined almost half a ton is wasted at the mine. All these wastes, however, are now being looked after much more carefully than in the past, for we realize that after this coal is gone we cannot obtain any more. Even greater waste is seen in the use of oil and natural gas. Carelessness in storage and in pumping is responsible for enormous waste, and since natural gas is cheap, it is also wasted both in homes and by cities. We find that oil or petroleum products are being substituted for coal, but this practice is unwise since at the present rate of production, natural gas and oil will last but about 20 years, while we have a 6000 years' supply of coal.

Conservation of our fish is being taken care of by the United States Bureau of Fisheries. Millions of fish eggs are hatched artificially each year and placed in our rivers and in the ocean. Laws are made with respect to the taking of fish in the season when they lay their eggs, and other methods of conservation are constantly being introduced. The Department of Agriculture through its Bureau of Animal Industry is watching our cattle, horses, sheep, and swine, making suggestions for improvement and aiding in production. The Department of Agriculture also has hundreds of experts working to increase the yield of crops, while the Government through methods of irrigation is throwing open new land constantly for the purpose of production.

Scoring our natural resources. — The score card which follows is intended to show in a general way the natural resources of your community. In scoring do not try to pick from all of the headings. Remember that your community, like all others, has probably two or three groups of natural advantages around which the life of the community centers. These may be agricultural, grazing, forestry, coal or oil, mineral wealth, or water power. Rarely do several go together. Therefore select with care from the different groups.

SCORE CARD. NATURAL RESOURCES OF MY COMMUNITY

Select five of the groups in the table below in which your community ranks the highest and score them. Omit the other five.

	Perfect Score	My Score
Land producing excellent cereal crops (20), moderate (10), poor (5)	20	
Land adapted for and used for market gardening — excellent (20), moderate (10), poor (5)	20	
Land adapted for and used to grow fruits and vegetables in quantity giving rise to packing or cannery industry (20), local consumption (10)	20	
Land covered with forests giving rise to industry on which community depends (20), forests for fuel only (5), no forests (0)	20	
Land suitable for grazing: horses, cattle, sheep or swine raising on large scale (20), locally used only (10)	20	
Presence of natural waterways (and good harbors, giving cheap transportation 20), one of above (10), none (0)	20	
Presence of fish in sufficient numbers to give rise to extensive industry (20), local markets (5), home consumption (2)	20	
Presence of coal as leading industry of the community (20), coal near enough to be cheap and plentiful for manufacturing and homes (10)	20	
Natural gas and oil abundant, oil fields close, fuel cheap (20), gas and oil centers within about 100 miles making them cheap (10)	20	
Sources of minerals make chief activity of community (20), minerals not present but used in many community enterprises (10)	20	
TOTAL	100	

REFERENCE BOOKS

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Bassett, *The Story of Leather*. Penn Publishing Company.
Bassett, *The Story of Lumber*. Penn Publishing Company.
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Rolt-Wheeler, *The Boy with the United States Fisheries.* Lothrop, Lee, and Shepard Company.

Rolt-Wheeler, *The Boy with the United States Survey.* Lothrop, Lee, and Shepard Company.

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Ziegler and Jaquette, *Our Community.* J. C. Winston Company.

PART II. WEATHER AND CLIMATIC CONDITIONS

CHAPTER IV

THE EFFECT OF CLIMATE ON COMMUNITY LIFE

Problems. — 1. *To learn the causes of the seasons.*

2. *To learn the relation of temperature, rainfall, heat, and cold to communal life.*

3. *To learn how health is influenced by climate.*

Experiments. — 1. To show the relation of sunlight to plant growth.

2. To show the relation of temperature to plant growth.

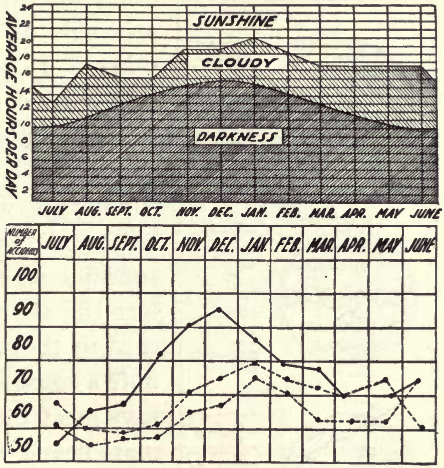
3. To show the relation of water supply to plant growth.

Project. — TO FIND HOW NEAR THE CLIMATE OF MY COMMUNITY APPROACHES THE IDEAL.

Make a list of elements essential to an ideal climate. Grade these elements in your community climate according to some standard scale you have prepared.

Climate and civilization. — In one of the most interesting scientific books that has recently been written, Professor Ellsworth Huntington points out that civilization and progress go hand in hand with a favorable climate. The effects of differences in seasons as well as moist and dry atmospheres all play an important part in acting upon living things that come under their influence. It will be the purpose of this chapter to show some ways in which climate may affect the life of our community.

Early settlers and climate.—We are told that the first Pilgrim settlers were much disappointed at the severity of the New England climate. Although it was fully one hundred miles south of the latitude of England, yet the winters were much more severe, and the summers hotter. These conditions are even more extreme in those parts of the United States that lie farther inland on the same parallel of latitude. The early settlers did not realize that England and the whole coast of northern Europe owed its mild climate to the westerly winds coming from the ocean. They doubtless owed their sturdy growth and endurance, in part at least, to the great changes in the climate to which they were exposed.

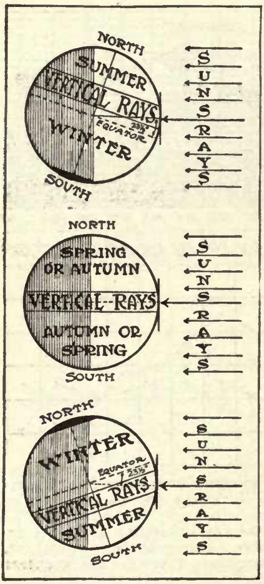


The top chart shows average hours per day of sunshine. clouds. and darkness for each month in 1910 in New York.
The lower chart shows the industrial accidents in three successive years. Notice that in general, on days with least sunshine, there are the greatest number of accidents.

The seasons and how they are caused.—The working out of the discoveries of Copernicus, Galileo, and Newton has given scientists the basis on which they have established most of our knowledge about the action of our earth in space. We remember, of course, that the earth revolves around the sun, making a complete circuit once in about 365 days, and we surely know that as the earth goes spinning through space, it rotates once on its own axis in

24 hours. But we are apt to forget that the place of the earth, the revolution of the moon about the earth, the tides, and many other phenomena are due to the important force of gravitation.

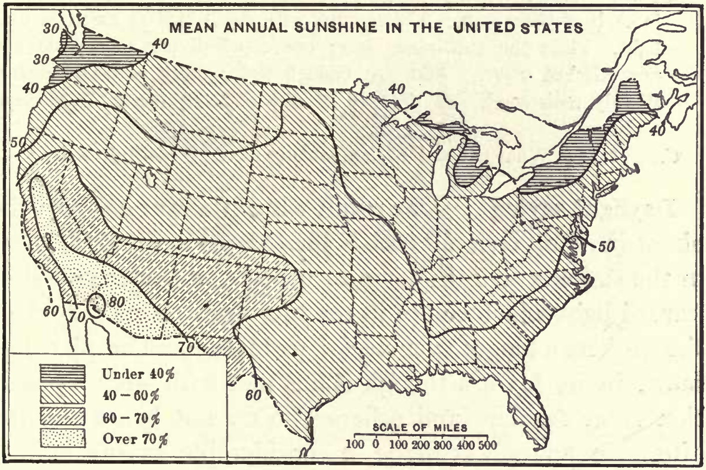
If we think back to our geography, we shall remember that as the earth revolves around the sun its axis is inclined towards the plane of the earth's orbit. Thus the sun's rays strike the earth's surface at more of an angle at certain times than at others. If you hold a piece of perforated cardboard about one foot from the floor, and parallel to it, early in the morning, so that the sun's rays will pass through the hole, and then compare the area of sunshine on the floor with the area formed at noon by holding the card in the same position, you will note a considerable difference. The rays meet the surface of the earth more nearly at right angles at noon, hence they cover less space. If the earth receives the sun's rays at a greater angle, they are spread over a greater surface and we receive less heat on a given surface. The seasons, also, depend upon the angle at which the sun's rays strike the earth. If we look at the diagram, we notice that in a similar manner the heat of the torrid zone and the lack of heat at the poles of the earth are due to this same fact. The sun is north of the equator in summer and south of it in winter. Can you explain why this should give us



The cause of our seasons explained.

a hot season in the one case and a cold one in the other? It is an interesting fact that in winter we are about three million miles nearer the sun than in summer, and yet the slanting rays make it colder.

Sunlight — a factor in climate. — We have already learned that sunlight is a very important factor in and about our homes. Sunlight in moderation makes our crops grow.



It gives necessary warmth to the soil, so that the longer day in summer with its vertical rays of sunlight warms the earth, rendering it favorable for the growth of crops. Evidence of the value of sunlight for plants is easily secured in the following experiment.

Experiment. — To show the relation of sunlight to plant growth.

Materials: Two beans.

Method: Plant the beans where they have the same temperature and moisture, but in one case in darkness and in the other case in the light. Notice the appearance of the sprouts after a number of days.

Conclusion: What does sunlight do to the bean plant?

Sunlight determines, very largely, the temperature, and so has another indirect influence upon the growth of plants. Just how this influence affects plant growth may also be shown by an experiment.

Experiment. — To show the effect of temperature on plant growth.

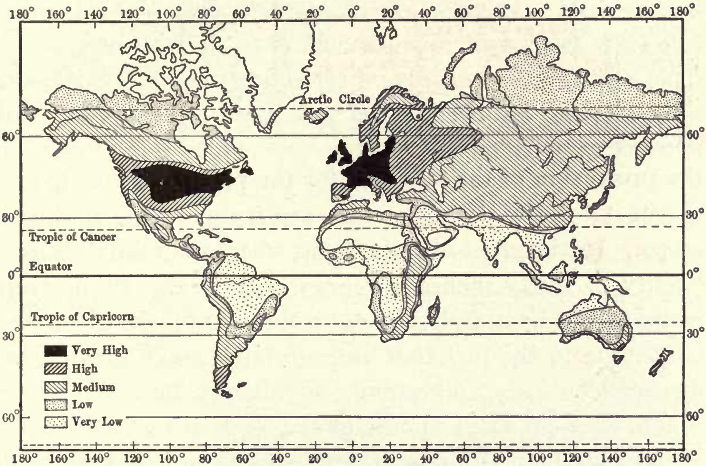
Materials: Three cups. Sawdust. Pieces of cardboard to cover cups. Beans or peas.

Method: Soak the beans or peas overnight. Place an equal number in each of three cups. Cover cups with cardboard so as to exclude light. Place one cup in ice box; one cup in living room; one cup near kitchen stove. Add just enough water daily to keep sawdust slightly moistened. At the end of five and ten days record your findings.

Conclusion: What effect does temperature have on plant growth?

Daylight saving. — One result which the war has brought about in many communities is the change of business hours in the summer months so as to utilize the longer period of unused light which comes in the morning. This also gives the workers a longer evening for recreation. The plan has much in its favor although it has met with some opposition from farmers and others who do not benefit by the afternoon hours. It made a considerable saving in fuel and light at a time when we needed coal most. A strong argument for continuing daylight saving is that it will save much fuel in the future, and it also means a lengthened play period to hundreds of thousands of workers who otherwise would be deprived of this playtime.

Changes in temperature in relation to community life. — Tropical climates or extremely cold climates are unfavorable in their effect on mankind. We have already spoken of this, and we know that Northerners going into the tropics soon lose their ambition and settle down to a life of short hours of work. This seems to be because of the lack of stimulation in such a climate. In the far north there are long periods of darkness, and the monotony brought about by the lack of temperature and light changes causes an unfavorable reaction on the people living there. The moderate changes which come in a temperate climate, especially the cold winters and warm summers, undoubtedly



The distribution of human energy on the basis of climate. (After Huntington.)

do much toward making our people the active and resourceful race that they are.

Rainfall a factor. — We have all seen that rain plays a very important part for the inhabitants of the earth. Let us see by a simple experiment the relation of water to plants.

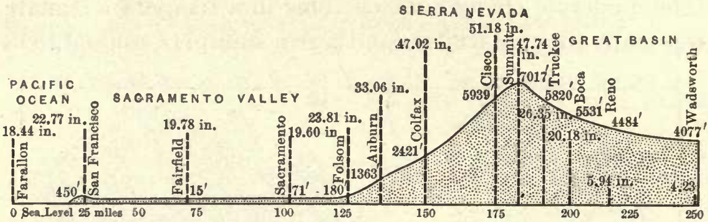
Experiment. — To show the relation of water supply to plant growth.

Materials: Two small trays or boxes. Sawdust. Pea or bean seeds.

Method: Soak the peas or beans overnight and plant in equal numbers in each box. Cover with sawdust. The sawdust in one box is kept well moistened. Add no water to the other. After one, two, and three weeks make drawings and report to the class.

Conclusion: What effect does water have on plant growth?

We see that plants need water no less than people do. Rainfall makes the type of community. Farming depends to a large extent upon the amount of rain and sun. If the summers are hot, rain becomes a necessity, both for



the protection of the soil and for the plants and seeds that are in it. Rain also is a necessary factor in the raising of crops. In the great Middle West, where the rainfall is from twenty to thirty inches a year, wheat is the staple crop, while in the East and the South there are more diversified crops, due to the fact that the rainfall is much greater, being between forty and seventy or more inches.

Influence of water upon climate. — It is not uncommon for us in the hot summer to make visits to the seashore or some mountain lake. Those of us who have lived near the shores of the Great Lakes know that the summers are much cooler and the winters somewhat warmer than they are in towns at some distance from these lakes. Along Lake Michigan and Long Island Sound an evening breeze from off the water blows over the land, cooling and refreshing those who live there.

If we think back to the heating of rooms, we remember that the stove set up convection currents in the room. The same thing occurs on a larger scale between land and bodies of water. During the day the temperature of the land rises higher than does the temperature of the water of the lake. The heated air rises from the land, and as it does so, cooler and heavier air makes its way in from the lake to take its place. This accounts for a breeze and a more even temperature of the city or town located near a body of water. In the winter months the lake or ocean loses its heat more slowly than the land and so prevents extremely low temperatures in its vicinity. Hence it is no uncommon thing to find no snow in New York City and along the sea coast while it is several inches deep less than a hundred miles from the coast. Bodies of water by means of their stored heat also have an effect upon the severity and the time of killing frosts.

The effect of storms. — We have seen that bodies of water influence winds. Such winds make life bearable in

A flooded city, the result of heavy rainfall causing rivers to overflow their banks.

many tropical countries, especially where the trade winds blow in from the ocean at certain intervals during the day, causing evaporation, which is a cooling process. The presence of wind belts over ocean and land is well known to all those who have studied geography. Our cyclonic storms occur in one of these wind belts. These storms, while they do damage, yet supply the needed rainfall. Thus the eastern part of our country owes much of its fertility to such storms. Prolonged and severe rainfall at times causes rivers to overflow their banks, doing much damage to crops, to buildings, and to railroads. Local conditions, such as high hills, mountains, lakes, or forests, may also have a great effect upon the prevailing winds, and may do much in making the community a pleasant or an undesirable place in which to live. The occurrence of severe wind storms, such as tornadoes with accompanying hail, is sometimes very destructive to crops.

The railroad industry is greatly affected by cold and snowfall. The snow blockades on the railroads of the northern part of the country have led to the construction of huge snow tunnels and wind breaks, and to the invention of the rotary snow plow. The freezing of harbors in the same way influences the commercial importance of a city, while on the other hand harbors which are located in regions where the trade winds blow constantly are much favored. Duluth, Vladivostok, Petrograd, and the northern ports of Germany are examples of inclosed ports. Canada is much handicapped by the winter closing of the St. Lawrence River, while the ports of New York, Liverpool, or Buenos Aires are examples of favored localities.

Industry affected by climate. — It goes without saying that such industries as farming or lumbering depend largely upon climate. Many manufacturers as well, especially those who use the products of the farm or raw lumber, build their factories near the source of supply. Others who make use of water power are also indirectly dependent upon the climate. More than this, workmen in factories, or indeed in any occupation, are very greatly influenced by climate.

A recent study of temperature by a committee on ventilation in New York State found that 15 per cent less work was done by a group of people working in a temperature of 70 degrees Fahrenheit than when the same group worked in a temperature of 68 degrees Fahrenheit, while if the heat became as high as 86 degrees they did 37 per cent less work than they did at 68 degrees.

Another authority on weather has shown that one of the chief conditions that enabled the German nation to fight for so long against what seemed great odds was the stimulating climate, which thus helped the people to do more work without feeling the fatigue that would come to those less advantageously located.

Frequent changes of temperature, such as mark the climate in most of the United States, are stimulating, and add to the total energy of the people.

Health influenced by climate. — An interesting study has been made by Huntington on what he calls the climatic energy in this country compared with the death rate in different parts of the country. His maps on climate energy have been worked out from a study of the civilization and achievements of people in all parts of the world, and based on the climate of that part of the world in which they live. The map for the United States shows that certain states to the east and north enjoy a somewhat more favorable climate than other states. He shows also that the death rate in areas that have the greatest climatic energy is less than in those states where the climatic energy is not so great. While many factors probably enter into the formation of these figures, yet we cannot escape the conclusion that climate does play a very important part in our success or failure in life, and in making a community a favorable place in which to live. It is also a well-known fact that there are more epidemic diseases among people in tropical climates than in the temperate. This is due in part to lack of sanitary measures.

What is an ideal climate? — From all that we have just seen, we are now ready to give some sort of answer to this question. The most favorable climate must certainly not be very cold or very hot. It must have some rainfall, at least thirty inches a year, to be ideal. We should be located near enough to large bodies of water so that we may benefit from their moderation of temperature and humidity. On the other hand, a high humidity, often found along bodies of water in summer, is uncomfortable. Above all, our climate should have a large number of sunny days, so that health may be an asset to our community.

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CHAPTER V

THE WEATHER AND THE WEATHER BUREAU

Problems. — 1. *To learn about air conditions affecting weather.*

2. *To understand the use of weather instruments.*

3. *To learn what is meant by relative humidity and how to measure it.*

4. *To understand the causes of clouds and rain.*

5. *To learn the nature of local storms.*

6. *To learn the nature of cyclonic storms.*

7. *To learn about the work of the weather bureau.*

Experiments. — 1. To make an experimental barometer.

2. To measure a height with an aneroid barometer.

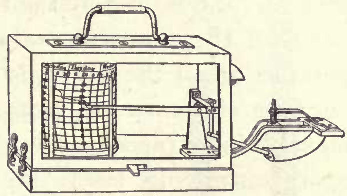
3. To show the relation of humidity and temperature to moisture capacity.

4. To measure the relative humidity of the air.

Project I. — TO KEEP A WEATHER RECORD FOR SIX MONTHS.

Project II.—TO MAKE A RAIN GAUGE AND TO KEEP A RECORD OF RAINFALL FOR SIX MONTHS.

A visit to the weather bureau. — Have you ever visited the weather bureau in any large city? If so, you doubtless remember the interesting trip taken to the top of a tall building where the government officials work with their various recording instruments. Here you saw barometers and thermometers, wind gauges and rain gauges, anemometers and hygrometers. Doubtless you learned something of their uses. Or perhaps, in your own school, you have had an opportunity to learn something about them and to use them. Each boy and girl, although not able to understand and use all of these instruments, yet should be able to read and comprehend the maps which are sent out by the United States Weather Bureau, and which may be obtained for the asking for your own school. The life in our community is controlled to a very great extent by the weather we have; and the welfare of the people, especially outside of large cities, depends, in part, on some knowledge of the weather.



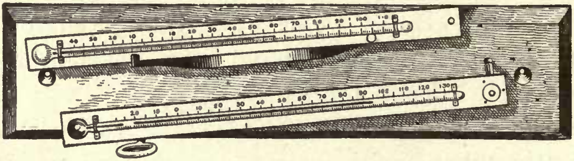
A thermograph.

What is weather? — We observe the various changes in the atmosphere which come to us day by day. It may be clear or cloudy, calm or windy, hot or cold, wet or dry. We speak of these daily changes as changes in weather, and the average weather, taken day by day, week by week, season by season, makes up our climate. These changes which occur in the weather can be predicted with a great deal of accuracy by any one who has made a careful study of clouds, winds, and especially of air pressure.

The thermometer. — We have already learned something of the principle of the thermometer, a glass tube with a bulb at one end filled with mercury or some other fluid that expands and contracts with heat and cold. The tube is sealed while hot, leaving a vacuum above the mercury when it cools. The scale is then marked on the glass tube according to the Fahrenheit or Centigrade marking, the Fahrenheit having the freezing point of water marked

"32 degrees" and the boiling point, "212 degrees," while the Centigrade has the freezing point marked "Zero" and boiling, "100 degrees." The Centigrade is used in most scientific work, although the Fahrenheit thermometer is in common use, and is used by the United States Weather Bureau.

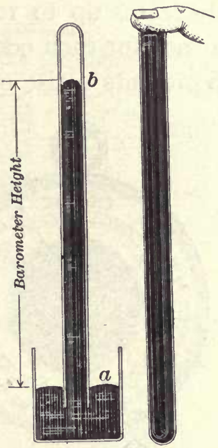
Useful thermometers for determining extremes of temperature are of the self-registering type, shown below. In one type of *maximum* thermometer, the mercury pushes a movable index placed inside the bore along ahead of it, and upon contracting, leaves the index marking the point of greatest expansion. In the *minimum* thermometer, the



Maximum and minimum thermometers.

index is covered with alcohol in the bore of the tube. When the alcohol contracts, the surface film draws the index along, but when alcohol expands, it moves by the index, which thus marks the lowest temperature reached. It is important for a study of weather conditions to have a continuous record of temperature. Such a record is produced automatically by an instrument called the thermograph.

Air pressure in its relation to weather. — We have already learned that air has weight. Its pressure on us at sea level averages about 14.7 pounds to the square inch. We sometimes get a little idea of this pressure by being suddenly dropped down in a rapidly running elevator. The change of air pressure may be noticed in the effect on the ears. The instrument which measures the pressure of the air is called the *barometer*. A simple barometer is quite easy to make, for we can perform an experiment made a great many years ago by Torricelli, a pupil of Galileo. He wished to know what the pressure of air was, and constructed an instrument to measure it in somewhat the same way as described in the following experiment.



Experimental barometer.

Experiment. — To make an experimental barometer.

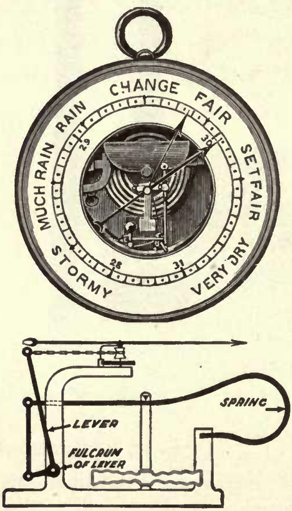
Materials: A stout glass tube 33 inches long, closed at one end. Mercury. Small funnel. Mercury trough.

Method: Hold the glass tube inclined a little from vertical. Place the funnel in the tube and pour mercury in to fill the tube. A suitable funnel may be made by heating the stem of a thistle tube near the bulb and drawing it out to reduce the diameter. Cut this off at its narrowest point. Work the air out of the tube by jarring. When the tube is full of mercury, cover the open end with the finger, invert, hold end under mercury in the trough, and remove the finger.

Result and Conclusion: What happens when the finger is removed? Hold the tube vertically and measure the height of the column of mercury in the tube above the level of mercury in the trough. What holds it up? Read the barometer. Why does this experimental barometer read lower?

Air bubbles in the mercury of the experimental barometer may be removed by the use of a fine wire. A barometer made in this way has some air left in it and so reads lower than a standard barometer. The air can be removed only by boiling the mercury in the tube.

How the barometer is used. — The height of a column of mercury under standard conditions is 30 inches and represents a pressure of 14.7 pounds per square inch. A rise or fall of the column indicates an increase or decrease in air pressure. The air pressure in your own locality depends on the altitude above sea level; for example, Leadville, Colorado, with an altitude of over 10,000 feet, shows a height of mercury of only 20 inches. The air pressure decreases up to 10,000 feet at the rate of approximately 1 inch for each 900 feet. A fall of 1 inch in the barometer represents a rise of 910 feet near the earth and 1500 feet 3 miles above sea level. If you lived at an altitude of 2500 feet above sea level, what would be the normal reading for your barometer?



Explain the working of the aneroid barometer from this diagram.

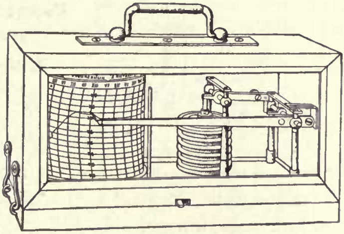
Aneroid barometer. — The mercurial barometer just described cannot be carried about easily, as it must be kept in a vertical position. The aneroid barometer may be carried about like a watch or clock, and thus is used by explorers and for practical work in the field. Just inside the case of the aneroid barometer is a small flat box of thin corrugated metal. From this box the air has been removed. The walls are so delicate that a slight increase in pressure causes the walls to come closer together, while a decrease in pressure allows them to go farther apart. This motion is transferred by lever action to a hand which moves along a scale to show the pressure of the atmosphere. The aneroid is used both for weather observation and to measure the height of mountains or the altitude of aircraft.

Experiment. — To measure a height with an aneroid barometer.

Materials: An aneroid barometer.

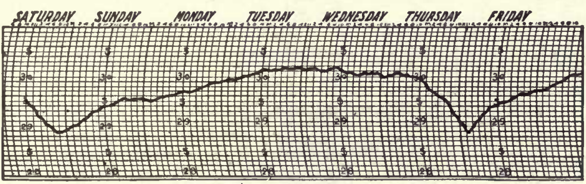
Method: Study the scale and learn how to read fractions of a division. Assume the relation of rise in altitude to the decrease in pressure to be 910 feet to 1 inch. Read the barometer at the base of a high building or better a high hill or small mountain. Carry the barometer to the top and read again. Read again at the top and again when reaching the base. Average the two results.

Results and Conclusion: From these figures what do you conclude the height of the building or hill to be?



A barograph.

The barograph. — The standard barometer for weather bureau readings is the mercurial barometer. But the aneroid is used in the self-

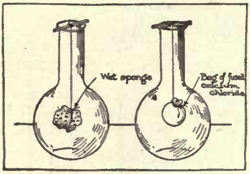


NEW YORK, N.Y., DECEMBER 8-14TH 1917

Barograph record.

recording instrument called the *barograph.* A pen which rises and falls under changes of air pressure records these changes on sheets of paper attached to the outer surface of a revolving drum, which is operated by clockwork.

Humidity. — What do we mean by humidity? We have felt an effect of it, for the discomfort of a muggy day in summer is familiar. If we place a dish of water in an air-tight box, the water will evaporate until the inclosed space holds all the water vapor it can. Then the air is said to be *saturated*, but we really mean that the *space* is saturated, because there would be the same amount of moisture in the space whether air were present or not. Some of the factors which determine the capacity of air (space) for holding moisture may be found out by this experiment.

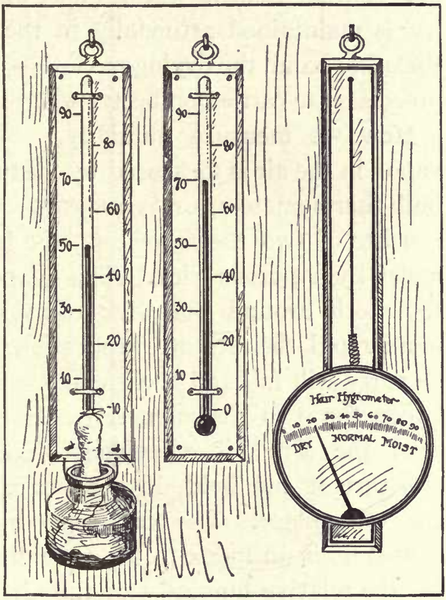


Experiment. — To show the relation of humidity and temperature to moisture capacity:
Materials: Four 1-liter flasks. Small sponge. Cheesecloth. Fused calcium chloride. Glass rod. Stoppers.
Method and Results: (1) Prepare a flask of moist air by hanging a small wet sponge in the flask. Prepare a flask of dry air by hanging a cheesecloth bag of fused calcium chloride in it. From a wet glass rod let *one drop* of water fall into each flask. In which case does it evaporate into the air in the shortest time?

(2) On a cold day close two dry flasks which have been open in the room for several hours. Place one of these out of doors where the temperature is 20 or more degrees colder than indoors. After 10 minutes, put a drop of water in the flask kept indoors and another drop in the flask kept in the cold. Observe from time to time until you have evidence to prove whether the cold or the warm air takes up the water first.
Conclusion: What conclusion do you draw from these experiments?

We thus see that when the air is cooled, less water is taken up than if the air is warm, and that dry air has a higher capacity for taking up vapor than moist air. It is possible to measure the amount of water taken up by the air. This weight of water which the air or space actually holds is called the *absolute humidity*, but the humidity which we see reported in the daily papers is the *relative humidity;* that is, the ratio between the amount of water that the air contains and what it would contain if it were saturated. For example, if the humidity is 60%, that means that the air contains 60% of the amount of water that it would contain at that temperature if the air were saturated.

Humidity in buildings. — Every one of us knows how uncomfortable a crowded auditorium becomes after we have been in it for a short time. The room seems suddenly hot, but, as a matter of fact, if we were to take the temperature, we should not find it very much higher. We should, however, find a very great rise in humidity. This rise in humidity is caused by the loss of water from the bodies of the people in the room from their breath and through their skin. Since the room has more moisture in the air, it appears hotter to the people in it. The ventilation of public buildings is an important matter, as is the ventilation of our schoolrooms. Heated rooms are sometimes made more comfortable by the use of electric fans, which produce a circulation of air. Hot rooms in homes are usually not humid enough, especially in buildings heated by a hot-air furnace. It is always a good plan to keep pans of water on the radiators and to hang cloths so that they dip into pans of water near registers, for in this way the air in the rooms is more humid and much more healthful. With higher humidity in the rooms of a house



Wet- and dry-bulb thermometers and hair hygrometer: useful instruments in determining humidity.

one can be comfortable at a lower temperature and one is much less likely to take cold upon going out of doors. A relative humidity of 60% to 70% is desirable in the house. Humidity is important in many industries. In weaving cotton cloth, the threads break more easily in dry, cold air than in warm, moist air, hence a high humidity is maintained artificially in the weaving rooms. On the other hand, the drying of clothes, making hay, and other processes are carried on better when there is a low humidity.

How we measure humidity. — The amount of water vapor in the air is measured by means of the wet- and dry-bulb thermometers, or *hygrometer*. This instrument really consists of two thermometers, the bulb of one being kept moist by a porous wick. The evaporation of water from the cloth around the wick cools the mercury, and the more rapid the rate of evaporation, the more rapidly the mercury will fall and the greater will be the difference between the two thermometers. If the two thermometers read the same, it is evident that the air has all the moisture it can hold, or 100 per cent, as no evaporation can take place. The difference between the two thermometers is an index to the humidity. It is well to measure the relative humidity of the air in the schoolroom, as can easily be done by the following experiment.

Experiment. — To measure the relative humidity of the air.

Materials: Wet- and dry-bulb thermometers.

Method: Wet the muslin covering the bulb and whirl the thermometer rapidly in the air or fan a current of air upon it, reading the temperature. Record the lowest temperature reached. Also record reading of the dry-bulb thermometer. Refer to the table, page 89, and record the humidity of the air as indicated in the table for the readings noted.

The following table gives the relative humidity at different temperatures for given dry-bulb readings.

TABLE FOR FINDING RELATIVE HUMIDITY. PERCENTAGES

Dry Therm. (air temp.)	Difference between Dry- and Wet-bulb Thermometers													
	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18
0	68	35	3												
2	71	41	12												
4	73	46	19												
6	75	50	25	1											
8	77	54	31	9											
10	79	57	36	15											
12	80	60	41	21	3										
14	82	63	45	27	10										
16	83	66	49	33	16	0									
18	84	68	53	38	22	7									
20	85	70	56	42	28	14									
22	86	72	59	45	32	19	7								
24	87	74	61	49	36	24	12	0							
26	88	75	64	52	40	29	18	7							
28	88	77	66	55	44	33	23	12	2						
30	89	78	68	57	47	37	27	17	8						
32	90	79	69	60	50	41	31	22	13	4					
34	90	81	72	62	53	44	35	27	18	9	1				
36	91	82	73	65	56	48	39	31	23	14	6				
38	91	83	75	67	59	51	43	35	27	19	12	4			
40	92	84	76	68	61	53	46	38	31	23	16	9			
42	92	85	77	70	62	55	48	41	34	28	21	14	0		
44	93	85	78	71	64	57	51	44	37	31	24	18	5		
46	93	86	79	72	65	59	53	46	40	34	28	22	10		
48	93	87	80	73	67	60	54	48	42	36	31	25	14	3	
50	93	87	81	74	68	62	56	50	44	39	33	28	17	7	
52	94	88	81	75	69	63	58	52	46	41	36	30	20	10	0
54	94	88	82	76	70	65	59	54	48	43	38	33	23	14	5
56	94	88	82	77	71	66	61	55	50	45	40	35	26	17	8
58	94	89	83	77	72	67	62	57	52	47	42	38	28	20	11
60	94	89	84	78	73	68	63	58	53	49	44	40	31	22	14
62	94	89	84	79	74	69	64	60	55	50	46	41	33	25	17
64	95	90	85	79	75	70	66	61	56	52	48	43	35	27	20
66	95	90	85	80	76	71	66	62	58	53	49	45	37	29	22
68	95	90	85	81	76	72	67	63	59	55	51	47	39	31	24
70	95	90	86	81	77	72	68	64	60	56	52	48	40	33	26
72	95	91	86	82	78	73	69	65	61	57	53	49	42	35	28
74	95	91	86	82	78	74	70	66	62	58	54	51	44	37	30
76	96	91	87	83	78	74	70	67	63	59	55	52	45	38	32
78	96	91	87	83	79	75	71	67	64	60	57	53	46	40	34
80	96	91	87	83	79	76	72	68	64	61	57	54	47	41	35
84	96	92	88	84	80	77	73	70	66	63	59	56	50	44	38
88	96	92	88	85	81	78	74	71	67	64	61	58	52	46	41
92	96	92	89	85	82	78	75	72	69	65	62	59	54	48	43
96	96	93	89	86	82	79	76	73	70	67	64	61	55	50	45
100	96	93	90	86	83	80	77	74	71	68	65	62	57	52	47

Cirrus clouds; found at an altitude of five miles or more above the earth.

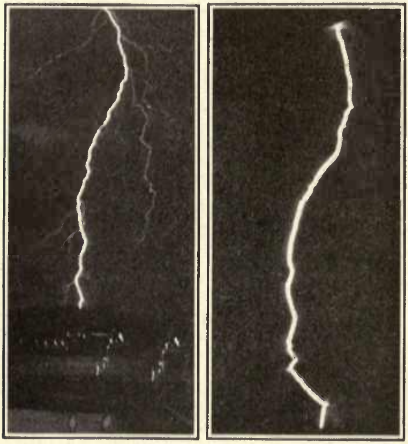
Cumulus clouds; often the forerunner of a thunderstorm.

Stratus clouds; low-lying clouds.

Formation of clouds and rain. — As the moist warm air rises it expands. When air expands, it becomes cooler. Cooling air reduces its capacity to hold moisture. As a result, at some height, conditions are such that the moisture in the air is condensed into clouds. The minute particles of moisture in the clouds may increase in size by further condensation upon them, or several particles brought into contact may unite, so that finally the particles are too heavy to remain suspended in the cloud and they fall as rain.

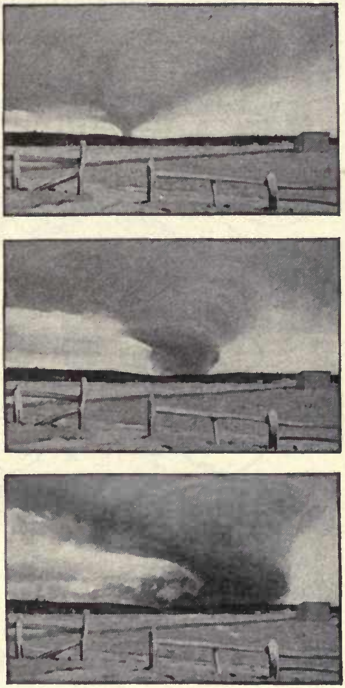
A study of the cloud pictures opposite will help us to make use of cloud observation in foretelling storms. Cumulus clouds, for example, may bring local storms, especially thunderstorms, but are not an indication of long-continued rains. They begin to form at the level where the rising column of air reaches a point where it will condense, and frequently extend into the atmosphere for a height of five miles or more. Cirrus clouds are light and feathery. They are formed at a very great height, and are usually composed of tiny crystals of ice. Stratus clouds are rather low, lying in long, horizontal beds, and are much more likely to indicate rain. Nimbus clouds almost always bring rain.

Local storms. — There are two general types of local storms, thunderstorms and tornadoes. The thunderstorms are common phenomena to most of us. They are rarely over twenty to twenty-five miles in width and travel as a rule for a distance of not over one hundred and fifty to two hundred miles. The electrical display depends upon the charging of the air envelope with electricity. Electricity seems to be present in the air up to a height of many miles. During clear and dry weather the electrical energy is fairly equally distributed, for dry air is a very poor conductor of electricity, but during rapid cloud formation great differences in the electrification of the air occur, and since moisture aids the conduction of electricity, the result is that a cloud may become charged with a bountiful supply. The electricity is discharged from the cloud by means of the flash of lightning, either to another cloud which is oppositely electrified or to the earth itself. A study of the figure shows the likeness of the electric flash to that which is artificially made in the laboratory. It is very easy to figure out how far away this discharge of electricity is by observing the flash and then counting the number of seconds that elapse between the time of the flash and the sound of the thunder, calculating that sound travels to your ear at the rate of 1100 feet a second. Considerable damage is done by thunderstorms, mostly from burning barns and forest fires set by lightning.



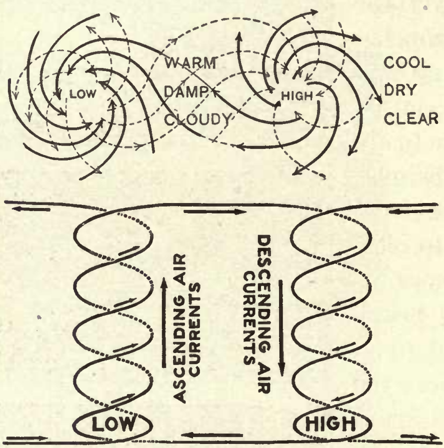
Observe the similarity between the natural and the artificially made electric flashes.

Tornadoes. — Tornadoes usually occur along the valleys of the Missouri and Mississippi rivers, and occasionally in some parts of the Ohio Valley, as well as south and east. They are not cyclones, although often wrongly so-called. They are extremely local storms, frequently varying from fifty to one thousand feet in width and may travel distances of from one mile to twenty or thirty, or, in rare instances, to two hundred miles. A whirling motion develops in the rising column of air, and when of great intensity, the characteristic funnel, which is only a part of the cloud itself, is formed. Air is believed to rush around in this whirlwind at the rate of three to five hundred miles an hour, and wherever the funnel of the tornado touches the ground, it sucks up and destroys everything in its path. Houses are actually blown inside out, because the suction outside the house causes the air inside to blow the walls and windows outwards. Frequently a heavy fall of hail with thunder and lightning accompanies the tornado. Much local damage is done by these storms, although fortunately they are restricted to comparatively small areas.



A tornado.

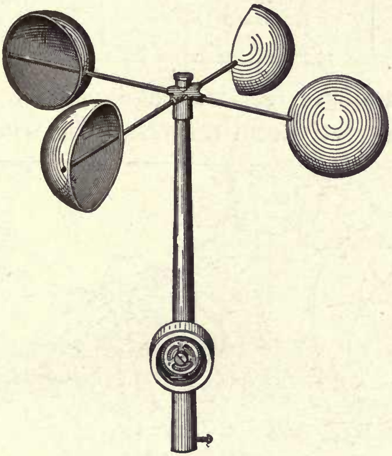
Winds and their cause. — If we make a study of the weather maps on pages 96 and 97, we notice wherever the air pressure is low that little near-by arrows point approximately toward that spot. If we read the map carefully, we see that these arrows indicate that the wind is moving spirally counter-clockwise around this point of low air pressure. This rotary movement around and toward a low-pressure area is called a *cyclone*. Most of our storms which move across the country in more or less regular paths are cyclones. Areas of high pressure, known as anticyclones, show just the reverse of the cyclone movement of air, the winds moving away from these areas. This cyclonic movement of air is sometimes interfered with by local conditions, such as the unequal heating of land and of water, or the presence of hills and mountain ranges, which cause them to move in irregular directions. Areas of low pressure have high temperatures and high humidity. High-pressure areas have low temperatures and low humidity. Warm air is lighter than cold air.



Explain these figures.

Moist air is lighter than dry air. These facts explain in part the existence of low pressures and high pressures. The heavy, dry, cold air of the " high " is drawn down by gravity with greater force than is the moist, warm air of the " low " and so the cold air flows in under the warm air and lifts it. About the center of the " low " there is always an ascending current of moist air; and about the center of the " high " there is a descending current of dry air. Complete convection currents are thus established. At the surface of the earth there is a movement of air or wind from the "high" to the "low." In the upper layers of air above the earth there is a current of air from the "low" to the "high," thus completing the circuit of moving air. Practically all of our variable winds are caused by natural convection currents in the atmosphere. The trade winds and prevailing westerlies are influenced largely by the rotation of the earth in addition to convection.

How wind velocity is measured. — Wind velocity is

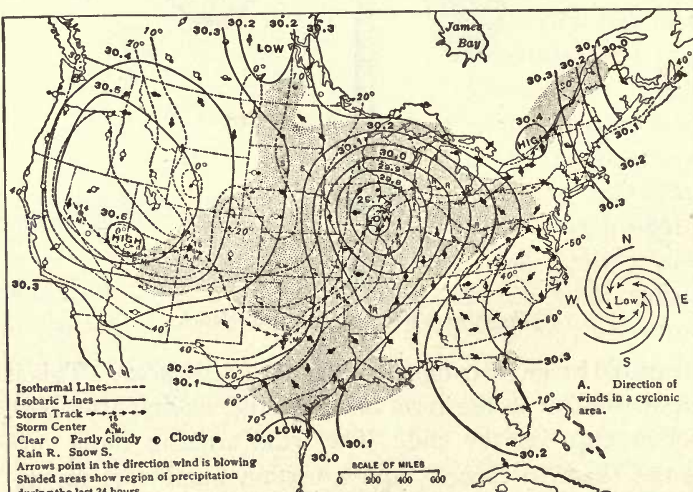


The anemometer determines wind velocity.

measured by an instrument called the *anemometer*. This is an instrument in the form of a spindle, having arms with hollow cups on the end. The wind striking these cups causes them to revolve, and a certain number of revolutions per hour indicate one mile of wind velocity. The following scale of wind velocity, called the Beaufort wind scale, issued by the weather bureau, will be found useful in working out home projects on weather.

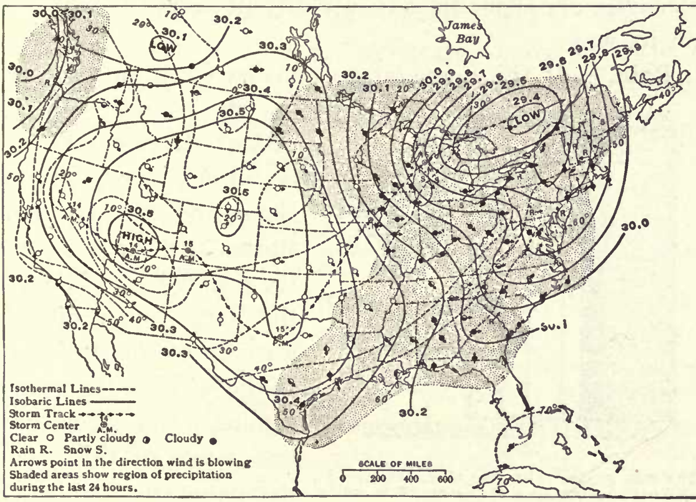
Scale Numbers	Kind of Wind	Miles per Hour
0	Calm	From 0 to 3
1	Light air	Over 3 to 8
2	Light breeze	Over 8 to 13
3	Gentle breeze	Over 13 to 18
4	Moderate breeze	Over 18 to 23
5	Fresh breeze	Over 23 to 28
6	Strong breeze	Over 28 to 34
7	Moderate gale	Over 34 to 40
8	Fresh gale	Over 40 to 48
9	Strong gale	Over 48 to 56
10	Whole gale	Over 56 to 65
11	Storm	Over 65 to 75
12	Hurricane	Over 75

Cyclonic storms. — As we have noticed above, areas of low pressure are storm centers. The wind blows in a



Tell the story of the weather as disclosed by this map.

spiral toward the low in a counter-clockwise direction in the Northern Hemisphere, but in a clockwise direction in the Southern Hemisphere. This spiral air movement we have called a *cyclone* and the type of storm accompanying it, a *cyclonic storm*. Cyclones pass across the United States from the northwest, southeasterly to the Mississippi Valley, then northeasterly, usually leaving the continent along the St. Lawrence Valley. They move rather slowly, at the rate of about 25 miles an hour in summer and about 35

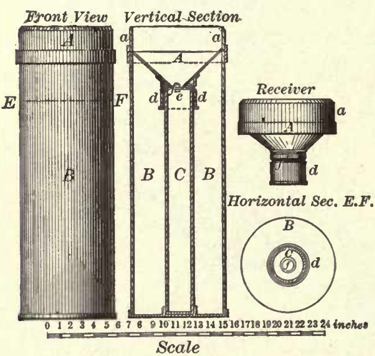


Weather conditions 24 hours later; what important changes have occurred?

miles an hour in winter. These cyclones occur with considerable regularity in the winter, each cyclone being followed by an *anticyclone* or area of high pressure, from which winds blow in a clockwise spiral.

Observation of many weather maps will show that the southeast quadrant of the cyclone is the area most likely to get rain. East and south or southeast winds, unless accounted for otherwise, indicate the approach of a "low," and so frequently precede rain or snow. North, west, and northwest winds, on the other hand, follow the low and precede the anticyclone, which brings cool, fair weather. A few of the cyclones seem to originate in the vicinity of the Gulf of Mexico and traverse the United States in a northeasterly direction. By telegraphic communication the progress and severity of any storm can be determined in advance. Sometimes it increases in strength, and sometimes its severity decreases as it travels on its way.

Rain. — If the temperature remains for some time below the point of condensation, enough moisture is formed to produce clouds and rain. Cyclonic storms as they pass over the country give back to the land much of this water in the form of rain. In the far West the storms coming from the coast lose much of this water in passing over the mountain ranges, so that the great plains east of the Rocky Mountains receive comparatively little rainfall. A study of the map on page 17 shows that the rainfall differs very considerably, being as high as 100 inches a year on some parts of the Pacific Coast, and being reduced in some places east of the Rocky Mountains to as little as 10 inches per year. Twenty inches a year is a minimum for dry farming, and a rainfall of from 30 to 50 inches is best for the great cereal crops of our country.



The rain gauge. The area of the receiver is 100 times the area of the vessel in which the water is measured (*C*). Why?

Dew and frost. — We have already seen that when the moisture in the clouds is condensed, it may form drops of rain. In somewhat the same way moisture may be condensed on objects and appear as dew. Vegetation, such as grass, holds little heat, losing it by radiation soon after the sun goes down. The grass thus cools the air immediately in contact with it, and the moisture in the air is condensed on the surface of the blade of grass. When the temperature of the air is at the freezing point or below it, the condensed particles of moisture are frozen into small crystals of ice or frost. Frost is an enemy of the farmer,

WHITEHALL BUILDING
17 BATTERY PLACE

U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU.
CHARLES F. MARVIN, Chief

SATURDAY
FEBRUARY 5, 1921

Highest yesterday 41° — FOR NEW YORK CITY AND VICINITY — Lowest last night 36°

Rain to-night. Sunday fair, colder. Moderate south to west winds. Minimum temperature to-night about 36 degrees.

EASTERN NEW YORK: Rain to-night, colder in extreme northern portion. Sunday cloudy and colder, probably rain or snow in north and central portions. Fresh south, shifting to west winds.

EASTERN PENNSYLVANIA: Rain to-night, warmer in south portion. Sunday generally fair and colder, except probably rain or snow in extreme north portion. Moderate south, shifting to west winds.

NEW JERSEY: Rain to-night. Sunday fair and colder. Moderate to fresh south, shifting to west winds.

SOUTHERN NEW ENGLAND: Unsettled to-night and Sunday, probably rain; warmer to-night; colder Sunday afternoon. Fresh south, shifting to west winds.

STEAMERS departing to-day for European ports will have fresh south, shifting to west winds and rain to the Grand Banks

Shipments of perishable produce should be prepared for the following temperatures Sunday morning:
Northern New York, 18° to 28°— Northern New England, 18° to 30°— Southern New England, 30° to 40°— Western New York, 28° to 30°—
Western Pennsylvania, 32° to 40°— Eastern Pennsylvania, 32° to 40°— New Jersey, 32° to 40°— + Indicates followed by warmer. — Colder.

A sample of information distributed by mail by the Weather Bureau.

and can usually be predicted by the weather officials. The United States Weather Bureau, by means of its warning signals and reports, is enabled to inform farmers when frost is likely to occur, so that they may take proper precautions. In Florida and California where citrus fruits are grown, frost is often kept away by the burning at night of many smudge kettles, which raises the temperature near the plants several degrees. Delicate plants may be covered, and other means of fighting frost are used.

The work of the weather bureau. — It can be seen from the foregoing paragraphs that through telegraphic communication with various parts of the country a weather bureau is able to tell accurately what weather may be expected. There are a large number of branches in various localities, and each day the weather signs, — temperature, rainfall, rate of wind, direction of wind, barometric pressure, and other necessary information, — are telegraphed to Washington and to all the different weather bureaus throughout the United States, where weather maps are made within an hour after the time the information is received. These weather maps are soon sent by mail to places all over the United States. Along the coast, shipping is at times at the mercy of storms. By heeding the warnings sent out by the weather bureau, large numbers of vessels and men have been saved. Truck farmers and orange growers depend upon the weather bureau frost warnings to protect their crops. Stations upon rivers which are likely to have dangerous floods report water levels and probable rise in level from predicted storms. In the World War, the work of the weather stations was of tremendous importance in determining the feasibility of air and gas attacks, as well as other movements.

Advance information about the weather is of importance in warfare, in commerce, in industry, and to a degree in controlling our own daily activities. While it is impossible at present always to make infallible predictions, yet in the large majority of cases the weather bureau predictions are correct, and so in general they may be relied upon.

The score card. — Climate and weather are advantages or disadvantages that we are not apt to think much about. Many large cities are at a great disadvantage in this respect, and yet have become great centers of wealth and industry. Study temperature, rainfall, and other conditions and see how your community scores.

SCORE CARD. CLIMATE AND WEATHER OF MY COMMUNITY

	Perfect Score	My Score
Extremes in yearly range of temperature not below 0° nor above 95° (20), below −15° or above 100° (15), below −25° or above 102° (10), below −35° or above 105° (5)	20	
Sunshine 60% of days (20), 50% (16), 40% (12), 30% (10), 20% (8). Consult sunshine map, page 71	20	
Rainfall 30 to 60 inches (10), 20 to 30 or over 60 inches (5). See map, page 17.	10	
No tornadoes (10), infrequent (2), frequent (0)	10	
No danger from lightning (10), infrequent (2), frequent (0)	10	
No long periods of severe heat or severe cold (10), infrequent (5), frequent (0)	10	
Freedom from damage by floods or excessive rains (10), floods very infrequent (5), floods frequent (0)	10	
Freedom from excessive heat, drought, high winds, or early frosts (10), crops infrequently damaged (5), frequently damaged (0)		
Total	100	

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PART III. WATER AND ITS PLACE IN THE LIFE OF THE COMMUNITY

CHAPTER VI

THE RELATION OF WATER TO POWER

Problems. — 1. *To learn how the earth holds water and how it loses it.*

2. *To understand what is meant by water power.*

3. *To learn about devices for utilizing water power.*

4. *To understand how some communities are dependent upon water power.*

Experiments. — 1. To see which kinds of soils hold water best.

2. To measure the horse power of a motor.

Project I. — TO STUDY THE CHARACTER OF LOCAL SOILS AND WATER TABLE.

Investigate and report on the character of the local soils and the probable rise and fall of the water table at different times in the year.

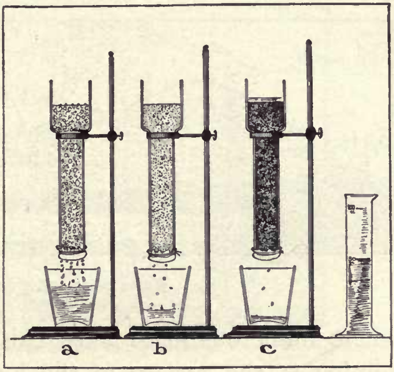
Project II. — A STUDY OF LOCAL WATER POWER.

1. To determine the amount of water power which can be secured from a small stream in your vicinity.

2. To investigate and report on types of water power plants near your home. What would work done cost if gas or coal were used? Is city water supply used for power?

The earth a sponge. — During a heavy shower we have all seen large quantities of water fall to the earth and quickly disappear. It goes without saying that rain water soaks into the ground. Millions of little particles of earth become covered, each with a film of water. In wet weather every space between the particles is also filled with water, and, in time of heavy rains, this water, as we know, runs off and fills our streams and ponds with its load of mud.

However, in a wooded country we do not see this effect. The water seems to sink into the soil and disappear beneath the coating of leaf mold and mosses which covers the ground. This material, with the tangle of roots of trees and the luxuriant vegetation, holds water in the soil.



Experiment. — To see which kinds of soils hold water best.

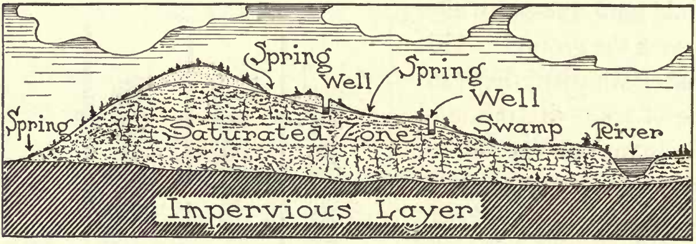
Materials: Three straight lamp chimneys. Cheesecloth. Sandy gravel, sand, and clay. Three glasses.

Method: Tie two thicknesses of cheesecloth over one end of each of the chimneys. Fill each to the same level ($\frac{3}{4}$ full) with the three kinds of soil respectively. These should be dry. Support each of these over a glass tumbler. Pour the same amount of water into each chimney. After all three of the soils have become saturated and all the water has run through that will, measure the water that has passed through.

Results: Which soil holds the most water? Which the least?

Application: What are the advantages and disadvantages of each of these types of soils?

Ground water and the water table. — A vertical section through any part of the earth's surface shows layers of different kinds of material before we come to the bed rock of which the earth is mostly made up. At a varying depth below the surface the absorbed water becomes so plentiful that it fills all the spaces between the soil particles. It is, indeed, a great underground lake, although it only occupies the spaces between the particles of soil. This is called the *ground water*. The *water table* or surface of the ground water may vary with the season, sinking deeper in dry weather. It follows, in a general way, the level of the land surface above it. When we dig a well, it fills up to the level of this water table. In parts of the country

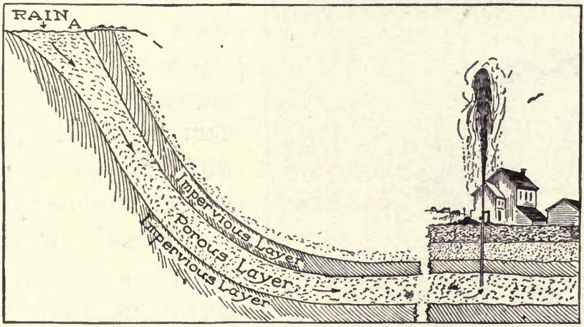


Water table and ground water.

where numerous little lakes exist, it is the ground water coming to the surface of the land. Beneath the ground water an impervious layer which does not let water through will usually be found; this tends to keep the water from sinking deeper into the earth at this spot.

Springs and artesian wells. — Frequently the ground water flows into valleys, there to gush out as springs. A glance at the diagram on page 105 will show how this comes about. If the spring gushes out under pressure, we may be sure that it has traveled from a higher level. When an artesian well is bored deep into the ground, then some deep supply of ground water which has been held between two impervious layers is tapped. This may have traveled many miles from land of a higher level, and now bursts to the surface as a fountain. A very famous region of such spouting wells is found in the eastern part of South Dakota. This water comes from a porous sandstone which, though far underground here, soaked into the ground in the Black Hill District about 1000 feet above the altitude of eastern Dakota.

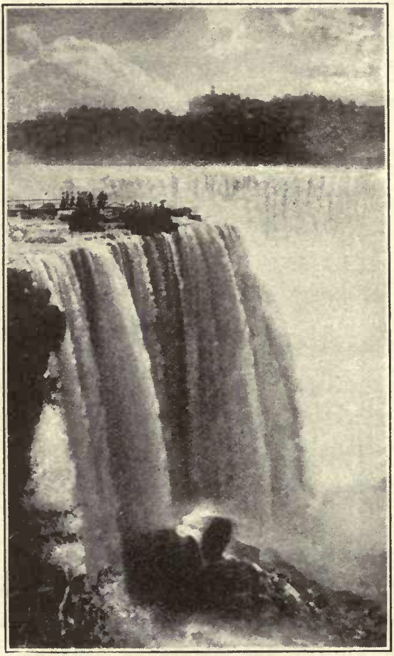
Communities and water power. — Our knowledge of geography has shown us that water plays an important part



Conditions making an artesian well possible.

in the location of towns and cities. Every boy and girl knows that large cities like London, New York, San Francisco, and Chicago owe their growth to the fact that they are located on navigable bodies of water. Many towns have come into existence because of the force of running water. Any one who has traveled through New England has noticed time and again that flourishing towns and cities have grown where falls in a river occur and where man has built a dam on the stream in order to develop water power. The reason for this is obvious: here is power to do work secured by man at a cheaper price than it can be obtained somewhere else where water power is not found.

Water power. — We use the term "water power" in a general way. We shall soon learn what it really means. We know that by means of this force held by the current of a river or mountain stream, wheels may be turned and electricity generated. What boy does not know of Niagara Falls with its 500,000 horse power development, of the Keokuk dam on the Mississippi with its 150,000 horse power turbines, or of the great Norwegian water power plants with over 500,000 horse power already in use! When we read that it is estimated that 5,000,000 horse power of water goes over Niagara Falls every hour, we realize how important this energy is to the country. And when we remember furthermore that this power may be sent hundreds of miles by means of wires, and that within 500 miles of Niagara Falls lives one-half the population of the United States and three-fourths that of Canada, we see the immense practical significance of the utilization of this water power.

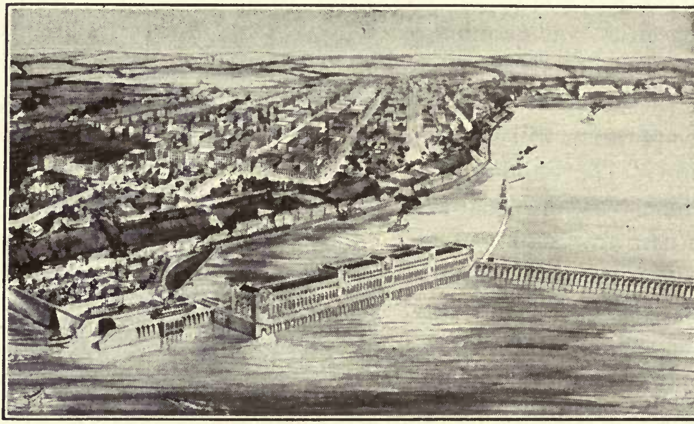


Niagara Falls.

Any intelligent boy or girl must also remember certain facts we have previously learned in geography about public supplies of coal, oil, and natural gas. All of these supplies are exhaustible, and, indeed, at our growing rate of consumption, will become exhausted, possibly within a few centuries. Water power will then become a very important source of energy for running railways, lighting cities, and running machinery in manufacturing plants and homes, as it is to a limited extent to-day. Water power is the cheapest kind of power. So long as we have a sun, evaporation will take place, rain will fall, and streams will flow. The building of a dam and the installation of machinery as an initial expense is large, but the running expenses are small.

It is estimated that in New England, where flows what is said to be the most completely developed river in the world (the Blackstone River in Rhode Island), only 50% of the available water power is used. This is largely due to the fact that the rivers in New England with available water power sometimes lose most of their water in summer. Great impounding reservoirs are proposed which will hold in reserve a supply of water until it is needed. It is expected some day that great central power houses will give most of New England heat, light, and power from these rivers now only partially harnessed.

What is water power? — No one who has ever seen a mountain stream after a heavy rain could fail to have noticed that the water was doing work. Big stones and small ones, tree trunks and logs, all tear their way down stream, borne on by the force of the rushing water. Visit the seashore and notice the work of waves. Look for evidences of the power of water in erosion. If you have ever rowed a boat against a current, you know the water pushes you back, and when you turn, the boat goes down stream more easily. Water power is force exerted by the water and can be measured in terms of work accomplished. For example, Niagara River pours over the falls every hour 22,000,000 tons of water, which, falling a little over

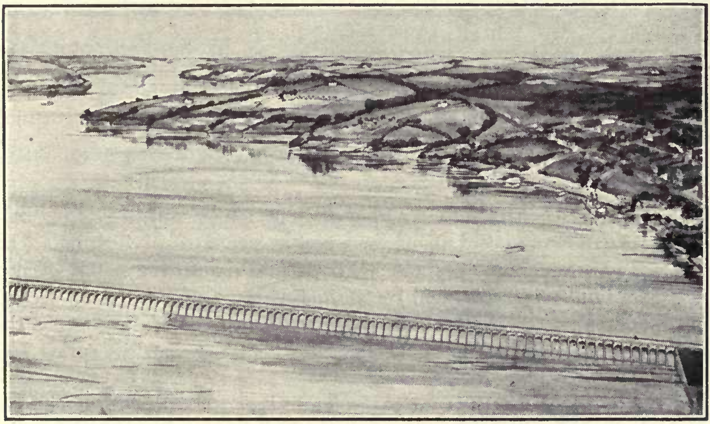


Keokuk dam across the Mississippi, showing power house and locks. It supplies St. Louis, 144 miles away, with electricity.

160 feet, gives rise to over 5,000,000 horse power of energy. Let us remember that *work*, in science, is the measure of resistance overcome through space; the simplest example is lifting something against the force of gravity. Or we may do work by moving a body along a level surface, overcoming the resistance of friction in doing this. The unit of work is the *foot pound*. A foot pound of work is done when we lift a pound weight one foot or when a pound falls one foot, or when we move a body a distance of one foot horizontally by using a pound force in overcoming friction or other resistance. Power is the *rate* at which work

is performed. For example, a stream which can turn a given wheel 100 times a minute has more power than one which will turn it 50 times a minute.

What is horse power? — The term "horse power" came into use in England before the time of steam. It was the amount of power based on the amount of coal a horse could



Keokuk is the greatest power dam in the world, being capable of developing over 300,000 horse power. It is nearly a mile in length.

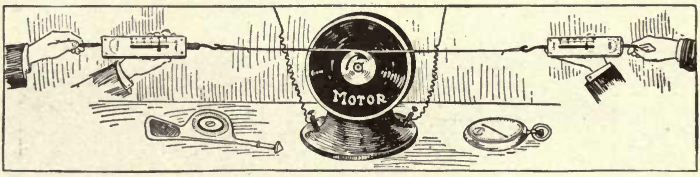
raise in a second. This has come to be used as a unit of power. One horse power is 550 foot pounds of work a second. Thus we are able to measure the horse power of a stream by dividing the amount of work the water can do per second by 550. This will be understood if we work out the following project.

Project. *To determine the value of a stream for water power.* Suggestions for work: Measure depth and width of stream at five points from 10 to 20 feet apart so as to get average width and depth, then measure rate of stream flow by placing a cork on surface in center and mark distance traveled in 1 minute. Repeat five times for average. Suppose the average width of the stream is 20 feet, average depth is 1 foot, average water flow 2 feet per second with a fall of 1 foot. A cubic foot of water weighs 62.5 pounds. Then weight of water passing over a given part of the stream would be 20×1×2×62.5 or 2500 foot pounds per second. If conditions were favorable to building a dam to increase the depth of water enough to give a 10 foot fall, what would be the horse power developed? Divide foot pounds per second by 550. Why? Would such a plant be sufficient to run a house-lighting plant? Ask a local electrician if you have obtained the horse power developed.

Experiment. — To measure the horse power of a motor.

Materials: Motor (as sewing machine motor). Two spring balances. Cord. Speedometer. Stop watch.

Method: Lay a cord around the grooved belt wheel to measure its cir-



cumference. Attach each end of a strong 3-foot cord to a spring balance. Loop the cord about the wheel as suggested in diagram. The spring balances are held perfectly horizontal. Start the motor. When under full speed one pupil keeps time, marking off minutes. A second pupil takes the speed of the shaft to see how many revolutions the wheel makes per minute. Two others hold and read the spring balances.

The friction of the cord is the "load" or work done by the motor. The load may be varied from light to heavy by changing the pull on the balance having the smaller reading.

Results: Calculate the amount of resistance. (Balance (*A*) reading minus balance (*B*) reading.)

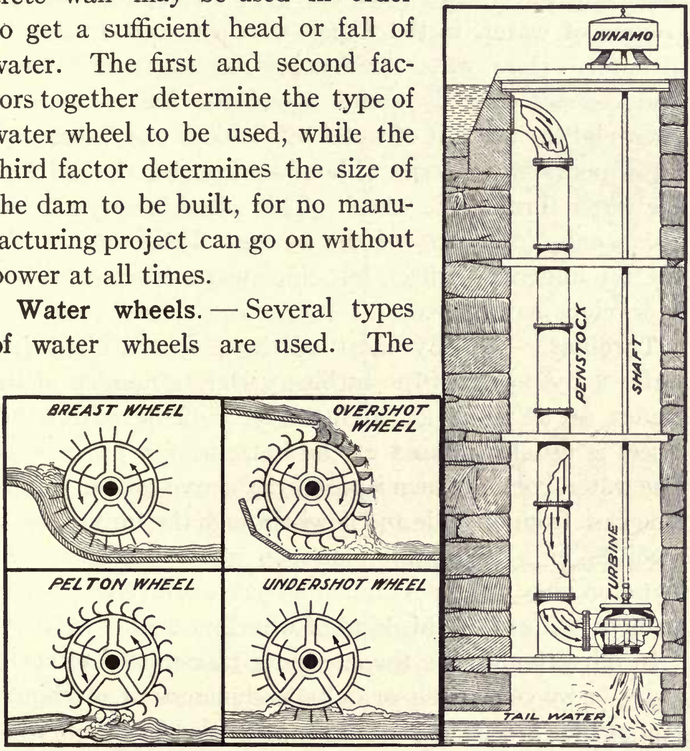
Work done = Resistance (lb.) × distance (ft.).

Distance per minute = Circumference of wheel × no. of revolutions per minute.

$$\text{Horse power} = \frac{\text{Foot pounds of work per minute.}}{33000}$$

Utilization of water power. — One of the first problems a manufacturer has to face, when he locates on a stream, is how he can make the best use of the water power at that particular point. Several factors have to be taken into consideration: the fall at that point, the amount of water available, and the steadiness of the flow. The first factor determines the height and size of the dam to impound the water of the stream. If a natural fall is already present, only a diverting wall at the top of the fall is necessary. On a wide but slow-falling river a large masonry or concrete wall may be used in order to get a sufficient head or fall of water. The first and second factors together determine the type of water wheel to be used, while the third factor determines the size of the dam to be built, for no manufacturing project can go on without power at all times.

Water wheels. — Several types of water wheels are used. The



Types of water wheels.

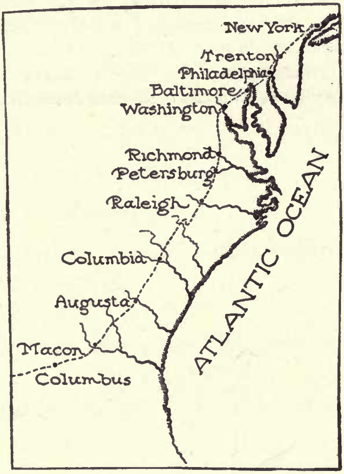
undershot wheel is most useful where a large amount of water is available but where there is little fall. This is the type seen in the many old tide mills found along the Atlantic Coast, in which water is stored in a mill pond at high tide and as the tide falls runs out through a narrow runway under the wheel. This type of wheel is not very efficient, losing about 70% of the energy of the water stored above the dam. A much more efficient undershot wheel, used when there is a strong flow but little volume of water, is the *Pelton wheel*, so called after the inventor. Here water pressure is the important factor. The *overshot wheel* is useful where the fall is not very great and the amount of water available is not large. The water pours into a series of box-like troughs, the weight of the water turning the wheel. This wheel is very efficient, losing only 10 to 20% of the power. The *breast wheel* is like the undershot wheel, but since water has some "fall" it develops more power.

Turbines. — To-day most of the power utilized from water is by means of the turbine. Here a number of thin blades, set at an angle, catch the force of the water. The wheel is usually located at the bottom of a pit or shaft. The water, coming down a pipe from above, enters the turbine case from one side and flows through the turbine, which revolves in a horizontal plane on a vertical axis. (See figure on page 111.) As much as 90% of the energy of the water is utilized by this kind of wheel.

In all water wheels the energy is transmitted either directly or by cog wheels or belts to dynamos or machinery. The turbine is used in most of the large electric plants which transmit the electricity to distant points for running street cars, electric lights, or operating machinery.

The relation of water power to the growth of communities. — No boy or girl who has studied commercial geography can fail to remember the numerous towns and cities in our eastern and middle Atlantic states which have come into existence along streams and rivers. The chief reason for the existence of such places is the presence of water. Either this water has been used directly for power, as we have seen in the cases of the Merrimac River in New England, or, as in the case of the hundreds of manufacturing towns in Pennsylvania, the rivers have served to float barges or other boats with their loads of raw materials or fuel.

A study of the accompanying diagram shows that a number of large and important manufacturing centers have come into existence a relatively short distance from the Atlantic Coast line. These places are located at or near the head of navigation of rivers or in any event at a place on the river where water power exists in quantity sufficient to be used for factory purposes. These cities owe their importance not only to water power, but also to their location on rivers which offer a route for either railroads or boats with which to transport the manufactured products to the coast cities for export.



What factors favor these cities?

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CHAPTER VII

RELATION OF WATER SUPPLY TO FOOD PRODUCTION

Problems. — 1. *To learn the water needs of food-producing plants.*

2. *To learn how plants use water.*

3. *To learn how water-soaked land can be reclaimed.*

4. *To learn how arid land can be watered.*

Experiments. — 1. To learn the water content of some common foods.

2. To show the effect of lack of water on a plant.

3. To show the effect of a surface mulch.

Project I. — To make a comparative study of the amount of water in various foods.

Project II. — To investigate the possibility of reclaiming swamp land in or near your community.

Project III. — A study of drought.

Learn what crops in your vicinity sometimes suffer from drought, and consider possible means of saving them.

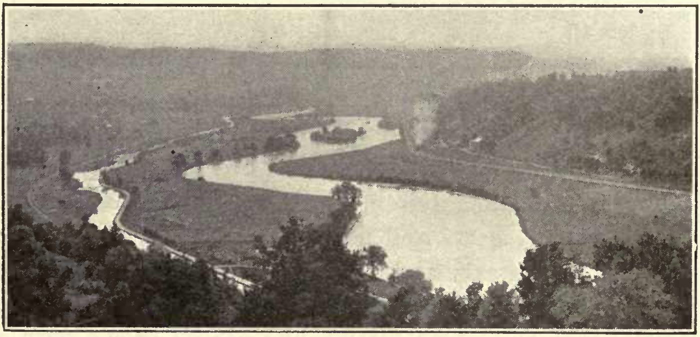
The world is dependent upon water for its food supply. — If you chance to visit the market this morning, you will doubtless see stalls full of fresh vegetables and fruits. Others display meats and fish, while in the grocery store you see nuts, cereals, and many eatables displayed. Have you ever stopped to think how dependent each one of these articles is upon water? Vegetables are all grown with a great deal of water in the soil, and the great fertile farms of the West require from three to four hundred tons of water per acre to raise their crops. The trees which bear nuts and fruits send their roots down deep in the soil after water, and the cattle and the fish which furnish food in their turn depend on the water supply. Everything we buy in the market seems to have required water.

Experiment. — To learn the water content of some common foods.

Materials: Test tubes, potato, meat, bread, cracker.

Method: Heat a small piece of each food in turn in a dry test tube, carefully observing the cold walls of the tube for condensed moisture.

Results and Conclusion: From these results would you infer that most common foods contain water? Which foods appear to contain most water?

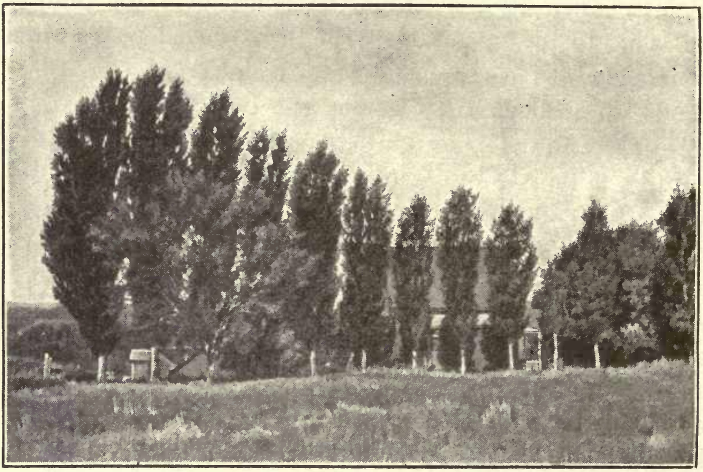


Compare the bare desert region with the plant-bearing, well-watered region.

Effects of differences in water supply. — A traveler going by train from New York to San Francisco passes through very different kinds of territory. In the East, he sees rounded hills covered with forests, broad, sloping valleys, beautiful streams, fertile farms, manufacturing cities and towns, and a rather large number of small lakes and ponds. Beyond comes the Middle West with its fertile acres of corn and grain, its rolling and almost level plains. Then after he speeds westward over the prairies he comes to the mountains with their rugged peaks often whitened with snow, and the train winds up through deep gorges cut by water through the mountain sides. Perhaps he obtains glimpses of some of the wonderful irrigation projects which have caused the "desert valleys to blossom as a rose." Farther west he passes great stretches of desert, some of which may never become useful for agriculture because of their distance from sources of water, and still farther west, near the Pacific Coast, he finds a land of vegetation once more.


Alfalfa root.

Plant life dependent on water. — Any one taking such a trip cannot help but be impressed with the relation of plant life to water supply. While light and favorable temperatures are necessary factors for the growth of plants, yet water plays an equally important part in their lives. It is very easy to prove that plants seek water. An experiment with a "pocket garden" or with a moistened sponge shows that roots grow toward the source of moisture. If you plant bird seed or mustard seed on the under side of a moist sponge and suspend the sponge by a string, you will find that the roots of the young plants, instead of being pulled downward by gravity, grow upward against it. Examination of the roots of trees and of some large plants shows that they grow downward many feet in search of this life-giving fluid.



Effect of water supply on trees. All these trees are of the same age. Why are those at the left the tallest?

Experiment. — To show the effect of lack of water on a plant.

Materials: Two single plants (beans or other common food plant) in separate pots.

Method: Water one of the plants regularly. Let the other go without water.

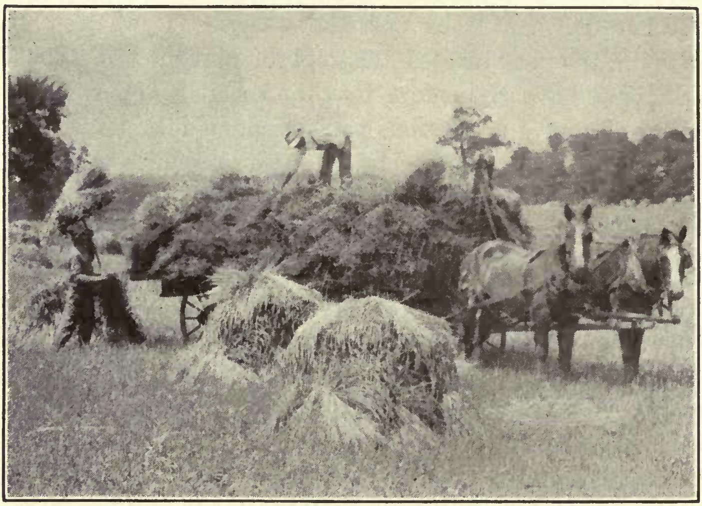
Results: What eventually happens to one of the plants? Allow to remain 24 hours after wilting is first noticed. Then try to restore by watering.

Application: What practical bearing do the truths learned from this experiment have on our production of food?

It is a matter of common knowledge that leaves of plants wilt when they do not have water. The plant leaves are really held up in part by the water in their cells. The picture shown here gives a very good example of the effect of water on the growth of trees. The size of the tree depends very largely on the amount of water it receives. The luxuriant vegetation of the tropics, where showers occur almost daily, is characteristic. Trees, as we know, form thicker rings of growth in a wet season than in a dry one; this shows plainly in the cross section of a log.

What the plant does with the water. — If we were to examine the structure of the root of a plant, we should find, as we have said before, that the roots are covered with millions of tiny projections called root hairs. These projections are really single cells, by means of which the plant absorbs water. The water is passed first from cell to cell, and later by tiny capillary tubes in the interior of the root, and finally, by means of bundles of these tubes, reaches the leaves of the plant. The leaf, as we have seen, is a great food manufacturer which supplies material for the growth of the plant. There, food is made which will be sent to the fruit of the plant. There, too, food which later may be stored in the fleshy roots of vegetables is formed. But in order to get the necessary raw materials to manufacture this food, more water is taken in than is required. Much of this water is passed out through the tiny holes in the under sides of most leaves, into the air in the form of vapor, which helps to equalize the climate, and makes the presence of plants desirable where people live.

Conditions favorable for some crops. — As we take our trip across the continent we cannot fail to notice that our country is favored with crops in great variety. To the south and in the far southwest we have some tropical fruits and fiber plants: we have the apples of Oregon and New York, we have the sugar cane of the South, and we have the wheat and the corn of the great Northwest. It is evident that variation in climate as well as differences in water supply are responsible for these different kinds of crops. Wheat, for example, needs a cool, moist growing season, and a warm ripening season;



Harvesting wheat.

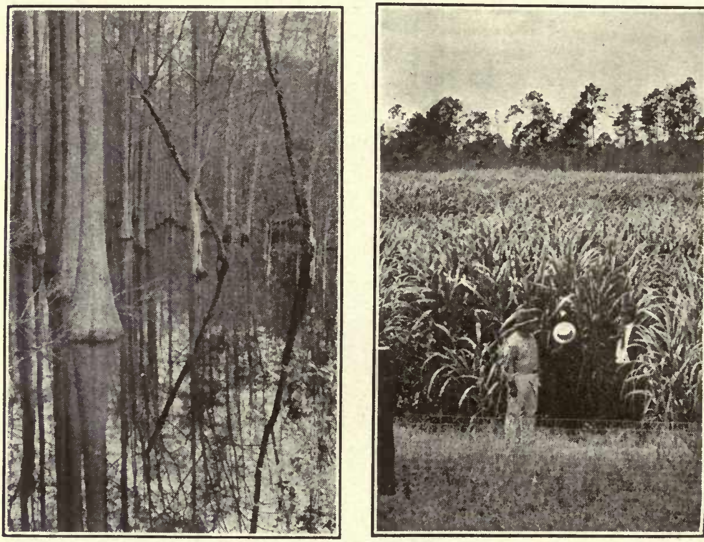
corn needs a longer and warmer growing season than wheat, and is very dependent upon water supply. Oats as well as barley and rye are more hardy and take a damp and cool climate. Rice is a water-loving plant, and thrives best in a warm, wet climate, while grass, the king among crops in this country because of its importance as food for animals, seems to thrive with a moderate supply of water and can even withstand considerable drought. In the case of some of the sugar-producing plants, we find that sugar cane requires a deep, moist, and well-drained soil and a long hot season, but the sugar beet grows in a cooler climate, and requires much less water.

Snow in relation to crops. — We do not always think of snow as favorable for the growth of plants, yet directly and indirectly it plays a very important part. Snow on the sides of the mountains packs down into the great glaciers which form the sources of some of our important rivers in the West. It thus helps to regulate the water supply during the hot and dry summer. In winter it covers fields and gardens with a blanket of insulating material, thus protecting seeds and tender plants in the ground underneath from great changes in temperature. In the northern part of the country it must help as well to protect the bacteria in the soil and keep them alive over the long, cold winters. Thus snow serves an important purpose, especially in the North, where the

A corn field.

temperature frequently goes to forty degrees below zero in winter.

The reclamation of swamp areas. — Some of the richest land in the United States is now under water. The United States Government Reclamation Service estimates that



Swamp, before and after draining.

there are one hundred million acres of undrained swamp land in the United States that will some day be available for use. This land, when drained, becomes useful for intensive farming because of the great amount of decayed organic matter in the soil. Some of this land has already been reclaimed, and many thousand acres are being added yearly by the Reclamation Service. In the Everglades of Florida, parts of which have already been drained, some of the great drainage canals serve as a means for transportation.

Experiment. — To show the effect of a surface mulch.

Materials: Two plants (beans) in separate pots.

Method: Water them both alike for several days. Sprinkle them out of doors or let them stay out during a heavy shower. After the surface has partly dried, scratch the surface of one, to loosen the surface layer of soil. Repeat this occasionally to keep a loose layer of dry soil at the surface. Do not touch the surface of the other. Leave the two under similar conditions protected from rains to see which shows the lack of water first.

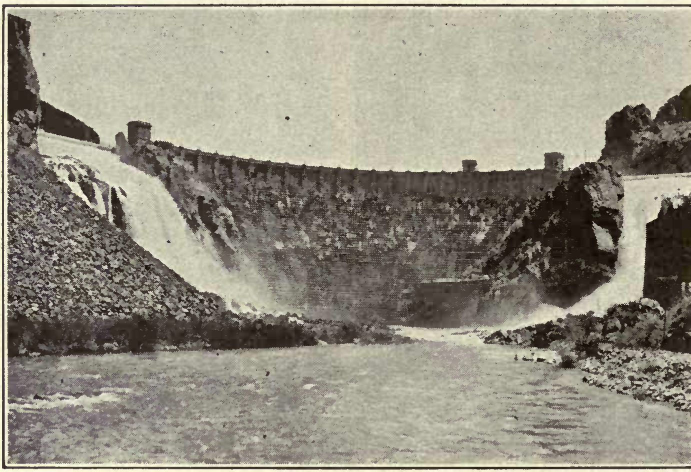
Results and Conclusion: Which plant wilts first? Why is this?

Application: How can moisture in your garden be conserved during a dry season?

Dry farming. — A study of the map showing rainfall in the United States on page 17 shows that a very large part of our western states do not get enough rain to support crops. The rain that does fall is soon lost by direct evaporation from the ground. To overcome this difficulty farmers are beginning to practice what is known as dry farming. To do this they must first plow the ground deep so that when the rain comes the ground will be ready to soak it up and retain it. Then the surface layer of the ground must be constantly worked and turned over so as to form a *surface mulch.* This is done by making a layer of very finely pulverized soil on top.

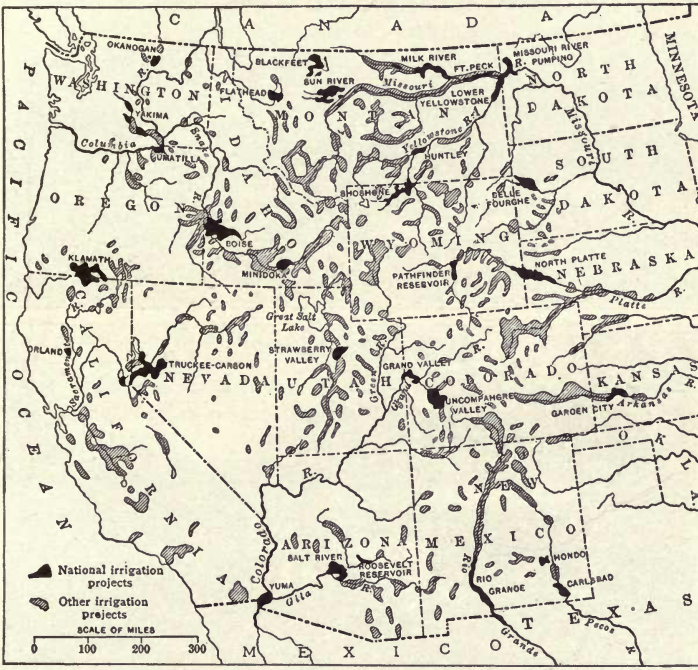
Ground water travels upward from particle to particle by capillary action. Compact soil allows water to pass rapidly by capillary action to the surface, where it escapes by evaporation. Breaking up the soil so that the particles lie loosely together prevents this action. Crops requiring little moisture are grown. Alfalfa, with its long roots, reaches the deep-lying ground water and adds to the soil fertility by means of its bacteria. Hard wheat, kafir corn, millet, and other crops may also be grown. In some places farmers can only grow one crop every other year because of the small amount of water. In such cases, the farmer keeps half of his land under cultivation, and the other half covered with a surface mulch so as to allow it to accumulate water.

Irrigation and irrigation projects. — Irrigation has been practiced from the early times of civilized man. If water is not present in soil, then it may be brought there by means



Roosevelt Dam conserves billions of gallons of water for irrigation purposes.

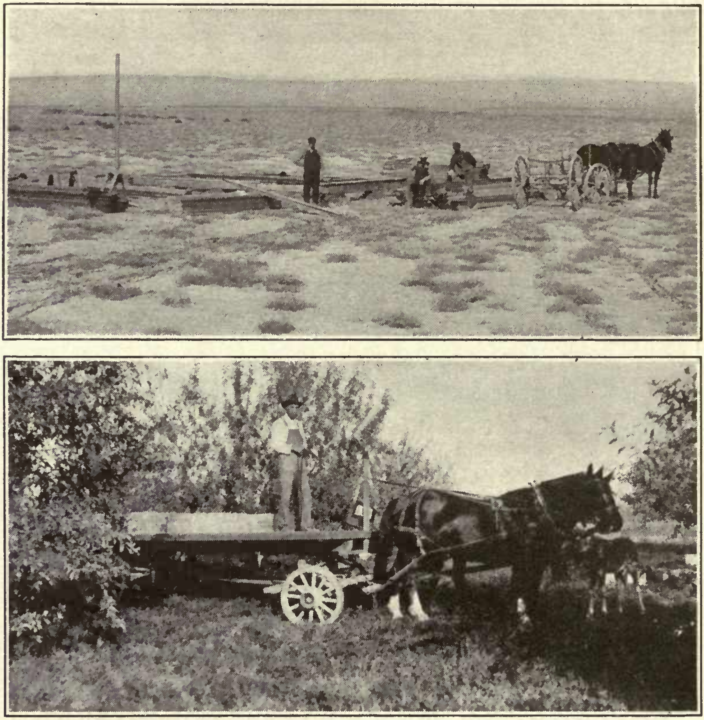
of canals. It has been found that there is much rich alluvial soil in the West which would be valuable if water could be supplied to it. This was found to be true in Utah, and when the first Mormons settled there, they brought water from the Wasatch Mountains, thus enabling the early colonists to cultivate gardens. In Utah many private irrigation canals were built prior to 1912. Then the United States Irrigation Service was organized, thanks to the farsightedness of Theodore Roosevelt. The stories of the work done by some of these government engineers in exploring and planning for the diversion of water into some of these territories are well worth reading. Take, for example, the story of the *Heroes of the Gunnison Tunnel*, by A. W. Rolks, and realize what dangers these



Map of irrigation projects. National projects are indicated by the solid black.

daring men of iron had to undergo before a tunnel from the Gunnison River to the Uncompahgre Valley could become a reality. This project alone changed 200,000 acres of desert land into a fertile valley with towns having a population of over 250,000 people.

A study of the map gives some idea of the number of projects finished and planned. Over eleven million acres of land at the present time are thus artificially watered, and more projects are contemplated, which will make more land useful for farming. Great dams have been built,



What irrigation does for a dry region. Above: first day on the homestead. Below: same place six years later.

and are being erected, which will hold the water from the melting snow for use during the hot dry months, allowing it to be distributed by means of canals to the surrounding desert country. Some of these canals are over a hundred miles in length, and have many small branches, which in turn lead into ditches, feeding the land with the much-needed water. As a result of irrigation, land becomes worth from sixty to three hundred dollars an acre. Through irrigation large crops of wheat are raised; potatoes, onions, cabbages, and garden truck of all kinds are grown; sugar beets and especially alfalfa and grasses are raised in great abundance. Wonderful orchards, especially of apples, have come into existence in Colorado and Oregon. Because of the intensive farming practiced, people live close together and have all the comforts of community life, for these irrigation projects furnish water power, which in turn is changed into electricity and used for manufacturing purposes. Irrigation, then, has become one of the greatest boons the West has ever had.

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CHAPTER VIII

RELATION OF WATER SUPPLY TO FORESTS

Problems. — 1. *To learn the part water plays in tearing down and building up the land.*

2. *To learn the effect of forests upon a water supply.*

3. *To learn where the forest regions of the United States are located.*

4. *To understand why a community needs trees.*

Experiments. — 1. To show the solvent power of water containing carbon dioxide.

2. To compare the water-holding power of leaf mold and sand.

Project I. — To IMPROVE COMMUNITY TREES.

Investigate and report on what the community is doing to increase the number of trees and to protect existing trees. To organize and carry out a tree planting campaign in my community.

Project II. — INVESTIGATE THE PUBLIC USE OF GOVERNMENT RESERVES.

Find out what use my family might make of the government forest reserves and the conditions under which we could use them.

Project III. — To MAKE A COLLECTION OF USEFUL PRODUCTS DERIVED FROM TREES.

Project IV. — To FIND OUT WHAT TRAINING I NEED TO BECOME A FORESTER AND WHAT A FORESTER'S DUTIES ARE.

Forests and water. — No boy or girl who has been fortunate enough to travel across the continent can have forgotten the western deserts with their miles and miles of sand and trackless wastes. One cannot help comparing the rich and level plains, covered as they are with vegetation, with the forests, rivers, and hills of the East or far western parts of the country. The forests have a beauty of their own, and, as we shall see in this chapter, play a very important part as well in serving to regulate the supply of water. When we realize that over eighty-two million dollars' worth of damage was done in 1902 by floods in the lower Mississippi Valley, and that every year our farms lose from one to two million tons of their most fertile soil which is washed from their surfaces into

A break in the levee on the lower Mississippi.

the rivers, then we begin to realize the value of forests as a national and community asset.

The climate also is regulated to a certain extent by forests; for plants, as we have seen, give off a large amount of moisture into the atmosphere, and wherever they are we are apt to find bodies of water, especially many small lakes, which render the climate more even and pleasant. To understand better the value of forests, let us first see what water has done in making over the surface of the land through which it flows.

Water as an underground solvent. — We use water in washing to dislodge and remove certain substances. We dissolve sugar in water in making lemonade. But we sometimes forget that water is also dissolving materials as it passes through the soil and rocks. Many of us have tasted mineral waters; these are waters which have dissolved mineral material as well as gases. Vichy in France and Saratoga in this country are well-known examples of places in which are located mineral springs having medicinal properties. In such waters the carbonic acid gas acts upon some of the solid minerals, causing them to dissolve in the water, while other minerals are dissolved by water alone.

Experiment. — To show the solvent action of water containing carbon dioxide.

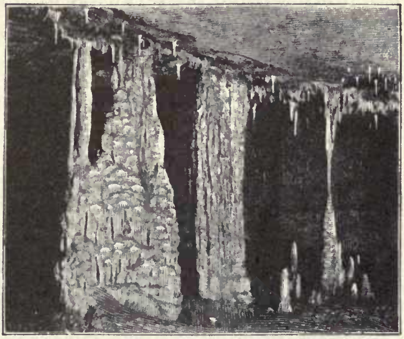
Materials: Limestone, hydrochloric acid, test tubes, glass tubing, a 1-hole stopper, and limewater.

Method: Generate carbon dioxide by adding dilute hydrochloric acid to a few lumps of limestone in a test tube. Pass the gas by means of a delivery tube into half a test tube of limewater. The white precipitate formed is just the same chemical substance as the original limestone.

Result: Will the "precipitated limestone" dissolve in water? Will it dissolve by continuing to pass carbon dioxide into it? Try it. What is the effect of heating the clear solution?

Application: How can these facts be applied to explain the formation of limestone caves? To explain the source of "hard" water?

Water by its solvent action has formed great caverns in limestone regions by slowly dissolving the rock along its underground channels. Such a cave is the Mammoth Cave of Kentucky. As we have just seen, water containing carbon dioxide will dissolve certain mineral substances. The carbon dioxide in some water in nature comes from the decay or oxidation of organic materials in the soil. When this ground water flows through rocks which are easily soluble, such as limestone, it becomes loaded with mineral matter. Such waters we call hard. The saltness of the ocean is due to the fact that the water has brought sodium chloride in sufficient quantity to give the ocean its load of salt.



Marengo Cave.

Water as a builder of rock. — Water not only destroys but also builds up rock. Certain soluble compounds, when brought together in water, unite to form new insoluble compounds. If water bearing such materials filters down into cracks of rocks, *precipitation* of these new materials may take place, and veins of mineral matter be thus formed. Precipitation may also result from cooling, from evaporation, and from the loss of some gaseous constituent, as carbon dioxide. In some of these ways veins of many valuable minerals have been formed. Such are veins of gold, silver, and copper.

Water as an eroding agent. — Our physical geography has shown us that the contour of land forms is largely due to the action of water. This action is still going on around us and may be seen by any interested boy or girl. In miniature the erosive or digging force of water may be seen after any rain. Notice how a gully is formed on a steep slope unprotected by trees. A study of almost any embankment will show the action of water, while mountain streams and swift-running rivers are constantly enlarging their beds and are digging out deeper channels day by day. A current running at one-third of a mile an hour can carry clay; at two-thirds of a mile an hour, fine sand; at two miles an hour, small pebbles are rolled along, while at four miles an hour stones as large as an egg are carried. Therefore streams which flow swiftly wear away their banks much more rapidly than those with slow motion.

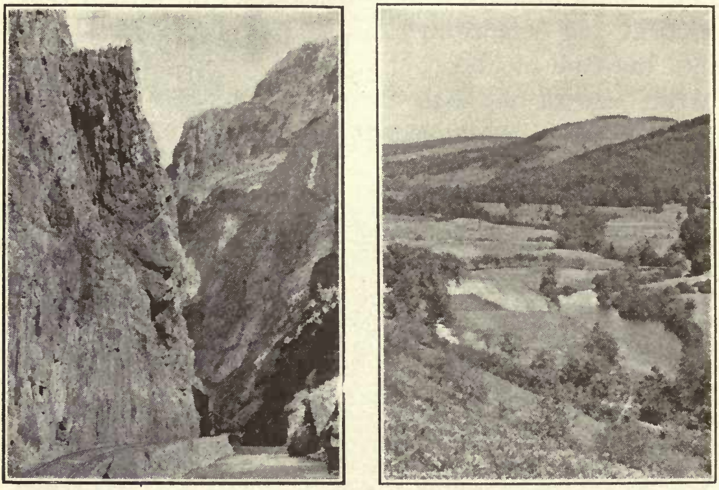
Water as a land builder. — In a similar manner rivers work on a large scale. Sand and particles of soil are torn

A deforested gully.

out and carried a long distance in rapidly flowing water to be ultimately deposited as deltas where the current of the river is stopped by reaching ocean level. Professor Salisbury of the University of Chicago has estimated that the Mississippi River carries down daily so much material that it would take nearly 900 trains of 50 cars each, each car carrying 25 tons, to carry an equal amount of sand and mud to the Gulf. He estimates that all the rivers of the earth together daily carry to the sea forty times as much material as does the Mississippi. The delta formed at the mouth of the Mississippi at present contains almost as much land as three times the area of Connecticut and is growing into the Gulf of Mexico at the rate of one-sixth of a mile a year. All the area occupied by Louisiana, and a large part of Alabama, Arkansas, Florida, Mississippi, and Texas, was once a part of the Gulf of Mexico, and these states have been largely formed by material which has been carried down by the rivers flowing from the north. The great glacier which covered all the northern part of the United States at one time must have furnished an immense amount of water and billions of tons of soil to the rivers which aided in the building of these states.

Delta of the Mississippi superimposed on the state of Rhode Island.

Changes in land contour brought about by the action of running water. — It is safe to say that all the valleys we have seen or are likely to see have been made by the wash of running water. A deep valley with steeply sloping sides is a young valley and is still in process of being cut out and deepened by the action of water. These valleys are seen to best advantage in the wonderful cañons of the West. The Colorado River, for example, runs for a thousand miles through a gorge which has cut from one to several thousand feet through solid rock. Such a gorge is of very recent origin in geological times. On the other hand, among the valleys the rounded hills of New Eng-



Contrast the steep walls of the cañon with the well-rounded hills which result from long ages of erosion.

land are much older, and have required a longer period of time in being formed.

Experiment. — To compare the water-holding power of leaf mold and sand.

Materials: Two cylindrical chimneys. Cloth. Beakers. Leaf mold and sand.

Method: Tie a cloth over one end of each cylinder. Fill one cylinder half full of leaf mold and the other half full of sand. Pour equal amounts of water upon these and compare the amounts of water which pass through, catching it in beakers.

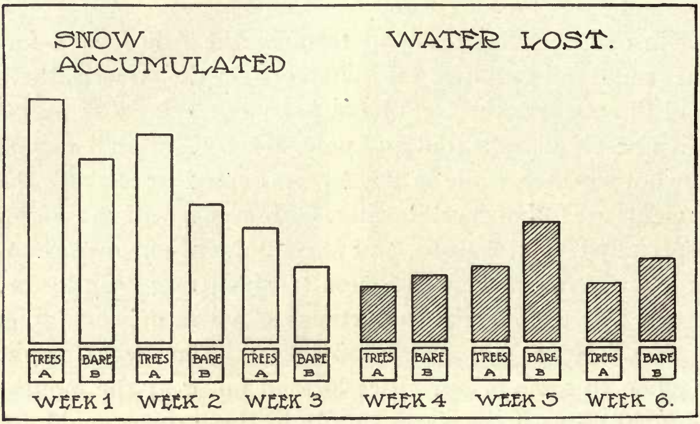
Result: Which retains more water?

Application: Of what practical value is this to forestry? To river flow?

The regulation and production of water supply by forests. — In the early history of the earth, when water did its most effective work, forests were not in existence, and nowadays we find that where forests are present, more than twice as much water is held in the soil as where they have been cut away. Trees form an attractive covering for the surface of the earth. Their roots and the covering of organic material which comes from their dead leaves and decaying trunks and branches hold the moisture in the ground by a sort of surface mulch and prevent the soil from washing away.

No one who has tramped through the Adirondack forests could fail to notice the difference in the streams there and those where the trees have been cut off. The latter have nearly disappeared and only dry beds are left during the hot weather, while in the forest-covered watersheds the streams are full of crystal water. Many parts of the world, especially China, Europe, and some parts of our own country, are now showing the results of cutting off the forests. The commercial importance of cities depends upon forests. Have you ever stopped to think what might happen to some of our cities located on or at the mouths of great rivers if the water supply in these rivers could not be regulated? In New York, for example, should the forest-covered sources of the Hudson be cut away, spring rains might bring down millions of tons of soil which would eventually render the Hudson unnavigable, and would build up great bars at the mouth of New York harbor so large that the harbor would become closed up, and New York would lose its commercial importance. Even now constant dredging of the channels leading through the bar in the lower bay is necessary in order to keep it open to navigation.

Regulation of floods. — Each year, especially in parts of the earth where forests have been cut down and not replanted, millions of dollars of damage is done, thousands of people are rendered homeless, and scores of lives are lost. The experiment of the United States Geological Survey, shown in the diagram on this page, proves that forests regulate floods by retaining the rainfall. Usually rivers which rise in hilly districts where the forests have been cut down receive the rainfall all at once instead of



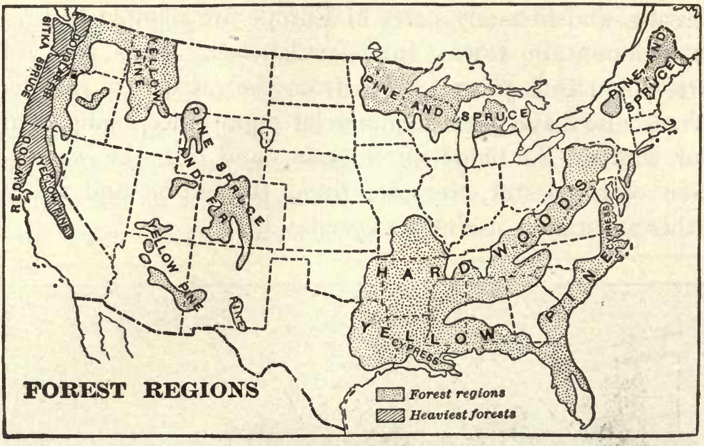
In the White Mountains the United States Geological Survey compared two areas, each about 5 mi. sq. Area A was covered with trees. Area B had no trees. A weekly estimate was made, first of the amount of snow that accumulated on the two plots, then later of the amount of water that was lost. What is the conclusion?

gradually. The result is a freshet or flood. One of the worst floods of recent date was that which isolated Dayton and many other cities in 1913. For several days transportation across the continent was interrupted and incalculable damage done. This flood was caused by excessive rains falling in a region which had been deforested.

Other uses of forests. — Besides the regulation of water supply, forests, as we have seen, make winters more moderate, and in summer reduce the heat and lessen the danger from storms. In some places they serve as wind-breaks, and in many parts of Europe are planted to protect mountain towns from avalanches. Birds nest in trees, and thus protect crops from the ravages of insects. Trees also have great commercial importance, being used for lumber, for food production, and for the extraction of acids, tar, creosote, resin, turpentine, and many other substances useful in everyday life.

This photo was taken in Macksville, Indiana, on March 28, 1913.

The forest regions of the United States. — The combined area of the forests in the United States, exclusive of Alaska, is about five hundred million acres, but this great area is rapidly decreasing in acreage, owing to the demands of increasing population, an unfortunate eagerness on the part of the owners of the land, and wastefulness on the part of wood cutters and users alike. A study of the map on page 138 shows not only the distribution of trees in the United States, but the principal types of trees found. You will notice that the principal areas are confined to the eastern and the western coasts, and to that region which borders on the Great Lakes.



The forest regions of the United States.

Uses of wood. — Wood is to-day the most used fuel, in spite of coal and natural gas. It is also the most used building material. It is used as a source of wood alcohol. Partially burned it becomes charcoal. Our daily newspapers and our magazines are responsible for the loss of hundreds of thousands of soft-wood trees such as spruce, hemlock, balsam, poplars, aspens, and basswood, and unfortunately, young trees as well as old are sacrificed for this industry. The cone-bearing trees, pine, spruce, and hemlock, and especially the great redwoods of the West, are used for heavy construction work, frames of houses, bridges, masts, spars, timber of ships, aircraft, floors, wood pulp, railroad ties, and many other purposes. Cedar is used for shingles, cabinet work, and pencils. Many kinds of trees go into the making of boxes for shipping purposes, it being estimated that 50% of all lumber cut finally is used for this purpose. The hard woods, ash, beech, birch. cherry, chestnut, elm, hickory, maple, oak, and walnut, are used largely for the finish of our houses, for the making of furniture, wagons, cars, and various other purposes.

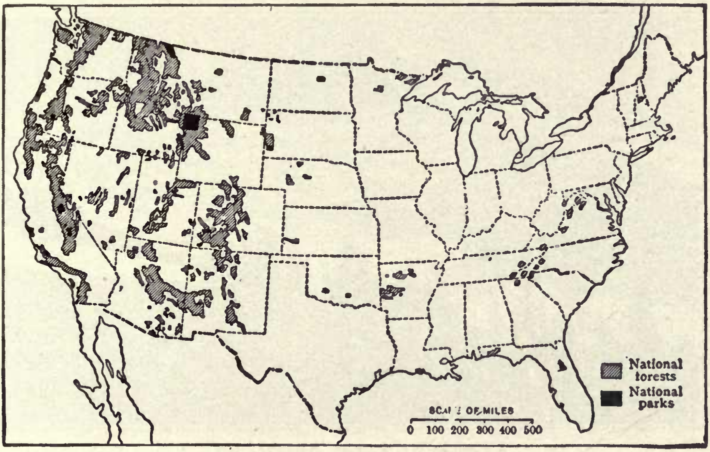
Destruction of our forests. — As we have just seen, the great demands of man are largely responsible for the over-cutting of our forests, but wastefulness and carelessness are

Unless checked early a small fire may become a disastrous forest fire.

found at every step. Hundreds of thousands of dollars' worth of timber is left each year on the ground through the careless chopping of trees or the cutting of the tree too far from the base. Fire also plays a prominent part in the waste of our forests. A study of the causes of forest fires shows that the largest per cent is caused by sparks from trains which pass through the forests. In New York state laws have been passed requiring locomotives to burn oil while passing through forest areas. Carelessness of smokers, hunters, and small boys makes a large number of fires, while burning brush and the fires of campers are responsible for others. "A single tree will make a million matches but a single match can destroy a million trees." Besides man, the forest has many natural enemies. At the present time the nation is fighting insect pests, some of which, as the brown-tailed moth, have been imported from Europe, and which are now threatening the destruction of many of our northern forests. The chestnut canker, another imported plant pest, has destroyed nearly all of the chestnut trees in the eastern part of the United States, and will probably ultimately destroy every live chestnut in the country, as its control is almost impossible.

Some methods of protecting our forests: forestry. — For a long time Europe has known the value of forests and has taken means of protecting them. In Switzerland, for example, cities and towns have grown forests in their vicinity for over six hundred years, and have found them profitable investments. The people of this country are beginning to realize this, and we see private individuals, corporations, and the state and national governments all engaged in taking means to preserve our forests. States such as New York and Pennsylvania have set apart tracts for the growth of trees. The Adirondack Park in New York contains nearly 1,500,000 acres of timber land. Schools of forestry are sending out young men trained to become foresters. These men are going into the country to show that trees must be planted where they are cut down, that trees must not be cut until they are "ripe," like any other crop, and that too thick a forest is just as bad as too thin a forest, for then trees do not get a sufficient amount of sunlight and plant food.

Forest reserves. — In the western part of the United States, as a study of the map will show, the government has set aside great tracts of land in those districts where forests are needed to prevent the supply of water from quickly running off the mountains. These great



This map shows where our national forests and parks are located.

national forests are watched over by rangers, trained men who move about from place to place protecting trees and preventing forest fires. They also supervise the cutting of the forest and planting where new trees are needed. The forest reservations are open to the public. The government allows cutting of the ripe or full-grown trees. It allows sheep and other animals to be pastured on the reserve on payment of a fee, and tourists and campers have the right to use the forests as their own under certain controlling restrictions. The government has set aside some of the most beautiful areas in the country as national parks. The most noted are the Yellowstone, the Glacier National Park, and the Yosemite in California.

The community's need for tree protection. — All of us know the value of shade trees. Many of our best cities are spending thousands of dollars each year in planting and protecting trees. They have set aside parks for

A view in Mt. Rainier National Park.

breathing spots, knowing that trees give off moisture and oxygen into the atmosphere, and many cities are encouraging school children to help in the protection of these trees. City parks and trees everywhere attract and afford nesting places for our native birds. We should do all we can to encourage birds to stay with us, both by erecting bird houses, giving them food and drinking places, and keeping the hunter cat from doing them harm. Birds destroy insects and aid in making our towns beautiful. Trees in our city streets should be protected. Thousands of city trees are killed, for example, by horses gnawing the bark. This may easily be prevented by placing wire guards around the trunks of these trees. The city of Chicago, through its city forester, has given the following reasons why trees should be planted in the city:

(1) Trees are beautiful in form and color, inspiring a constant appreciation of nature.

(2) Trees enhance the beauty of architecture.

(3) Trees create sentiment, love of country, state, city, and home.

(4) Trees have an educational influence upon citizens of all ages, especially children.

(5) Trees encourage outdoor life.

(6) Tree purify the air.

(7) Trees cool the air in summer and radiate warmth in winter.

(8) Trees improve climate and conserve soil and moisture.

(9) Trees furnish resting places and shelter for birds.

(10) Trees increase the value of real estate.

(11) Trees protect the pavement from the heat of the sun.

(12) Trees counteract adverse conditions of city life.

Arbor Day has been set aside in many states as a day for tree planting and tree protection.

An excellent home project would be the planting, care, and protection of some one good, rapid-growing tree for your home grounds. Better yet would be the organization of a campaign of your boy and girl friends to plan for the yearly planting and care of trees in your neighborhood; thus you can make Arbor Day of real practical use in your community.

Score card. — This score card includes items that we have been talking about in the last three chapters. Water supply and water power are, after all, closely dependent upon our forests. Here again your score must be based upon a certain type of community and not upon several types. Therefore score only 50 from items (1), (2), or (3), and then the second 50 from item (4), which deals with features common to all communities.

SCORE CARD. RELATION OF WATER TO ECONOMIC LIFE OF COMMUNITY.

Score (1), (2), or (3), and (4), making a possible total of 100 points for your community.

		PERFECT SCORE	MY SCORE
1. WATER POWER	Over 200,000 horse power produced in my community (10), over 100,000 (5), over 10,000 (3) All water power utilized by the community (10), partly (5), none (0) Impounding dams for regulation and storage of water (5) Many manufactories as result of water power (15), few (5), none (0) Electric light and power cheap as result of water power (10), moderate (7), expensive (3)	50	
2. AGRICULTURE	Farms well watered (10), moderately (5), poor (2) Farm soil never lost as result of floods (5), soil sometimes lost (3), often (0) Snow protecting land in winter (5) Farms workable from Apr. 1–Nov. 1 (10), May 1–Oct. 1 (7), June 1–Sept. 1 (5) Rainfall abundant (10), moderate (7), scant (2) Reclamation of all swamp areas (5) Irrigation of all dry areas (5)	50	
3. FORESTS	Protection afforded against forest fires (10) Protected against overcutting (10) Forest reserve areas or large forests near (10) Forestry practiced by lumbering companies (10) River watershed protected by forests (10), few trees (5), none (0)	50	
4. COMMUNITY TREES	Public parks with many trees (10) Tree protection in streets practiced (10) Spraying (2½), pruning (2½), screens (2½), tree surgery (2½) Tree planting practiced (7) Arbor Day observed (3) Many trees on city streets (10), few (5), none (0) Many trees in community home grounds (10), few (5), none (0)	50	
	TOTAL	100	

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CHAPTER IX

THE COMMUNITY WATER SUPPLY

Problems. — 1. *To learn what constitutes a pure drinking water.*

2. *To learn what are the community needs of water.*

3. *To learn how a community may obtain a supply of safe water.*

4. *To learn how water is purified by filtration and by chemical treatment.*

5. *To learn the proper care of a public water supply.*

Experiments. — 1. To show the danger of judging the purity of water by its appearance. (1) Chemical test. (2) Biological test.

2. To see what impurities are removed from water by filtration.

3. To illustrate gravity distribution of a water supply.

Project I. — TO INVESTIGATE AND REPORT ON THE PUBLIC WATER SUPPLY OF MY OWN COMMUNITY.

Project II. — TO LEARN ABOUT THE WATER SUPPLY OF SOME LARGE CITY.

New York, Cleveland, Los Angeles, or Philadelphia.

Water supplies. — It goes without saying that a town or city could not exist without drinking water. The people of Greece or Rome and those of other ancient cities, if unable to obtain water on the spot where they built their cities, went to great expense to build long aqueducts to bring water to their homes. The modern community, no less than those of ancient times, has gone to very great expense and labor to obtain pure water. When the Pilgrims landed at Plymouth, they looked for a suitable place to settle. An old journal tells us that Captain Miles Standish and his party "marched into ye land and found there cornfields and little running brooks, a place fit for a situation." So here, with the "little running brooks" for their water supply, they founded their first community.

What is pure drinking water? — We have already learned that water can and often does contain other matter than what falls from the clouds as rain. Rain water, before it comes in contact with anything on the earth, is practically *pure* water. But water may be perfectly good to drink and contain mineral matter in solution. Such water is *pure* as far as necessary for drinking purposes. Water which contains organic matter, especially if there is much decaying material present, is *not* pure. Why? Simply because it contains germs. Decaying matter means the presence of germs which may be harmful to the human body, hence such water is impure and unfit for drinking purposes. Would you be willing to drink any water that was clear and sparkling? The following experiment will give you a reason for not judging by appearance alone.

Experiment. — To show the danger of judging the purity of water by its appearance.

Materials: Filtered salt water. Distilled water. Solution of silver nitrate. Test tubes.

Method: Observe how clear the salt water is, add a few drops of silver nitrate solution to 10 c.c. of the water in a test tube. Similarly add silver nitrate to distilled water.

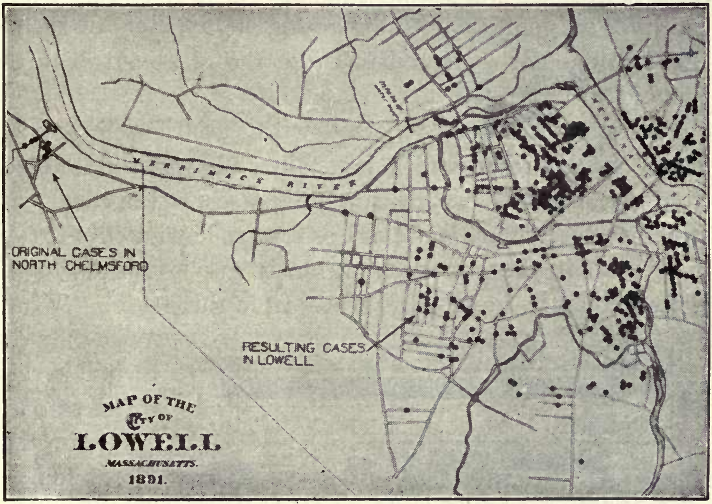
Results and Conclusion: Compare results. Was the water tested pure?

(*Note:* The white cloudiness produced when silver nitrate is added to the salt water is due to the presence of chlorides in the water. Chlorides are in water polluted by sewage or drainage from houses. Polluted water will usually show a large number of bacteria when tested. When a drop of water is placed on sterile agar and set away in a warm place, the number of colonies of bacteria which develop roughly indicate the purity of water.)

Sources of water. — The household which takes its water from a well or spring has one problem. But the community which must provide water not only for drinking but also for washing, street cleaning, manufacturing, and fire protection has another. It is evident that a single spring would not meet the demands of even a small community. And even a number of artesian wells rarely provide enough water for a town to use for all its needs. So the city must depend largely upon surface water, streams, or rivers, the banks of which are often used for human habitation. Surface water, no matter how careful people may be, often receives some drainage containing the body waste of animals and man. So our problem is to find out how such water coming from streams or rivers or lakes may be made safe to drink.

Problems of water supply for communities. — The need of an abundant as well as pure water supply in a large community is most important. We know, at the present time, that many cities are forced to take their supply of drinking water from sources which are bound to be contaminated. Take, for example, Buffalo or Cleveland, which take their water supply from the lakes on which they are situated, and into which the sewers of these cities flow. Or, take Philadelphia or Pittsburgh, which must draw their supply from rivers which are greatly contaminated by sewage from the many small cities and towns located above the point from which they take their water. A third type of city might be New York or Los Angeles, which have no near source of water supply and must, in order to get an abundant supply of pure water, tap sources far distant from the city. For each of these three types of cities the problem of obtaining a pure water supply is quite different.

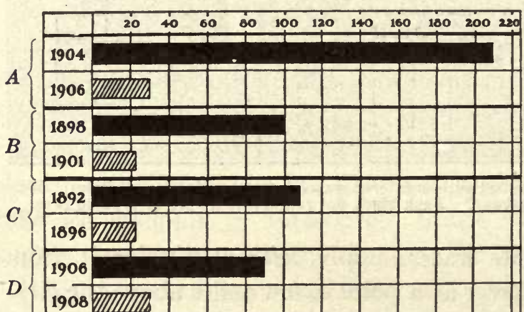
River water supply. — For many years cities which took their water supply from rivers had a notably high typhoid death rate, and it was not until the year 1891 that the reason for this was scientifically demonstrated. In that year, Allen Hazen, and a number of experts on water supply, made a study of a typhoid epidemic which occurred in the cities of Lowell and Lawrence, Massachusetts. The city



In 1891 Lowell was supplied with unfiltered water from the Merrimack River. Why is such a supply dangerous? Each black dot represents a case of typhoid fever.

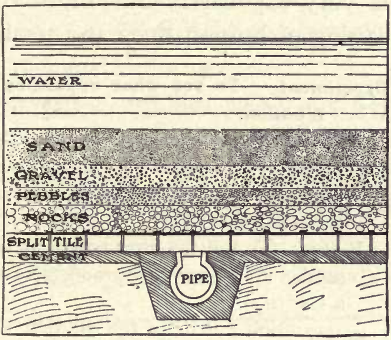
of Lowell took its water supply, *without filtering* it, from the Merrimack River at a point a few miles above the city. Typhoid fever broke out in the little hamlet of North Chelmsford, a few miles above Lowell. About two weeks later a great epidemic of typhoid broke out in Lowell. Almost a month later a similar epidemic, although not so great in magnitude, occurred in Lawrence, about ten miles further down the Merrimack River. A little thought will show us what happened. The typhoid germs from the sewage of North Chelmsford passed into the water pipes of Lowell and were taken into the bodies of the people who drank the water. The germs were passed out from their bodies in great numbers into the sewers and thus down the river to Lawrence. Fortunately for the latter city, typhoid germs are killed rather easily, and the exposure of the millions of germs to the air and sunlight as they passed down the river was sufficient to destroy great numbers of them. But still enough remained to cause the great outbreak of typhoid in Lawrence.

This story has been repeated with variations in almost every city or town which has taken its water unfiltered from streams into which sewage passes. Inasmuch as streams usually have more or less sewage flowing into them, it is evident that no such water is safe to drink. But cities frequently have to get water from this source. What must they do to make this water safe?



Cases of typhoid per 100,000 inhabitants before filtering water supply (solid) and after (shaded) in *A*, Watertown, N. Y.; *B*, Albany, N. Y.; *C*, Lawrence, Mass.; *D*, Cincinnati, Ohio. What is the effect of filtering the water supply?

Filters and filter beds. — The studies of Hazen showed without a doubt that filters of sand would take out enough germs from contaminated water to make it fairly safe to drink. A glance at the accompanying diagram shows the effect of such filters in the number of cases of typhoid in Watertown, Albany, Lawrence, and Cincinnati. The number of germs in the water was so much reduced that only about 2% of the original germs got through the filters and into the pipes of the city. Consequently, the number of typhoid cases was very greatly reduced. A study of the accompanying diagram and picture will give you some idea of how a filter bed is made.



Structure of a filter bed.

You will notice that the bed consists of small stones, gravel, coarse sand, and fine sand in layers. If these layers are of sufficient depth to allow


A modern filtration plant.

the water to trickle through very slowly, they will take out about 98% of the germs, which, of course, are left behind in the fine sand. Consequently, in order to make a filter fit for service a number of beds must be planned so that certain ones of them may be put out of use every few weeks, the sand removed or sterilized, and the filter bed thoroughly cleaned. The installation of filter beds is very expensive, but more than pays for itself in the saving of human lives and health.

Experiment. — To see what impurities can be removed from water by filtration.

Materials: Funnel. Fine sand. Powdered animal charcoal. Test tubes. Filter paper. Impure water containing a sulphate in solution, suspended matter (mud), and cochineal (coloring matter). Barium chloride solution.

Method: (1) Fill the filter paper in the funnel nearly full of clean fine sand. Pour some of the muddy water upon it and catch the filtrate in a test tube.

(2) Boil a little of the solution with the powdered charcoal. Pour it upon a filter paper placed in a funnel. Pour back the first spoonful that filters through, then catch the filtrate in a test tube.

(3) Test the filtrate in each case for a sulphate by adding barium chloride solution. If it turns milky, the sulphate is present.

A comparatively pure water supply.

Results and Conclusion: What are the results in each case?

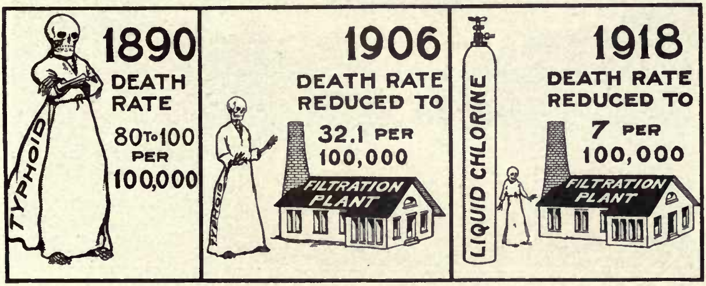
Formulate a statement summing up the value of filtration in purifying water.

If the water contained bacteria would you expect to find them in the filtrate or in the sand?

Use of reservoirs. — An additional protection to water supplies of this sort is a reservoir. Germs remaining in a large body of water for even a relatively short period of time lose their vitality and die. This is due to the fact that they have no food, for there is no vegetable or animal matter to feed upon. Air and sunlight also assist in the destruction. Therefore, any large reservoir holding a reserve supply of water aids in the destruction of germs.

Use of chemicals. — Most water supplies which are not reasonably pure are protected nowadays, in addition to other means, by the use of chemicals. Bleaching powder and liquid chlorine are used very successfully and kill all harmful germs.

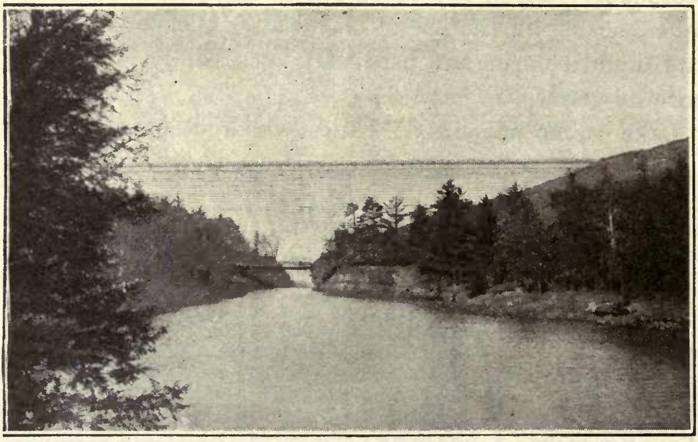
Lake water supplies. — Cities which take their water



Notice how deaths from typhoid diminished upon the introduction of the filtration plant and diminished again when the use of chlorine was introduced.

supplies from a lake into which sewage flows, such as Chicago, Buffalo, or Cleveland, have frequently had a high death rate from typhoid. In fact, in Chicago prior to 1900 the average yearly death rate from typhoid was 66.8 per 100,000. In the next decade its average was reduced to 22.3 per 100,000. At present its death rate is less than 5 per 100,000. This change was brought about to a large extent by the digging of a drainage canal, which drew the sewage of Chicago into the Chicago River and passed it into the Mississippi.

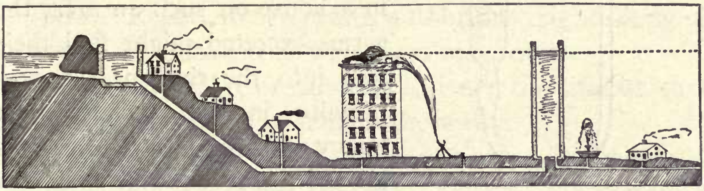
A modern city water supply. — The city of New York offers an excellent example of a modern project for the supply of pure water to a large city. New York found many years ago that it must go a distance of about fifty miles from the city in order to get a pure supply in sufficient quantity for use. In 1842 it began using water from the Croton



The Ashokan dam, seen from below; beyond it, hidden from view, is the great reservoir of the Catskill water supply of New York.

River some forty miles from the city. Here a great dam was built across the river, an aqueduct constructed, receiving reservoirs built, and a fine supply of pure water was thus obtained. In 1890 this system was again enlarged, but after the city grew, its needs became greater, and it soon became evident that it must go farther away for its supply of pure water. So large tracts of land, 900 square miles in all, were acquired in the Catskill Mountains. Great aqueducts over 127 miles in length were built, and the huge Ashokan reservoir was constructed on the Esopus River. This tremendous undertaking cost over $200,000,000 to complete. A supply of almost one billion gallons of water daily has been obtained. The present available supply should be sufficient for a city of 8,000,000 inhabitants, allowing 125 gallons a day for each person.

Pressure necessary. — In the case of the water supply of Los Angeles, where the water comes in a main nearly 250 miles from the Sierra Nevada, the pressure, or head of water, as it is called, is obtained through gravity. When the source of the supply is many feet above where it is to be delivered, this pressure is sufficient to cause the water to flow to the tops of the highest buildings. Can you see why? But in the case of water supplies drawn from lakes or rivers near at hand it becomes necessary for the city



Distribution of water from a reservoir or a standpipe.

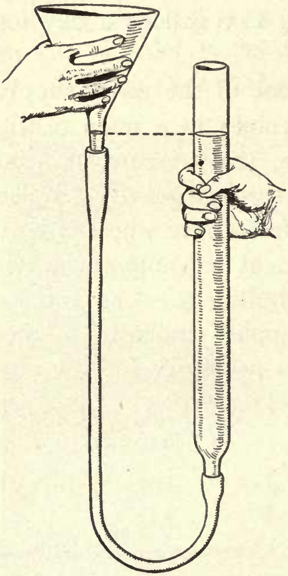
to install a pumping plant. Water is pumped into a reservoir or standpipe situated on an elevation above the city; it then flows by gravity through the pipes of the city. Pressure in the main varies as the height of the source, but also with the length and diameter of the main. The city must provide numerous fire hydrants and drinking fountains, all of which are supplied directly from the city mains.

Experiment. — To illustrate gravity distribution of a water supply.

Materials: A burette. A medium-sized funnel. Rubber tubing.

Method and Results: Let one boy hold the funnel and another the burette (page 156). Pour water into funnel. Why does water run into the burette?

If air in the rubber tubes hinders the flow of water, squeeze the tube to make the air bubble out. Raise and lower the burette. To what height will the water rise?



What must be the relation of the pipes in a house where water is to be used to the reservoir?

Protection of water supplies. — Where a city obtains its water supply either from the source of a small river or from a mountain lake, it becomes necessary to protect the watershed or surface of the land down which water may flow into this river or lake. If a case of typhoid should occur in a house on such an area, the germs excreted might find their way into the river or lake, especially in the spring when heavy rains occur. Many cases are on record showing how lack of proper protection for the water supply has caused an epidemic of typhoid.

It therefore becomes necessary to remove when possible all people in the area which drains into a water supply. Where this is impossible, as is the case in the water shed of the city of New York, there must be strict regulations to prevent pollution. New York maintains a sanitary police force which sees to it that there are no violations of the laws which protect the water. Every boy or girl who wishes to be a good citizen should remember, when camping or picnicking near any public water supply, that the utmost care in the protection of the water should be used.

Why this chapter was written. — If those of us who want to become future voters could realize our obligations, as well as the benefits which are given us by our communities, we should become better citizens. What are some of these obligations which involve the care of public water supplies?

First. We should never injure public property. Cost of repairs is a large item of expense in the keeping up of public property of all kinds, and this is equally true in the upkeep of hydrants,. water pipes, and reservoirs.

Second. Care of public watersheds Damage done by careless picnickers may be much greater than one imagines. Always clean up all rubbish and decaying material. Use only public toilets in parks or near watersheds.

Third. Report to the health authorities the breaking of any rules of sanitation of which you may know.

Fourth. If fishing or camping is done, the utmost care must be observed not to pollute the water.

Fifth. Care in the use of water at home. Leaks should be reported at once and stopped. Leaking faucets are a source of very great expense to the city and often to the private owner, where the water is metered. Water should be used carefully during the dry seasons, as we cannot afford to be selfish in the use of any public commodity.

Sixth. Personal hygiene. Avoid drinking water that you do not know about. Boil all water before drinking if it is suspicious. Learn the source of your own water supply, its strong and its weak points. Especially beware of drinking from open wells in visits to the country.

How to score my own city water supply. — For this purpose direct inquiry from the city department of water supply may result in obtaining first-hand information and pamphlets which will give you the desired information. Visit the city reservoirs and filter beds; the city pumping station, if you have one, and best of all, if possible, the source of your community water supply. In making out the score card which follows observe these directions.

SCORE CARD. COMMUNITY WATER SUPPLY

		Perfect Score	My Score
SOURCE	Water from pure source, well protected, public excluded (20) Water from river or small lake, where public is allowed, but where no sewers empty (10) Water from bodies of water in which sewers empty (3)	20	
SAFE WATER	No epidemics were ever traced to the water (10) Diseases have on rare occasions been traced to the water (5) Diseases frequently traced to water (0)	10	
SAFEGUARDS	Water is tested frequently and is filtered or chemically treated, and filter cleaned regularly (10) Water is rarely tested but is filtered (5) Water is rarely tested and is not filtered (0)	10	
DESIRABLE WATER	Water is soft, odorless, tasteless, colorless (20) Water is hard (10) Water is hard, and has color, taste, or odor (3)	20	
ADEQUATE SUPPLY	Water under good "head" at all times and no restrictions imposed on its use in dry season (20) Good pressure but use restricted during drought (10) Low pressure at times and restricted use (3)	20	
PUBLIC CONVENIENCE	City maintains public fountains, wading ponds, drinking troughs for animals, and bubble fountains for people (10), three of these (5), none (0)	10	
COST	Rate where unmetered not over $10.00 a year for family of five, or cost where metered not average over $10.00 a year for family of five (10), not over $14.00 (5), over $14.00 (0)	10	
	TOTAL	100	

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PART IV. HOW THE COMMUNITY CARES FOR ITS CITIZENS

CHAPTER X

ORGANIZATION OF A CITY GOVERNMENT

Problems. — 1. *To learn how the community government is organized, how new regulations are made, and the relation between various departments.*

2. *To understand the reasons for placing certain supplies and privileges under the control of the community.*

3. *To learn how we may coöperate with the community government.*

Project I. — TO BECOME FAMILIAR WITH THE METHODS OF CONTROL OF PUBLIC AFFAIRS IN MY OWN COMMUNITY.

1. Names of the principal public officials, their offices, duties, and terms of office.

2. New regulations and ordinances passed within a year. Reasons for these.

3. What is the method of procedure for enacting new regulations?

How city governments came to be organized. — A community is a group of people who live together, having more or less the same interests and who are governed by common laws. In the early growth a community may consist of very few people and these people may live so far apart that carelessness on the part of one family would not endanger the health or rights of another. But when people live near one another in larger communities common needs come into existence, and then certain rights of different members of the community must be respected. For example, people own buildings or land or farming utensils or some other things which they have bought or earned, and these things belong to them. Other people must respect this right and must neither harm property nor attempt to carry it away. Hence certain laws or restrictions have developed in the community, which all people agree to respect and obey. But suppose that one member of the community does not agree to do this, or pretends to agree but steals his neighbor's goods. Then there is the need in that community for some means of making that member of the community obey the common laws. For this purpose we have organized certain bodies which we call the *courts*. We have organized also, first voluntarily by citizens and later in the development as a paid department, a *police force*, compelling the careless man to obey the laws which are made for the common good.

Common supplies placed under the control of the community. — As the community grows in size, it becomes necessary that the health of its citizens be safeguarded by the control of all supplies that are used in common. Water, for example, may at first be obtained from wells, but a growing community soon needs more water than can be drawn from wells. Besides, a well may become contaminated with sewage, since human and other wastes soak into the ground and may get into the water used by the citizens. It then becomes necessary either to dig deep wells or to get water from some other pure source. The milk supply also must be carefully safeguarded if people in the community are to remain healthy. The sale of various kinds of materials, especially foodstuffs, must be carefully supervised and regulated, for upon pure food and water depends much of the health of the community.

The organization of schools. — Very early in the life of a community, we find some one qualified to teach who brings the children together and sets up a tiny school. In small places in the country we see such schools now-

Many old tenement buildings lack proper fire escapes and often where they exist they are loaded with rubbish contrary to city regulations.

adays where twenty or thirty students are brought under the care of a single teacher. But as the community grows larger, we have a graded school with children of different ages under different teachers. Ultimately the schools expand until the older students are sent to high schools and perhaps to college. In our large communities in this country we find all kinds of institutions of learning which furnish free education to those who wish it.

Fire protection. — Another thing that people living together must protect against is the common enemy, fire.

When Benjamin Franklin lived in Philadelphia many years ago, the entire fire department consisted of three pumping engines. When a fire broke out, all the citizens who were interested in fires went to help, but with no organized effort on their part their work was often ineffectual. As late as 1870, the city of New York had no paid firemen, and the citizens entered into volunteer work to help put out fires. To-day New York has the largest and perhaps the most efficient fire department in the world, with nearly 10,000 men

Modern apartments: fire laws respected.

and over 500 pieces of apparatus. Fire protection in a community is also obtained by means of proper laws restricting the kinds of buildings put up, the nearness of such buildings to each other, their construction and provision for fire escapes. In a community with good laws which are properly observed, there are very few fire traps, but in one large city under a bad administration not many years ago, out of over 300 tenement houses which were built only 15 conformed to the laws which were designed to make them safe from fire.

City streets. — At the present time most communities in our country have well-lighted streets with curbs and gutters to prevent flooding of the sidewalks. They are also provided with letter boxes and other conveniences. A well-organized community also takes care that its streets are watered and swept when dirty, that garbage and ashes are collected and properly disposed of, and that all possible care is taken to make the city a safe place to live in. The people enjoy the advantages of these things, and the city pays the bills.

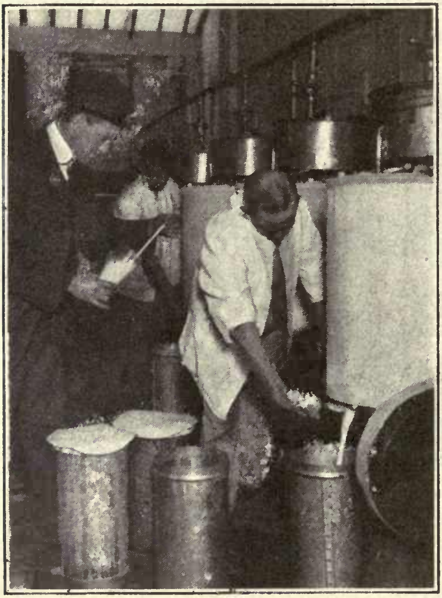
Public recreation. — Nowadays cities and towns are coming to recognize the fact that adults as well as children need a place to play in. Not only does the ideal community furnish parks which are designed to be beautiful as well as healthful, but it also provides playgrounds, public baths. community meeting places, stadiums in which games are held outdoors, theaters, and many other opportunities for recreation and amusement.

The work of the department of health. — No part of the organization of a community government is of more importance than the health department. Too many people are careless, and others are selfish, and still others are not well informed, so that diseases which are catching may be spread by innocent people who know nothing about such diseases. For this reason, the health department is of much importance because by means of laws it can quarantine or isolate people who have contagious diseases which might be carried to others. Moreover, the department of health is expected to look after the welfare of all sick people who are unable to pay for the services of a doctor. In such cities as New York, Chicago, Cleveland, Cincinnati, St. Louis, and many others not only does the health department provide many hospitals for almost every kind of disease, but the city also provides ambulances in which to carry the sick. In case of an accident on the city streets or in a building, an ambulance takes the person to a city hospital, where a city doctor attends him and nurses take care of him. These doctors and nurses are paid out of the city budget. The community also, if it is a large one, has special sanatoria for people who have tuberculosis; it has special homes for the feeble-minded, for the insane,

A modern hospital ward.

and for those who are incurably sick; and it provides shelter for the needy.

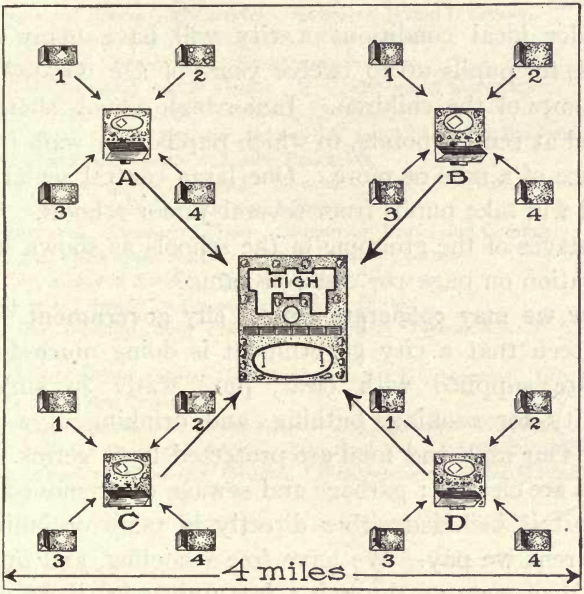
Inspection of food. — The department of health also inspects the conditions under which food is manufactured and sold. Dairies, for example, are carefully watched by either state or community inspectors. Regulations are made for the care of milk, both at the farm where it is produced and on the cars when it is brought to the cities. Milk is not permitted to be sold in open cans in most cities, for in this way germs and also flies, which bear millions of germs on their feet, might get to it and contaminate it. Canned goods are carefully inspected at the factories and sometimes at the places of sale. Many goods are inspected by the government, and most communities have laws with reference to the sale of unscreened and uncovered vegetable foods. These laws are of great importance in the summer when foods may easily receive harmful germs from dust. The sale of decayed foods is prohibited since they might harm those who use them.



Inspection of milk.

Regulation of drugs and patent medicines. — The health department also, with the aid of the Federal Government, supervises the sale of drugs and patent medicines. Habit-forming drugs, such as cocaine or heroin, are not allowed to be sold without a doctor's prescription. There are patent medicines which contain heart depressants or other dangerous drugs; these must be labeled so that all may know what they buy. Drugs containing alcohol must also be labeled stating the amount of alcohol.

Care of school children. — One of the most important pieces of work of the department of health is the care of school children. It has been shown that the death rate in recent years is declining in the cities, while in the country it remains about stationary. This decline is due to the care taken of young babies and school children by the departments of health in the cities. Not only do most well-



An ideal arrangement of school buildings. The four groups of 1, 2, 3, 4 are elementary schools for grades 1–6. A, B, C, and D are junior high schools. The senior high school with its classical, household arts, technical and commercial departments is shown in the center. Each school has appropriate playground. This illustrates a city area of 4 square miles. (From a suggestion by Dr. Snedden.)

regulated schools have a school physician and nurse, but in many cities they have in addition clinics for the care of the eyes, nose, and teeth, in which pupils may have this work done free of charge. Many large communities have established out-of-door schools for anemic and tubercular children. In other cases, kitchens have been established in the school building, where hot, nutritious meals are served at cost for those who can afford to pay, and free for those who cannot. These and many other things of a similar nature are done by the departments of health, in coöperation with school boards, in progressive communities.

Under ideal conditions a city will have many small schools for pupils up to twelve years of age, located near the homes of the children. Junior high schools should be located at central points, to which pupils may walk from a distance of a mile or more. One large central senior high school will take pupils from several junior schools. What advantages of the grouping of the schools as shown in the illustration on page 167 can you name?

How we may coöperate with a city government. — We have seen that a city government is doing much for us. We are supplied with clear, pure water in sufficient quantity for cooking, bathing, and drinking at a small cost. Our milk and food are protected from germs. The streets are cleaned; garbage and sewage are removed; and the cost is included either directly in taxes or indirectly in the rent we pay. We have free schooling, and in some cities may even go through a free university if we desire. And above all these things our health as well as our neighbor's is safeguarded. Should we not, therefore, even though we are not actual voters, be just as much interested in good government as if we were paying the taxes; for after all we are getting more out of the community than does the voter who actually pays the money into the city treasury. Every boy and girl who reads these lines should have the interest of his or her community at heart, for some day all may become adult citizens in that community. We should do all in our power to help the officers and the members of the board of health, the police and the fire department, and our teachers as well.

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CHAPTER XI

HOW THE COMMUNITY PROVIDES FOR PURE FOOD

Problems. — 1. *To learn the steps taken by government, state, and town in insuring a pure food supply.*

2. *To learn the dangers from milk and how to avoid them.*

3. *To learn the advantages and dangers of cold storage.*

4. *To learn the essential requirements to make a food store sanitary.*

Experiments. — 1. To discover if the milk we buy is clean or dirty.

2. To pasteurize milk and learn the effect on its keeping quality.

3. To discover the effect of a freezing temperature upon bacteria.

Project I. — TO INVESTIGATE THE SUBJECT OF PURE FOODS IN MY OWN COMMUNITY.

1. Health officer — duties — how equipped for his work.

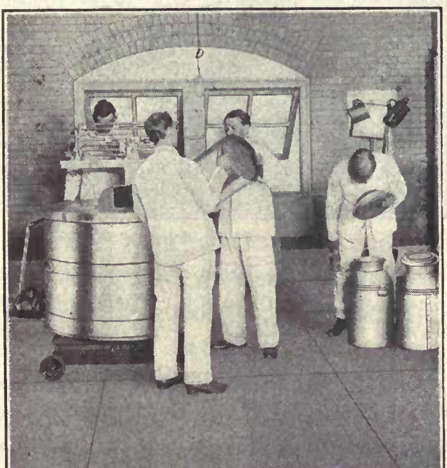
2. Regulations — government, state, and local.

3. By personal inspection, find which grocers, bakers, meat and fish dealers, fruit and candy shops and restaurants best meet the pure food regulations.

4. Try to interest your friends to trade with those dealers whose food is best protected against contamination.

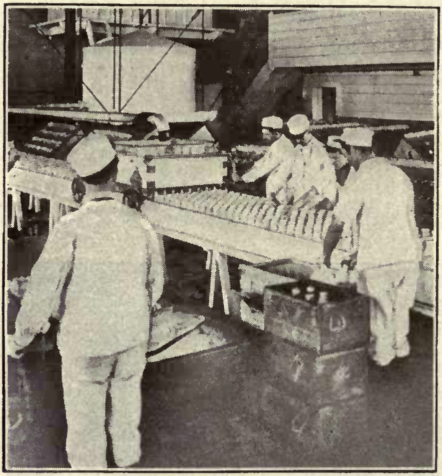
5. Make a full written report to submit to your teacher or to present to the class.

Did you ever stop to think how the foods we eat are protected and made safe for us? Not only does the United States Government have laws which deal with the protection of foods, but most state governments do as well. Both have a staff of men whose business it is to go from place to place and inspect all kinds of foods which are used in a community so as to keep them safe for human consumption. The milk you drink has been inspected at the farms where it was taken from the cow. It was packed in ice and sent in refrigerator cars to the city, where inspectors again examined it to see that it was not contaminated before it was pasteurized and bottled by the great milk companies. In the cities, the health departments supervise the work and also see that fish, meats, vegetables, fruits, and other easily spoiled foods are put on sale under conditions of cleanliness and safety to human beings. Meats bear the mark of inspection by federal officials. Groceries and canned goods are protected from adulteration by pure food laws. All preserved goods are labeled so that each one may know just what preservatives are used. This is done so that no poisonous materials may be put into the preserving substances in quantities injurious to health.



Examining and weighing milk upon its receipt.

Means of protecting food supplies. — It was not so long ago that communities did not take very great care of their food supplies. We have gradually become educated, so that now most communities have the proper facilities for caring for foods on sale. Some communities, however, are not so careful, and although laws may be made they are not kept. Especially is this true of smaller places where the members of health boards or other officials do not see the need for close supervision. This is *your* opportunity to do your duty as a young citizen. Are there farms near where you live that produce dirty milk? Are there stores in which milk is sold in cans unprotected from flies and dirt? Do you do your part at home in protecting your milk and other foods in hot weather?



Bottling milk for delivery.

Experiment.— To discover if the milk we buy is clean or dirty.

Materials: Funnel. Absorbent cotton. Milk.

Method: Wet the cotton with water and place it in the funnel. Filter a quart of milk through it. If the milk is clean, there will be no black dirt on the cotton.

Are your food supplies bought when fresh and used when fresh? Do you read the labels on your canned goods and preserves, and do you know what these labels mean? If you are to be a really useful member of your community, you should not only know the pure food laws and their meaning, but also you should do your part in making it possible to carry out these laws.

What is pure milk? — Most of us, especially when young, use a good deal of milk. It is indeed one of the most important of human foods, but also one of the most easily contaminated. We know that milk spoils readily. We know also that the souring of milk is caused by bacteria. Milk, even when it comes direct from the cow, contains some bacteria. In order to grade milk according to purity certain standards have been agreed upon by medical associations and public health societies, usually followed in most places where good milk is obtained. They recognize three grades of milk. The first is *Grade A*. This milk must come from cows which are free from all disease and which are examined frequently by inspectors, and when the milk is delivered raw (which means not pasteurized), it must have not more than 10,000 bacteria to the cubic centimeter. To have such a condition means that the barns must be clean, that the cows must be clean at the time of milking, that the workers must be free from dirt and disease, and that the dairy and its cans must be in spotless condition. Milk such as has just been described is very expensive because of the care needed, but it is the purest milk. Grade A milk which is pasteurized must be produced from cows free from disease, the general sanitary conditions must be good, and the bacterial count must not be over 200,000 before pasteurization, and not more than 30,000 before delivery to the consumer. *Grade B* milk, which is the kind usually bought in most large cities, when sold raw must contain not more than 300,000 bacteria to the cubic centimeter and when pasteurized must contain not more than 1,000,000 to the cubic centimeter before pasteurization and not more than 100,000 per cubic centimeter at the time of delivery. Any lower grade of milk than this should be used only for cooking purposes, as the bacteria are too numerous to allow it to be used in other ways with safety.

Experiment. — To pasteurize milk and learn the effect on the keeping quality of the milk.

Material: Two half-pint milk bottles. A pail or kettle large enough to hold one of the bottles. Thermometer.

Method: Fill each bottle two-thirds full of fresh milk. Close the bottles with a plug of absorbent cotton. Set one bottle of milk on a strip of wood in a pail or kettle. Add a pint of water and heat gradually to 160° F. Keepat this temperature 20 minutes. Remove the bottle of milk; cool it quickly by running water or setting it in cold water. Label the two bottles of milk and leave them side by side in a warm room for two days. The souring of milk is caused by bacteria. The sourness then is an indication of the amount of bacterial action.

Result and Conclusion: After two days carefully remove a teaspoonful of milk from each bottle. Test sourness by taste. What effect does pasteurization have on the growth of bacteria in milk?

How pure milk is obtained. — In order to have pure milk it is necessary that the utmost care be taken from the time the milk reaches the milk pail until the time it is delivered to the user. In an effort to have the farms and cows kept in the best of condition, a score card (see page 175) is used by the inspectors, and each dairy which falls below a certain grade is not allowed to supply milk until it brings up the condition of the cows or buildings to the required score. The purest milk comes from cows which are healthy and kept in clean cow yards, and yet one dirty or sick milker might send his germs in the milk to do harm in the city where it is delivered. Care then must be exercised at every point. The milk must be cooled, put into clean containers and kept at a temperature not higher than 50 degrees Fahrenheit during its transit from the farm to the city. When we remember that the city of New York gets its milk supply from eight states and Canada, and that some of its milk is over four days old when it

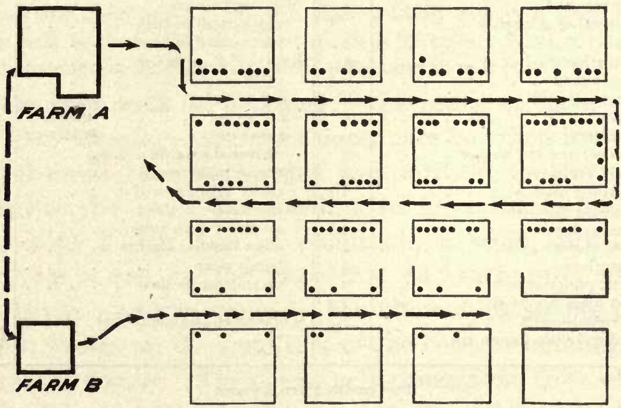
CITY MILK DEPOT SCORE CARD

Equipment	Score	Methods	Score
No barn within 500 ft.	2.5	Clean yard	2.5
No open privies within 500 ft.	2.5	Clean utensils	5
Locality insanitary — deduct 2.5	0	Clean floor	1
Separate building	5	Clean windows	1
Part of residence	2.5	Clean walls	.5
Grocery dairy	1	Clean ceiling	.5
Cellar dairy	0	Flies, none	5
No other business done	2.5	few	1.5
Salesroom separate	.5	swarms . . . . . deduct 10	0
Floor, cement	2.5	Utensils	
tight boards	1	sterilized in autoclave	5
dirt	0	sterilized by steam	3
Walls cemented or painted	1.5	sterilized tank hot water	2
whitewashed	1	scrubbed	1.5
papered	.5	only rinsed	.5
Lighting good	1	Milk kept covered	2.5
natural or electricity	.5	pasteurized in bulk	1
gas	0	pasteurized in bottles	2.5
Ventilation good	5	Kept 45° F. or below	5
Screens good	2.5	45° F. to 50°	1.5
broken	1	50° to 60°	.5
none	0	60° to 70° . . . . deduct 5	0
Machinery:		above 70° . . . . deduct 10	0
bottler and can washer	2	delivered ice cold	5
milk cooler	5	thermometer used	2.5
bottling machine	1.5	cooler kept covered	1.5
capping machine	.5	Men cleanly, healthy	2.5
pasteurizer	2.5	sterilized duck suits	1
cold storage plant	2.5	clean dustless clothes	1
autoclave	5	hands clean	5
Water, purity known	2	no spitting on floor	2
Wash basin provided	1.5		
Individual towels	.5	Total score (maximum 50)	...
Total score (maximum 50)	...		

Full credits given, or none

reaches the consumer, we can see the need not only for ice in order to prevent the growth of bacteria but also for pasteurizing the milk to kill the bacteria already present. In most cities, the large milk companies pasteurize their milk on a large scale by passing it over pipes filled with steam. This raises the milk to a temperature of about 178 degrees Fahrenheit for less than a minute. This method of pasteurization (the flash method) is not as good as the slower method of heating the milk to 145 degrees for thirty minutes, but it kills, at least, the harmful bacteria in the milk. After all, dirty milk is *dirty*, and no amount of pasteurization can make it clean. An interesting project would be for you to inspect a plant of some milk company and score it from the score card which is shown on page 175. The same can be done by the boy or girl who lives in the country for the farm which produces milk in his or her neighborhood.

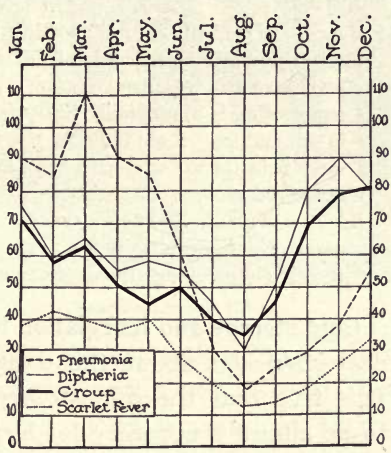
Milk-borne diseases. — One of the chief reasons for exercising great care in the production of milk is the fact



A case of typhoid exists at farm A, which has a large milk route. Farm B has a small milk route and supplies some milk to A. The cans from B are washed at A and returned to B. Each black dot represents a case of typhoid caused by infected milk. How do you account for the cases along B's route?

that milk frequently carries certain diseases. Typhoid, diphtheria, scarlet fever, tuberculosis, and septic sore throat are all human diseases which may be carried in milk, while diarrhea, dysentery, whooping cough, and measles are *probably* carried in this way. Although the germ which causes tuberculosis in cows appears not to be the same as that which occurs in human beings, yet over 30% of tuberculosis in children under five years of age is of the kind that is found in cows. Children seem to be more susceptible to the cow tuberculosis than adults, so this makes it all the more necessary to inspect the cows for tuberculosis and to prevent the use of infected cows in the production of milk. One of the most serious diseases carried by milk is typhoid fever, and many epidemics have been traced to this source. A recent milk-borne epidemic of typhoid in the city of New York had over 400 cases. The preceding diagram shows how typhoid fever germs may be brought to the city and given out in the milk supply.

Seasonal variations in diseases. — In some cities where the board of health keeps careful records we find that certain diseases, such as diarrhea, are much more prevalent in the summer than in the winter. This seems to be due, in part at least, to the fact that foods do not keep as well in warm weather as in cold because warm weather aids the growth of germs. Milk, as well as other food, is easily spoiled in warm temperatures. As milk is the food of babies, they are often attacked with intestinal diseases in summer. It was found recently in New York that in two



Average number of deaths per month for 1897–1916, of four common diseases in Chicago.

groups of babies, one of which was fed on pasteurized and the other on raw milk, 64% of those fed on raw milk were ill with diarrhea during the summer, while only 24% of those fed on pasteurized milk were ill. When we remember that flies are very prevalent in the summer time, that they frequent dirty places, and that they might take up the diarrhea germs and carry them to the milk, we believe this is one reason for the seasonal variation in disease. Typhoid fever is another disease which is more prevalent in warm than in cold weather. There are other diseases, as pneumonia, diphtheria, and scarlet fever, which are more prevalent in the winter.

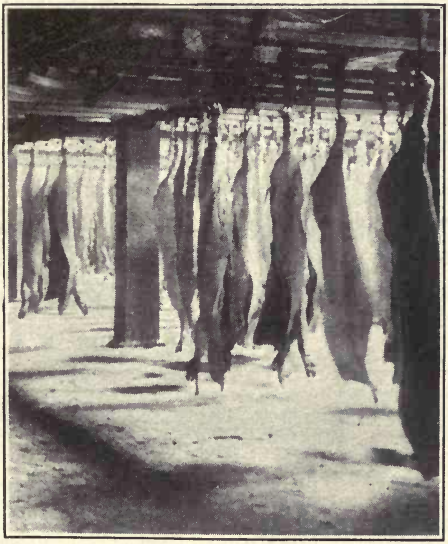
Experiment. — To discover the effect of a freezing temperature upon bacteria.

Materials: One half-pint milk bottle. Milk.

Method: Fill the bottle half full of fresh sweet milk. Close the bottle with a wad of absorbent cotton. Place this out of doors when the temperature is considerably below freezing. In warm weather pack it in salt and ice. Keep it below the freezing point for 4 hours. Then leave it in the air at usual room temperature for two days. If sourness develops, bacteria must be alive in it.

Results and Conclusion: After two days test for sourness by taste. Compare with the results in the preceding experiment. Which is more effective in checking growth of bacteria, pasteurization or freezing?

Cold storage and its relation to foods. — We hear a good deal nowadays about the danger of cold storage foods. It is true that the cold storage plants, which have come to be almost a necessity for large communities, frequently keep meats, fish, and other foods for periods of from several weeks to several months, or even longer. While storing foods in ice at a freezing temperature changes their flavor, yet if the food is fresh when it is put in cold storage and if it is used soon after it is taken from cold storage, no harm is done. Foods kept in cold storage a long time are softened so that bacteria grow rapidly in them. Sometimes fish or meats are put into cold storage after the bacteria have begun to spoil them. Such foods would be unfit to eat after coming from cold storage. On the whole cold storage is a boon to modern society, for it enables us to have fresh vegetables, eggs, and other perishable foods at times when they could not otherwise be obtained.



Meat kept in cold storage.

How our meats are protected. — All over the United States the government has placed federal inspectors whose business it is to see that all animals killed for meat are in good condition. These inspectors work in the great slaughterhouses and packing houses. Work is carried on in over 244 cities and in over 3000 different large establishments. Pork is examined for trichina and beef for tuberculosis, while the buildings in which the work is done are regulated according to certain sanitary standards. The clothes of the workers, the appliances for sterilizing buckets, knives, tanks, and other parts of the plant, and the control of pests are all regulated by law. In many cities the slaughterhouses must be rat proof, screened against flies, and all refuse must be at once disposed of. Is there a slaughterhouse in your town? If so, are the conditions sanitary there? You should make a trip to this place and see if conditions are favorable, and then report on the visit as a home project.

The sale of meats, milk, and groceries. — One of the most important functions of your board of health is to see that the stores in which milk, meats, fruits, and groceries are sold are clean and sanitary. In many communities the law provides that all perishable goods must be kept under glass or well screened, especially in the summer season. Can you see a reason for this? Does the grocer with whom you deal have a clean and well-ventilated shop? Are the receptacles containing flour, sugar, etc., always kept covered? Are vegetables and fruits exposed

CARE OF FOODS IN A STORE

Kept Closed under Glass	Shielded from Flies, Dust, and Hands	In the Refrigerator	Elevated 12 Inches above Floor	May be Kept on Floor
bread	berries	butter	artichoke	canned goods
cakes	celery	cottage cheese	cabbages	carrots
candy	cherries	dried currants	cantaloupe	cucumbers
cheese	crackers	eggs	cauliflower	nuts (whole)
opened fruits	dates	fresh fish	cranberries	onions
pastry	figs	fresh meats	dried fruits	peas
pies	grapes	milk	dried meats	potatoes
radishes	lettuce	mincemeat (fresh)	grapefruit	pumpkins
shelled nuts	peaches	oysters	lemons	squash
watermelon (cut)	pears	raisins	oranges	turnips
	prunes		plums	watermelon
			pickled food	
			spinach	

so that people may handle them and flies and other vermin touch them? If so, you should not patronize the place. Food, when exposed for sale, should be kept covered so that germs cannot get to it, for this is one of the easiest ways for germs to be spread. Suppose a man with tuberculosis should come into the shop and cough on the fruits, vegetables, or into an open can of milk. What would prevent you from innocently carrying home those germs and taking them into your own body? An ounce of prevention is worth several pounds of cure in this case. Let us all work together to make our community a safer place as a result of reading this chapter.

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CHAPTER XII

THE "PURE FOOD AND DRUG ACT" AND HOW IT OPERATES

Problems. — 1. *To learn what is meant by the "Pure Food and Drug Act."*

2. *To learn what constitutes "adulteration of food."*

3. *To learn what the most common forms of adulteration are.*

4. *To understand some of the dangers from patent medicines and drugs.*

5. *To learn how to help my community to demand pure foods and to reduce the use of patent medicines.*

Experiments. — 1. To see if "butter" used at home is real butter, oleomargarine, or renovated butter.

2. To test jelly, jam, or ice cream for glucose and starch.

3. To test cheap candy and jam for artificial coloring.

4. To test milk for formaldehyde.

Project I. — To make a collection and study of labels on package foods and patent medicine.

1. Contents of food packages not food.
2. Claims made for medicines and drugs.
3. Deleterious substances in medicines.
4. Preparations which are probable frauds.

Project II. — Test various foods for adulterants.

Make list of foods with the most likely adulterant. Look up methods of testing for these adulterants. Make the tests and report all results.

What is the "Pure Food and Drug Act"? — We hear a good deal nowadays about pure food, and people are becoming educated to the necessity of having food neither contaminated nor adulterated. Not many years ago many of our prepared foods were adulterated. Of many samples of food tested before the year 1906, 40 per cent of one lot of 500 samples, 41 per cent of another lot of 500 samples, and 60 per cent of a third lot of 500 samples were found to be adulterated. This showed to the Congress of the United States the need of protecting people against the adulteration of foods, and so in 1906 the Pure Food and Drug Act was passed. We found also that our meats were not always protected in the killing and carriage to the consumer. Then, too, patent medicines were labeled in such a way as to make people think that they could cure diseases when often such a cure was impossible. In other words, they were *mislabeled* and did not tell what substances were contained in the medicine. The Pure Food and Drug Act has caused the makers of patent medicines at least to label these medicines so that we may know some things that are contained in them.

An inspector purchasing a sample food product for testing.

While misrepresentations cannot be made by the labels, the law has no control over newspaper and circular advertising. Compare the claims made in advertising with those on the package to see if they agree.

What is adulterated food? — This act first of all defines what *adulteration* is. It says that adulteration is anything which is added to food to cheapen it: anything mixed with food to reduce or injure its quality; any valuable part taken away from the food; the mixing of colored or stained material with food to conceal damaged or inferior material; the addition of poisonous materials or the use of any decayed animal or vegetable substances unfit to eat. Adulteration then is a very large term under this act, which also provides for the punishment of any one who is detected practicing any of these adulterations.

How the Pure Food and Drug Act operates. — Although Congress doubtless thought it had made good legislation in the case of the Pure Food and Drug Act, the results are not satisfactory in all respects. The act has prevented the adulteration of foods where the civic authorities are active, but if the board of health of a town or city is not alert, foods kept in bulk may be adulterated by dishonest manufacturers or storekeepers. The act *does* make it necessary for the firm putting up the goods in containers to tell exactly what is in the container. For example, if your grocer keeps cheap jellies, jams, marmalades, or flavoring substances, you may find labels on the bottles or cans stating that artificial coloring, a preservative and 10% glucose are used. The federal Food and Drug Act exercises no control over the sale of foods and medicines prepared in one state and sold in the *same* state. The law applies only to *interstate* commerce. The state laws apply to preparations manufactured and sold in the state and some states are very lax in this matter. What are the food and drug laws in your state? Are they well enforced?

Cheap candies are often adulterated and colored with cheap dyes. They are frequently sweetened with saccharin and contain white clay or glue and are sometimes covered with shellac mixed with iron rust or lamp-black. Different fruit flavors are made synthetically out of coal-tar products. There is also danger from soda fountains where saccharin is used in place of sugar and many fruit flavorings are made of coal-tar products. In addition to this, the glasses back of the counter in the soda fountains are often not well washed and there is much danger of the transfer of bacteria from one person to another by this means. We should patronize only soda fountains which use individual paraffin paper cups.

Lack of knowledge decreases the effectiveness of the Pure Food and Drug Act. — The Pure Food and Drug Act permits the use of certain adulterants of foods and drugs provided the adulterant are plainly named on the label of the container. But the majority of people are not educated in these matters so that they know what is harmful and what is harmless. The only way for us to know how properly to make use of the Pure Food and Drug Act is to get some reliable information as to what constitutes harmful preservatives and also what materials are harmful in medicines. Then if we take the trouble to read the labels which the Pure Food and Drug Act causes to be placed on the containers, we can sometimes avoid taking poisons into the body. There are, however, many drugs, some of which are poisons, which may be used in "patent medicines" without being named on the label.

Experiment. — To see if the "butter" used at home is real butter, oleomargarine, or renovated butter.

Materials: "Butter" to be tested. An iron tablespoon. Test tube. Toothpick. Glass rod. Ice. Fresh milk.

Method: Heat a small piece of the sample in the spoon, stirring with a wood toothpick. Real butter boils quietly but foams freely. Both oleomargarine and renovated butter boil noisily and with little or no foam.

Add a teaspoonful of the sample to test tube half-full of fresh milk. Heat and stir until the fat is liquid. Surround the test tube with crushed ice or ice water and stir with the glass rod. If the sample is *real* or *renovated* butter it will make many separate solid grains throughout the milk; if oleomargarine, it will solidify in one hard lump.

Result: What is the result of these tests?

Some common adulterations. — Many adulterations are met with every day and are not at all harmful. Oleomargarine with coloring matter in it is sometimes unlawfully sold as butter. As a matter of fact, oleomargarine is perfectly wholesome, as are also nut butter, nut oils, cottonseed oil, and other substitutes for butter. Cottonseed oil is frequently an adulterant or substitute for the much more expensive olive oil. Molasses, honey, and maple sirup are often adulterated with glucose or corn sirup. Corn sirup is a good enough food, but it is cheaper than the materials for which it is substituted and is therefore an adulterant. Cheap grades of condensed milk may have sugar added to them to take the place of foods which were removed from the milk. Coffee, tea, and cocoa are frequently adulterated by the addition of such materials as cornstarch, old tea leaves, chicory, cocoa shells, and other cheap products. Some foods may have adulterants of a harmful nature. We have spoken of candy having saccharin, clay, glue, and other materials added to it. We also have chemicals used to change the color of meats, such as saltpeter, which brings back the red color to partly decayed meat, and in the case of flour, alum and other poisonous compounds may be retained by the flour.

Chicory can easily be detected in coffee by simply adding the ground material slowly to a glass of water. Chicory sinks at once. Starch in coffee can easily be found through the iodine test. Saccharin is soluble in chloroform, while sugar is not. Glucose added to honey can be detected by the addition of a few drops of a weak solution of potassium iodide. If the color disappears from the honey, glucose was present.

Experiment. — To test jelly, jam, or ice cream for glucose and starch.

Materials: Samples to be tested. Test tubes. Fehling's solution.[1] Iodine solution. Funnel and filter paper.

Method: Add a teaspoonful of the sample to a test tube half full of water and heat. Filter. To one-half the filtrate add 5 c.c. Fehling's solution and boil. A red precipitate indicates the presence of glucose. To the remainder of the filtrate add a drop or two of iodine solution. A blue or blue black color indicates starch.

Result: Do any of the foods tested contain glucose or starch?

Experiment. — To test cheap candies and jam for artificial coloring.

Materials: Brightly colored candies, cheap jams, evaporating dish, white woolen yarn.

Method: Mix a tablespoonful of jam or a piece of colored candy in an evaporating dish half full of boiling water. Put into this a piece of white woolen yarn and boil for ten minutes. Then remove and wash the yarn in hot water. A bright color left on the yarn indicates artificial dyes.

Result: What substances tested were colored with artificial dyes?

Some harmful preservatives. — But more harmful in some respects is the use of preservatives. Food preserved by means of heat or cold is good food, but if we add chemical substances to it in order to prevent bacteria al-

[1] Fehling's solution, made by dissolving 6.2 gm. copper sulphate, 3.5 gm. Rochelle salts, and 2 gm. potassium hydroxide in 100 c.c. of water.

ready in it from causing further decay, then such preservatives become harmful. Many foods contain, under the Pure Food and Drug Act, small quantities of alum, borax, benzoate of soda, benzoic acid, and certain sulphites. These quantities used are probably harmless to any one taking a small quantity of the substance in question, yet they are not substances we wish to have added to food, as they may indicate that such foods may have been close to the point of decay when they were put into the cans or bottles.

Experiment. — To test milk for formaldehyde.

Materials: Evaporating dish. Concentrated hydrochloric acid. Ferric chloride mixture made by adding 2 c.c. of 10% ferric chloride solution to 1 liter of hydrochloric acid.

Method: Mix 10 c.c. milk with 10 c.c. of the acid-ferric chloride solution in the evaporating dish. Heat slowly to boiling, stirring occasionally. A violet color results if formaldehyde is present.

Result: What is the result of your test?

Patent medicines and the Pure Food and Drug Act. — The American people are probably the greatest consumers of "patent medicines" of any people in the world, but we are gradually becoming educated through the working of the Pure Food and Drug Act to realize that many patent medicines are harmful rather than beneficial. Medicines should seldom be taken except under the advice of a physician, for the human body is usually capable of curing itself when it is out of order. The chief advantage of the act with reference to patent medicines lies in the fact that the labels on the bottles must not tell untruths, as they have done frequently in the past, because the act prohibits fraudulent statements on the package or bottle. When a medicine is advertised to cure everything, it is evident that it is a fraud. Such labels have been changed to substitute the word "remedy" for the word "cure."

There are eleven drugs which must be declared on the label if present in the medicine. They are: alcohol, morphine, opium, cocaine, heroin, alpha and beta-eucaine, chloroform, cannabis indica, chloral hydrate, and acetanilid. Other drugs, even poisons, like arsenic and strychnin, need not be disclosed under the present law.

Drugs and their dangers. — Patent medicines might be divided into several groups, according to their composition and uses. The most dangerous of them contain habit-forming drugs, of which we shall speak in a moment. Another type of patent medicine includes the so-called cough sirups which are used to soothe the suffering of people who have tuberculosis. Still another type of drug is said to cure people who have incurable diseases. Such drugs are usually sold to people in the last stages of disease, and most frequently these people are harmed instead of helped. Drugs are dangerous to use except in the hands of expert physicians. Last of all are the medical fakes, "cures" to make thin people fat and fat people thin, instruments to cure deafness, or to bring about vitality to weak people.

Most headache cures are harmful and even dangerous. They usually contain phenacetin, acetanilid, chloral, morphine, or some other drug which depresses the heart, causing it to beat more slowly. They also deaden the sensation of pain. Such drugs do not *cure* headaches, and their use simply covers up the real cause of the trouble and makes the user addicted to the drug. Moreover, if a person has a weak heart, these drugs may slow down its action until death follows. No one should use headache powders without first knowing what they contain nor should they be used except by advice of a physician so as to be sure they do not contain habit-forming drugs or poisons.

Habit-forming drugs. — The basis of many patent medicines used as home remedies is alcohol. Some of these contain over 50 per cent of alcohol. In some parts of the country people have become drunk on patent medicines when they could not obtain liquor. Too often such medicines have been the cause of the formation of a habit of taking alcohol. The person taking the drug containing alcohol feels better temporarily because of the deadening effect of the alcohol and wants more of the same drug. As a result, he soon becomes addicted to the alcohol habit. Other habit-forming drugs contain opium, morphine, or heroin. The users of these soon become dope fiends.

Medical fakes. — Under such a heading would be placed the so-called *cure-alls* for incurable diseases, such as cancer cures, consumptive cures, the obesity cures, the cures for deafness and epilepsy, and many others. Many of these are pure and simple fakes. Cures for over-fatness, for example, have been found to be made of such materials as cream of tartar and baking soda, sweetened and colored pink. It is perfectly plain that such materials would not make a fat person thin. Tuberculosis can be cured only by treatment and not by drugs. Cancer is curable only in its early stages and so far as known not by drugs at all. Some pieces of apparatus sold to make deaf people hear are absolutely valueless, and if used may harm the middle ear.

How to make this chapter benefit us. — We have already said that the chief reason why the Pure Food and Drug Act is ineffective is because people do not have sufficient knowledge to understand it. Those of us who have been fortunate enough to learn something of its applications can easily learn more by working up a project on some interesting phase of this chapter. The American Medical Association has published many pamphlets on medical frauds which will suggest material for several interesting reports before the class. Visit your home grocery store and make a list of all the foods with labels which show that harmful preservatives are used. Visit some good-natured druggist and note what medicines have recorded on the labels any of the eleven drugs mentioned on page 189. Learn if you can, from your druggist or physician, other prepared medicines which contain harmful or poisonous drugs not indicated by the label. Collect newspaper advertisements of medicines and compare the claims made in these advertisements with those on the labels. Above all, talk over the subject of adulterants and patent medicines with your fathers and mothers and with other people who you think might be interested.

It is only by enlightening many people that we can finally make public sentiment which will result in making new laws which will better protect the people of this country against harmful preservatives and still more harmful patent medicines. And finally, after you have the facts, score up your community, or at least that part in which you live, with reference to the points suggested in the score card on the community care of food which is printed on the following page.

SCORE CARD. COMMUNITY CARE OF FOOD

		Total Score	My Score
MILK INSPECTION	Milk inspected at farm where produced (2) Milk inspected in transit to city (2) Milk inspected in bottling establishment (2) Milk inspected at point of sale (2) Tubercular tested cows furnish all of supply (8) Laws with reference to typhoid carriers enforced (5) Grading of milk sold based on standard of American Medical Association (see p. 175) and sold as graded; all milk below grade "A" pasteurized; no dipped milk sold (9)	30	
FOOD INSPECTION	Regular inspection of slaughterhouses and meats (5) Regular inspection of cold storage plants (2) No cold storage goods unfit for public use sold (3) All bakeries regularly inspected (3) Modern baking plant in community (1) Foods in store kept according to schedule, p. 180 (3) All foods on push-carts covered (3) Butcher shops inspected regularly and free from flies and offal (5) Shellfish and fish supplies safeguarded and inspected (5) All persons handling foods free from disease, restaurants clean and inviting (5) Soda fountains, individual and sanitary drinking cups (5) Regular inspection of weights and measures (5)	45	
PURE FOOD AND DRUG ACT	No adulterated candy sold (5), some (2), much (0) No medical fakes sold (10), some (4), many (0) No headache cures sold without prescription (10), some (4), many (0)	25	
	TOTAL	100	

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CHAPTER XIII

HOW DISEASES ARE SPREAD AND HOW TO FIGHT THEM

Problems. — 1. *To understand the dangers from common contagious diseases.*

2. *To learn how we may fight contagious diseases.*

3. *To understand the relation between diseases and germs.*

4. *To understand how to obtain immunity against certain diseases.*

Experiments. — 1. To discover the distance germs may be scattered by the "droplet method of infection."

2. To see if fumigating with formaldehyde will kill bacteria.

Project I. — TO INVESTIGATE THE SPREAD OF DISEASE IN YOUR NEIGHBORHOOD.

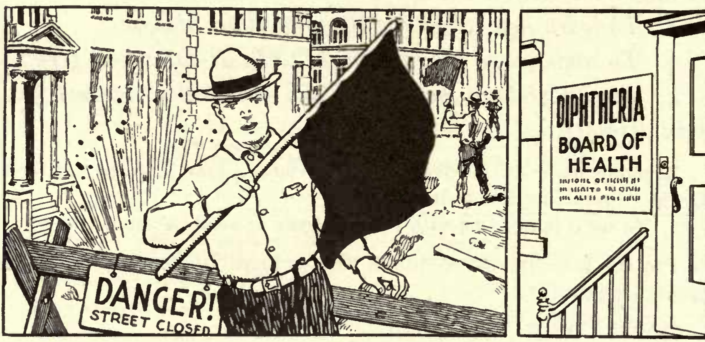
(Cover a period of at least 3 months.)

1. What diseases — (1) contagious; (2) not contagious.

2. Observe habits which help to spread disease — whether the persons are at the time suffering from disease or not. List them.

3. Observe habits which help check the spread of disease. List them.

Quarantine. — You have probably all seen a blasting gang at work. You have noticed just before the blast is sent off that one or two of the members of the gang go out into the street, waving red flags and calling out loudly, "Fire! Fire!" You have all been interested to see what happens, how the men set off the blast with electricity, how the whole mass rises into the air with perhaps a few rocks or logs flying quite high, then the workmen troop back to the place where they were drilling; work goes on as before and traffic on that street is again resumed. By means of a red or other conspicuous placard the health department in the community in which we live warns people who pass of the fact that there is a contagious disease in a particular house. The health officer in a community has a right to keep people in who are sick with certain catching or contagious diseases, and to put a placard on the house, that all may know of the danger from



Two kinds of warnings which are to save lives.

disease there Restriction on a sick person or one suspected of being infected is known as quarantine.

What is a contagious disease? — But we might well ask what are contagious diseases. The word means "catching," and such diseases are said to be catching diseases. We know some of them very well: whooping cough, measles, diphtheria, sore throat, and common colds. Practically all such diseases are communicated to others in much the same way and by the same means. Little bacteria or germs which cause the diseases find an excellent place to grow in the soft mucous lining of the throat and nose.

The germs causing many children's diseases grow in just such places and are communicated usually in one way, that is, by the germs from the mouth or nose of an infected person getting into the mouth or nose of some one else and causing the disease.

Experiment. — To discover the distance germs may be scattered by the "droplet method of infection."

Materials: Four petri dishes with sterile agar.

Method: Cough into one dish of agar at a distance of 2 feet, into a second at 3 feet, and into the third at 5 feet. Hold a fourth dish 2 feet away but cough into a clean handkerchief. Cover the dishes and leave them in a warm dark place for several days. Examine them to see which has developed the greater number of colonies of bacteria.

Result and Conclusion: What is the result in each case? What dangers are there from the "coughs" of people having colds and throat diseases?

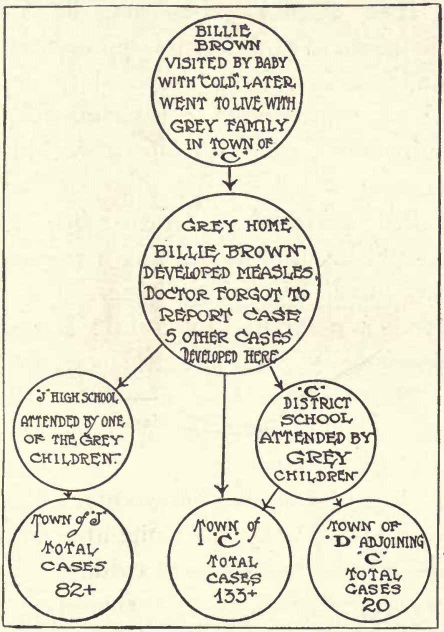
Application: How can the spread of disease by coughing be greatly reduced?

Always cough or sneeze into your handkerchief. Why?

Some ways in which contagious diseases are spread. — We have already seen that germs grow rapidly in moist, warm places where there is food for them. When this warm, moist place is the throat or nose, then evidently the easiest way to spread such diseases is by coughing or spitting. The next time you are talking with your schoolmates, stand between them and the light and you will notice that as they talk, little droplets fly out of their mouths and pass into the air in a constant spray. This spray reaches from eighteen inches to three feet from the person who talks. It is quite evident that any one who has germs in his throat or mouth could easily pass these germs out with these little droplets to some one who stood within that three-foot limit. It is also evident that any one who puts any article into his mouth after it has been placed in the mouth of one having a contagious disease will probably take that disease. One of the frequent methods of contagion is by giving your neighbor a bite of your apple or a piece of candy which has been in your mouth.

A good way to spread colds. Explain.

How to know a contagious disease. — Since all who read this book go to school, we are most interested in diseases that affect children. Such diseases are mumps, measles, scarlet fever, chicken pox, whooping cough, diphtheria, tonsillitis, and a variety of colds. Practically every child's disease at the outset begins with sneezing, running at the nose, and a slight cough and fever, so it is very evident that if any one has any of these symptoms, he should be kept at home. The period from the time that the disease germ begins to grow in a person's body until the time that the symptoms of the disease are evident is called the *incubation* period. During this period of time the disease germs are growing in the body but not making themselves known because the poisons which they give off have not been formed in large enough quantities to seriously affect the person's system. This incubation period differs greatly in different diseases. With mumps, it is 15 to 22 days; in whooping cough, 14 days; in chicken pox, 11 to 22 days; in the case of measles, 8 to 15 days; while in diphtheria, it is only from 1 to 5 days. When one has been exposed to a contagious disease it is easy to tell if he has taken it; for if the symptoms do not make themselves known within the time of the incubation period, we may know he has escaped.



According to Health News, N. Y., the failure of a doctor to report the first case of measles resulted in its spread until there were 270 cases.

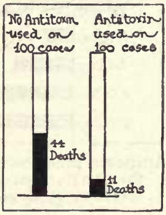
How we may help to fight contagious diseases. — The first and biggest thing that any person can do to help fight contagious diseases is to be *unselfish.* If brother has the symptoms of a contagious disease, it is more trouble to keep him at home out of the way of other children than to send him to school. But are we good citizens if we let him go? If he does go, he will surely spread the disease to a good many innocent boys and girls. It is necessary to be honest, unselfish, and to observe health regulations; if a contagious disease does appear in our home, we must see to it that the case is strictly quarantined from other members of the family and that all the dishes, clothes, bed clothes, and everything else used by the patient are carefully disinfected. Perhaps you already know that disinfection by the use of some substance like chloride of lime, mercury bichloride, lysol, carbolic acid, boiling water, and, best of all, sunlight, will kill germs.

How disease germs may be killed. — We have seen by means of experiments that germs need moisture, warmth, and food in order to grow. Dry air, sunlight, lack of food, all are unfavorable to their growth, but certain poisonous substances, called *disinfectants*, kill them at once. Substances which simply stop the growth of bacteria are called *antiseptics*. Antiseptics and not disinfectants should be used in cleaning a wound, for disinfectants are too harsh for living tissue. The growth of bacteria in foods is prevented by certain harmless substances, called *preservatives*, such as salt, sugar, vinegar, and spices.

How germs cause disease. — We have seen that there are two different types of germs, those which cause disease and those which do not. The former are called *pathogenic*, and the latter *non-pathogenic*. Some of the disease germs cause trouble by the formation, as they grow in the body, of substances which are poisons. Just as when we eat and work we give off wastes, so these germs give off wastes which are taken into the blood and passed around the body in the circulation. These wastes, which are called *toxins*, cause the symptoms of disease, and the disease begins to affect us when there is a sufficient amount of these wastes to make themselves felt. Other germs destroy tissue, as is seen in tuberculosis.

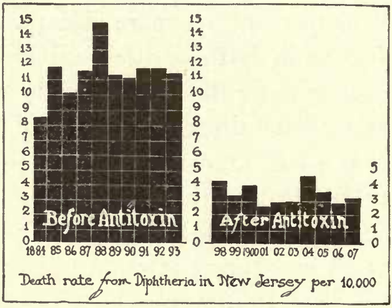
Immunity: natural and acquired. — Sometimes, as we well know, a boy or girl who has been exposed to a contagious disease does not take the disease. When a person exposed to a catching disease does not take it, we say he is *immune.* Some persons are more susceptible to diseases than others. Just as in cattle or other animals, some resist the attack of disease more than others, so in human beings, some people easily resist disease and are said to have natural immunity. It is a well-known fact that white people are more immune to tuberculosis than dark people, while the black race is less susceptible to malaria than the white race. Most important of all in securing immunity is the condition of the body at the time we are exposed to the disease. If we are fatigued from overwork, or if we have been misusing our body in any way, either through the use of drugs or alcohol, then the blood is not able to resist the toxins of the bacteria and we are less likely to have natural mmunity to the disease.

It is also possible for the body to acquire immunity against diseases through the use of *antitoxins* and *vaccines.* Both antitoxins and vaccines are furnished free by the boards of health of most communities, and as a study of the diagram shows, they are very important factors in the prevention of certain diseases.

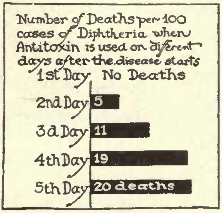


Typhoid antitoxin has greatly reduced the danger from typhoid.

Use of antitoxin for diphtheria. — Perhaps the most widely known antitoxin is that used for the prevention of diphtheria. An antitoxin is a substance which is produced by the living cells of the body under the stimulation of a toxin or poison. Each antitoxin will neutralize or destroy only the toxin which caused it to come into existence, and so in the preparation of antitoxin for diphtheria, they use horses into whose blood is introduced a certain amount of diphtheria toxin. This causes the cells of the horse to manufacture antitoxins which get into the liquid part of the blood of the horse. After two or three months the blood of the horse thus treated has a large amount of antitoxin in it. This blood is drawn off and allowed to clot. The serum or liquid part contains all of the antitoxin, and after preparation with the greatest care it is put up in small tubes and is injected into the body of a person who either has diphtheria or who has been exposed to the disease. As a glance at the diagram shows, this antitoxin is most efficient in the early stages of the disease.



Antitoxin has greatly reduced the death rate from diphtheria.



Antitoxin must be used in the early stages of diphtheria to be of value.

Vaccination. — Another form of acquired immunity is brought about through the use of vaccines. In the case of vaccination for typhoid, the dead typhoid germs are injected into the body and their toxins cause the cells of the body to form some substances which resist the disease. In the case of the use of vaccine, the healthy cells in the body are stimulated to *produce* substances which cause the body to become immune. In the case of the use of an antitoxin, the substances *already prepared* are poured into the blood and neutralize the products formed by the disease germs which are already there. In your community the board of health prepares and gives out antitoxins and vaccines. These substances are the most important we have to fight disease, and every person should coöperate with the board of health in his community to have these substances used. An outbreak of smallpox occurred a few years ago in Niagara Falls, New York, simply because a number of people refused to allow themselves or their children to be vaccinated Uneducated people sometimes do not understand the reason for certain hygienic actions. Will you do your share toward making your community one where coöperation is the watchword and where no epidemics can occur because of the watchfulness and unselfishness on the part of all its citizens?

Use of the score card. — To make the score card (page 202) useful the entire class ought to devote at least one period to making it out. It will first be necessary for each member of the class to take some one part of the work of finding out how the city is protected against disease and then all of the information brought into class from different sources can be discussed, graded by the class as a committee, and the final results placed on the score cards.

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SCORE CARD. WORK OF THE BOARD OF HEALTH

		Perfect Score	My Score
EQUIPMENT AND PERSONNEL	Board of Health active and free from politics (5) Equipment good (5), fair (3), poor (1) Physicians employed give entire time to work (5), part time (1)	15	
QUARANTINE AND SERUMS	Quarantine laws strictly enforced (5), partly (2) Contagious diseases reported by school physicians (5), not reported (0) Disinfection required by law and law always enforced (5), sometimes (1) Free antitoxins and vaccines (5), not free but obtainable at all times (4)	20	
HOSPITALS AND RESEARCH	Hospitals ample for community needs (5) It has various types of hospitals or special departments General (4) Eye, ear, nose, throat (4) Surgical cases (2) Maternity (2) Contagious diseases (2) Tuberculosis hospital or sanatoria (4) Division of research formed (1) Bureau of vital statistics (1)	25	
COÖPERATION AND LAW ENFORCEMENT	Private institutions coöperate with board of health. Coöperation with board of health on part of school children (5), parents (5) Law enforcement on spitting (5) Laws other than Interstate Commerce Act on killing and sale of meats, with enforcement of such laws (5) Supervision of food supplies (5) Law enforcement on manure heaps and outdoor privies. Campaigns of health education started (3) Coöperation with state and public health service (2) Coöperation with civic associations in health or clean-up campaign (10)	40	
	TOTAL	100	

CHAPTER XIV

THE RELATION OF INSECTS TO DISEASE

Problems. — 1. *To understand the menace of the fly to a community.*

2. *To learn some methods by which a community may exterminate flies.*

3. *To understand the menace of the mosquito to a community.*

4. *To learn how malaria is caused, carried, and cured.*

5. *To learn the relation of yellow fever to mosquitoes.*

6. *To learn how to fight the mosquito.*

7. *To understand how fleas, bedbugs, and some other insects may carry disease.*

Experiments. — 1. To discover what food materials are most attractive to flies.

2. To try the effect of borax or kerosene when used in the breeding places of flies.

3. To see if oil will prevent development of mosquitoes in water.

Project I. — TO LOCATE THE "FLY NUISANCE" CENTERS IN MY COMMUNITY AND TO ASSIST IN THEIR REMOVAL.

1. Observe stores, dumps, homes, street dirt, barns, stables, or other outhouses for prevalence of flies.

2. Consider methods of combating the nuisance in each case where conditions show a serious menace to the community.

3. Devise means of helping destroy the community fly menace by using chemicals, cleaning up, and by making and using fly traps.

4. Work out in the laboratory the complete life history of the fly and report on the results to the class.

Project II. — To make a survey of the community mosquito problem.

1. Locate possible breeding places.

2. Consider methods of removing favorable breeding places as drainage, use of oil, and "cleaning up."

3. Try to start a general community campaign to war on the mosquito.

4. Work out the life history of mosquitoes breeding near home and demonstrate before the class.

When you visit a town or a city for the first time and see all the porches screened in, you say, "They have mosquitoes here. I wouldn't want to live in this place." Or, if in the summer time we notice great swarms of flies about stores and in the kitchens of the houses we are apt to think: "This isn't a very pleasant place to live in." Indeed, such a town would be neither a pleasant nor a safe place in which to live. But why unsafe, you ask. Why should flies or mosquitoes make me or any one else sick? A moment's thought on your part, together with the additional knowledge that this chapter will give you, ought to make it very evident that mosquitoes and flies are not good neighbors.

Flies and foods. — You have probably noticed in summer that a butcher shop or a bakery often contains many flies, and possibly you have wondered why more flies are there than in a drug store, or a grocery store, or a florist's establishment. The following experiment will give us a reason why more flies are found in certain places than in others.

Experiment. — To discover what food materials are most attractive to flies.

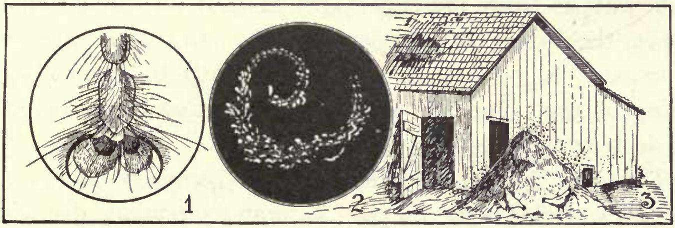
Materials: Six small butter dishes. The following food materials: fish skin, stale meat, bread, milk, fresh slice of apple, slice of decaying banana.

Method: Place a small piece of each food material on a butter dish. Place these about 1 foot apart where flies have ready access to them and withdraw to a distance from which you can watch results. Count the number of flies on each material at the end of 2, 4, 6, 8, and 10 minutes.

Results and Conclusion: Tabulate the results and draw conclusions.

Application: What suggestion does this give to help you explain the reason for the number of flies found in a store, in a shop, or in your back yard?

The reasons why flies are attracted to foods. — It is very evident from this experiment that certain foods are much more attractive than other foods to flies. It is also evident that flies have a sense of smell, or at least that they can distinguish different kinds of food in some way. Unfortunately, flies are attracted to many decaying substances. We find them, therefore, swarming in garbage pails, in manure heaps, and even in privy vaults and open toilets. Flies are not at all particular where they wipe their feet. A

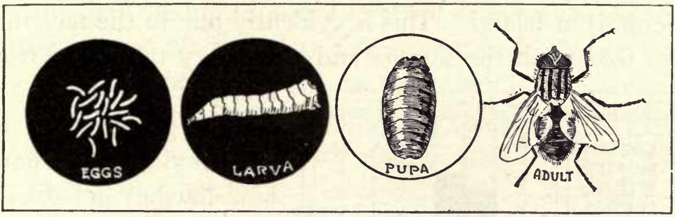


1. Foot of fly. 2. Growth of bacteria in agar along path of fly, which walked on it. 3. The manure pile is the favorite breeding place of flies.

study of the accompanying illustration will show you what happens when a fly walks on sterile agar in a culture dish. Millions of germs may be thus carried on the feet of a single fly. The little pads on the foot of a fly are quite sticky and as the fly walks over a surface, germs may easily be picked up and stick to the pads and to the hairs which cover the leg and foot. In a recent experiment made at the Connecticut Agricultural Station, it was found that a single fly might carry on its feet from 500 to 6,600,000 bacteria.

Why flies may carry disease. — But, you might say, a fly could light in a garbage pail or on decayed food and yet might not carry disease to me or anybody else. True, a fly *might not* carry disease germs from a garbage pail or from decaying matters. But it would be likely to carry such germs if it had lighted in a spittoon or if it had been attracted to some toilet or privy. It is not very pleasant to think of flies carrying germs from such places to one's food, but it is quite easy in the summer time for such a thing to be done. Baby's milk, if exposed to the crawling fly, makes an excellent place for spreading the germs of typhoid or diarrhea, which multiply rapidly in milk. Flies also may carry germs which cause tuberculosis from the expectorations left on the sidewalks or in the street by careless people. Certainly flies are a menace to health, and it is our duty to know something of their life history so that we may properly plan to destroy them whenever possible.

The life habits of flies. — The common house fly seems to prefer horse manure, human excrement, decaying kitchen refuse or other fermenting material in which to lay its eggs. Stables where manure is not removed regularly make an excellent place for the breeding of flies. The female fly lays from one to two hundred eggs, and in warm weather these eggs hatch in from eight to twelve hours. They develop into little "maggots" or *larvae* which feed actively for six to ten days, depending upon the temperature. They then burrow into the ground under manure heaps and are transformed into brown *pupae*. After about three days in this stage they emerge as adult flies. It is



The four stages in the life history of the fly.

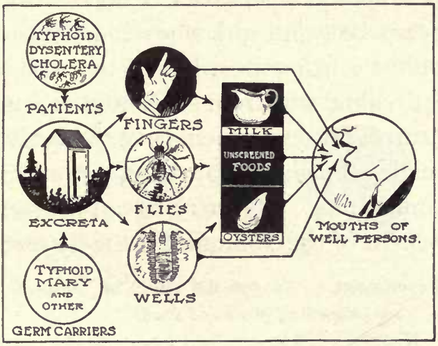
evident, therefore, that any manure which is left for from a week to ten days without turning, or without being carried from the stables, becomes a menace to health. We should do all in our power to persuade people who have stables to clean them out carefully every day, and not to leave any moist manure where it will remain for over two weeks untouched, to put in oncrete floors under the manure heaps, or to have the manure treated with chemicals to kill the fly larvae.

Flies and typhoid fever. — Typhoid germs are found in the urine or excrement of persons having the disease. Many people become "carriers" of typhoid, and carry the germs in their bodies for months or even years after they have had typhoid or even without ever being ill with the disease. Such people are a very serious problem to the health officials. They also become a source of danger because flies may visit privy vaults and carry germs from these people to foods, especially to milk, where the typhoid germs multiply very rapidly. In New York it has been shown that typhoid and other diseases of the digestive tract are more prevalent during the season when flies are abundant than at any other time. It has also been shown that there are more cases in New York close to the mouths of sewers which empty into the rivers surrounding Manhattan Island. This is evidently due to the fact that flies feed upon the sewage and then carry the germs from this polluted sewage to food. A glance at the accompanying chart shows how diarrhea in babies is much more serious in summer time when flies are most abundant.

Flies are a serious menace to children's lives.

Flies and disease. — Flies undoubtedly carry tuberculosis germs also. They are known to feed upon the sputum or "spit" of consumptives and they are often seen walking about on the edges of cuspidors or other receptacles of this sort. Flies which feed upon tuberculosis germs may keep those germs alive in their bodies for fifteen days. This shows the danger of fly specks, or the excreta of flies. Flies carry cholera, leaving the germs in milk in the same way as they do in the case of typhoid. Bubonic plague, which is known to be carried by rats, is also believed to be carried by flies. Experiments show that flies may carry these germs in their bodies for several days, and may even die of this disease. Many people believe that anthrax, smallpox, and other diseases are also carried by flies.

How to fight the fly. — From what we have just read it is evident that the proper way to get rid of flies is to destroy their breeding places. Any one may "swat the fly" all day long in September and make very little impression upon the myriads of flies which have come into existence since early May. A few flies remain alive over the winter, hiding in cracks or crannies in our houses, and early in the spring they come out and lay their first batch of eggs. It is evident that if all material containing the eggs of flies breeding at this time could be removed, the first generation of flies would not come into existence; but if this is not done, as soon as the flies begin to breed they multiply with tremendous rapidity.



What is the story told by this diagram?

It has been estimated by Professor Hodge that in three months, from May 1 to August 1, a pair of flies might produce 5,746,670,500 flies. This would be enough to fill over 143,000 bushel baskets. By the end of September he estimates that 1,096,181,249,310,720,000,000,000,000 flies might be produced. Fly traps and poisons used in May and June in our homes will prevent many flies from ever getting an opportunity to start this chain of descendants.

Why not start early in *your* home? In order to protect ourselves from disease we should screen all out-of-door privies, keep the garbage cans covered, and scald them at least twice a week during the hot weather. Rubbish heaps should not be tolerated.

How a community fights flies. — After all, the fly nuisance is largely in the hands of the community. If people wish a town to be free from flies, they can have it so, and if they wish to have flies as a nuisance, all they have to do is to let the flies breed freely. It ought to be the work of every boy and girl who reads these paragraphs to arouse public sentiment in his, or her, community; so that every individual who from selfishness or ignorance allows a manure heap to become a menace to the health of the community will realize that he is not doing a fair thing to the rest of the community. By carrying out the sanitary laws made for the benefit of the community, the fly menace can be prevented.

Experiment. — To see the effect of borax or kerosene when used in the breeding places of flies.

Materials: Borax. Kerosene. Table waste or stale meat. Empty tin cans.

Method: Make three portions of table waste (garbage), or stale meat may be used instead if preferred. Put one portion into a tin can, filling it half full. Mix a second portion with a tablespoonful of borax. Put this into a second can. Put the third portion, thoroughly mixed with one or two tablespoonfuls of kerosene, into a third can. Place these three cans where flies may readily reach them. Examine them at 3-day periods for several weeks, to see if maggots and flies develop.

Results and Conclusions: Tabulate the results and draw conclusions.

Some communities, as Washington, D. C., have made laws which cause manure to be placed in receptacles which must be emptied twice a week in hot weather. The city of New York requires that all stables shall be screened and the manure removed at frequent intervals. All places should have some efficient laws which will prevent the flies from maturing in stables. Manure heaps may be treated with borax at least once a week, one pound per horse. Iron sulphate and lime may also be used. This prevents flies from breeding in the manure heaps, but unless care is taken in cleaning the stables, flies will breed in small heaps of manure that have been overlooked in cleaning.

Fly traps and their use. — Professor Hodge of the University of Florida has invented a trap which deserves a wider use than it now has. This trap is placed over a hole in the cover of the garbage pail. If the cover is tilted a little, flies go into the garbage pail, but in trying to escape through the hole they go into the trap. In this way many thousands of flies may be trapped. One of the best ways to help keep down the fly is to have fly traps placed in the stable. In the house, while fly traps and fly paper may be used, the best method is the simpler one of poisoning flies by adding a one to two per cent formaldehyde solution to milk sweetened with a little sugar. If all other liquids are covered up, flies will go to the poison in great numbers. Where flies are found all food which attracts them at home and in stores should be screened.

One of the best ways to trap flies.

How to start an anti-fly campaign. — One of the best ways for boys and girls to interest themselves in civic betterment is to start an anti-fly campaign. For this purpose your school class in general science or biology can be used. Advertising material can be secured; the newspapers will help you; even the churches will probably be willing to aid in such a good work. The American Civic Association, with offices in Washington, D. C., will assist you in starting the campaign. If public sentiment can be aroused by means of meetings, your city will wake up, make effective laws, and see that they are enforced.

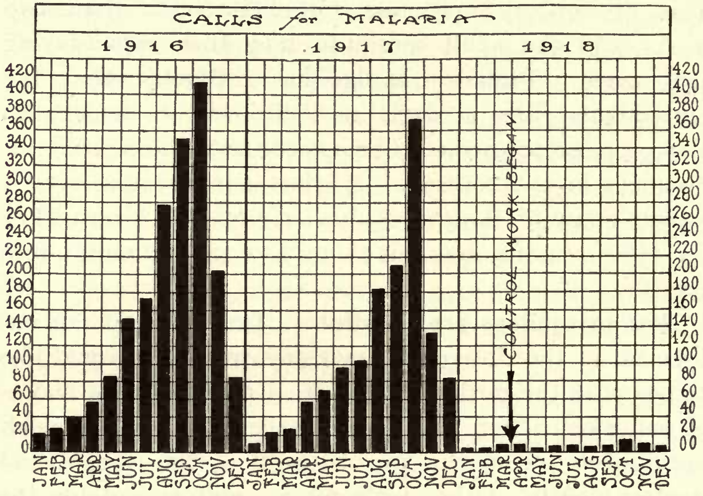
The life history of mosquitoes. — We all know that mosquitoes are found in some localities and not in others. The mosquito nuisance is very largely related to the presence of water, and we know that wherever marshes are found there we find mosquitoes in abundance. If we examine them carefully, we are able to distinguish several kinds. As a matter of fact, there are over 340 different species of mosquitoes. Of those, the ones that we are most likely to meet are the *culex*, and the *anopheles*.

So far as we know, mosquitoes all lay their eggs in quiet water, stagnant pools, slow-running brooks, rain barrels and cisterns, stopped-up gutters, even tin cans or broken crockery found in rubbish heaps. These places may breed enough mosquitoes to make life miserable for people in the immediate neighborhood. The common culex lays from one to two hundred eggs in small rafts. The anopheles or malarial mosquito lays its eggs in scattered groups. The eggs of both mosquitoes usually hatch in from 36 to 48 hours, forming little segmented or jointed larvae, which we call "wigglers." They propel themselves through the water with a curious, jerky motion, coming to the surface to breathe. They take in air through a tube located near the hind end of the body.

After a week or ten days the front end of the body becomes larger and they are called pupae. They now breathe through two tubes near the back of the very much enlarged head. During this stage they are much quieter and do not eat. After a week or more the pupa's skin splits down the back and the adult mosquito emerges. This life history may take but little more than two weeks, and the adult mosquito may then begin laying eggs again. Professor Hodge has estimated that the descendants from a single mosquito might amount to 2,000,000,000,000,000,000,000,000,000,000,000,000,000 individuals in the course of a short summer season. Of course, many of these mosquitoes die from lack of food or for other reasons, but this shows how rapidly mosquitoes breed.

How mosquitoes are harmful. — They prevent our enjoyment at the close of summer days when we would like to be out in the garden. They are a pest along the shores of our lakes, rivers, and ocean beaches. The salt-marsh mosquito is one of the greatest pests of the eastern and western coasts. Other kinds of mosquitoes, notably the *anopheles*, which carries malaria, and *stegomyia*, which carries yellow fever, are very harmful. In our Civic Science in the Home, we read how the experiments of Dr. Ross of the English Army, based upon his belief in the theory of Sir Patrick Manson, resulted in the discovery of the malarial parasite in the body of the anopheles mosquito. We also read how Dr. Warren and Dr. Manson, son of Sir Patrick Manson, verified Ross's discovery by proving that mosquitoes which had bitten malarial people could carry malaria to others. We shall now learn a little more about the disease.

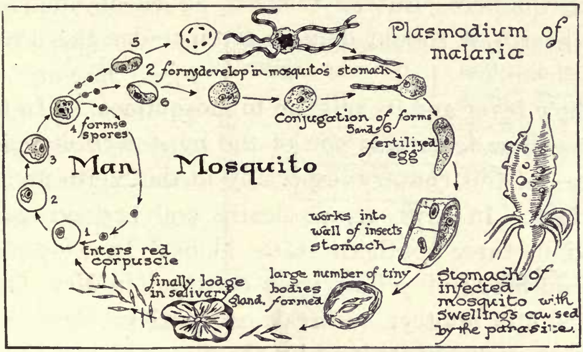
Malaria. — For a good many centuries the development of certain areas in the world had been retarded by malaria. Italy suffered greatly, until she discovered that the extermination of mosquitoes meant the elimination of malaria. Many tropical countries are backward in their growth and in their production simply because laborers are not able to



Notice how malaria decreased in a town in Arkansas after mosquito control work such as draining swamps and screening houses was begun.

work on account of malarial fever. In some parts of the South there are regions where malaria is so prevalent that from twenty to thirty per cent of the people living there have the disease. Although the death rate from malaria in this country is low (only 3 per 100,000), yet the number of persons who are kept from doing a full week's work is very great. It is estimated that the cost in dollars to the people of this country is $100,000,000 a year from malaria. It is time, then, that we took every means to stamp out this disease.

What causes malaria? — The malarial mosquito, anopheles, does not cause malaria. It transfers the disease. The cause is a tiny one-celled animal parasite. In order to live, this little animal (*plasmodium malariae*) must pass part of its life in the body of the mosquito and part in the blood of a human being. When the anopheles mosquito sucks the blood from a person having malaria, the parasite passes with the blood into the stomach of the mosquito.



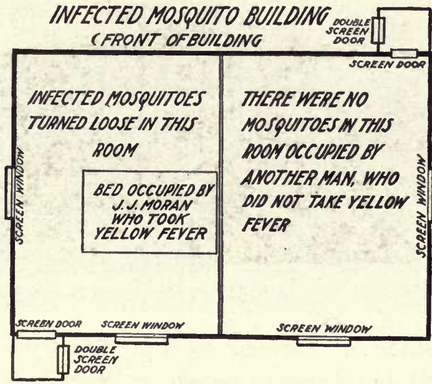
Life history of the malarial parasite.

It passes part of its life in the walls of the mosquito's stomach. It multiplies very rapidly and gets into the body fluids of the mosquito and from there into its salivary glands. The mosquito's mouth waters when it starts to suck the blood from a person, and some of these little parasites are transferred into the blood. Here they enter the red corpuscles, and multiply rapidly. Eventually they fill the corpuscles full of little spores which break the corpuscle down, get into the blood, and then each spore enters another corpuscle. Thus are formed millions upon millions of these little parasites, each in a different corpuscle. When the corpuscle is broken down, a small amount of *toxin* or poison is released into the blood. The chill and fever of malaria is due to the breaking down of these blood corpuscles and the subsequent release of the poison.

How malaria is cured. — Of course, any one having malaria may move away from the place where it was received, but since the spores remain in the blood, attacks of malaria may recur from time to time. The only known cure is quinine. But as this has an effect upon a person's health, it should only be given under the advice of a physician.

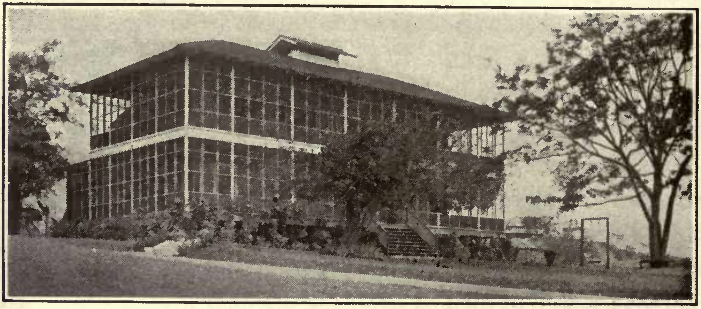
Yellow fever and its relation to mosquitoes. — In former times yellow fever was one of the most terrible epidemic diseases of this country, especially in the South and along the coast. In 1878, 12,000 deaths and 125,000 cases occurred in three southern states alone. In 1897 another great outbreak of yellow fever occurred in New Orleans. In 1906 still another outbreak occurred in New Orleans, but it was quickly stopped by the discoveries of the army commission headed by Dr. Walter Reed. These discoveries make one of the most thrilling stories of heroism connected with our army. For a great many years Havana, Cuba, had been a hotbed of yellow fever. In the summer of 1900 a commission of four United States army surgeons worked there. Up to this time there had been two theories as to the transference of yellow fever. The prevailing one was that it was given by contact with matter given off from the patient. The other theory was that it was transferred by mosquitoes. Dr. Carroll, one of this group, was the first man to allow himself to be bitten by a mosquito carrying the yellow fever germ. Dr. Carroll had a severe attack but recovered, while Dr.

Jesse Lezear, who also allowed himself to be bitten by an infected mosquito, gave up his life as a result to prove the theory. A little later another experimental laboratory was established, and two young soldiers, John R. Kissinger and John J. Moran, volunteered their services in the cause of humanity. These men lived for twenty days and nights in a small, poorly ventilated room with a temperature over ninety degrees, in close contact with articles of clothing and other materials taken directly from persons who had died of yellow fever. The soldiers were, however, all of this time screened so that no mosquitoes could come near them. At the end of twenty days they were perfectly well. Moran then allowed himself to be bitten by a *stegomyia* mosquito which was known to have bitten a yellow fever patient. He came down with the disease, but fortunately recovered. These results showed undoubtedly that yellow fever is carried by the stegomyia mosquito.



Camp Lezear, where first experiments to determine if the mosquito carried yellow fever were performed.

This discovery made possible our work on the Panama Canal. It is reported that when the French government was working on the canal, eighteen young French engineers came over in one vessel and within a month all but one died of yellow fever, while of thirty-six nurses brought over, twenty-four died of the fever in a short time. As soon as the United States Government applied the knowledge gained in Havana, the Canal Zone rapidly became safe to live in. The last case of yellow fever occurred in this district in May, 1906. This is a



A building in the Canal Zone protected by screens.

splendid tribute to the effective work of the United States army surgeons.

Experiment. — To see if oil will prevent development of mosquitoes in water.

Materials: Two pails or large tin cans. Kerosene.

Method: Fill two pails with water. Place these out of doors close to bushes or shrubs where mosquitoes are found. Pour a tablespoonful of kerosene upon the water in one pail. Let them remain for several weeks, examining every 3 days for the presence of wigglers.

Results and Conclusion: What are the results? What is the value of the oil in helping to reduce the mosquito evil?

How to exterminate mosquitoes. — From what we have already learned about mosquitoes it is evident that in order to destroy them we must first destroy their breeding places. Swamps and pools, slow-running streams, ditches, cesspools, rain barrels and catch basins, even hollow trees or broken receptacles may be breeding places. Mosquitoes are likely to breed in any place that will hold water for two weeks in warm weather. Our first effort should be, therefore, to clean up all dumps where broken cans or crockery exist, screen all rain barrels, cisterns, and privy vaults, ditch swamps, and where the latter is not possible, place crude oil upon them. It can easily be proved that the

A health officer inspecting swamp water for mosquito larvae.

A member of sanitary squad applying crude oil to swamp.

larvae and pupae of mosquitoes are quickly killed if a film of oil is placed over the surface of the water where they breed. Such a film not only prevents the female from laying her eggs in the water, but clogs up the breathing holes of the larvae and pupae in the water and kills them.

Small fish may be introduced into the ponds and streams. The best fish for the purpose of ridding a pond of mosquitoes are top minnows, goldfish, sticklebacks, and killifish. Night-flying birds, especially night hawks and swallows, feed on mosquitoes. Toads, frogs, bats, and dragon flies also are active enemies, and should be protected wherever mosquitoes abound.

Protection in the home against mosquitoes. — The most effective protection, of course, is to have no breeding places near one's home, for most mosquitoes fly only a short distance from where they breed. Screens on all windows become a necessity if we are to sleep in peace. In the tropics a bed net is used, which effectively keeps out mosquitoes that get into the rooms. The use of pyrethrum powder or sulphur for fumigation is also helpful. Pyrethrum powder burned in the room usually stupefies the mosquitoes so that they can be killed. Those of us who go fishing in mosquito season know that the most effective "dope" is made of oil of citronella. A very useful preparation is composed of 1 ounce oil citronella, 1 ounce spirits of camphor, and ½ ounce oil of cedar mixed with 4 ounces of vaseline.

How the community may fight the mosquito nuisance. — The strongest factor in fighting mosquitoes or flies in a community is public opinion. Since educated people make public opinion, and since children of school age are being educated along these lines, it goes without saying that they can do much towards improving conditions. The school children of San Antonio, Texas, took up the task of exterminating the breeding places of mosquitoes and eliminated malaria within two years after they started to work. This is only one example of what has been done in many other places throughout the United States. The best way to start work is for the general science class or the biology class to make a survey of the community and find out where the breeding places are, then go to the board of health or the school board and get its assistance. Oil all the places that cannot be taken care of otherwise, have the children clean up yards or vacant lots where breeding places exist, and then show the public, by means of articles in the newspapers, and, if possible, through public meetings, what other work there is to be done. Report the facts of your survey to the county and state health offices. See what they will do to help. By means of such work the mosquito menace can be reduced if not eliminated.

The relation of fleas to the bubonic plague. — Plague, the Black Death of the ancients, was estimated in the fourteenth century to have killed 25,000,000 persons in Europe alone. It is now prevalent in Asia, and, as we know from the recent experience of San Francisco, its introduction

Do rats find anything to attract them to your back yard?

into this country is always possible. Rats and ground squirrels become infected with the disease, and thus fleas, which live upon them. When a rat dies of plague, fleas leave this rat and go to another, or, possibly, to a human being; then if they bite a human being he would be inoculated with the plague. In San Francisco fully 1,000,000 rats were killed, thus partially removing one means of infection. To exterminate rats completely is almost impossible. General clean-up measures are necessary, and by the use of pyrethrum powder, benzine, or naphthalene flakes one may rid a house of fleas.

The relation of lice to trench fever. — During the World War many problems of disease transmission were solved and conquered, thanks to the splendid work of the sanitary and medical officers of the allied armies. One serious menace to the soldiers was trench fever. This fever was

A clean-up campaign will do much to rid a city of rats, mice, and fleas.

proven, by experiments performed on 66 volunteers from various units in the ambulance and hospital service, to be transferred by the body louse or "cootie" as the soldiers called it. Germs which caused the disease were present in the blood and were transferred by the mouth parts of the "cootie." After this discovery, disinfecting plants were established for men coming in from the trenches, their clothes were carefully disinfected as well, and the danger was greatly reduced.

Other diseases carried by insects. — Many tropical diseases are known to be carried by insects. The most dreaded of these is "sleeping sickness." This is caused by a tiny one-cell animal called a *trypanosome* which is carried by the *tsetse fly*. This fly we find not more than 150 feet from the banks of streams or lakes, so that it is quite possible that the disease may be successfully fought by keeping away from bodies of water where these flies live. Elephantiasis is caused by a wormlike parasite called *filiara* and is carried by mosquitoes and insects. Dengue or "break-bone fever," as it is called, is a rare but an intensely painful disease caused by a one-celled animal, and carried by the *culex* mosquito. Other diseases carried by insects are "malta fever," "kala-azar" and probably leprosy.

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CHAPTER XV

DISPOSAL OF WASTES

Problems. — 1. *To learn about different methods of sewage disposal in a community.*

2. *To understand the construction and operation of a septic tank.*

3. *To see how streets are cleaned and how to help keep them clean.*

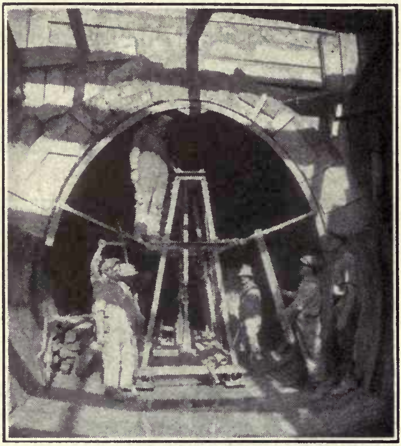
4. *To know how other wastes are best disposed of.*

Experiment. — 1. To compare the wet and the dry methods of street cleaning.

Project I. — To MAKE A STUDY OF THE DISPOSAL OF WASTE IN MY OWN COMMUNITY.

1. What regulations apply to the disposal of waste?
2. To what extent are the regulations observed?
3. Is the system effective? Does it pay for itself?
4. Is any part of the system self-supporting?
5. How are the streets cleaned? How often?
6. Are there better methods in use in any communities that you know of or have read of?

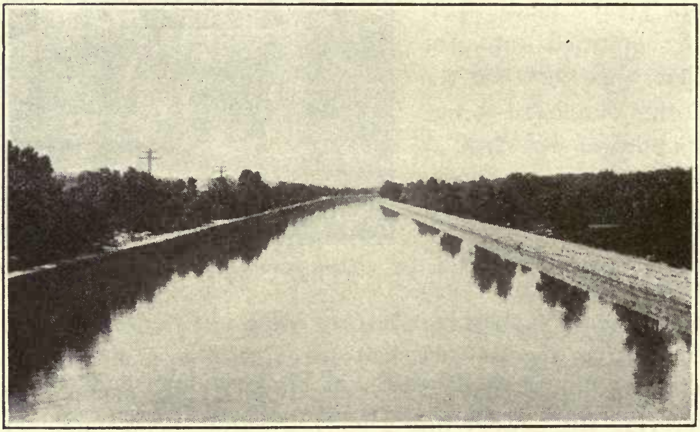
Most boys and girls who read this paragraph have seen men at work digging a sewer. You have noticed how the long, deep excavation is always graded so that as the big pipe is constructed at the bottom it always has a gentle grade toward the outlet in some distant part of the town. Perhaps if you followed it to its end you would find that it emptied into a river or some large body of water. In such a sewer you may find openings from the street into which the rainfall may pass, with large catch-basins to hold the solid matter. You may also notice that each house along the line of this sewer is connected with it by a smaller pipe.



Men at work building a large sewer.

Purpose of sewer system. — Sewers date back to Roman times. The great Cloaca Maxima emptied into the Tiber just beyond the Forum of ancient Rome. Its purpose was then, as is the purpose now of certain sewers, to carry off the overflow or rainfall and street wastes. Since some of these wastes are solid, the sewer system must have a grade sufficient to carry along solid matter with the liquid that passes off. If a city has a means of carrying this sewage into a body of water, then a single set of pipes having connections with houses and with the street pipes by means of catch basins is sufficient. Thus a sewer serves to carry off rainfall as well as to dispose of its household waste. But if a community has to dispose of its sewage in some other way, then a separate system of pipes is usually laid for household waste so that the sewage will not be too dilute when it is treated at the disposal plant.

Sewage disposal into rivers. — Sewage consists of about one part of organic matter to one thousand parts of water. In rapidly flowing rivers a small amount of sewage may be carried off without harm, since the bacteria of decay adhering to the stones in the rivers act on the solid wastes and soon break them down into harmless liquid substances. But in a large city, sewage disposal is a big problem, both because of the volume of sewage, its odor, and the possibility of the spread of disease from it. The city of New York empties daily 450,000,000 gallons of sewage into the rivers surrounding it; thus Manhattan Island is bathed in dilute

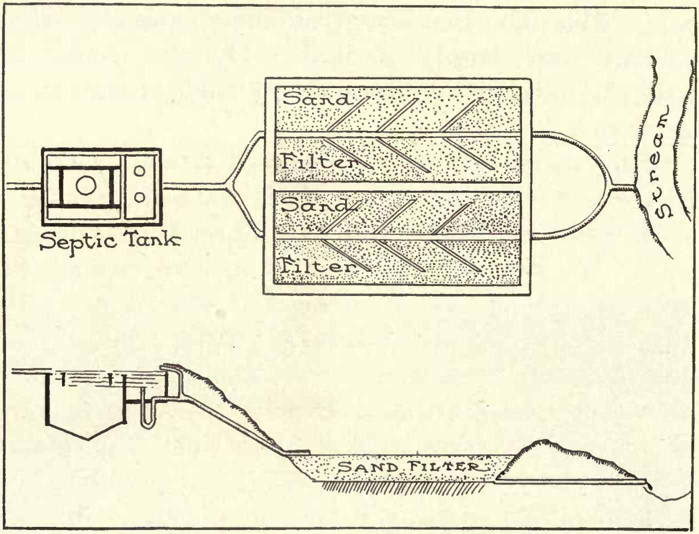


Chicago drainage canal.

sewage. Chicago, a few years ago, discharged its sewage into Lake Michigan. At that time a large number of typhoid cases existed in the city, and it was discovered that some of the sewage found its way to the intake of the city water supply in the lake about two miles from the shore. Chicago then spent $40,000,000 to build a drainage canal which connected the Chicago River with the Des Plaines River. Through this canal the water of Lake Michigan flowed into the Mississippi, carrying the sewage of Chicago with it. The city of St. Louis brought suit against the city of Chicago, attempting to prevent the use of this drainage canal, but the verdict given was "no cause for action" because it was found that Mississippi water about St. Louis contained no more germs than it did before the canal was built. This shows that sewage, after flowing long distances, becomes very largely purified. Harmful germs are gradually killed off by the action of sunlight and oxygen and from lack of food.

Septic tanks as factors in sewage disposal. — Where sewage cannot be run into a body of water the problem is not so easy. One method is to pass the sewage to a disposal plant. We have already seen that in rural communities where no sewage system exists, the septic tank is the best method for proper sewage disposal. In this tank the solid wastes are acted upon by certain bacteria which thrive without air (the *anaërobic bacteria*). These cause the complex waste substances to break down into simpler ones. Since a septic tank soon becomes coated with grease from the household waste, it becomes practically air tight and then forms an excellent place for these bacteria to work.

In somewhat the same way septic tanks on a larger scale are used in the city disposal plants. These plants are used to decompose the sewage. Then the sewage is passed through screens to remove solid matter and the clean sewage is passed on to contact filter beds of broken stone, where certain other kinds of bacteria which live in the air complete the process of breaking down or oxidizing the organic matter which was begun in the septic tank. The fluid which is drawn off is absolutely harmless and nearly odorless. Such filter beds, however, can only be used a part of each day, so that a large city requires a considerable amount of space devoted to this purpose. Some small communities use sand filter beds for the disposal of sewage as it passes through the septic tanks. The sand filter is



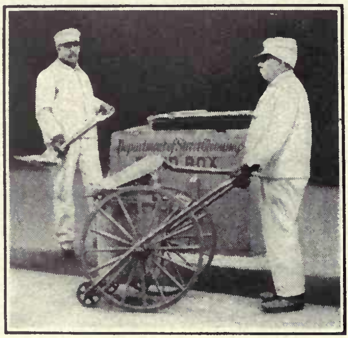
Septic tank and sand filters used to purify sewage.

much more efficient than the contact bed, although it filters much less sewage in the same time.

Sewage farms. — In some small cities in this country, and in larger ones in Europe, sewage is taken without treatment and allowed to pass by a system of irrigation ditches into areas of sandy soil. The soil thus fertilized is made use of for farm purposes by the city. While this method is useful for a time, it does not seem practical for long periods of time, as the land becomes water soaked and unfit for cultivation.

The city care of sewage. — In most large communities we have a department of sewers. The cost of the sewers and their maintenance is put in as part of the city budget Property owners usually pay directly for sewers which pass by their land and which they use. The cost of the larger trunk sewers and the sewage disposal plants is assessed upon the city as a whole, since the entire city gets the benefit.

How the streets are kept clean. — Most of us are familiar with the "White Wings" seen in many of our city streets. These street cleaners, especially in large cities, like New York and Chicago, form quite an army, over three thousand men being employed by the city of New York for the work. Their work is to clean the streets with hand brooms, brushes and machines; to flood the streets, usually at night, and to assist in the collection of the sweepings from the streets. Most large communities own street-sweeping machines which are far more efficient and do more work than a number of men. The sweepings are collected in carts and then disposed of. It has been found that very many street cleaners are subject to tuberculosis. This indicates the need of the enforcement of a law against spitting in the streets. We know that such laws when made are rarely observed.

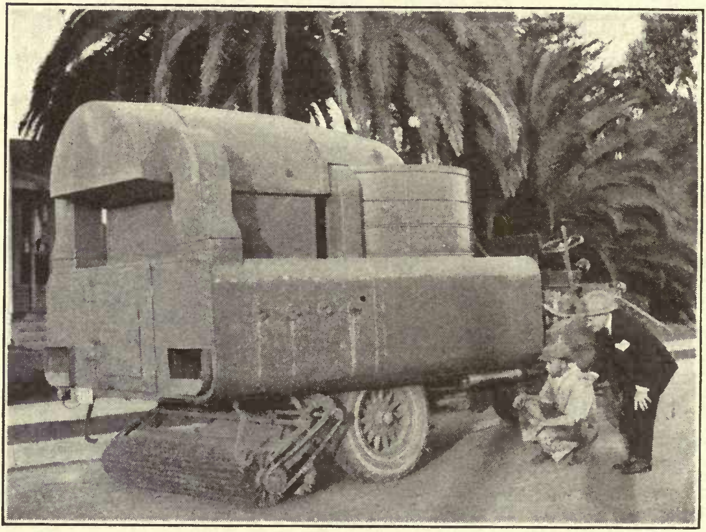


"White wings."

Experiment. — To compare the wet and the dry methods of street-cleaning.

Materials: Petri dishes. Sterile agar.

Method: If possible, select two localities where streets are cleaned differently: one by dry sweeping and the other by wet cleaning. Expose a petri dish to the air in each locality for five minutes. Put the dishes away in a dark warm place for three or four days. Instead of the two places cleaned as above, the experiment may be carried out by



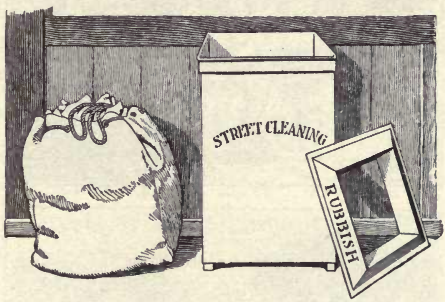
Vacuum cleaning in the street.

exposing one dish in the street after a rain and the other dish in dry weather while the street is being swept.

Result and Conclusion: Compare the number of bacteria colonies which develop in the two dishes. Explain.

Application: Which method of street cleaning would you advise for your neighborhood?

Disposal of ashes and garbage. — The garbage may be defined as scraps from the kitchen, waste animal matter, or vegetables unfit for use. Rubbish includes tin cans, broken glass and crockery, waste paper and rags, while ashes are the remains from fuel. Since these substances are so different, most communities require that they shall be put out and collected separately. Ashes should be kept covered, so that our streets may not be filled with dirt during a high wind. Papers and tin cans should be placed in separate receptacles. Dr. Rosenau of Harvard has estimated that the waste in New York amounts to one ton a person a year. This means over five million tons of waste has been collected annually in this city alone. The ashes may be used in filling in marshes or tidal flats, and much valuable land is thus formed. A large part of Boston lies on land thus reclaimed, while the park along the lake front of Chicago is largely built on city ashes.

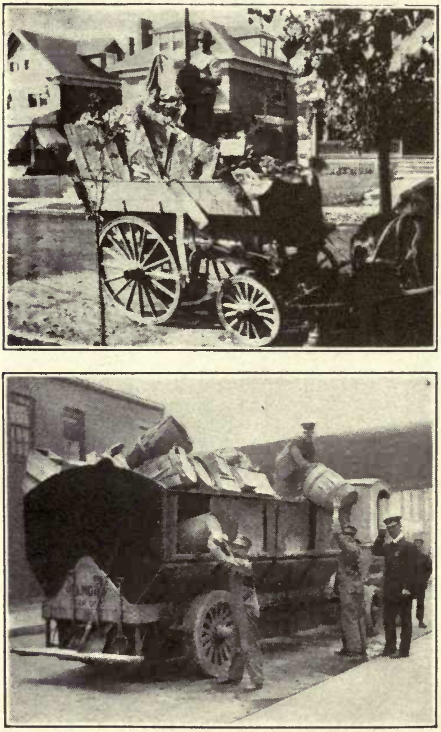


The use of a bag inside the rubbish can facilitates the removal of waste.

Collection of rubbish. — In many communities a good price is paid for the privilege of collecting rubbish. Papers and rags are used for papermaking; the iron, tin, and solder from old cans may be used over again, and organic matter can be used for fertilizers. In some small towns certain men are licensed to collect garbage, rubbish, and ashes, but an up-to-date community does all of these things itself, thus making a handsome profit on the business.

Garbage removal. — In small communities garbage may be burned, buried, or, better yet, fed to the pigs; but in larger communities where pigs cannot be kept, the garbage must be carefully placed in covered pails and put out for collection. It should be taken up once a day in hot weather.

Most large communities see that this is done. The garbage is usually collected in metal carts and disposed of in several ways. One of the best methods is that of burning. Many cities now own their own incinerating plants. The city of Minneapolis requires that each day's garbage be wrapped in newspaper so that it can be burned more readily. Such a garbage disposal plant usually pays for itself in the steam power or electricity generated. Some cities dump their garbage and then bury it, but this method is costly and wasteful.



The old and the new cart for collecting garbage.

Reduction of garbage. — Another method used by New York and other cities is the reduction method. Garbage is taken by means of scows, or in wagons, to a reduction plant where bones and other dry waste are removed by means of machinery. The organic waste is then heated from eghit to ten hours under a high steam pressure, and treated with chemicals; the fats are extracted from it, and the solid matter remaining is pressed into flat cakes and sold for fertilizers. Fats taken from garbage by this process are used in soap and perfumery making, and all of the waste matter is put to some use again. The plants, although expensive ones, are now being made so efficient that they more than pay for themselves.

How we may help the community to keep the streets clean. — Already in a number of cities boys and girls have formed Sanitary Squads, Civic Leagues, or other organizations which have as their object the care of the city streets. The Juvenile Street Cleaning League of the city of New York has a membership of over 25,000, most of whom are boys and girls in the elementary schools. Work of this nature has been undertaken by a similar organization formed in one of the large city high schools. Every boy and girl should have the best interests of the community at heart. Let us keep garbage pails thoroughly clean, wash them well at least twice a week, and keep them covered, thus helping to keep down the fly nuisance. If we separate ashes, paper, and tin cans, and thus obey the city regulation, we make it just that much easier for the city to do its part in cleaning up. But most of all we need to remember that the streets and sidewalks are under *our* care. If we throw fruit peelings or scraps of paper into the streets, we are selfishly making some one else do our work. If we go on a picnic in one of the city parks, and leave the remains of our lunches with scraps of paper scattered about on the ground, we are doing an unfair and an uncivic thing. Remember every careless act makes work for some one. Refrain from spitting in the streets; it may mean death for some one. Have pride in your city and help make it the best place in your part of the country in which to live.

Scoring our community. — We have learned enough about flies and mosquitoes to know the harm that they are capable of doing. We can also see the relation between these pests and a clean community. Let us be rigid in making out this score. If it is low, then community sentiment ought to be aroused so as to make it better.

SCORE CARD. PUBLIC SANITATION

	Perfect Score	My Score
Mosquitoes and Flies If no mosquitoes (10); if culex only (5); anopheles present (0) If no flies in public places, in stores, on street, etc. (10); if few flies (5); if many (0) An effort is made by community to destroy mosquito breeding places (5) Public inspectors prevent fly breeding places, as accumulations of stable manure (5) Interest aroused in anti-fly campaigns or anti-mosquito campaigns (5)	35	
Removal of Waste Garbage removal daily in hot weather (5); twice weekly (3); weekly (0) Ashes and rubbish collected weekly (5) Public sewer or septic tanks used (5) Sale of refuse pays the city in part at least for its removal (5) Vacant lots and roadsides well kept; free from weeds and rubbish (5)	25	
Streets Manure and litter removed twice a week (5) Cleaned by wet process. Flushed or swept while wet (5) Dust kept down by frequent sprinkling or by oil (5)	15	
Food Restaurants clean and inviting; food appetizing (5) Have paper cups at soda fountains (5) Food usually eaten unwashed kept in stores where it cannot be handled (5) Food usually eaten unwashed kept in stores where customers will not cough or sneeze into it (5) Fruits and bakers' foods protected from dust and flies (5)	25	
TOTAL	100	

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CHAPTER XVI

STREET LIGHTING

Problems. — 1. *To learn how street lighting began.*

2. *To learn the source of various street illuminants.*

3. *To understand the processes of gas manufacture.*

4. *To understand how electricity is produced.*

5. *To see how street lighting fixtures may beautify rather than mar the city streets.*

Experiments. — 1. To examine some of the products resulting from the destructive distillation of soft coal.

2. To compare acetylene with city gas for illumination.

3. To see how an electric current is produced.

4. To demonstrate the use of a transformer.

Project I. — TO MAKE A SURVEY OF STREET LIGHTING IN A SECTION OF MY COMMUNITY.

1. Select a section that includes a portion of the business district and let this extend to the residential or remote part of the city or town, preferably to your own neighborhood.

2. Make a plan of this section approximately to scale.

3. Determine the kind of lights used in different parts of the section. Their relative strength. Distance apart and location. Show all this on the diagram.

4. Determine the source of the light — electric or gas, and make a special study and report on the electric or gas plant which supplies the street lights.

5. Compare different parts of this section in regard to intensity of illumination, even or irregular distribution of light, and judge whether or not there is adequate light for each street, considering its use.

6. Are there ugly electric light poles and wires in any streets? Where do you find ornamental lamps and absence of wires?

7. Prepare to report the results of your investigations to the class.

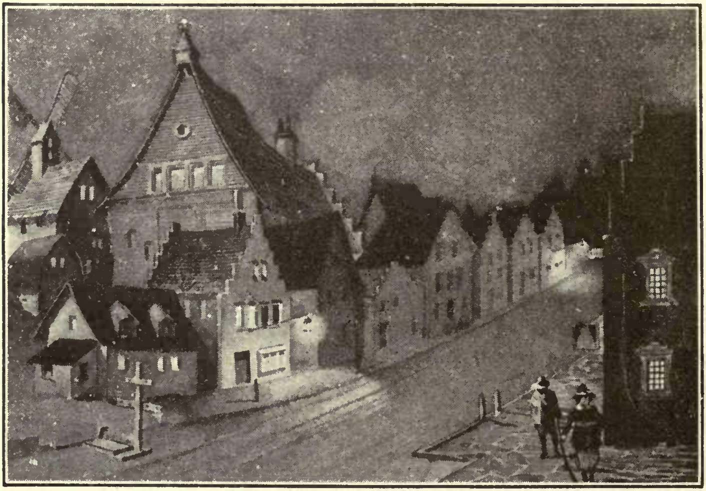
Project II. — MAKE A MODEL GAS PLANT FOR MANUFACTURING GAS FROM SOFT COAL. Demonstrate it to the class.

Project III. — MAKE AN ACETYLENE GENERATOR AND LAMP FOR HOME USE. Demonstrate before the class.

The history of street lighting. — Gas and electric lights are so common to most of us that it seems as if cities had always been lighted in this way, but it was not until 1415 that street lights were introduced into London. For three hundred years householders were obliged to hang lanterns in front of their houses during the winter evenings. Forgetful people were reminded by the passing watch with these words:

> Light here, maids, hang out your light,
> And see your horns be clear and bright,
> So that your candle clear may shine
> Continually from six to nine,
> That honest men may walk along,
> May see and pass safe without wrong.

Street lighting began in this country when New York passed a law in 1698 to the effect that every seventh house should hang out a light on the end of a pole. Previous to that time the only street lights were those that shone from the houses. Many small towns in Colonial times required citizens to keep a light in their front windows until certain hours each night. In the latter part of the eighteenth century London was well lighted with oil lamps having wicks and glass chimneys. These were cared for by the city. Street lighting by gas was introduced in England



A night scene in New York about 1698.

in 1807, and in this country in 1817, when Baltimore installed a gas plant for that purpose.

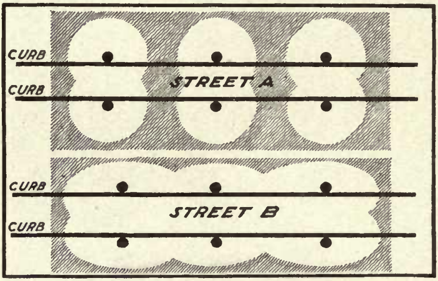
Chief sources of street lighting. — At present the two principal sources of artificial light for city streets are gas and electricity. In some rural sections we still find oil lamps, in others acetylene is used. Many sections of the country are favored by the presence of natural gas near enough to have the supply piped, but in most cities artificial gas is made from coal. Both natural and artificial gas were burned as bare flames until within recent times, when gas mantles were introduced. In sections where gas is used, a pilot flame is often left burning in each lamp during the day, and then turned on at night causing the entire mantle to light up. The competition between gas and electricity has been very keen. Both have been much improved of late in methods of control and service rendered. During this period of competition the price was constantly reduced until the greater cost of coal during the war caused an increase in the cost of lighting to the consumer.

The reasons for lighting streets. — To any one who has traveled through a well-lighted district and a poorly lighted one the reasons for street lighting are very apparent. Good lighting results in increased traffic, increased trade in the

A well-lighted street.

stores, increase in property value, decrease of crime, and decrease in accidents. Industrial accidents are shown to increase during the season of short daylight when more work is done under poorly lighted conditions. Street accidents increase for the same reason, more accidents occurring in poorly lighted streets. An up-to-date community demands better lighted streets; more light without objectionable glare, since in these days of strong auto headlights this removes the necessity of using such headlights in a city.

What constitutes good street lighting. — Good street lighting means soft and cheerful lighting with absence of glare. Lights must be placed close enough so that there are no dark recesses and no objectionable shadows. Reflectors which spread light in ovals instead of in circles along the street give greater efficiency and effectiveness in lighting. In the small community we frequently find lights not turned on while the moon is up, but all large cities now have an all-night system. This calls for about 4000 actual hours of lighting per year from each lamp.



Are there dark areas between the street lamps in your town? Compare streets A and B above.

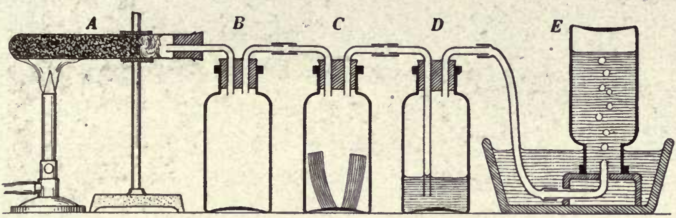
Lighting by natural gas. — Natural gas is obtained by drilling in much the same way as they drill for oil, and it is found closely associated with oil. Frequently in drilling for oil natural gas is found instead. West Virginia is the greatest natural-gas-producing state. Cities more than one hundred miles distant from the wells are supplied with gas for one-fourth as much as artificial gas costs. Natural gas can be used without any purifying, but since the high price of gasoline it is robbed of its gasoline contents before it is distributed through the gas mains.

Manufacturing artificial gas. — Gas for street lighting is usually manufactured by one of two methods: either by the process of destructive distillation of coal or by what is known as the water-gas method. Since the use of gas mantles for street lighting, both kinds of gas are frequently produced in the same plant, and are mixed in the mains for use with the mantle lamps.

Experiment. — To examine some of the products resulting from the destructive distillation of soft coal.

Materials: Soft coal, red litmus paper, filter paper, lead nitrate or lead acetate, limewater, hard glass test tube, and collecting bottles.

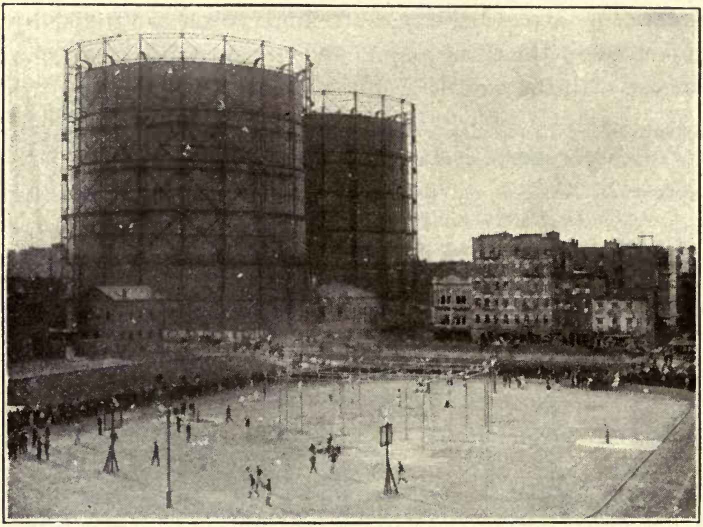
Method: Set up apparatus as in figure. *A* is a hard glass test tube containing coarsely ground soft coal $\frac{2}{3}$ full. *B* is an empty bottle. *C* is a



bottle holding (1) a piece of filter paper moistened with lead nitrate or acetate solution, and (2) a piece of moist red litmus paper. *D* contains limewater. *E* is a wide-mouth gas-collecting bottle. Place the litmus paper as near as possible to the mouth of the inlet tube in *C*. Heat the hard glass test tube gently at first, and when thoroughly warmed increase the heat, using two flames if possible. Look for any change in the litmus paper. This does not always occur even when the experiment is carefully performed, as the temperature condition for driving off a sufficient amount of ammonia is difficult to attain. An acid turns blue litmus red and an alkali turns red litmus blue. Hydrogen sulphide, an impurity in the gases from coal, turns lead nitrate or acetate black. Collect two bottles of gas after all the air has been driven out of the apparatus.

Results: Determine if the gas will burn. Describe and name the product in *A*. Note the properties of the matter in *B*. Account for any change in the two papers in *C*. Explain the change in *D*. Give the commercial name of the gas collected in *E*. What substances identified are of importance commercially?

How coal gas is manufactured. — In the process of destructive distillation of coal the complex substances of

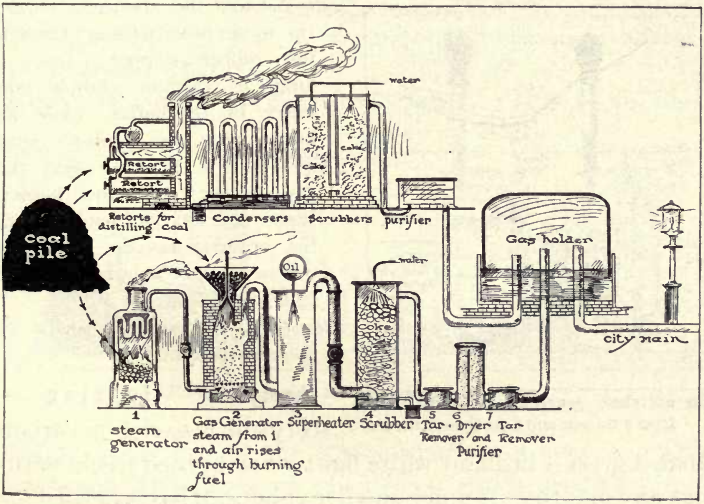


Gas holders where millions of cubic feet of illuminating gas are stored.

the coal are broken up into simpler substances by the heat, and many of the resulting gaseous products are condensed. Illuminating gas, the main product of this process, is not condensed and after being purified is ultimately stored in the gas holder. Bituminous coal, which contains from 30 to 40% of volatile matter, is heated in iron retorts. This volatile matter is driven out at a temperature of about 800° Fahrenheit. In making gas a ton of coal produces on an average two-thirds of a ton of coke, 13 gallons of tar, 20 pounds ammonium sulphate and 12,000 cubic feet of gas. The by-products obtained from the coal tar are far more valuable than the gas or coke obtained. Such substances as aniline colors, light and heavy oils, carbolic acid, and naphthalene flakes are some of the products thus obtained.

Steps in the process of the manufacture of coal gas. — Soft coal is placed in the retort, and in the process of heating is turned into coke. The gases and by-products pass off into what is known as a hydraulic main. In the hydraulic main some of the tar is condensed and disposed of, still more of it being taken out a little later by what is known as the tar extractor. The gases are then forced through a spray of cold water in condensers and scrubbers by means of which the ammonia and other by-products are removed. After the gas has been purified it is passed to the huge tank or holder, which is a familiar blot on the landscape of so many cities. From this holder it is passed out through the city mains and distributed to the street lights and to the homes, where it is used for cooking, lighting, and heating purposes.

Water gas. — Water gas is often made in the same plant, and, as we have said, is mixed with ordinary coal gas



Manufacture of city gas, combining coal gas and water gas.

for purposes of street lighting and home use. It is made by passing steam under pressure through incandescent hard coal or coke. The gases pass off into a structure called the *carburetor*. Here coal oil is sprayed into the gas. It then passes to the superheater, where it is changed to a permanent gas which will burn. It is cheaper to make water gas than coal gas, but without extensive enriching with oil it is not suitable for lighting unless mantles are used. A third kind of gas called " producer gas " is made in some plants for fuel purposes only.

Experiment. — To compare acetylene with city gas for illumination.

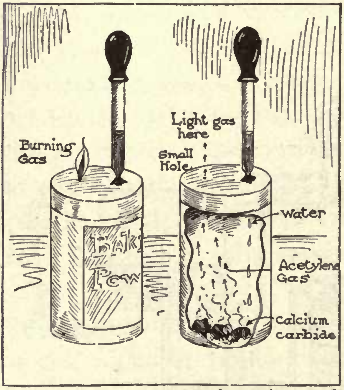
Materials: An 8-ounce bottle with 1-hole stopper to fit. Acetylene burner tip. Ordinary gas tip. Calcium carbide.

Method: Fill the 8-ounce bottle with illuminating gas. Apply a match to the gas. Observe whether it burns with much or little luminosity and black smoke.

Pour 25 c.c. of water into the 8-ounce bottle. Drop a small lump of calcium carbide into it. Light the gas at the mouth of the bottle. Compare luminosity and smoke with result when city gas was burned.

Connect the acetylene burner tip to a tube passing through the rubber stopper. Drop a lump of calcium carbide into water in the bottle. Close the bottle with the stopper. After a couple of minutes, light the gas issuing from the burner. Light the city gas issuing from the ordinary gas tip. Compare the two flames for whiteness and intensity of light.

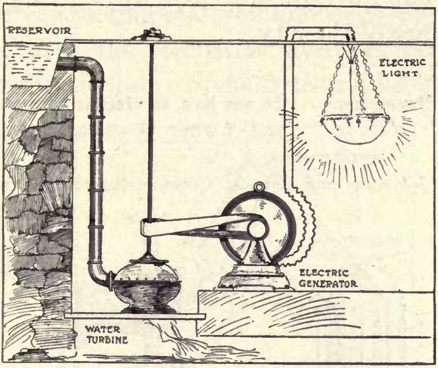
Results : What are the results of these experiments?



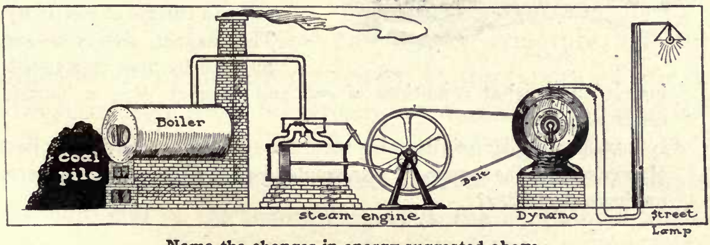
An acetylene generator is easily made from a tin can and a medicine dropper.

Acetylene lighting. — Acetylene is so rich in carbon that it gives a brilliant white light when burned freely without any mantle. A much smaller volume of gas is needed for a given intensity of light than where natural or coal gas is used. The equipment for manufacturing enough gas to light a small village or factory is much less expensive than required to manufacture coal or water gas. Acetylene gas, however, is more expensive than the other types of gas when they are made in a large plant.

Electricity for street lighting. — We have already seen that electricity can be made more cheaply where there is water power. The energy locked up in water falling from a height turns turbines or water wheels which in turn operate a generator and make electricity. Falling water has mechanical energy which is changed to electrical energy. This is an illus-



Energy of falling water changed to light.



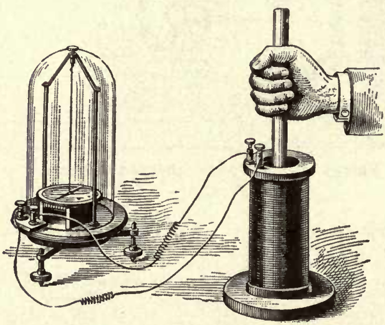
Name the changes in energy suggested above.

tration of the law of the transformation of energy. This law is equally well shown when electricity is produced from coal. Coal is burned in a furnace under a boiler. Steam from the boiler makes the wheels of a steam engine revolve. The steam engine in turn rotates the armature of a dynamo and electricity results. How many changes in energy are there in producing electricity from coal? Barges or cars bring to the plant tons upon tons of stored energy in the coal from which a little later electricity flows out through insulated wires to light every nook and corner of the city.

Experiment. — To see how an electric current is produced.

Materials: A coil of wire. A strong bar magnet, a galvanometer. Connecting wires.

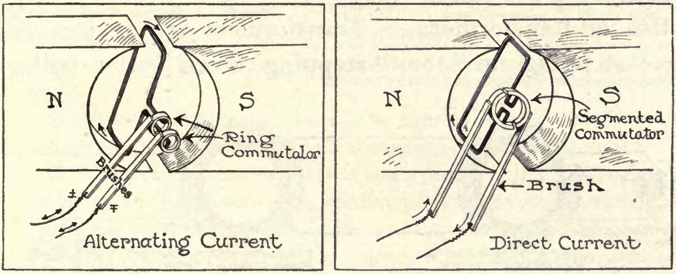
Method and Results: Connect the ends of the wire forming the coil to the galvanometer, thus making a "closed coil." Move the magnet in line with the axis of the coil down into the coil. Quickly withdraw the magnet. Observe the galvanometer needle in each case. Hold the magnet still inside the coil. What result?



Conclusion: The movement of the galvanometer needle is due to a current of electricity. The magnet always is surrounded by lines of magnetic force. Under what conditions of coil and magnet does a current result in the coil?

Application: Similar relations between closed coils and magnetic lines of force exist in the dynamo. Can you tell how it is then that a dynamo produces electricity?

How electricity is produced. — When a closed coil of wire is moved across the lines of force in a magnetic field a current of electricity is produced. The dynamo is a device which produces this current. It has an electromagnet by means of which a powerful magnetic field may be produced. Between the poles of the dynamo an armature consisting of many coils of wire is rotated. The two ends of each coil of wire terminate in the commutator consisting either of a pair of metal rings or of segments separated by insulated material. As the commutator revolves it touches fixed strips of conducting material known as the brushes. Wires which carry the electricity away to do its work are attached to the brushes. Some dynamos have



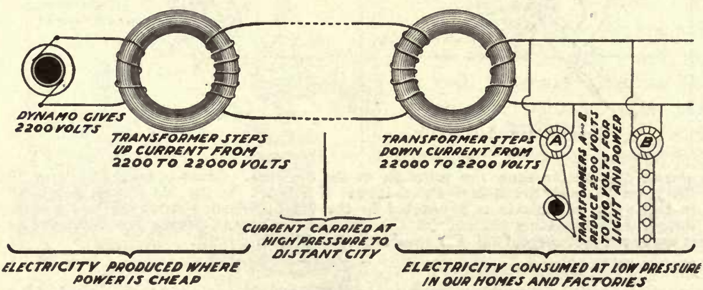
A simple diagram to show the principle of the dynamo. Lines of magnetic force fill the space between the ends of the magnets N and S. As the coil of wire is rotated in this space electricity is generated in the wire. When distributed just as produced, an alternating current (A. C.) results, but when a segmented commutator is used, a direct current (D. C.) results in the outside circuit.

a revolving magnetic field and a fixed armature, but the principle of producing electricity is the same. There is always relative motion between the magnetic field and the coil of wire. The dynamo is also called a *generator*.

Alternating current and direct current. — As one side of the wire coil of the armature passes the north pole of the magnet a current results in a certain direction. As it passes a south pole the current is produced in the opposite direction, thus in every revolution of a coil of wire between two magnetic poles two currents of electricity are produced.

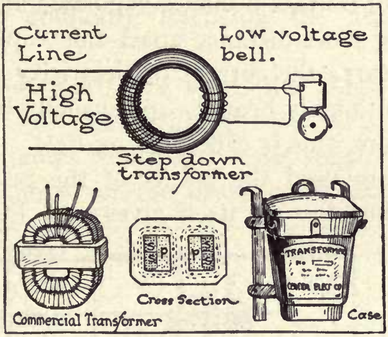
As the coil continues to revolve the current is alternating; going first in one and then in the opposite direction. This current is called from its change of direction, an *alternating current*. The alternating current is taken off by brushes in contact with a ring commutator. If, however, a segmented commutator is used the brushes take off a *direct current* of electricity. Just how this is done will be explained when you study physics. Either a direct current (D. C.) or alternating current (A. C.) may be used with incandescent lamps but as a rule the direct current is preferred for arc lights.

Use of transformers. — Transformers are devices used for "stepping up" or "stepping down" the voltage.



The use of transformers in a system of distribution of electrical energy.

When a large current of electricity is carried a long distance there is a very great loss of energy due to the heating of the conducting wires. When electricity is carried the long distance at a high voltage and correspondingly low current, there is little heating effect and so only a small loss of electrical energy results. The transformer makes it possible to carry electricity at high voltages and to step it down just before it is used. A direct current cannot be changed by the use of the transformer to a different voltage, but the alternating current can. For this reason electric lighting circuits usually have the alternating current.



How can three different voltages be produced if there are only two separate secondary coils?

Experiment. — To demonstrate the use of a transformer.

Materials: Two bell transformers for changing 115 V. to 6 V., 12 V., and 18 V. An A. C. voltmeter reading to 130 volts. Wire.

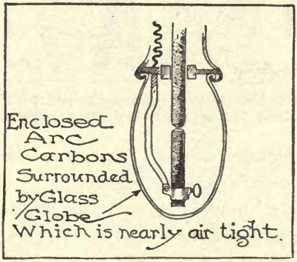
Method and Results: Measure the voltage of the A. C. electric light current.

(*a*) Connect the transformer to the lighting circuit. Measure the voltage obtained in each of the three secondary circuits. Results?

(*b*) Connect two binding posts of the secondary circuit of one transformer to the two corresponding binding posts of the other transformer. Connect the primary of one to the lighting circuit and what would ordinarily be the primary of the second, but which as now used is a secondary to the voltmeter. Result? How do you account for the result?

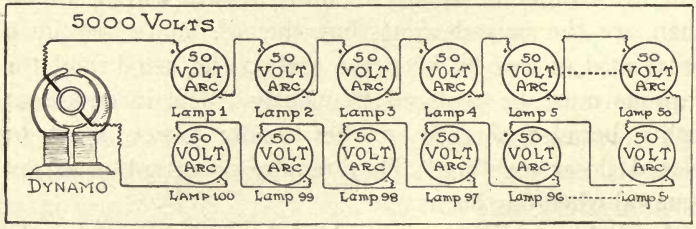
Types of electric lamps. — There are two types of electric lamps used for street lighting, the arc lamp and the incandescent, and there are many forms of each type. The arc lamps are usually of much greater candle power than are the incandescent, but the arc lamps require a great deal of care to keep the carbons adjusted, and the carbons must be replaced frequently. The incandescent lights, because of their smaller candle power, must be placed closer together. They require no attention except renewal when one burns out.

Arc lights. — When an electric circuit is closed by the contact of two carbon pencils, great heat is generated by the resistance at the point of contact. Carbon at the point of contact becomes vaporized and if the carbons are drawn a short distance apart this vaporized carbon continues to carry the current of electricity. Inasmuch as this stream of highly heated vapor usually bends out in the form of an arc, this is called an *arc light.* When pure carbon pencils are used the points of the pencils are intensely lighted but the arc itself gives very little light. In order to increase the amount of light in the arc a core containing calcium salts is made in the carbon. This gives a brilliant yellow arc known as the "*flaming arc.*" If the carbons are replaced by a heavy copper rod (upper) and a tube of magnetite (lower) a brilliant *magnetite arc* results. Both of these luminous arcs are used in street lighting. Inclosed rather than open arc lights are now almost always used because they require less attention.



The inclosed electric arc used in street lighting.

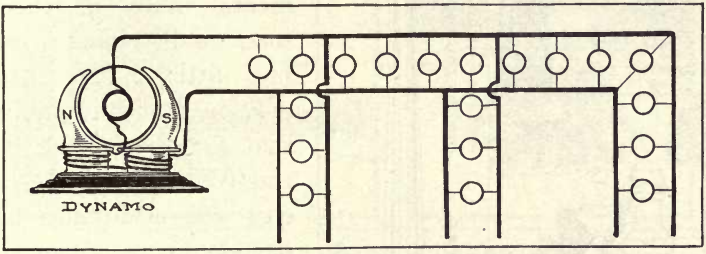
Incandescent lights. — The most important use of the heat factor of an electrical current is in the heat of the fila-



Arc lamps are connected in series.

ments of incandescent lamps to produce light. The larger tungsten lamps run from one hundred to five hundred or more candle power, and are in common use for street lighting. These lamps are gradually replacing the arc lights in many cities.

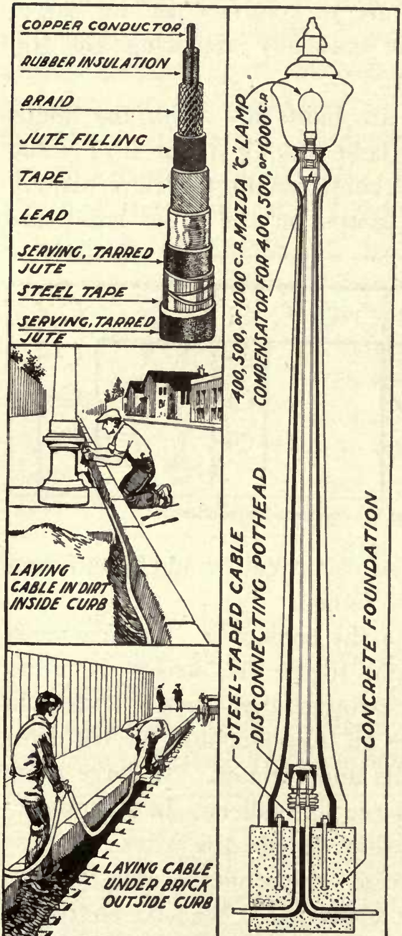
Lamp circuits. — When arc lights are used, the lamps are placed in series, each lamp taking about fifty volts. A circuit with one hundred lamps would, therefore, require 5000 volts. Incandescent lamps, on the other hand, are



Incandescent lamps are connected in parallel.

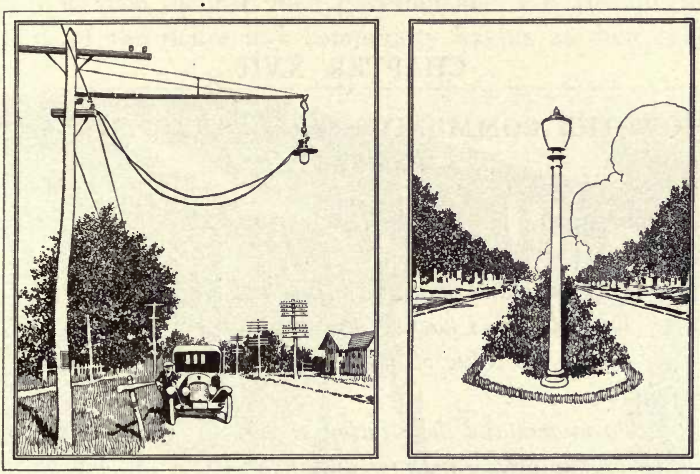
connected in parallel. A 110-volt circuit would be sufficient for any number of lamps so joined.

How electricity is sent to the consumer. — A few years ago it was a common sight to see the streets of cities disfigured by huge poles bearing many wires. To-day in well-regulated communities all telephone and electric light wires are placed in conduits underground. In large cities they may be placed in one large pipe gallery. In other places vitrified tiling is used in which to run the wires, but it is quite expensive. The use of underground cables instead of overhead wires is a great advantage. We have no trouble from broken wires in storms, less danger to people and more beautiful streets. While the first installation is expensive, the wires are so well protected that they last much longer, and the final cost of underground cables is not much greater than that of the overhead system of wiring.



Electric street lamp showing wiring. Method of cable laying. Insulation of cable.

Beauty a detail in street lighting. — While utility is the first consideration in street lighting, yet the modern community must consider beauty as well. Ornamental fixtures, reflectors, and globes cost but little more than ugly ones, and it may be that for the added attractiveness they give, a city will eventually be repaid in a financial way. There is no doubt but that they pay in the satisfaction they give to one's aesthetic sense. Compare the street of a few years ago with its crooked posts and a large arm with its pulley cord and loose wires, with the street of to-day where ornamental standards have the group system of lighting with underground wires. In many towns the value of property along certain streets has been increased 50% by the introduction of adequate and ornamental street lights.



Utility lighting vs. ornamental lighting.

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CHAPTER XVII

HOW THE COMMUNITY SAFEGUARDS LIFE AND PROPERTY

Problems. — 1. *To learn the various duties of the police force.*

2. *To understand the value of law and order.*

3. *To understand how the fire apparatus " works."*

4. *To see the value of heeding traffic regulations and fire regulations.*

5. *To understand the relation of various city departments in the promotion of safety for citizens.*

Experiments. — 1. To see how the force pump works.

2. To demonstrate the automatic sprinkler.

Project I. — TO FIND OUT ALL THE TRAFFIC REGULATIONS OF MY COMMUNITY.

Project II. — TO STUDY THE FIRE EQUIPMENT AT A NEAR-BY FIRE STATION.

1. By personal visits learn the different pieces of apparatus. List them.

2. Find out the purpose of each and how it is used.

3. Find out the method of operation of the extinguishing pumps, engines, and signal devices.

4. Report on these and other interesting things which can be learned by conversation with the firemen.

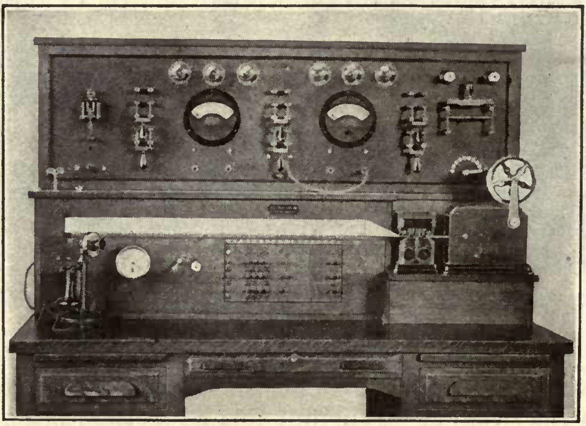
Two important city departments. — Two of the most important departments of a city are the police and fire departments. None but anarchists want to live in a community given over to lawlessness, and even anarchists believe in protection against fire unless it be used by them as a weapon against good government. We are apt to think of the police in a community having as their sole

Modern fire apparatus in service.

duty the care of that small group of people who do not respect the rights of others, but this is far from being their only duty.

A modern police system. — The city of New York has an army of police of somewhat over ten thousand men. These policemen are divided into a number of squads. Certain men, called patrolmen, have charge of the law and order on the streets of the city. Another squad patrols the harbor, using over a dozen boats for this purpose. Another squad has charge of the violation of the motor vehicle laws. Still another squad inspects the steam boilers in various parts of the city, while a separate squad makes up the bureau of criminal identification. This has charge of the "rogues' gallery" with its systems of measurements, its criminal records, and its finger print system. This bureau also conducts a school for detectives. Besides, there is a headquarters building with its squad of officials whose business it is to direct the entire police system.

The police patrol signal system. — The police headquarters in city districts have a signal system which is



Police signaling desk at headquarters.

electrically equipped so that it registers approximately the location of every police patrolman at any time and makes it possible to hold a telephone conversation with him whenever he reaches the police signal station from which he sends word of his presence. There is a double advantage in this system. The patrolman can easily send messages to headquarters with little delay. The line is never " busy " but is always open for his message. Headquarters can, within a short time, reach any patrolman if it is necessary to send him a message. This signal system more than doubles the efficiency of the police department.

Law and order. — When a group of people live together in a community each individual has certain rights which must be respected by the others. There is considerable difference in the way different individuals who insist upon their own rights accept the restrictions of their own actions. In most communities there are likely to be some people who insist upon violating the rights of others when any opportunity offers. It is to the advantage of every community to be governed by national and state laws and in addition by the regulations of the city or community. For this purpose we have in the community the police and a system of courts. In serious discord such as strikes and riots, the officers, the militia, or even the army and navy may be called upon for assistance, but under ordinary circumstances the police can effectively maintain law and order within the comumnity.

A traffic officer.

Work of the patrolmen. — A good many years ago the policeman was a sworn enemy of the small boy of the community, but now the small boy has learned to know him better. Not only do the kindly patrolmen make it possible for us to pass safely to school in the morning, but they also help other people to keep safe on the streets. The

DIVISION	POLICE DEPARTMENT CITY OF INDIANAPOLIS	DIST. NO.

PATROLMAN'S REPORT

Date____________19____

To the Board of Health through the official channels of the Police Dept.

At____M. I observed the following condition and took the action noted

Location

Insanitary Alleys	
Insanitary Backyard	
Insanitary Garbage Cans	
Insanitary Vaults	
Overcrowded Houses	
Improper Ventilation of Public Buildings	
Food Unprotected from Dirt and Flies	

REPORT HERE ANY OTHER MATTER NOT LISTED

Action Taken

(Rank) (Signature) (Badge No.)

P.D.509

BLANK FOR PATROLMAN'S REPORT TO BOARD OF HEALTH

DIVISION	POLICE DEPARTMENT CITY OF INDIANAPOLIS	DIST. NO.

PATROLMAN'S REPORT

Date____________19____

To the Board of Works through the official channels of the Police Dept.

At____M. I observed the following condition and took the action noted

Location

Broken Curb Stone		Broken Electric Wire	
Broken Manhole Cover		Sagging Electric Wire	
Broken Sidewalk		Broken Street Lamp	
Defective Bridge Culvert		Leaking Gas	
Defective Sewer Catch Basin		Leaking Hydrant	
Hole in Street		Broken Water Main	
Street Opening not Repaved		Unclean Street-Gutters	

REPORT HERE ANY OTHER MATTER NOT LISTED

Action Taken

(Rank) (Signature) (Badge No.)

P.D.511

PATROLMAN'S REPORT BLANK FOR RECORDING CONDITIONS FOR ATTENTION OF BOARD OF WORKS

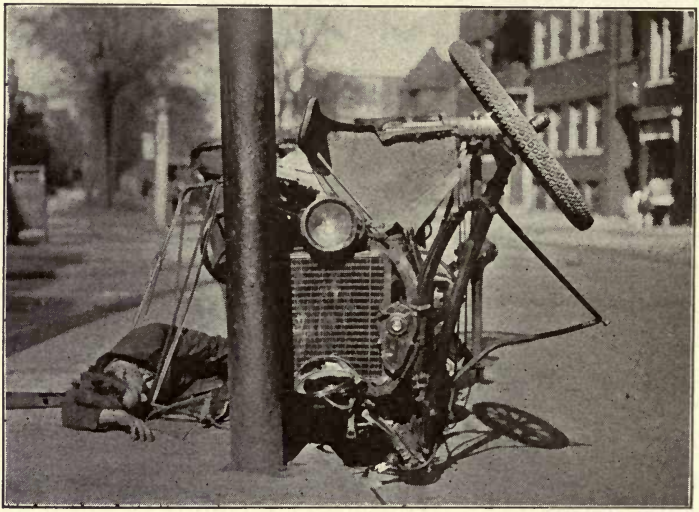
Blanks for patrolmen's reports.

little boy or girl who is lost instantly goes to the big patrolman on the corner to find the way home. The stranger within the city asks his way to this or that place. The patrolmen regulate traffic on the busy streets. They keep crowds back when parades are moving through the streets, and of course, at all times they are the servants of the people. It is their duty to take offenders against law and order, to protect property against theft, and to protect our lives against violence. The police department of a city works with the sheriff of a county and his deputies, and in times of danger the police department has a right to call upon private citizens to give aid in the maintenance of law and order.

The patrolman in the city police department is also an inspector of the general conditions of the streets, of defective sewers, broken electric wires, broken street lamps, leaking gas mains, leaking hydrants, broken water mains, and has many other duties which we should not guess. The records which are turned in by the police have to be models in accuracy and in detail, and after having seen such a record we should certainly have more respect for the duties which these men have to perform. In the city of New York the police at the present time have an aviation force, and during the World War they were prepared to cope with any emergency that might arise from bombing by a hostile air force.

Prevention of accidents. — Traffic police officers are the greatest factor in the prevention of accidents. Almost as many thousands of American people were killed in the United States during the World War from accidents as were killed in France. It is not merely in the street traffic that there is very great danger, but street cars and railroad grade crossings, fallen electric wires, unguarded excavations, unsafe railings, and icy sidewalks and pavements all add their quota to the list of accidents.

Safe and sane driving. — No regulations and no officers can prevent accidents which are invited by the recklessness or carelessness of drivers. Fortunately, since police regulations are strict within cities, most drivers heed traffic regulations fairly well. Careful drivers seldom get into trouble. They cannot, however, escape from danger into which they are forced by the careless driver. It is only right



Wreck of the reckless driver.

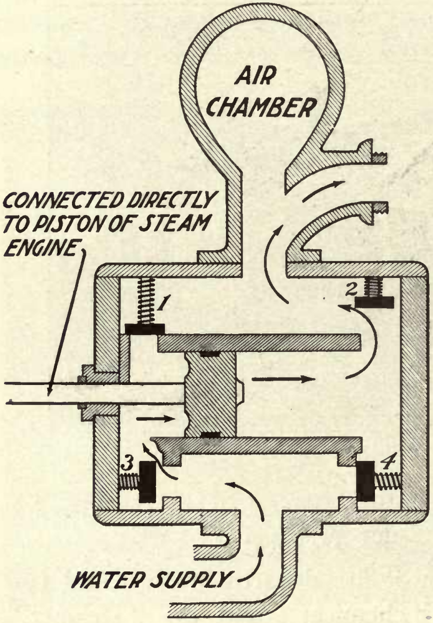
that the careless driver should lose his license, as he is a menace to the community as long as he is allowed to drive a car.

The equipment of a fire department. — Most of us have enjoyed a visit to the fire station. The wide open doors, the shining brass of the engines and trucks, the stall where motor apparatus has replaced the intelligent-looking horses, and the brass pole from the upper story where the firemen slide down when hurrying to a fire, have all left their impressions upon us. The complicated system of fire signals has always interested us, and perhaps we may have been fortunate enough to have been in the building when an alarm was rung in. Then we remember the visit

A fire station on a corner lot.

to the upper part of the fire house where the sleeping quarters and the social rooms are located.

The engines. — In most fire departments we find two kinds of engines, the "chemical" and the "steamer." The "chemical" is usually the first to arrive at the fire and is able to extinguish a small fire without any hydrant connection at all. It is really a large carbon dioxide fire extinguisher in which a solution of sodium bicarbonate and concentrated sulphuric acid is used. In addition small hand extinguishers are carried by the chemical engine. The "steamer" is a true engine in which steam is generated over a soft coal fire. The steam in the engine drives a powerful double acting force pump. This force pump draws water from any source hydrants, reservoirs, wells, or rivers, and will throw a stream of water more than one hundred feet. The action of the pump will readily be seen by studying the figure which shows how the piston rod of the steam engine is joined to the piston of the pump.



Explain how the piston in moving back and forth drives water out on each stroke.

Experiment. — To see how the force pump works.

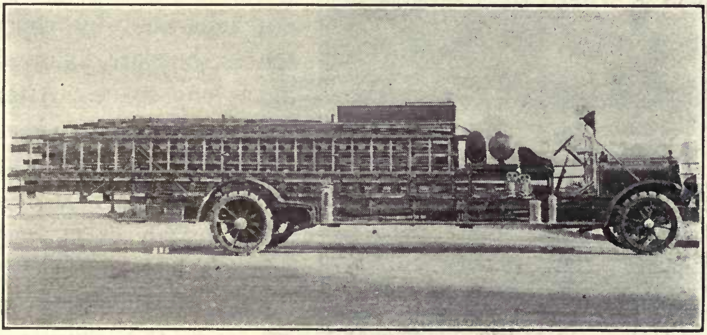
Materials: Glass model force pump with air chamber. Shallow jar or basin.

Method: Operate the pump. Watch the valves.

Results and Conclusion: Explain the action. What seems to be the purpose of the air chamber?

Application: What advantage over this type would the double acting force pump used on fire engines have?

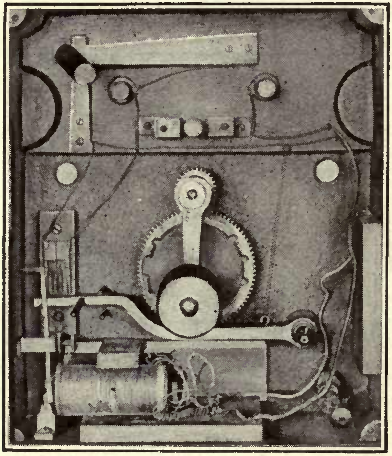
Other fire equipment. — In addition to the engines, firemen must have means of reaching the fire from the outside, and also means for cutting through roofs and pulling or pushing over partly burned walls. The hook and ladder answers this purpose. In some large cities water towers are used which are really extension ladders, bearing a large nozzle from which a stream of water may be directed to better advantage; safety nets to catch people who may have to jump from windows in burning buildings are also a part of the equipment. We also find most up-to-date fire departments equipped with oxygen helmets by means of which firemen may go into dense smoke without being suffocated. They also have pulmotors by means of which persons who have been suffo-



Ladder truck with hooks, poles, axes, and chemical equipment.

cated may be brought to normal breathing. The pulmotor gives oxygen under pressure to the lungs of a suffocated person at regular intervals, in somewhat the same way as air is given by the Shaefer method of resuscitation.

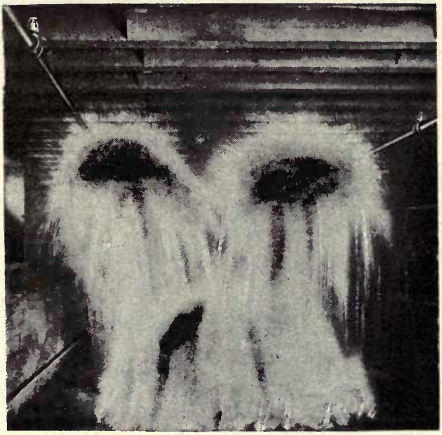
The fire alarm system. — The first fire alarm telegraph system was installed in Boston in 1852. The original box contained practically nothing but a telegraph key operated by a notched wheel that opened and closed the circuit. To-day there is scarcely a city or large town which does not have a telegraphic system. The red fire alarm box that you find along your city streets contains clock work which is started when the lever is pulled down. A " character wheel " is made to revolve. This opens and closes an electric circuit at regular intervals causing the box number to be sounded at headquarters. The number of the box is made by the arrangement of cogs and spaces on the "character wheel." For instance, to give the signal 1—3—2—— the "character wheel" would have one cog with a long space either side. Then three cogs are separated by short spaces, but are followed by a long space. After which there are two cogs separated by a short space. All this is followed by an extra long space. Each cog closes the circuit, while between the cogs the circuit is broken; a larger break in the circuit separates the first signal from the repeated signal. In the modern system all wires are placed underground. This improves the efficiency of the system and also the appearance of the streets.



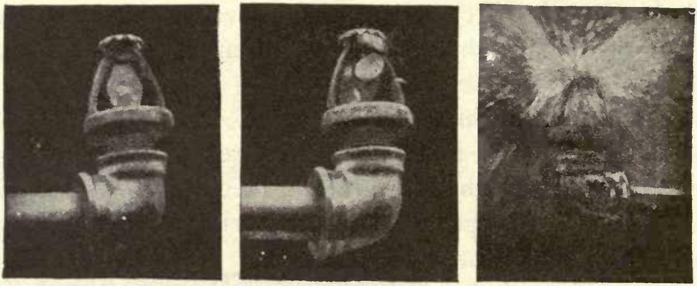
Inside mechanism of first fire alarm box, used in Boston in 1855.

Fire traffic regulations. — In late years motor fire apparatus has rapidly replaced horse-drawn apparatus. Its greater speed has reduced fire losses, but at the same time has increased the danger to traffic. Accidents from collision between fire apparatus and other vehicles are usually due to carelessness of general traffic. Many of these accidents could have been avoided by more efficient laws, and by better means of warning of the approach of fire apparatus. In some places semaphores and warning gongs are placed at corners where much traffic passes, and city ordinances are made which prevent vehicles from standing near fire hydrants, or stopping in certain streets close to where fire houses are located.

Fire protection in public buildings. — It was reported by the Russell Sage Foundation that fire wipes out of existence each week of the year in the United States, ten school buildings, two college buildings, two hospitals, three public halls, two jails, and twenty-six hotels. In 1918 the damage to school buildings alone was over $5,500,000. Buildings can be replaced but lives cannot. Thousands lose their lives in fires every year, and as a rule public buildings, especially schools, are not properly protected against fire. Every school, orphanage, hospital, and other public building ought to be equipped with a private fire alarm system, and in schools this system should be arranged so that it can be detached from the city alarm when fire drills are held. Most fires that occur in schools originate in closets or in the basement; therefore, these parts of the building should be equipped with an automatic sprinkler system. By means of such a system whenever a certain temperature is reached in a room, the valves which close the water pipes automatically open

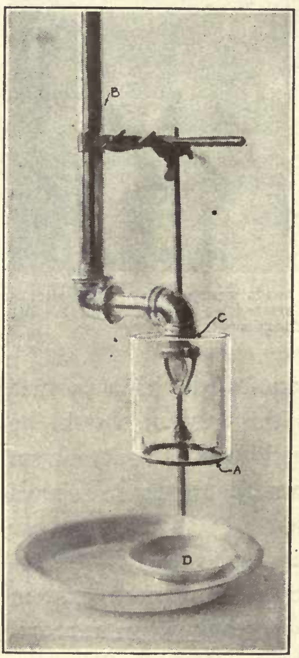


These sprinkler heads opened very soon after a small fire was started on the floor and the fire was quickly extinguished.



The soft solder which holds the valve closed melts at about 180° F. When melted it opens in the fraction of a second. The pictures above were taken with a moving picture camera.

through the melting of a soft metal cap, and the water flows out to extinguish the fire.



Sprinkler demonstrating set.

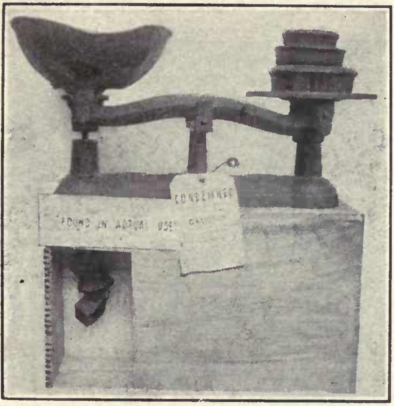
Experiment. — To demonstrate the automatic sprinkler.

Materials: A sprinkler demonstration set. (This outfit can be obtained at cost from the General Fire Extinguisher Co., Providence, R. I.)

Method: Place the sprinkler demonstrating set over a sink or place a large heavy paper under it to protect the table top. A large shallow pan will catch most of the water. A small metal dish (*D*) to hold the fire is placed in the larger pan and is separated from it by a thick layer of asbestos. Shredded asbestos wet with denatured alcohol is placed in the small dish, covering the base to a depth of $\frac{1}{4}$ inch. "Canned heat" may be used in its place. A glass cylinder is used to prevent the water from spreading too much. This is supported by the iron ring (*A*) a few inches above the fire pan. Adjust the elbow (*C*) to 5 inches above the iron ring. The pipe (*B*) is filled with water and the fire lighted.

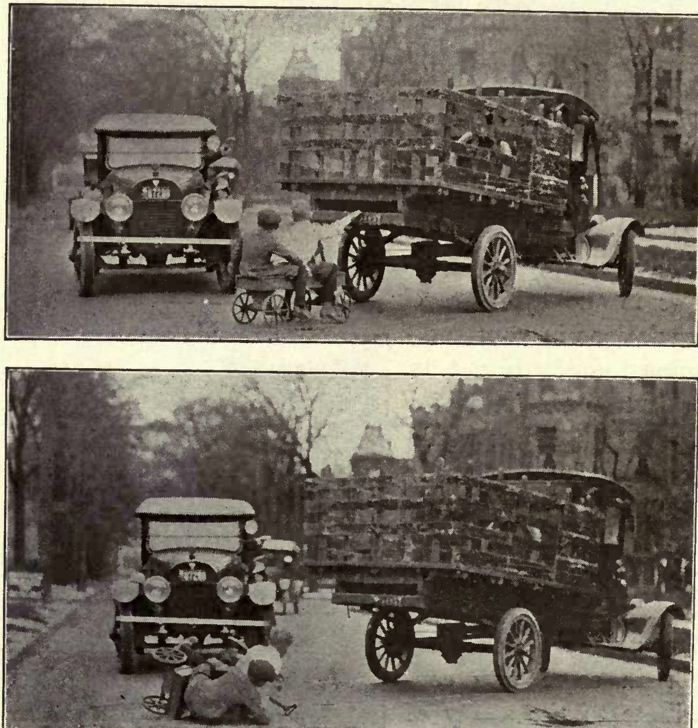
Result and Application: Describe just what happens and apply the result to a real fire in a school basement.

Fire regulations. — In nearly every large community the city government has passed certain ordinances relating to fire hazards. These regulations relate to the storage of inflammable materials, to the location of garages, to the methods used in building, to the location of exits and fire escapes on buildings, to the use of fire safeguards in theaters, and to the separation of the more congested districts into fire zones where stricter regulations against fire are enforced. Every citizen of any community should make it his business to see that the fire laws in the town are obeyed. Do you know what the regulations in your community are? If not, a project in the form of a report to the class would be very helpful.



The sealer of weights and measures prevents much fraud. Explain how the dishonest dealer who used the scales shown above cheated his customers.

Other departments concerning the safety of life and property. — There is scarcely a city department which does not in some way contribute to the safety of the citizens and of their property. Besides the fire, police, and health departments we have the department of streets, which looks after construction, pipe laying, and keeping the streets and sidewalks safe for public use; the water department, which furnishes water to extinguish fires as well as for home or factory use; the building inspectors, who prevent new fire hazards; the department of weights and measures, which prevents fraud through the use of false weights and measures; the department of street



A hazardous practice. How much better it would be always to avoid danger. (Travelers Insurance Co.)

lighting, which, as we have seen, helps to make the city safe at night, and, finally, each individual in the community who must play his part.

How citizens may help. — "Safety first" is a very good slogan; not only one's own safety but that of the other fellow, and safety of the property of others; care on your part of city supplies; help on your part that city ordinances are enforced; willingness on your part to coöperate in obeying all laws or ordinances with reference to safety of buildings; and, finally, willingness to enter into such routine as the fire drill in school, for by means of this same fire drill a score of lives may be saved if a real school fire occurs.

Washing windows without a safety strap is dangerous.

The score card. — A study of the two previous chapters, together with such visits as you may make to a fire house and a police station, ought to give you a good idea of how to score your own community on this card. Be critical in your score so that any weak points may be called to the attention of the proper authorities. If you have made a real investigation, the score card may be of value; if not, it is worthless.

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SCORE CARD. SAFEGUARDING LIFE AND PROPERTY IN THE COMMUNITY

	Perfect Score	My Score
Street Lighting Lamps lighted cloudy and moonless nights (5) No dark areas between the lights (5) Wires in business section underground (5) Lighting service well maintained (5)	20	
Street Traffic No "blind" corners (5) Traffic "cop" at congested street intersections, and at schools on streets with much traffic (10) No grade crossings (5) Traffic regulations enforced, indicated by few street accidents (10)	30	
Police Report neglect on part of careless citizens (5) Little or no lawlessness goes unpunished (5) Actively aid other departments (5) Efficient in detective work (5)	20	
Fire Department Paid firemen on day duty (2½), night duty (2½) Hydrants, reservoirs, or natural bodies of water within 300 feet of any buildings (5) A motor chemical engine (5) A "steamer" and a "hook and ladder" truck (5) An electric fire alarm signal system (5) Strict fire laws and building regulations in business area enforced (5)	30	
TOTAL	100	

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CHAPTER XVIII.

ADVANTAGES FOR EDUCATION AND RECREATION

Problems. — 1. *To learn about the development and work of schools.*

2\. *To see what building construction and equipment is required for the welfare of children in schools.*

3\. *To see how libraries and museums may aid in our education.*

4\. *To see the value of public playgrounds and parks.*

5\. *To see how various amusements may also be educational.*

6\. *To see what community forces are working for higher standards of morality and to aid moral education.*

Project I. — TO LEARN THE EDUCATIONAL POSSIBILITIES OPEN TO BOYS AND GIRLS IN MY LOCALITY.

Project II. — TO MAKE A STUDY OF THE WAYS IN WHICH LIBRARIES, MUSEUMS, AND PARKS CAN ASSIST IN MY EDUCATION.

What city taxes pay for. — A city budget is made out not only to insure us pure water and milk, to pave our streets, to give us a fire department to protect us from fire, and police to guard us while we sleep, to give us scavengers to carry off our refuse, and street cleaners to keep the streets clean, but it also must provide for the moral, the educational, and the physical well being of the citizens. Taxes must provide for our schools, our public libraries, our playgrounds, and our parks.

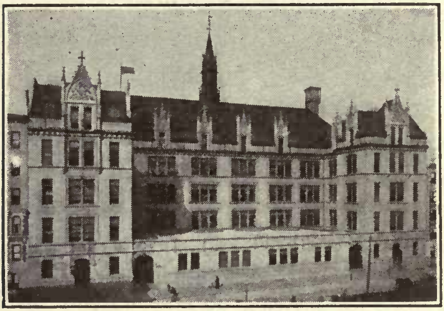
The development of the public schools in this country. — Among the first laws that the Massachusetts Colony passed was one which provided that in each settlement of fifty householders, intermediate schools must be established, and in every town of one hundred householders a grammar school. This was the foundation of our free school system which now is established in every state and territorial possession. Congress in 1787 passed an ordinance for the government of new lands in the West which provided that, "religion, morality, and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged."

The first free public school in America was established in Dedham, Massachusetts, in 1644.

As the schools grew in the East, private schools came into existence largely for the purpose of those who wished to go to college. Some of these academies still exist in the well-known schools at Andover and Exeter, and others scattered throughout the East. Since this country is a democracy, and schools and education are the right of all people, the public school system gradually is crowding out the private schools, especially throughout the West. Here a complete state system of education is worked out, for here we find elementary and secondary schools leading directly to the state-controlled colleges and universities.

Different states have different methods of control of public instruction, although in general there is a state superintendent of public instruction or commissioner of education either elected by the people directly or appointed by the government. The state board of education, or the state commissioner of education, plans and maintains uniform standards in the schools. State money is also appropriated for public school purposes. Teachers are usually supplied from normal schools which are also under state control. These normal schools usually have training schools where the young teachers may work under supervision with the pupils whom they are to teach later. The Commissioner of Education at Washington assists in the educational work of the whole country and through educational publications supplies information and makes public such new experiments in education as are worth while.

Laws regarding attendance at school. — In most states children are required to attend school from eight to ten years. The average age is from seven to fifteen. It is possible for children in many communities to go through the entire system from kindergarten to college without any cost, even free textbooks being provided in many cities. Statistics show that those who go to high school get much better living wages than those who stop their education before high school age, and those who go to college receive even more salary and a higher place in the world. Of the men and women whose names are in "*Who's Who*" a very large percentage are college graduates. But since only a small percentage go through college our schools are continually placing new "practical" subjects in the curriculum so that a girl or boy may be more useful at home or in the business of life into which he may be called. Sewing, cooking, woodworking, metal working, and commercial branches of various kinds have all been introduced into the schools. Mental tests are now being used in many school systems so that those who have little ability for book work may be helped to a more useful kind of education in the vocational schools which train for practical everyday work.



A high school in New York.

The school system of a great city. — The city of New York has probably the largest school system in the world, including more than five hundred elementary schools, thirty secondary

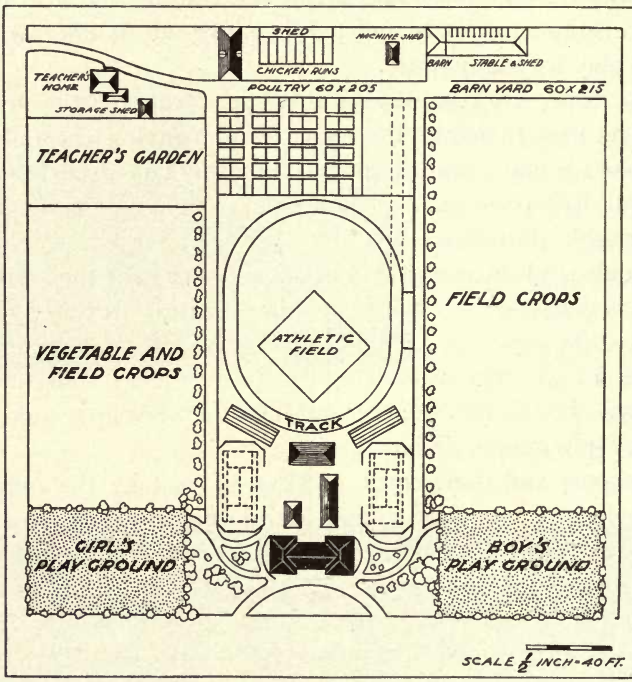
Foreign born learn to be Americans in night school.

schools, several teachers' training schools, and two colleges. These, together with its twenty thousand teachers, give enormous opportunities for free education for those who wish to go to the top of the ladder. All books and many other materials are free. Night schools and free lectures are provided to help those who cannot give day time to school work. Vocational schools and continuation schools are an additional part of the system of education; while summer schools and public playgrounds offer work and play for many more.

In New York about twenty per cent of the total budget goes to defray the expenses of running the public schools, — much more than for any other city department. About five per cent of the people's money is spent for charitable purposes, about two per cent for parks, playgrounds, and museums, and about one per cent for correctional purposes. Schools in many cases are used for recreation centers at night; over fifty of these centers have an average attendance of twenty-five thousand a night. For all this the city expends the very large sum of over forty million dollars a year.

Schools and their work. — Most of us take the public schools as a matter of course, and do not always even say "thank you." As a matter of fact, the public school system in this country is something for all of us to be proud of. Nearly $500,000,000 a year is spent for free schools, an average of $26 per child enrolled. This democracy of ours will be great because the children avail themselves of educational advantages. A child may get much from our free system of education, but later we expect him to pay for it, and more, in his work as a citizen. Schools should train for life in the community because the school is a kind of community. It should train for citizenship by making every subject we study help us, in some way, to become better citizens. Science should teach us to think straight and to understand many civic problems;

language will help us to speak and write intelligibly; history and civics will show us how to become good citizens. Athletics ought to help us toward certain splendid stand-

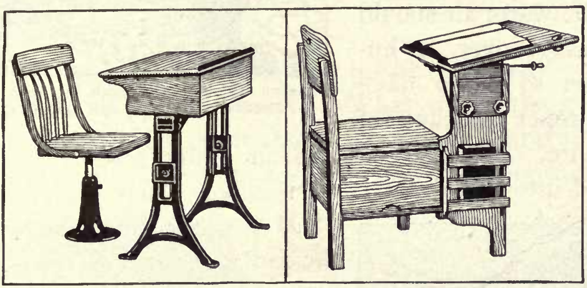


Ideal plan for rural school grounds. Can you plan better grounds for your community?

ards of citizenship: honesty, good sportsmanship, quickness in decision, and square dealing with the other fellow.

Colleges, universities, and technical schools. — All parts of our land to-day are supplied with institutions of higher learning. More and more the young people of this country are availing themselves of the opportunities for higher education. Especially is this true in science. We have awakened to the fact that training in science is necessary not only for straight thinking but also for advancement in the world of to-day. Engineering schools, medical schools, and all kinds of technical schools are to-day more important than ever before, and their attendance is growing year by year. Manufacturing and engineering corporations are endowing scholarships so that worthy young men in their employ may get a free education along lines necessary to earn promotion. No young man with ability to-day need fear that he may not succeed if he is willing to work.

Modern school buildings. — The modern school build-

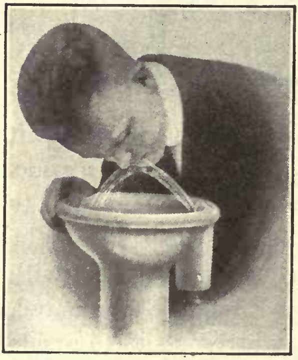


Adjustable seats and desks.

ing should be fireproof since many children are within it for several hours each school day. It should have wide, well-lighted halls and stairs and attached fire escapes to give quick exit in case of fire. The school should be equipped with fire alarm signals connected directly with the city system, and all fire hazards should be eliminated. The large, airy rooms should have, where possible, outside overhead lighting, and where this is not possible, light should come in from large windows on one side of the room only, so that no shadows are formed on the paper when children are writing. The desks and seats should be adjustable, so that each individual child may have a desk of the right height. The artificial lighting should be arranged to give plenty of light without glare.

Curtains adjustable at both top and bottom remove much glare and eye-strain.

The ventilation system should be so arranged that the air is passed through a strainer, by which dust and germs are in part removed, and the warm air should be passed over a humidifier so as to have the proper amount of moisture. For this purpose in many schools steam is passed into the air ducts. In schools where the air is dry, pans of water should be kept on the radiator.



A good fountain for public use.

Since hygiene is taught in the schools, it should be practiced in every way. Sanitary drinking fountains should always be provided. The bubble fountain with the nozzle stream pointing directly upwards has been proved insanitary. The best form is one which throws a stream out to one side, so that the lips may not be pressed against any part of the fountain. It goes without saying that individual paper towels should be placed in the wash rooms and that the toilet and urinals should have no wood in their construction, should be well ventilated, and flushed frequently.

Dry sweeping should not be allowed. Experiments in certain New York schools have shown that where dry sweeping is done by careless janitors' assistants the bacterial content of the air in the rooms becomes very great, owing to the constant movement of the children in the rooms and halls. Any school that lives up to the standards just given will be a credit to its community. Do your own schools measure up to the standard?

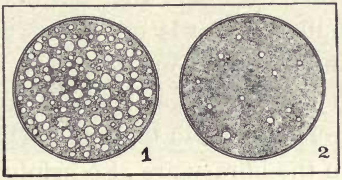


Plate cultures. 1. Dry sweeping. 2. Damp sweeping.

Libraries as a public asset. — What would the average school boy or girl do without the public library? We have come to regard it as a part of our environment,

A library reading room.

thanks to the benefactions of Andrew Carnegie or some wealthy citizens of our own town. Not only do most communities have free libraries, but many of them use the building for more than the purpose of taking out books.

Many boys and girls not fortunate enough to have a quiet room of their own in which to study use the reading room of the public library or some room that is set apart for the purpose of study. Libraries are used as meeting places for literary and other clubs, and for lectures as well. Modern libraries have specially fitted children's rooms with the most interesting children's books; they use attractive bulletin boards on which to display the latest topics of interest, and many a boy and girl has here formed the habit of reading good books. This habit will prove of much value in later life. The newspapers and periodicals in the library are also helpful in our education.

How public libraries are maintained. — Many libraries are endowed and receive the income from such endowment for their running expenses, but on the other hand, most of the libraries are supported wholly or in part from public

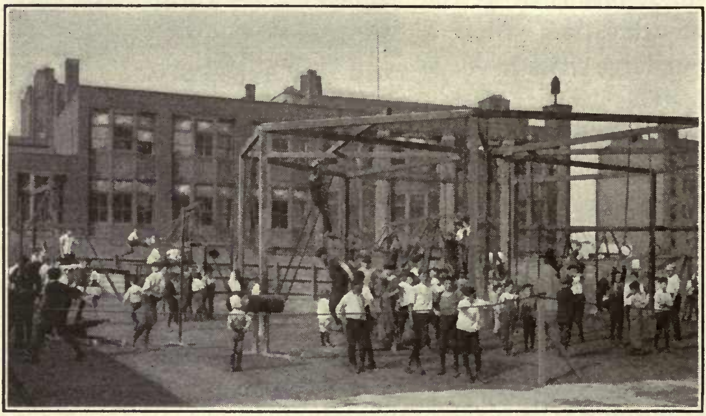
Minerals and gems displayed in American Museum of Natural History.

funds raised by taxation. The Carnegie libraries were given to communities only on condition that the cost of their upkeep would be met by the citizens of the community. Some states control not only the large library at the capital but also traveling libraries which are sent from one small place to another, each one remaining in a given place for a few weeks and then moving on. In this way small communities are constantly supplied with new books at a relatively low cost.


Class taking notes at the Aquarium in New York.

Art and other museums as educational aids. — Indirectly a great museum is one of the finest means of getting an education. Most of our large cities have collections of paintings and sculpture. There are also museums of natural history as well as commercial or economic museums. Examples of such are the American Museum of Natural History in New York, the Commercial Museum in Philadelphia, the Fine Arts Museum of Boston, the Carnegie Museum in Pittsburgh, and the Field Museum of Chicago. In most cases, either the building, the contents, or both are gifts of public-spirited citizens, and the community's only duty, if any, is to maintain the upkeep. Most museums have lecture courses, loan collections to public schools, have rooms set apart to which the collections may be taken by students and teachers and in which laboratory work may be done. In these and many other ways a most important part in rounding out the education of boys and girls is accomplished. It is estimated that a total of over 2,500,000 persons visit the three great museums of New York and Brooklyn annually.

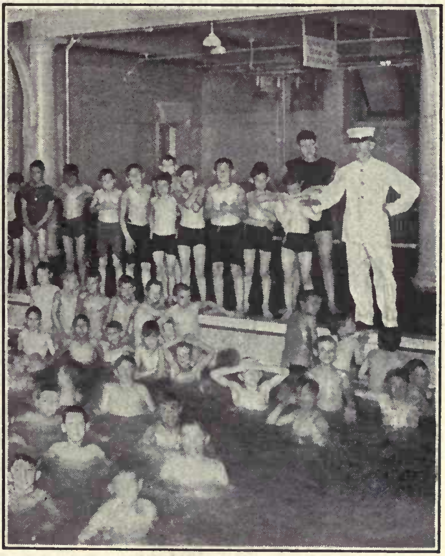
Playgrounds and the playground movement. — Any boy who reads this chapter may well object that up to the present time nothing has been said about recreation. He might well ask, "What does the city do for a red-blooded boy?" Fortunately, we have come to realize that boys and girls of school age need play and recreation as well as work. In the past ten years hundreds of playgrounds have been opened in cities or towns, maintained by the park departments, boards of education, settlement houses, or associations interested in the playground movement. In these places boys and girls as well as grown-ups can



The place for enjoyable exercise in summer.

play in safety and under the supervision of a trained playground instructor. In many large cities we find one playground to each ten thousand inhabitants, especially in congested communities, where the playground movement is a great boon. In some cities it is the custom to keep traffic off some streets during certain hours in the afternoon so that children may play in safety near their homes. Massachusetts in 1908 passed a wise law providing that cities of over 10,000 should provide and maintain a public playground. As we have seen, many cities now have their own forester and are caring for their shade trees and planting new ones. It is the wise city that looks into the future. Is your community one of these?

Some types of playgrounds. — Many cities, notably New York, Chicago, and Washington, have well-equipped playgrounds and recreation centers with club houses, swimming pools, bath houses, out- and in-door gymnasiums, running tracks, and fields for games. School yards, and the roofs of school buildings are set apart for playgrounds in some localities. These are especially useful for basket ball and games requiring a small space. In communities which border on bodies of water, recreation piers are built which are furnished with comfortable seats, with sand boxes and other amusements for young children. Here in the evening bands play and free dancing is enjoyed. Many schoolhouses are now thrown open evenings for community dancing. Public baths, swimming, and bathing are found in most cities, especially those near bodies of water. New York, for example, has twenty-one bath



The public bath is popular with the boys.

houses scattered throughout the city, thirteen free floats, and a very large municipal bath house at Coney Island, furnished with accommodations for nearly 7000 persons at one time. Over 12,000,000 separate baths have been given in a single year by these agencies in the city of New York.

Public parks and their use. — Public parks have been rightly called the "breathing places of a city." We all know the value of green plants in giving off oxygen to the

Parks are the "breathing places" of our large cities.

air, and absorbing carbon dioxide from it. Many cities are provided with park systems embracing thousands of acres. Chicago, for example, has seven large and five small parks, and about forty miles of parkway connecting these. The city of New York has a system comprising 237 parks with a total of nearly 8000 acres of land. This park system includes one of the finest and largest zoölogical parks in the world as well as three free museums of large size and several historical buildings which are open to the public. Washington, D. C., has a wonderful system of large and small parks which, combined with the museums and botanical gardens and the expermiental stations of the zoölogical park, make it one of the most useful adjuncts available to public education.

Not very long ago parks were looked upon as show places. Now, however, they are more than that for they have become a part of the great public playgrounds. Golf links and public tennis courts are found in most of these parks. We have baseball and polo in summer and hockey and skating in winter. Every opportunity is given to the citizens for healthful exercise. This, added to the beauty of the parks, makes a citizen feel that the money put into public parks is well spent.

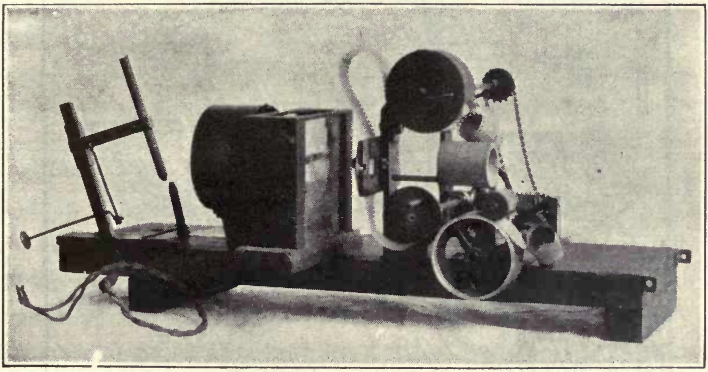
Other means of education and recreation. — Perhaps the finest example of community spirit is seen in the formation of community centers. More and more these organizations combine the club and social forum with the playground and education. Here is a place where lectures and concerts may be given, a place where community dances may be held under proper supervision, and where pageants or social gatherings may be held.

The moving picture as an educational factor. — The moving picture has come to stay and may be used as an educational asset if one chooses wisely which films he shall see. During the World War hundreds of thousands of young men saw educational "movies" in the huts of the Y. M. C. A. Many of these "movies" having distinct educational value illustrating life in France, England, or Italy were shown to the men who were soon to go to those countries. At the present time the Public Health Service, as well as many manufacturing companies, have collections of free films on different educational topics. Especially important are those of the Public Health Service which show different aspects of health and disease. Is your community availing itself of this opportunity of seeing these films?

How moving pictures were invented. — The idea of taking moving pictures is usually credited to Edward Maybridge, an Englishman who, when living in California in 1872, experimented in taking a series of pictures of moving objects. The application of this idea was worked out in the invention of Thomas Edison called the kinetoscope. This, thanks to the development of the sensitized film by the Eastman Kodak Company, was made into a device by means of which a strip of film was passed before an opening in a box into which a person looked. Just under the peep-hole was a revolving shutter. A motor caused the film to move past the shutter rapidly so that objects in the picture appeared to move. The kinetoscope was exhibited at the World's Fair in Chicago in 1893, but attracted little attention because its commercial possibilities were not then thought of. The first real moving pictures were shown in England in 1895 by Robert Paul. Lumiere & Sons a little later invented the cinematograph, which was first exhibited in this country in 1896. Since that time rapid strides have been made in the moving picture business. Now, thousands of people are engaged in staging and manufacturing pictures, thousands more operate theaters, and between fourteen and fifteen million people go to the "movies" every day in the year in this country, while enough film is shown each day to go almost around the globe at the equator.

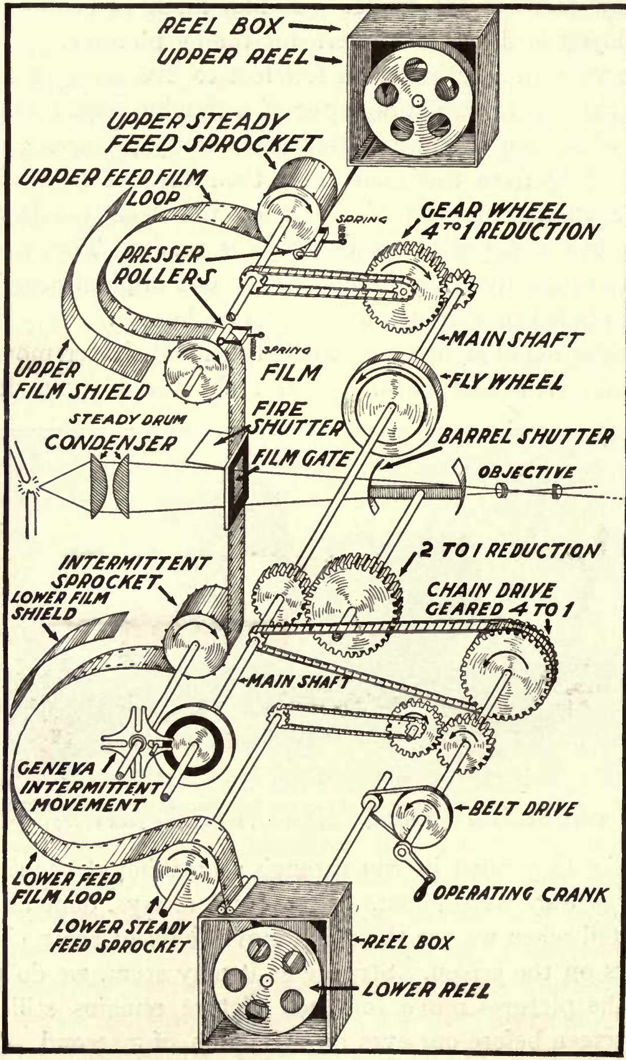
How pictures are made. — A film made of celluloid is employed in a special camera for taking pictures. These films vary in length from a few feet to five hundred feet. The camera takes photographs of a moving object at the rate of sixteen to one hundred and twenty pictures a second. Negatives are made and then contact prints are made on another roll of film from the negatives in the same way as a positive photograph is made. Thus many copies of the film may be made from one original negative and retailed to various moving picture houses.

Projection of pictures. — There are about sixteen moving pictures to a foot of film. To make the pictures look



First machine used to project moving pictures in America. Pictures were exhibited with this machine by Jenkins, in Richmond, Indiana, on June 6, 1894.

life-like they must be run through a machine at the same rate as they were taken. This is not always, done as we can tell when we see the rapid movements of some characters on the screen. Strange as it may seem, we do not see the pictures move, for each picture remains still on the screen before our eyes for a fraction of a second. We appear to see the picture move because of a peculiarity of



Essential parts of the moving picture machine. (After Hawkins.)

the eye. Any image seen by the eye remains impressed on the retina or sensitive portion a fraction of a second after the eye has seen it. Since these pictures come to the eyes so rapidly there is always the image of the preceding picture left on the retina. Hence the pictures appear continuous and seem to move. Light is cut off from the screen while each picture is being moved into place. Color effects are obtained by passing the light through tinted screens or by coloring the film.

With the establishment of non-combustible films and the simplification of the moving picture machine, schools, social clubs, and even homes, are bound to be equipped with moving picture apparatus. They may be used to demonstrate scientific experiments or discoveries that are almost impossible to produce in the laboratory because of the length of time involved in preparation; the development of living plants and animals, for example, can be shown by moving pictures with the aid of animated labels, a trick device by means of which names or descriptions of the parts are then run into the picture. Much educational work can be made of such pictures. The "movies" can be used to make geography and history and science more real and interesting. How much more our Shakespearean plays mean to us after we have seen the characters on the screen than when we have only read the play; and when we think of the amusement afforded millions of people we are glad that the "movies" have come to stay. We should, however, use our influence to have only the better class of pictures shown in our community.

Religious and moral education. — Religion has played a prominent part in the history of the world. The desire to spread religion led the French and Spanish missionaries to establish missions after they had colonized. The Puritans came to Massachusetts Bay to enjoy freedom of religious worship. Our Constitution says, "Congress shall make no laws respecting the establishment of religion or the free exercise thereof," so, as our country grew it became part of the belief of its citizens that church and state should be separate and that freedom of worship should be enjoyed here. For that reason perhaps, this country of ours has become the haven of every persecuted sect under the sun, and religious tolerance is exercised here as nowhere else in the world.

Methods of giving religious instruction. — There are about fifteen million Catholics and thirty million Protestants in this country with several million Jews and other religious bodies. It is evident from these figures that not all the people are members of church denominations, but most of our people believe in some sort of religious or moral instruction for children. Such instruction can be obtained and is given in the Sunday schools, but many people think the school is the place for this instruction. This point has been much debated among educators. Leaders of some types of public schools, the so-called "Gary Schools," have made provision for religious teaching part of each day by priest, minister, or rabbi. Many private schools exist in which religion is taught. Just how the matter of teaching religion will be settled is not easy to determine at the present time.

Moral instruction. — Since the welfare of any community is directly concerned with the morals in that community, no one can object to moral instruction in the schools. We should all believe in the law "Do unto your neighbor as you would like him to do unto you" rather than the often substituted one, "Do your neighbor or he will do you." A community where the Golden Rule is practiced is surely better off than one where tricksters and shysters make people suspicious of each other. A certain amount of competition is good if honest and above board. Honest practices in politics and daily life may go far towards teaching young people to live straight and look down on dirty practices in the home, in business, and in politics. Moral teaching does not only this but it also shows up selfishness and greed on the part of individuals and corporations. On the other hand, it makes the employee recognize the rights of the employer. It shows that life, if it is to be worth while, is made up of "give and take" with honesty and coöperation as the corner stones. In our anxiety to remove sectarian religious instruction from our public schools we have forgotten moral instruction and its great value. The leaders in every community should get together and add to their system of instruction such moral truths as are generally acceptable to all citizens.

Aids to moral education. — The World War has taught the value of welfare agencies such as the Y. M. C. A., the Y. W. C. A., the Knights of Columbus, the Salvation Army, settlement houses, and other private societies in promoting better moral and physical conditions among the young men and women of our nation. After all, the best way to teach good morals is by example. If the men and women who represent the welfare organizations live lives that shine in contrast to those around them, if they show unselfishness and courage, sympathy or coöperation in helping others, then the problem of better morals in the community is partly solved. How much better is the pleasant sociability of the club house of this sort than the dance hall or the pool room. Prohibition has placed new responsibilities on these welfare agencies. They must work out a substitute for the saloon and give the community a poor man's club house. Have the welfare agencies in your town awakened to their responsibility?

The score card. — This score card ought to be made the basis of a class discussion after different members of the class have visited and scored the parts of their own community in which they live. By taking these individual opinions from parts of the community, we can, after weighing all the evidence, make a card which will be a fair estimate of the entire community. After the scoring is done, let each one of you think over the particular advantages the community offers which you most need. Are you making the best use of your time as regards these opportunities?

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SCORE CARD. INTELLECTUAL, RELIGIOUS, SOCIAL, AND PHYSICAL ADVANTAGES OF THE COMMUNITY

	Perfect Score	My Score
Intellectual Betterment: Schools Elementary schools within 5 minutes from home (5); 15 minutes (4); too far to walk; free transportation (3); no free transportation (1) Secondary schools within 15 minutes' walk home (5); within 30 min. (4); too far to walk; free transportation (3); no free transportation (1) Classical, technical, commercial, and vocational schools (5). Take off 1 for each type of school not represented Summer schools for time saving and failures (2) Special schools for defectives (2); out-of-door school for tubercular children (2); school nurse (2); school clinics (2) College, technical, or normal schools in city (5); within commuting distance (4); over thirty miles distant (1) Free library system, with branches in schools (5); without branches in schools (4); pay library (1)	35	
Intellectual Betterment: Other Sources Museums, — art, natural history, and historical, all free and well patronized (6); having pay days (5); never free (3) Free lecture and music courses (2) Free municipal band concerts (2)	10	
Religious and Social Betterment Churches, many (5); fair number (4); few (3) Churches active in civic affairs (5); not active (0) Boy scouts (5); camp fire girls (5); other clubs active (2); not active (0) Y. M. C. A., Y. W. C. A., and other welfare organizations, active and well housed (5); poorly housed (3); inactive (1) Settlement houses and community centers (5); one lacking (3); none (0)	30	
Physical Betterment Public parks with baseball fields, golf links, boating, tennis courts, other sports (5). Take off 1 for each sport lacking Public playgrounds under supervision at all times (5); part time (3) Public playgrounds equipped with basket-ball courts, running track, gymnasium, wading pool, swings, sandbox for children (5). Take off ½ for each point lacking Public baths and bath houses free (3); small fee (2) Good movie theater (2); good theaters (2) Recreation centers for dances under supervision (3)	25	
TOTAL	100	

PART V. TRANSPORTATION AND COMMUNICATION

CHAPTER XIX

GOOD ROADS

Problems. — 1. *To learn something about the history of roads.*

2. *To learn the need of good roads.*

3. *To understand how a load is most easily moved.*

4. *To learn about different road materials.*

5. *To understand the advantage that good roads are to a community.*

Experiments. — 1. To compare rolling with sliding friction.

2. To explain inertia.

3. To illustrate the advantage of large wheels for rough and sandy roads.

4. To show the effect of different grades.

Project I. — TO INVESTIGATE AND REPORT ON THE ROADS OF MY TOWN.

Kinds of roads (based on material). What kind of traffic is most common on each. Cost of building. Cost of maintenance. How kept in repair. How dust is taken care of. What improvements seem advisable.

Project II. — A STUDY OF THE ADVANTAGE IMPROVED ROADS WOULD BE TO MY CITY OR TOWN.

The history of road building. — Road building is not a new art, for it has been practiced over four thousand years on the earth. The Romans were the greatest road builders of ancient times, and some of their highways paved with huge flat stones are in use at the present time. After the fall of Rome, very few roads of importance were built in Europe for several centuries. It was not until 1776 that France began an elaborate system of road building, completing in fifteen years fifteen thousand miles of broken stone roads, many of which were used for military purposes. About 1815 Telford and McAdam in England became known through their use of broken stone in road building. Our own macadam roads are built after the plans used by these men. Roads in Europe are much more numerous, and, as a rule, better built, than those in this country, and have proved their value in the World War as a means of transportation for tens of thousands of motor trucks and other vehicles used in transporting the great armies.

The Appian Way. An ancient Roman road, still in good condition.

Early American roads. — The earlier roads in America were built largely to help settle new territory and to aid the traders and farmers in exchanging their goods. The first roads followed rivers or kept close to the seaboard.

Then came the development of post roads, for soon after the close of the Revolutionary War there were 75 post offices and over 2000 miles of post roads. Bridges were of flimsy construction and built only over small rivers, the larger ones being crossed by ferries. It is interesting to know that the main wagon roads first built toward the West, and the railroads afterward, followed the old buffalo paths over the mountains. For example, in general, the routes now followed by the Baltimore and Ohio R. R. and Pennsylvania R. R. through the Alleghanies were originally broad buffalo paths.

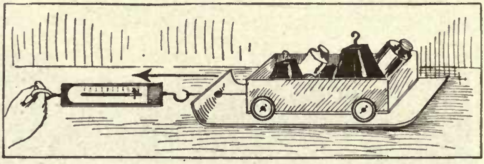
When in the beginning of the nineteenth century it was proposed that the United States Government should build a national road from the Atlantic to the Mississippi River, there was much opposition to the scheme, on the ground that thousands of men engaged in carrying people on horseback would be thrown out of employment. This short-sighted policy, however, did not prevail, and in 1806 Congress authorized a national road, which was completed about 1838. Soon after this, railroads came into existence, and as commodities could be carried for long distances more advantageously on them than on roads, the latter soon became largely local, centering around railroad stations and towns. This condition continued until the automobile began to be widely used. People soon found that in order to get the best use from these new machines they must have smooth and well-made roads, so state and county taxes have been levied on the owners of automobiles, so that, with their assistance, a splendid system of roads is coming into existence in all parts of the United States. Several great national highways are already projected and have been partly completed, and we shall

Lincoln Highway, a transcontinental automobile road.

soon see this country vying with Europe in the number and condition of its roads.

Necessity of good roads. — Have you ever thought that the rural mail carriers in this country travel over a million miles of road every day in order to carry news, messages, and supplies to people who, a few years ago, were cut off from the outside world? These mail carriers travel over some of the poorest roads in our country, in districts where agriculture is often the only industry. The farmer, however, must have good roads in order to market his crops and become a better citizen through contact with other people. Good roads will do more toward making this nation a unit in thought and in patriotism than almost any other one factor.

Why does the smooth road save work? To lift a weight requires work or energy. Every time a wheel is pulled out of a hole or rut, or every time it goes over a bump, a part of the load borne by that wheel is unnecessarily lifted, and work is wasted. This kind of work is continually being done on rough roads, and requires so much more power that a horse or an automobile is able to carry but half the load that would be possible on firm and smooth roads.



Experiment. — To compare rolling with sliding friction.

Materials: Small spring balance. Small wheel cart. Piece of heavy pape somewhat larger than the cart.

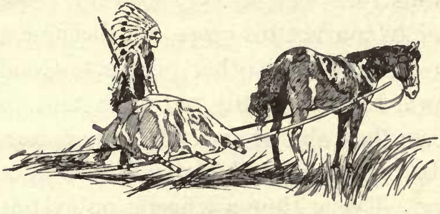
Method: (1) Place the cart on the heavy paper. Connect both the paper and the cart by a string to the spring balance, in such a way that both cart and paper will be pulled together. Hold the balance horizontally so that the bar will not bind on the sides. Drag them over the surface of the table.

(2) Place the heavy paper in the cart. Connect the hook of the spring balance by a string to the cart. Draw it over the table. This time the wheels turn.

Results and Conclusion: In each of the two above cases note the reading of the balance scale when the load starts to move and again when it is under way and moving steadily. Tabulate the results.

Draw a conclusion from a study of the results.

Use of wheels. — A good many years ago in this country, Indians moved their loads about on a kind of vehicle made of two long saplings, the ends of which dragged on the ground and held the load. To-day we use wheels under our load. The use of rolling friction instead of sliding friction marks a great advance in moving loads. If we had a small cube of wood and a small wooden



Drawing a load on two saplings.

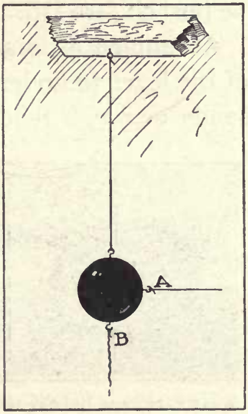
ball placed side by side on the table, and struck them each a blow of equal force, we know which one would go farther. A ball has less surface touching the table, and therefore there is less friction to overcome when it moves. In this same way the wheel cart has much less friction to overcome than the stone drag or the ox sled.

Experiment. — To explain inertia.

Materials: A 5 to 7 pound weight. Thread capable of holding a 10-pound pull.

Method: (1) Suspend the weight by a thread. Connect a thread at the side *A*. Pull on this thread gently and slowly until the weight has been displaced several inches. Now bring the weight to rest. With a quick jerk, pull on the string. Is the weight moved as before? Why does the string break?

(2) With the weight suspended as before. (*a*) Pull with a quick jerk downward on a thread attached under the weight, at *B*. (*b*) Attach the thread again and pull downward with a slow, steady pull. Why does the thread break below the weight in (*a*) and above the weight in (*b*)?

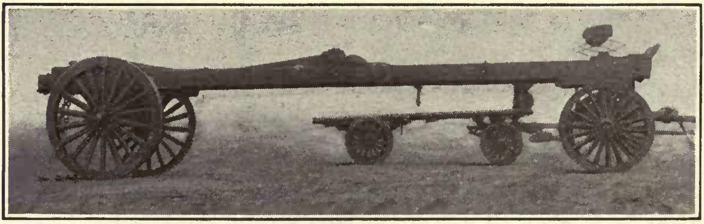


Conclusions: Sum up the conclusions drawn in each part of this experiment and explain inertia of rest, which is defined as the tendency of a body at rest to remain at rest.

Drawing a load. — Do you ever wonder why it is harder to start a wagon than to move it after it is started? It requires from two to eight times as much force to start a load as it does to keep it in motion after it is started. This is due to what we call *inertia*, or that tendency of a body at rest to remain at rest, or of a body in motion to continue in motion. We have all tried to stop a heavily loaded wagon and also to start it. Extra force is required to overcome inertia, to raise a load from holes in the road bed, and to increase the speed of the vehicle. All three taken together explain why so much more force must be used to start than to keep a load moving.

How a load is moved. — If a load is drawn by hand it is the friction between your shoes and the pavement that makes it possible for you to get a " grip " and move the load. In the same way the friction between the horseshoes and the pavement and the direct pull against the projecting parts of the wagon make it possible for the horses to move the vehicle forward. In the automobile where the power is inside the car, friction between the tires and the road surface is depended upon to move the car. As the tire revolves, it pushes back on the road, at the same time giving a forward thrust to the car axle, and since the road cannot be pushed back, the car must be pushed forward.

Advantage of large wheels. — We have learned enough of the lever to understand why a large wheel is better on a sandy or rough road than a small one. Greater diameter



What advantage has the truck with large wheels over the one with small wheels?

of the wheel gives greater leverage, thus requiring less force to move the wheel. Wheels of large diameter do less damage to a road because they revolve more slowly and pick up less of the material from the road. However, wheels for vehicles drawn by horses must not be so large that the traces attached to the horse are inclined downward, for then part of their power will be lost in pressing the wheels against the ground. Can you explain this by means of a diagram?

Experiment. — To illustrate the advantage of large wheels for rough and sandy roads.

Materials: Spring balance. Two small carts, one with wheels of large diameter, the other with wheels of small diameter. A long box of dry sand. Weights.

Method: Measure with the spring balance the force required to draw each of these carts, loaded heavily and equally, over the sand.

Conclusion: From the average results of three trials draw a conclusion.

Experiment. — To show the effect of different grades.

Materials: The small cart used in the experiment, page 298. A board 3 feet long. Blocks to elevate one end of the board. Spring balance.

Method: Find the force necessary to draw the cart in each of four cases.

1. Horizontally
2. When rise is 1 inch in 10 inches (10% grade)
3. When rise is 2 inches in 10 inches (20% grade)
4. When rise is 3 inches in 10 inches (30% grade)

Results and Conclusion: Record the results in a neat table. Draw conclusion and apply it to a practical situation.

Resistance due to grade. — If we think over the problem of the inclined plane, we can see why it is that a steep grade offers more resistance than a gradual one. We are lifting against gravity. If the road rises one foot in one hundred, the resistance is twenty pounds per ton, but if it is one foot in twenty feet, the gravity resistance amounts to one hundred pounds per ton of load. We thus see that a steep grade is bad in any road, especially as the smooth surface of a road offers little foothold to horses. Where steep grades are necessary and much hauling is done, the hill should be paved with stone-block,

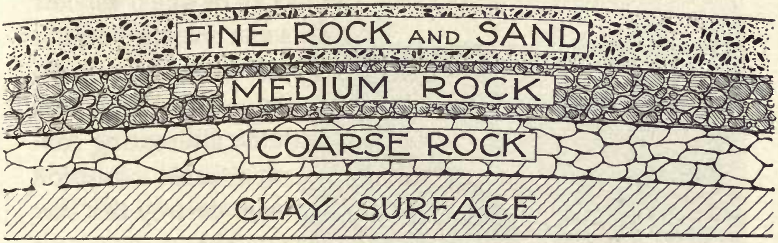
Observe the steep road partly hidden by trees in the upper picture and the gentle grade of the road in the lower picture.

or brick, so as to give the horses a foothold. The following table[1] gives the amount of load (in pounds) horses can take on different pavements of different grades.

Surface	Level	Grade 5%	Grade 10%
	Pounds	Pounds	Pounds
Asphalt	13216	——	——
Broken stone, best condition	6700	1840	1060
Broken stone, slightly muddy	4700	1500	1000
Broken stone, ruts and mud	3000	1390	890
Earth, best condition	3600	1500	930
Earth, average condition	1400	900	660
Stone-block pavements, dry and clean	8300	1920	1090
Stone-block pavements, muddy	6250	1800	1040
Sand, wet	1500	625	390
Sand, dry	1087	445	217

[1] Table from Highway Construction, Byrne, Am. Tech. Soc.

Road making. — In this country, the method of Telford and McAdam is used most commonly in making roads.

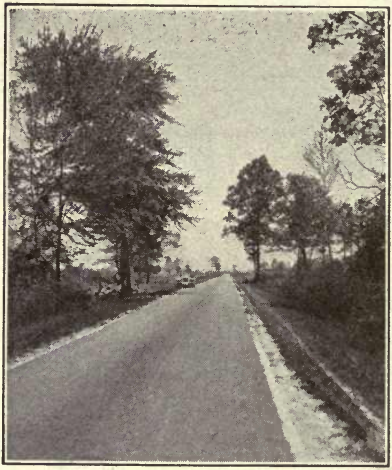


Cross-section of macadam road.

First, the road is excavated to a depth of two or three feet, and several layers of large stones are placed at the bottom of the excavation. These are covered by other layers of smaller stone, and still smaller on these, the particles becoming finer as they come toward the surface, until the surface of the road is made of a fine stone dust. The road is then covered with asphalt or tar, or bituminous material as the binder. This sticky material running in between the stones holds them in place. The road is a little higher in the middle than on the sides for the purpose of drainage.

Other road building materials. — In cities where there is much hauling of loads by horses, cobblestones of granite or sandstone, vitrified brick, or wood blocks are used. Brick makes a good paving for both level and hilly roads, is durable, and resists the action of water and frost. Wood blocks have to be treated with creosote in order to protect them from decay. They are laid on a concrete or cement foundation and bound together with tar. They are comparatively noiseless, and are excellent for use in city streets.

Use of concrete. — In late years a number of our best roads are being made of concrete. They are made in huge blocks with a little area between the blocks in which asphalt or some expansive filler is placed so that the action of frost and heat with the alternating contraction and expansion will not destroy the surface. These roads, if built deep enough, are practically indestructible, and thus cheaper in the end than almost any other kind of road.



A concrete road.

What is the best road surface to have? — This question would be answered best by determining the use of the road and the place where the pavement is laid. Granite block is most durable for heavy loads, but is the most noisy. Brick is less rough and less noisy, but goes to pieces under heavy traffic. Wood blocks are pleasing in appearance, and quiet, but slippery in wet weather, and difficult to keep clean. Asphalt cracks in severe cold and becomes soft and wavy under extreme heat. Macadam gives a good foothold to horses, and is a good appearing road, but needs constant attention to keep it in repair. Concrete and cement are pleasing in appearance, durable, and probably best for general traffic, though they give little foothold for horses up grade.

An interesting project would be a study of the roads of your community with respect to their efficiency, durability, and usefulness for the purposes for which they are used. Find out how many different kinds of roads there are, and the reasons why these roads were built in these particular places.

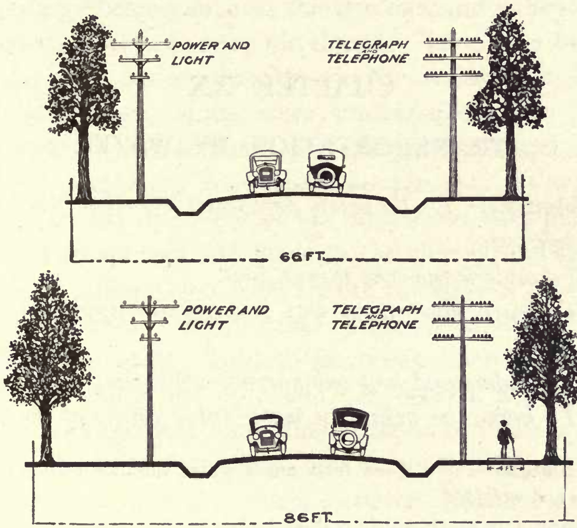
Result of water action on a road. The road might have been saved by small repairs made earlier.

Destruction of roads by traffic. — When an automobile or other wheeled vehicle goes rapidly over a road, a partial vacuum is produced behind the wheels, which have a tendency to pull up materials from the road bed. The rush of air into the partial vacuum carries small loose particles which have been displaced by the tires of automobiles or hoofs of horses. This continual withdrawal of dust and other small particles finally loosens large fragments, and so a road with its surface full of holes is produced. Cement or block pavement obviates this difficulty to a large extent.

Dust in the community. — One of the evils a community must fight is dust. We have all seen street cleaners in a large community, but in a small place we do not always have street cleaners and street cleaning machines, therefore we must have other means of getting rid of dust. Sometimes we have sprinkling carts, or the hose from the hydrant is played on the street. Sometimes oil or a mixture of tar and oil is sprayed over the road. This keeps down the dust, but comes into our houses on our shoes, and gets on our clothes. It is far better for a community to have the road surfaces covered with asphalt, bitumen, or concrete.

How roads may beautify our community. — No town nowadays should be allowed to grow in a haphazard way. It should be planned, the main business streets being made wide enough for future growth, and trees and shrubs should be put out in abundance. The principal commercial street should be at least eighty feet wide, with sidewalks having a width of twenty feet. In the residential districts we should have streets at least forty feet in width, with ten-foot sidewalks. Boston has only 26 per cent of its area devoted to streets, while Duluth, Minnesota, has 33 per cent. We should have some winding streets, as these tend to break up the monotony of streets running at right angles. Parks should be planned, and plenty of small squares. The city of Washington has numerous circles with broad avenues running diagonally to the main street of the city, giving it a most pleasing appearance, for one is constantly coming to small parks in passing from one part of the city to another.

City planning. — Most modern cities are planned with an eye to future growth. Boston and other old New England towns have grown up with no idea of future development, while cities like Philadelphia and Washington were planned from the very beginning. The beauty of a city is a very practical asset and most cities have come to realize this. Streets are built with provision for wide sidewalks and shade trees. The laying out of boulevards and drives to take advantage of natural scenery, as well as the planning of roads to facilitate business, is an important part of a city planning board's duties. Old cities are helped in many cases by a vigorous program of street widening. This usually necessitates the removal of many old buildings, but improvement often demands drastic action.



Trees are frequently injured and eventually destroyed in making room for electric wires and poles along narrow streets.

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CHAPTER XX

TRANSPORTATION BY WATER

Problems. — 1. *To learn how water transportation began and developed.*

2. *To understand why things float.*

3. *To learn how steam was successfully applied to drive boats.*

4. *To understand how submarines are managed.*

5. *To know the principal water trade routes of the world.*

Experiments. — 1. To see how much water floating bodies displace (volume and weight).

2. To see how much weight sinking bodies lose in water.

3. To explain center of gravity and center of buoyancy.

4. To show how the submarine may rise and sink in water. (Cartesian diver.)

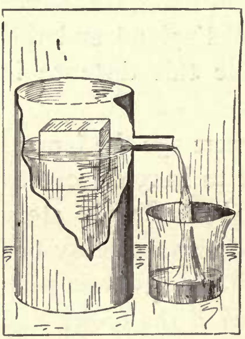
Project I. — To become a skilled motor boat operator. One must understand the principles of the engine, propeller, rudder, flotation: the care of engine and of the boat in water and out of water.

Project II. — To become expert in handling a sail boat or ice boat.

Project III. — To make a toy sail boat, power boat, submarine or periscope.

Development of water transportation. — Long after the land was used as a means of transportation, primitive man must have developed the idea of going over streams or bodies of water on logs or other floating objects. It was a long step to the hewing down of the tree and cutting a canoe out of a hollow log, and still a longer period elapsed before large vessels such as the triremes and galleys of the Romans and Greeks were developed. Then men began to use the wind for locomotion on the water, but he still used oars when winds were unavailable. The Middle Ages saw the development of sailing vessels and Spain's and then England's supremacy on the sea. It was centuries after the discovery of the new world that the application of steam was first made in the clumsy inventions of Fitch and others who used steam to move a number of oars or paddles. Then came Fulton's triumph with a paddle-wheel boat. To-day the ocean liner is moved by turbines turning one or even four screws which propel vessels over 900 feet long, displacing 60,000 tons of water. One hundred and fifty years ago a month was considered good time on a sailing vessel between England and this country. To-day our best liners make this distance in about five days.

Why things float. — A great many years ago the famous old mathematician, Archimedes, is said to have discovered the significance of what we now call *density.* The story goes that King Hiero of Sicily had a crown made by one of his goldsmiths which he suspected did not contain pure gold. He asked Archimedes to discover if the crown had been made of mixed metals, but would not allow him to bore into it or mar it in any way to find out. The philosopher, while taking a bath one day, noticed that his body displaced a certain amount of water, and seemed to be buoyed up by it. He was so impressed by this that he applied the idea to the crown, and thinking that he had found the solution of his problem, he rushed, philosopher-like, from his bath without thinking of clothes, and ran down the street crying, " Eureka! Eureka! " which means, " I have found it! I have found it! " He had really found the solution of his problem. By weighing the crown in the air, then in water, he found how much it lost when weighed in water. This loss was due to the buoyancy of the water and was equal to the weight of water displaced. The volume of the water displaced was of course the volume of the crown. The weight divided by its volume gave its density, since density is the weight of a unit volume. The density of pure gold being known it was an easy matter to compare the density of the crown with that of pure gold and so detect any fraud of mixing lighter metals with the very heavy metal gold. The principle of buoyancy thus discovered is stated, " A body immersed or floating in a fluid is buoyed up with a force equal to the weight of the fluid displaced."



Experiment. — To see how much water a floating body displaces (volume and weight).

Materials: Overflow can and catch bucket. Spring balance. A floating block of wood. Thread.

Method: Fill the overflow can until some water runs out the spout. When all has stopped running out, weigh the empty catch bucket and place it under the spout. Weigh the dry block. Lower the block into the can. Weigh the bucket and water which was displaced by the block.

Result: How much water did the block displace? Compare this with the weight of the block. Does the same relation hold in trials with other floating bodies?

Conclusion: What do you conclude is the weight of water displaced by a floating body, stated in general terms? Does a floating body displace its own volume of water?

Application: What is meant by the *displacement* of a ship?

Experiment. — To see how much weight sinking bodies lose in water.

Materials: Overflow can. Catch bucket. Spring balance. A solid glass stopper. A rock. Thread.

Method: Weigh the glass stopper in air. Fill overflow can to the proper level. Suspend glass stopper by thread in water in the overflow can catching the overflow and at the same time weighing the stopper. Find weight of the water displaced and the loss of weight of the stopper. Repeat the experiment with the rock in place of the stopper.

Result and Conclusion: Compare the loss of weight of the body when weighed in water with the weight of the water displaced. What do you conclude?

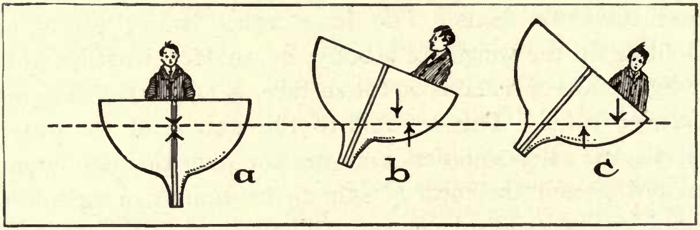
Note: Knowing that the volume of water displaced equals the volume of the immersed body, s ggest a way for finding the volume of an irregularly shaped body.

Buoyancy. — When we say a substance is *buoyant* we simply mean that it is lighter than the same bulk of water, and therefore floats. The force which water exerts in holding up the weight of a body, no matter whether this weight sinks or remains on the surface, is called the *buoyant force* of water. This is equal to the weight of the water displaced. Boat builders knowing the densities of different materials and the form of ship to be built can calculate quite easily its displacement. The following table shows the densities of some common substances.

Substances	Density Pounds per cubic foot	Relative Density Specific gravity	Substances	Density Pounds per cubic foot	Relative Density Specific gravity
Water	62.5	1.	Glass	162	2.6
Cork	15	.25	Aluminum	166	2.65
Cedar	35	.4	Iron	470	7.5
Pine	29	.5	Lead	710	11.4
Oak	53	.8	Gold	1205	19.3

Stability. — We all know the danger of being careless in a canoe or a narrow row boat, for if we go too far on one side and raise the body too high above the surface of the water, we may suddenly find ourselves in the water with an upset canoe or boat. The reason for this is that we have changed the positions of both the *center of gravity* and the *center of buoyancy.* The center of gravity of a body is a point in that body about which the entire mass seems to be centered. The center of buoyancy is the center of mass of that part of the boat which is below the water line or it is the center of the space from which water is displaced.

When a person sits close to one side of a boat that side sinks deeper into the water and the center of buoyancy is shifted toward that side. The center of gravity of the



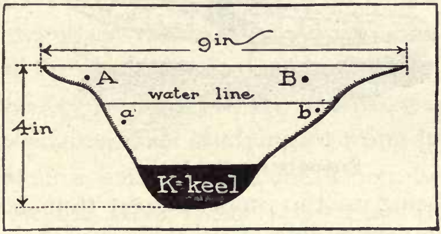
The lower arrow represents buoyant force, the upper arrow, gravity force. In *a* these are in the same vertical line and the boat is in stable equilibrium. In *b* and *c*, the boat is shown in unstable equilibrium. What will be the next movement of the boat in *b*? in *c*?

person and boat also moves toward the side. If the new center of gravity is between the new center of buoyancy and the keel, the boat will become stable, but if it is between the center and the side of the boat it will upset. (See diagram.) A high center of gravity will cause an upset quicker than a low center of gravity. Can you tell why? Boat builders in order to keep the center of gravity low add a keel weighted with lead, take on a heavy load of ballast, or fill tanks with water close to the bottom of the boat.

Experiment. — To explain center of gravity and center of buoyancy.

Materials: A piece of heavy cardboard or thin board cut in the shape of figure in accompanying diagram. A large pin. A plumb line. Shears. Gummed paper. A piece of lead.

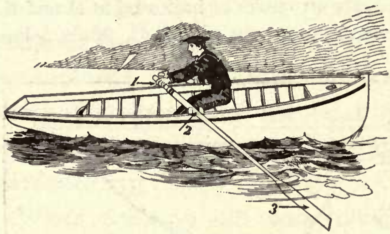
Method: (1) *Center of gravity.* Make two holes as indicated at *A* and *B*. Support the cardboard and plumb line on the pin at *A*. Make a line across the cardboard to coincide with the plumb line. The center of gravity must be some point in this line. Repeat, using *B* as the point of support. The center of gravity must be in this second line determined by the plumb line. Can you mark the point which represents the center of gravity? Label it *G*1. Attach a piece of lead to *K* to represent a heavy keel. Find the center of gravity as before. Label it *G*2.



(2) *Center of buoyancy.* Draw a line across the cardboard to represent the water line. (See figure.) Cut the cardboard on this line. The lower portion represents that part of the boat under water. The center of gravity of that portion of a body immersed in water is the *center of buoyancy.* Find the center of gravity (center of buoyancy) of this portion without the lead as in (1), label this *B*1. Use *a* and *b* as points of support. Attach the lead to the keel and repeat, label the center of gravity (center of buoyancy), *B*2.

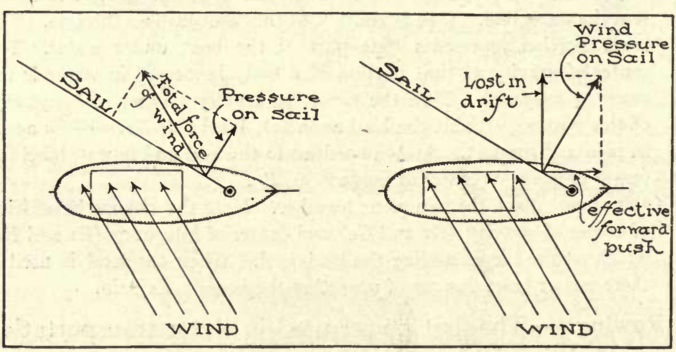
Application: Place the two parts together. Note the change in position of center of gravity (*G*1 and *G*2) and center of buoyancy (*B*1 and *B*2) which resulted from adding the lead keel. When the lead is used is there less or more danger of upsetting the boat? Explain.

Rowing. — The first power used in water transportation was probably a pole. Then came the paddle. We all have read of the wonderful skill of the North American Indian with his light birch bark canoe. But the paddle would not do for heavy loads. Here came the use of oars, an oar being used as a lever, applied at the oarlock to the weight to be moved, while the blade of the oar acted as a fulcrum. A stroke against the water would pull the boat forward a little and the oar would be lifted from the water, sent back through the air where there was little resistance, and again another pull would bring the boat forward.



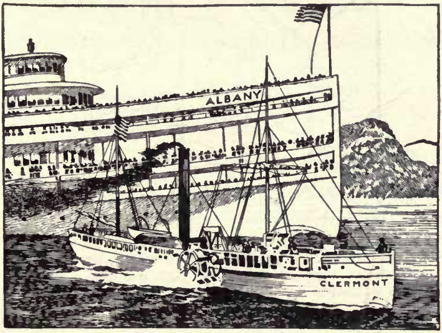
Explain lever action here.

Sailing. — The boats in ancient times were always provided with oars, sometimes as many as three rows of slaves being used to propel a great Roman trireme. But with an understanding of the laws of physics came the use of sails. When the wind meets a sail at right angles its full force tends to move it. When the angle between the wind and sail is oblique a part of the wind spills over the side so that



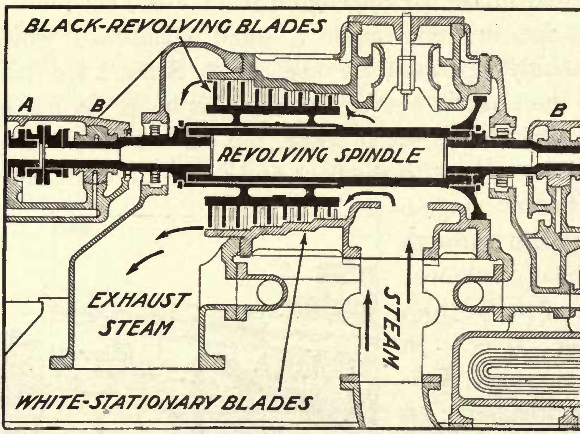
only a portion of the force of the wind is effective in moving the boat. The law which applies to this is known as the *law of the resolution of forces*. This will be explained to you in a future course in physics. By shifting the sail and letting the wind work on one side and then on the other and thus make a zigzag course it is possible to sail against the wind. This is known as "tacking."

Use of steam. — In the latter part of the eighteenth century, men began to experiment with steam as a motive power for boats. A man named Fitch rigged up paddles along the sides of a small boat and by means of an engine drove it through the water at the rate of seven and one-half miles an hour, but it was the good fortune of Robert Fulton to make the first serviceable steamboat. He had become interested in the steam engine while studying painting in Paris, and in 1803 made a small steamboat which he successfully operated on the River Seine. He tried to enlist the interest of Napoleon in this boat. A committee was appointed to see it work, but on the morning of the trial, Fulton went to the boat and found to his dismay that the heavy engine had broken through the boat and was lying on the bottom of the river. In 1806, however, Fulton purchased an engine in England, built his boat on the Hudson, and announced that on a certain day it would begin its trip to Albany. Crowds of people lined the wharves and the river banks, most of them expecting that the trial would fail, but when they saw the *Clermont*, as it was called, move out under perfect control of the engineer, they realized that a new epoch had begun in transportation



The *Clermont* compared with the Hudson River boats of to-day.

on water. The boat made a successful trip to Albany in thirty-two hours, while the ordinary sailing vessels took about four days. Rapid development of the steamship followed, so that by 1858 we had a record breaking ship for size in the *Great Eastern*, a boat 692 feet long, 83 feet wide, and 58 feet deep. She was driven by paddle wheels and propellers, and rendered great service in laying the first transatlantic submarine cable. Unfortunately she was so far in advance of her time that she was not a success

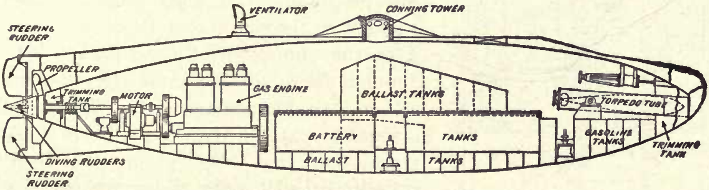


The stationary and revolving blades are so arranged that the force of the steam causes the inner blades and spindle to which they are attached to revolve. This revolving spindle is supported by bearings *BB* and the axle of a machine operated by the turbine attached at *A*.

commercially. At the time of the Civil War, iron came into use in the making of ships' hulls, and now as we know, steel has come into extensive use and even concrete is being used. The modern greyhounds, such as the *Aquitania*, the *Lusitania* of unfortunate fame, and the *Olympic*, the latter 890 feet in length, give one some idea of modern transportation in water. They have two, three, or four screw propellers, thus enabling more rapid turning in a limited area. The steam engine, too, has taken wonderful strides. The latest type is the so-called steam turbine, which was first used by Sir Charles Parsons in 1897. With this type of engine, a speed of forty miles an hour is obtainable as against twenty-five or thirty miles with an ordinary steam engine. One serious disadvantage of the turbine is the fact that it cannot be reversed, so that separate turbines have to be made for reversing the ship.

Electricity as a motive power. — One interesting development which is being applied to our latest battleships is the attachment of the turbine to electric generators, these generators being used to drive motors which turn propellers. Reversal of the electric motors does not interfere with the working of the turbine, and very rapid manipulation of a ship is thus obtained.

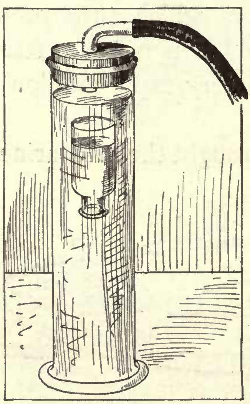
The submarine. — The World War brought the submarine



Section of Holland submarine.

into notoriety, and caused its rapid development. A submarine is made so that its weight is a little less than the weight of its own volume of water. Along the sides are numerous air-tight tanks. Water is admitted to these tanks and forced from them by the use of compressed air. In this way the boat may be made to sink to any depth and come to surface again. By use of horizontal rudders the boat can be made to dive or come up, depending on the way in which the rudder is operated. When on the surface, the submarine usually employs a Diesel oil engine. During this time it generates electricity for a large number of storage batteries. When under water it moves by means of the power stored in these cells. The storage batteries also furnish current for lighting. Some of the German submarines captured in the late war were over 300 feet long, and submarines planned for our navy before the Disarmament Conference was called were to be even longer than this.

Experiment. — To show how the submarine may rise and sink in water.

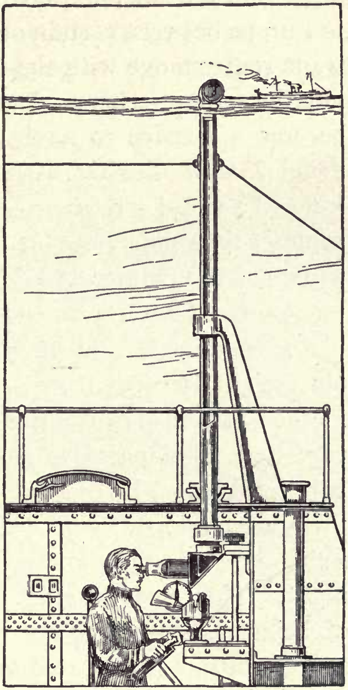


Materials: A glass cylinder fitted with a 1-hole stopper. Glass and rubber tubing. A pill vial.

Method and Result: Pass a 3-inch length of glass tubing through the stopper. Attach rubber tubing to the glass tube. Fill the cylinder nearly full of water. Fill the vial $\frac{1}{3}$ full of water and drop it mouth downward into the water. If it sinks, remove enough water from the vial so that it will just float. Close the cylinder with the stopper and blow through the tube. If the vial does not sink add a little more water to it. Change the amount of water in the vial until it is so adjusted that upon blowing into the closed cylinder the vial sinks and upon releasing the pressure it rises. Watch carefully the change in water space and air space in the vial. Account for the sinking and rising.

Application: Explain one way for making a submarine sink or rise in water.

The periscope. — Another invention which made the submarine the dangerous menace that it was is the *periscope.* A study of the diagram will show how this periscope could be used. Light from objects on the surface is transmitted through this instrument by an arrangement of lenses and mirrors, so that the person at the wheel of a submarine can see all that is taking place about him, and the torpedo can be directed toward its mark.



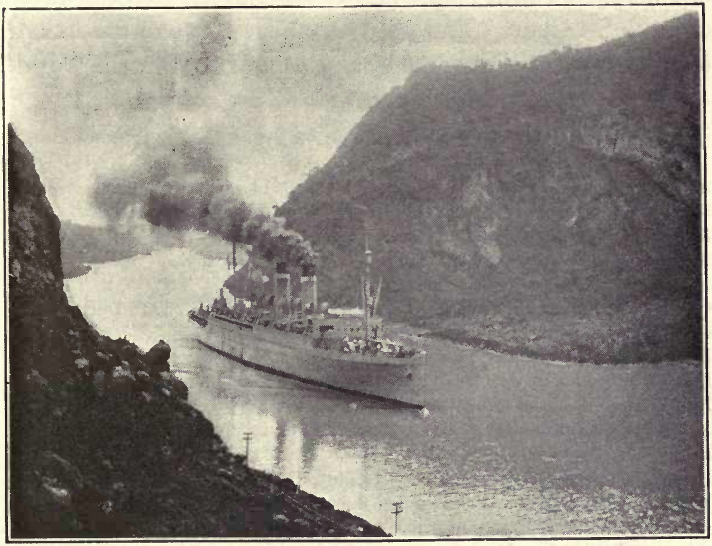
The periscope is the eye of the submarine. Explain.

Ocean trade routes. — A study of a trade route map shows that the principal trade routes on the Atlantic Ocean run from England or continental ports chiefly to New York, but some to Boston and Canadian ports. Other routes extend to South America around Cape Horn and the Cape of Good Hope, while in the Pacific Ocean the chief trade routes are from San Francisco to Japan, Australia, and New Zealand, and to the East Indies and Philippine ports. The opening of the Panama Canal with its enormous locks and electric towing system has made important changes in trade routes from Atlantic to Pacific ports. Much time is saved, especially from England to San Francisco, Japan, and Australia.

Seasonal changes in trade routes. — Since the ocean is free to the world the main routes of travel are fixed by international agreement, and especially in the North Atlantic Ocean where many ships pass, these routes serve as double tracks on a railway. All boats moving from Europe to American ports are required to keep between certain degrees of latitude, and boats moving from American ports to Europe between certain other degrees of latitude. These trade routes move with the seasons, for during the summer months great icebergs float down from Greenland and become a menace to navigation. We still remember the awful *Titanic* disaster where nearly a thousand lives were lost. To avoid a recurrence of such a catastrophe, in the summer time ships pass far to the south of Newfoundland, while in the winter they take a much shorter course, passing by the southern end of that island.

Government aids in navigation. — Since a great part of our freight is carried on water, because this is a cheaper method of transportation, governments have come to take care that all dangers to navigation are carefully charted and marked. These marks are called buoys. Some of them are equipped with whistles to warn one of danger; some mark channels and are often provided with lights at night. Then we have great lighthouses with lights capable of being seen from thirty to forty miles distant. Life saving stations are located on dangerous parts of our coast and during a storm men constantly patrol the shore so as to render quick aid in case of a wreck.

Canals as waterways. — In early days before the railroads, rivers were of much importance as a means of transportation. Then came a period roughly from 1820 to 1840 when canals were built in great numbers, over 4468 miles being ultimately built. Most of these canals, however, were destined to failure when the railroads entered competition with them. The Erie Canal with its 363 miles of waterway, the Chesapeake and Ohio Canal, and a few others are still in existence. Of much importance is the more recent Barge Canal in New York state. This was completed in 1918 and has a capacity for boats several times the size of the canal boats used on the old Erie Canal. Our modern achievement in the digging of the Panama Canal is one which we can well afford to be proud of as a



The Panama Canal saves 8000 miles in a water trip from the Atlantic to the Pacific coast.

nation. One of the most notable undertakings of modern engineering is that of the Marseilles-Rhone Canal in France, where not only has the canal followed this river, but part of its route actually cuts through a range of mountains with a tunnel about 5 miles long and 77.5 feet wide by 47.5 feet high.

Inland waterways. — The development of North America has been greatly influenced by its splendid inland waterways. Not only have we several great river systems navigable for thousands of miles, but the chain of the Great Lakes forms a cheap and easy means of transport for ore and grain. In addition, Canada and the United States have built great canals with locks at the "Soo" and between Lake Erie and Ontario, and the United States has dredged a wide ship channel through the shallow waters of Lake St. Clair. The yearly tonnage through the "Soo" locks is greater than that in any other canal in the world.

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CHAPTER XXI

DEVELOPMENT OF LAND TRANSPORTATION

Problems. — 1. *To learn how development in transportation has changed our habits and customs.*

2. *To learn how the steam engine was developed.*

3. *To learn how the steam engine works.*

4. *To learn how the locomotive is operated.*

5. *To learn the value of electricity in transportation.*

6. *To understand the types and value of bridges.*

Experiments. — 1. To show the value of rails.

2. To see if steam can do work.

3. To see if the atmosphere can do work.

4. Demonstration of steam engine model.

Project I. — A STUDY OF LOCOMOTIVES.

1. Make a collection of pictures of locomotives. Compare for types.

2. Observe locomotives. Record facts. Observe number of drive wheels — number of cylinders — size of wheels. Engines used for what type of work?

3. Observe tender. Its use?

4. Compound engine. Principle?

5. How is the engine reversed?

6. Other facts and explanations.

Project II. — TO MAKE A MODEL STEAM ENGINE.

Project III. — A STUDY OF BRIDGES.

1. To make bridges, illustrating different types of construction. Use mechanical construction toys.

2. To find bridges in your vicinity of the different types — girder, truss, cantilever, arch, and suspension.

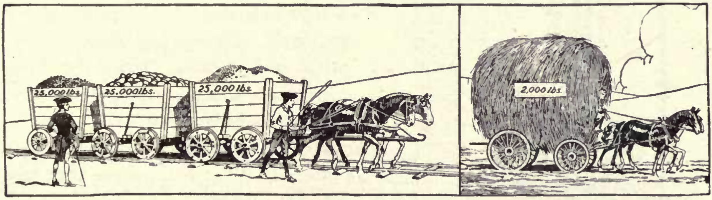
Early travel in America.—The earliest settlers in America had no way of travel except on foot. It was six years after Virginia was settled before the first horses, only nine of them, were brought from Europe. And it was a great many years later before roads began to take the place of trails.

Changes in transportation. — Two generations ago a New York business man who wished to go to Philadelphia had the choice of a hazardous boat trip or a tedious two days' journey by stage coach. To-day he travels in comfort in a little over two hours. In 1843 Marcus Whitman took five months to travel across the continent. To-day New York and San Francisco are less than five days apart by train, or two days by airplane. Our trains now run frequently a mile a minute, and our best expresses average fifty miles an hour including stops, while airplanes are built that can travel one hundred and fifty miles an hour.

Heading an advertising circular seventy years ago.

How we depend on transportation. — Our customs develop by transportation. Our early ancestors who lived in America had much more varied industries than we have to-day. Clothing, food, and even household utensils were made, either at home or in the near vicinity. To-day all is changed. We have become specialists. In farming, one man raises wheat, another corn, and another horses. One factory makes cotton cloth, another woolen cloth, and in the mills where these cloths are made, each person performs a single piece of work in the complicated process. We have also, owing to the fact that transportation has developed so greatly, come to depend on other parts of the world for our various needs. For example, a boy may have had for his breakfast grapefruit from Florida, or an orange from California, corn flakes from Kansas City, with milk from a town from fifty to three hundred miles away. The wool in his suit came from the West; the silk in his necktie came from Japan, the material in his gloves from India, the leather in his shoes from South America, his hat from Panama, and he studies from a book made in New York, and reads a magazine from Chicago. The World War has brought forcibly to our minds the importance of transportation in movement of food, fuel, and men, for it was by means of Paris and London busses that some of the critical battles of the war were won.

The use of rails in transportation. — The first methods of transportation made use of roads with stone or earth



Comparison of loads which can be drawn by horses on dirt roads and on rails

foundations, but in 1630, wooden rails were used, as it was found much larger loads could be pulled along such tracks. Iron rails were first used in 1737 in transporting coal in England. In about 1800, a flanged iron wheel was used in connection with the rails, and by this, more work could be done, for ten horses could draw on this road as much as four hundred horses could on an ordinary street.

Experiment. — To show the value of rails.

Materials: A toy car and track. Spring balance. A tray of moist sand. String.

Method: Load the car heavily. Connect to spring balance and see what force is necessary to draw it over the tracks. What force is required to draw it over the moist sand? over the floor?

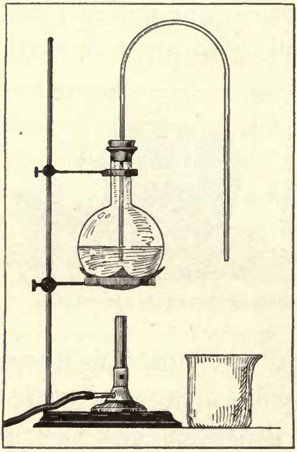
Results and Conclusion: Tabulate the results. What do they show?

The first use of steam. — So far as we know, Hero of Alexandria, about one hundred and fifty years before Christ, contrived a toy in which steam caused a ball to revolve, but it was a great many centuries before steam was actually put to practical use.

Experiment. — To see if steam can do work.

Materials: Half-liter flask. 1-hole stopper. Long glass tubing. Beaker. Ring stand.

Method: Fill the flask ¼ full of water. Make a wide bend near the middle of a 3-foot piece of glass tubing. Pass one end of the tube through the stopper far enough so that when inserted in the flask the lower end is within half an inch of the bottom of the flask. Place a beaker under the other end of tube. Heat the flask to generate steam. Be sure the stopper is tightly inserted.



Results: Is water lifted in the tube?

Conclusion: What is the force that has lifted the water?

Experiment. — To see if the atmosphere can do work.

Materials: The same materials used in the experiment above. An empty sirup can. Stopper to fit the opening.

(1) *Method:* Boil the water in the flask and allow the water to be forced out as in the preceding experiment. Remove the flame. Lift the beaker of water so that the end of the bent tube extends into the water. Cool the flask by placing a wet cloth over its surface.

Result: As the steam condenses, what happens?

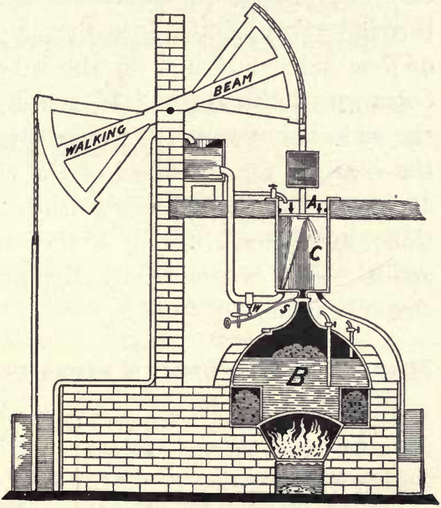
Conclusion: What causes the water to do this?

(2) *Method:* Put a little water in the sirup can. Boil it until the air is driven out. Close the can so tightly that no air can enter after the steam condenses. Remove the flame at the same time the can is being closed.

Result: As the can cools and the steam condenses what happens to the can?

Conclusion: Explain the observed result.

The first steam engine was not the work of any one man. Denys Papin, a Frenchman, made the first model of a steam engine with a piston, the idea being suggested to him by an experiment in which the atmosphere would lift a weight if a vacuum were created in a cylinder under a piston. The principle used by Papin was developed by Savary, a Cornish miner, who made the first useful engine. In 1710, Newcomen, who was an English iron worker, completed an improved engine. This engine had a piston which was raised by steam pressure. The steam was condensed in the cylinder C by a jet of water (see figure), thus reducing the pressure. This allowed atmospheric pressure at A to push the piston to its original position. Newcomen



The Newcomen Engine. When valve S is open, steam from B pushes the piston up; when S is closed and W is open a jet of water condenses the steam and the atmosphere pushes the piston down.

used the first engine for pumping purposes and transmitted this power from his engines to the pump by means of a beam somewhat like the walking beam of our old steamboats.

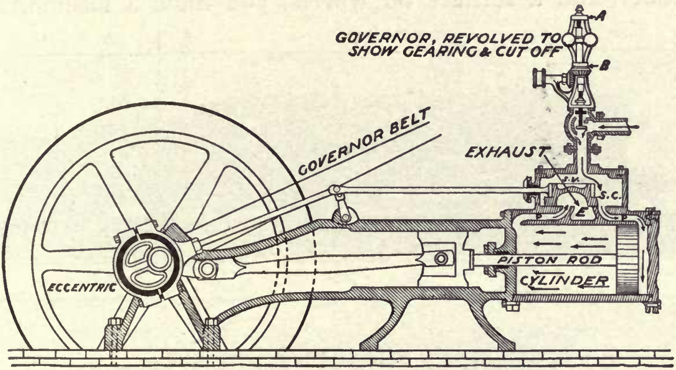
Watt's engine. — Half a century later James Watt was asked to repair a model of the Newcomen engine used for demonstration in Glasgow University after London mechanics had failed to make it work. Watt became greatly interested, and as a result of his study, the modern engine with its slide valve and piston was invented. Steam generated in the boiler enters the steam chest. After entering the steam chest, the steam passes alternately through two openings into the ends of the cylinder, first on one side and then on the other of the piston. The entrance of the steam into the cylinder is controlled by the slide valve, which is moved by an eccentric placed on the shaft of the fly wheel of the engine. Steam entering at one end of the cylinder pushes the piston in one direction; and when entering at the other end pushes it back again. This is practically the principle of the modern steam engine.

Experiment. — Demonstration of steam engine model.

Materials: Steam engine model.

Method: Turn the fly wheel until the slide valve is in position to admit steam first on one side of the piston head and then on the other. Make two diagrams of the cylinder and steam chest to show these two positions of the piston and slide valve. Examine the eccentric to see how it works and explain its purpose.

Watt's improvements were these: first, he kept the cylinder hot all the time instead of having it alternately heated and cooled; second, he had steam pushing the piston on both of its strokes instead of one only; third, be regulated the flow of steam to the cylinder so that the steam from the boiler was cut off when the piston had made one-fourth of its stroke, which more than doubled the efficiency of the engine, the added work coming from the

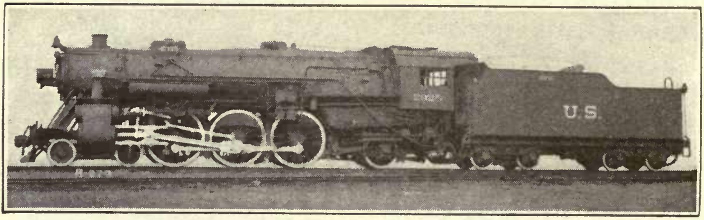


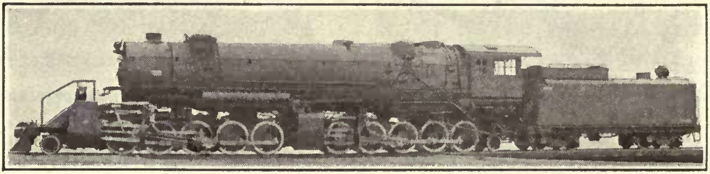
A steam engine. Study the working parts. Can you explain how the governor cuts off the supply of steam?

expansion of the steam; fourth, he used oil for lubrication and to keep the steam from escaping around the working parts.

The steam engine of to-day. — The steam engine in use to-day, although having some improvements, works on the same principle as Watt's engine. Two devices give it an even and a regular motion. These are the fly wheel and the governor. The fly wheel, by its momentum, prevents a slowing up of the engine when the load is suddenly increased. The governor automatically regulates the supply of steam entering the steam chest. This is done by the centrifugal action of the balls of the governor (*A B* in diagram). As these balls rotate faster they swing outward and partly close the steam valve. This causes the engine to slow up a little. The balls revolve less rapidly, and more steam is allowed to come in. These two opposing actions soon become adjusted so that an even speed is maintained.

The locomotive engine. — Wonderful as the locomotive is, if one understands the principle of Watt's engine, he can apply it to locomotives. If you mount an engine, a boiler, and a furnace on wheels, you have a locomotive.



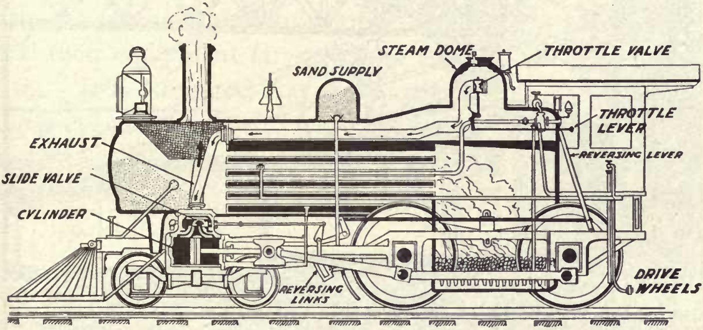


Which of these engines is for speed and light loads? Which for heavy loads and slow traffic? How do you know?

You will notice that some locomotives have larger driving wheels than others. Freight engines which draw heavier loads have smaller driving wheels, while passenger engines built for speed have larger ones. Can you see why there should be this difference?

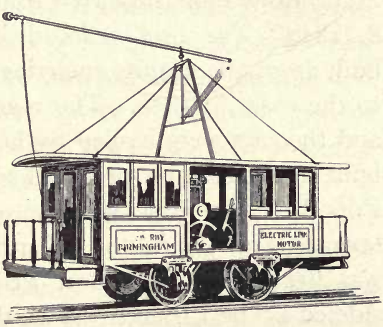
A detailed study of a locomotive engine should be made as a home project. If you use the diagram which is given on page 331, and study about the operation of a locomotive in an encyclopedia, you should be able to report fully in class how this wonderful device works.

The replacing of steam by electricity. — In many parts of the country electricity is taking the place of steam power to propel locomotives. Steam locomotives are not very efficient in their use of coal, as it takes a large amount of coal to furnish the amount of power necessary. In some parts of our country, coal is not as easily obtained as is

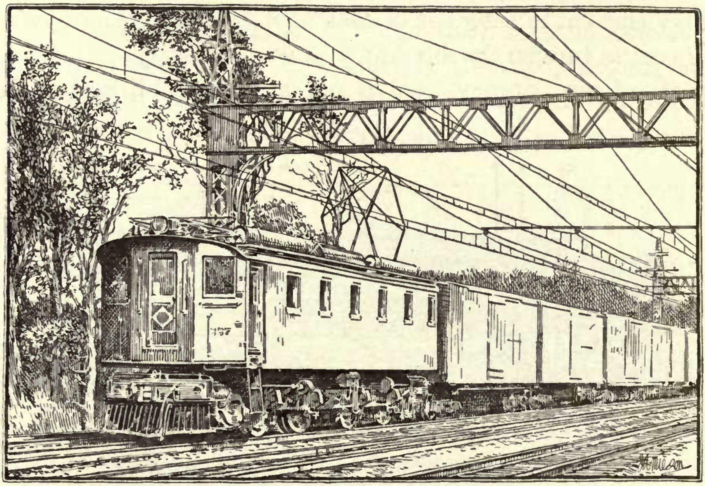


Essential parts of the locomotive. Locate the piston and boiler.

water power. Water power can be harnessed so as to produce electricity by means of great dynamos, consequently it is much cheaper, because water power is usually abundant where railroads have to go up heavy grades. In many parts of the West, railroad systems have been, or are now being, rapidly furnished with electric power. The Chicago, Milwaukee, and St. Paul Railway, for example, now operates nearly six hundred miles of road by electricity, while the Pennsylvania, the New York Central, the New York, New Haven and Hartford in the East are gradually electrifying more and more of their systems.



Model of an electric locomotive built in the U. S., 1888.



A modern electric locomotive.

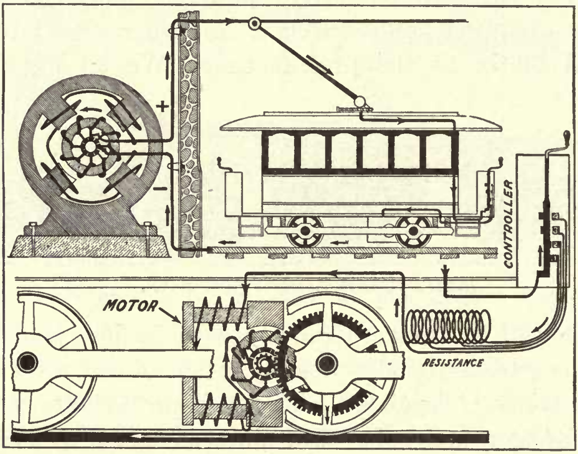
The development of railways in the United States. — The first locomotive to be operated in America was the Stourbridge Lion, imported from England, and run August 8, 1829. The first railroad in the United States was built from the granite quarries in Quincy, Massachusetts, to the coast in 1826. The road was only four miles long, and the cars were hauled by horses. The first locomotive built in America for practical service was called the "Best Friend." The first railway opened to the public was operated in Charleston, South Carolina, and the train was drawn by the "Best Friend," which was not considered a "best friend" by all the passengers, for it belched out black cinders and live sparks, setting fire to their umbrellas and clothes. But with all these discomforts, railroad traveling was begun in this country with a subsequently enormous development. By 1835 eight hundred miles of railroad had been built in the United States.

By 1861, there were thirty thousand miles, while at the present time there are probably about two hundred fifty thousand miles of railway. Railroad systems have been brought to their highest degree of efficiency in America and their equipment far surpasses that of all other countries. It is estimated that there are probably about ninety thousand locomotives, sixty thousand passenger cars, and nearly three million freight cars on railways in the United States at the present time. We all know the

In the early days of steam railway travel.

efficiency of the modern railway with its low grades, its automatic block signal system by means of which the passing of trains is regulated, and the improvements in road beds, bridges, and rails. The war has shown us that the American engineer and the American railway system were very efficient in France, and the future will probably show even greater improvements.

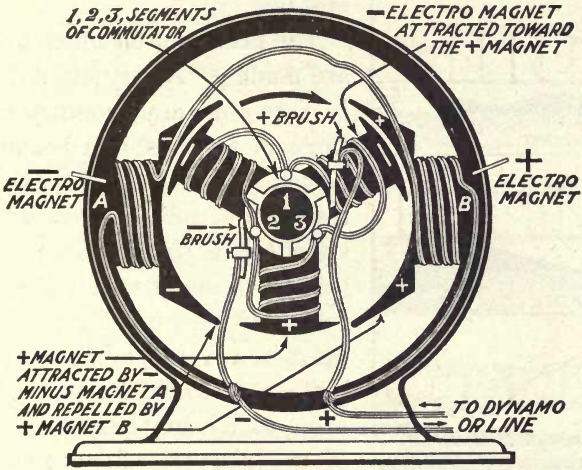
Electric railways. — Any of us who live in large cities can appreciate better than others what the "electrics" mean to hundreds and thousands of people who depend upon them for their daily use, when we see a tie-up in the street railway traffic during rush hours. Electric cars have to-day become necessities in every large community. The motorman excites our admiration as we watch him move the lever of the controller and see the car respond so quickly. A detailed study of the electric car cannot be made here, but any one who will take the trouble to work up a project can understand a great deal about the mysteries of the action of the electric car and the growth of electric lines in this country. In 1884 public electric railways were in operation in Providence, Rhode Island, and in Kansas City. In 1888 an electric road with



Trace the trolley car circuit from power house dynamo to trolley, controller, motor, through car wheels to rails and back to the dynamo.

twenty cars was operated in Richmond, Virginia. When we realize that to-day thousands of towns and cities are equipped with complete electric railway systems, and that thousands of other towns are connected by suburban lines, we can realize how much electricity has done for us in these recent years.

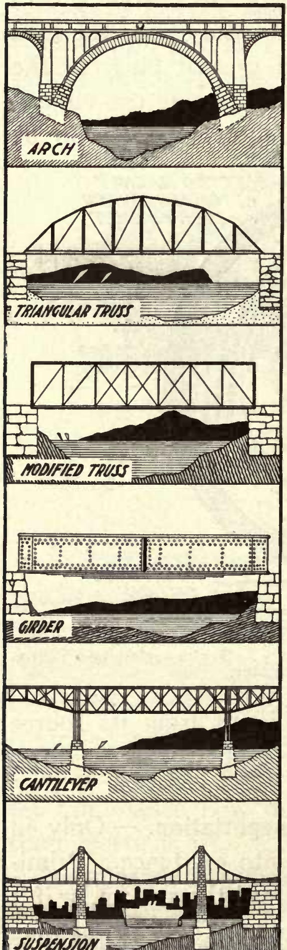
The electric car circuit. — Electricity from the dynamo in the power station is conducted to the trolley wire. It is brought through the trolley to the electric motors beneath the car, but goes through a number of controlled resistances. The motorman by moving the controller handle determines just how much resistance is to oppose the electricity, and thus he regulates the amount of current which passes through the motor. The current passes from the motor through the wheels of the car to the rails and is conducted by the rails and ground back to the dynamo in the power house, thus completing the circuit, for you doubtless remember that electricity can do no



North magnetic poles are marked + and south poles –. Try to explain how continuous motion results in this motor.

work unless there be a complete circuit from its source out through the wires, motors, or other instruments, and back to its source again.

Bridges and their part in transportation. — Only in civilized times have bridges come into existence. Primitive peoples when traveling used to ford the stream, or if it was too deep, they would cross by boat. The Romans were bridge builders of the stone arch type. But with the coming of steam and electric railways, bridges came to have a much greater significance. Railways which must hold to a nearly even level frequently used a bridge to keep an even grade, and it is often found cheaper to throw a bridge over a valley or wide stream than to pay out the extra money in grading and laying rails, to get around the obstacle.



Types of bridges.

The principles on which bridges are made. — A very simple bridge is seen on any country road. Logs, or perhaps iron beams, are placed across the brook, the ends resting on solid piers. This is known as a *girder* bridge. Such bridges do very well for a short span, but where a long distance must be covered, a bridge may be built so as to hold the load without using such heavy beams. A study of the diagrams shows how this is done by means of what is called the *truss* bridge. When still greater distances have to be bridged, such as in the case of the great bridge over the Saint Lawrence River, Quebec, where the principal span is 1800 feet long, we have the principle of the *cantilever* used. Other types of bridges that we are all familiar with are the *arch*, built of stone or steel, and the *suspension* type. The last named is the most graceful bridge of all. A familiar example of the arch is the new Hellgate bridge in New York, while one of the most beautiful suspension bridges in the world is the old Brooklyn bridge spanning the East River.

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CHAPTER XXII

THE AUTOMOBILE AND GAS ENGINE

Problems. — 1. *To learn about the early development of the gas engine and automobile.*

2. *To understand how power comes from gas.*

3. *To learn how the four-cycle engine works.*

4. *To understand the value of such accessories as the carburetor.*

5. *To learn how gasoline is fed from the tank into the engine.*

6. *To learn how kerosene may be substituted for gasoline.*

7. *To learn about the uses of tractors.*

Experiments. — 1. To show explosive and non-explosive mixtures of gases.

2. To explain momentum.

3. To illustrate the difference between the "jump" spark and the "make-and-break" spark.

Project I. — To become an efficient automobile caretaker.

1. How to replace a tire and to patch an inner tube.
2. How to wash and dust an automobile.
3. Proper care of the oiling system.
4. Proper care of grease cups and other parts.
5. Proper care of storage battery.
6. How to diagnose engine trouble.
7. How to remove carbon from the engine.
8. How to clean spark plugs.
9. What attention must be given to the cooling system.
10. How to leave the car for the winter if not to be used.

Project II. — To become an automobile driver.

Project III. — To understand the transmission system of an automobile.

The clutch, the gear shift, the universal joint, the differential.

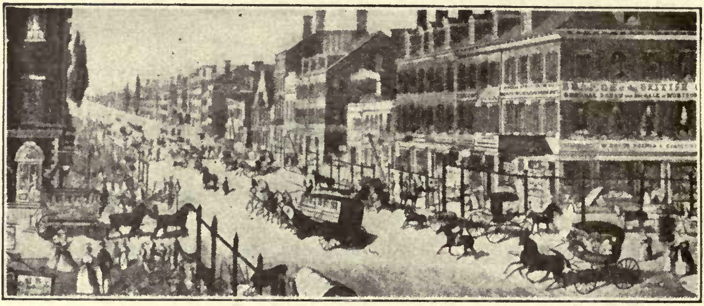
Project IV. — To make a simple storage battery.

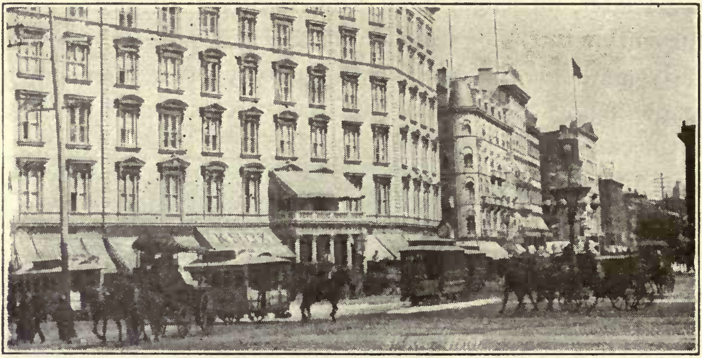
Project V. — To make an electrolytic rectifier.

Early development of the gas engine. — As early as 1680, Huyghens, an astronomer, showed that an engine could be driven by exploding gun powder in a cylinder, the resulting pressure being used against a piston. A hundred years later, an Englishman, Robert Street, suggested that turpentine might be used in place of gun powder. In the early part of the nineteenth century, two Frenchmen made engines which used gas instead of steam, but none of the early attempts were put into practical use, the first real gas engine being devised in France in 1862. This gas engine, called an internal combustion engine, was the forerunner of the modern automobile engine.

An English horseless carriage in 1833. Operated by steam.

The development of the automobile. — It seems hardly possible that the first motor cycle was not made until 1886, and it was almost ten years later before automobiles began to be seen on the streets. The first automobile race in this country was held in 1895 in Chicago, and there were only two contestants, one of which broke down and the winner could only make seven miles an hour. Twenty years

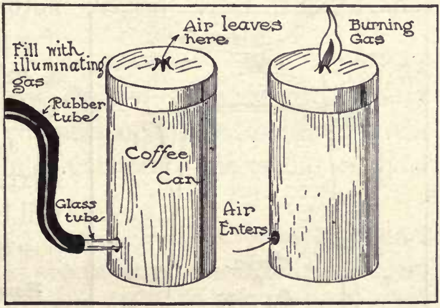




The automobile monopolizes our streets to-day. Typical street traffic in the city of New York in 1836, 1886, and 1921. Notice also that three periods of lighting are shown by the street lamps, oil, gas, and electric. Telephone poles are shown in the 1886 picture. Why not in the other two?

ago there were not more than one hundred automobiles in the United States: to-day there are over 7,000,000 motor vehicles of different kinds registered. A speed of over two hundred miles an hour has been attained in racing, and in some parts of the country motor trucks are taking the place of railroad trains for rapid transportation of freight.

How we get power from gas. — The fuel for the internal combustion engine, whether liquid or gas in its natural state, must be in the form of a gas when it enters the engine cylinder. Gasoline, kerosene, and alcohol are three liquids which may be vaporized easily, and therefore are suitable fuels for the gas engine. Alcohol is too expensive, however, for common use. Kerosene finds limited use in slow speed engines. Gasoline vaporizes readily and is the fuel most commonly used. When the vapor is mixed with the right amount of air and lighted it explodes. When the gas explodes it generates heat. This heat expands the gases in the cylinder of the engine, drives the piston, and thus gives power.



Experiment. — To show what gas mixtures are explosives.

Materials: Test tubes. Illuminating gas. 1-pound coffee can with a hole ½ inch in diameter in the cover and another similar hole in the side of the can 1 inch from the bottom. Test tubes. Rubber bands.

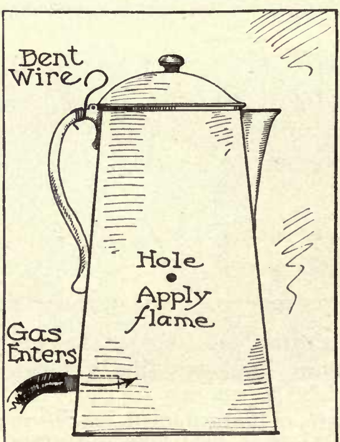
Method: A. Measure off on 5 test tubes lengths from the closed end to represent 5%, 10%, 15%, 20%, 25%, of the total length, respectively. Mark these positions with rubber bands about the tubes. Fill tubes with water. Let illuminating gas enter tubes to fill them respectively with 5%, 10%, 15%, 20%, and 25% of gas. Then take each in turn, let the water run out and air enter. Close the tube, invert and shake to mix the air and gas thoroughly. Bring a lighted match to the mouth of the tube, to test for an explosive mixture.

B. Put the cover tightly on the can. If the cover fits loosely tighten it with paper. Fill completely with illuminating gas. Apply a flame to the hole in the cover and allow the gas to burn as long as it will. Note all changes in the flame. As the gas burns what is entering the can through the hole on the side?

Results and Conclusion: What are the results in *A*? in *B*?

What can you say in regard to "explosive limits of gas-air mixtures"? Explain changes in the flame and the final result observed in *B*.

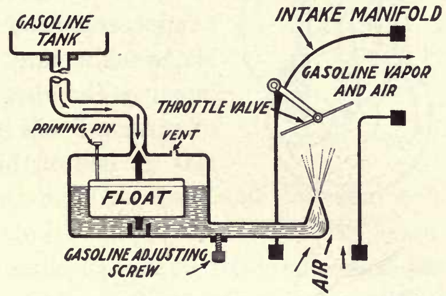
An explosive mixture. — Experiments with mixtures of illuminating gas and air show that the proportion in which the two are mixed is very important in producing an explosive mixture. Not all mixtures will explode. The range of explosive mixture of illuminating gas and air is from 93% air and 7% gas to 80% air and 20% gas. If five parts illuminating gas are mixed with ninety-five parts air and a lighted match is brought to the mixture, nothing will happen, but if a flame is introduced into a mixture of air and gas which is 15% gas there will be a violent explosion. A mixture with over 20% gas will burn quietly where exposed to more air.



Home experiment with gasoline. — Make a quarter-inch hole about halfway up the side of a pint tin coffee pot. Warm the bottom of the pot until just too hot to hold in the hand. Put ten drops of gasoline into the pot. Close the cover.

Bring a flame to the opening on the side of the pot. When the right mixture of air and gasoline vapor is secured the ignition of the explosive charge will throw the cover open violently and give a good illustration of the power derived from exploding gases. Illuminating gas may be used in place of gasoline.

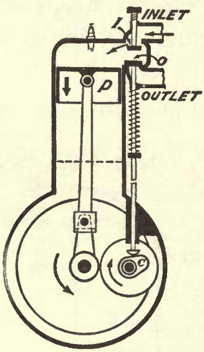
The carburetor. — All automatic engines have a device called the carburetor in which a liquid fuel is vaporized and mixed with air, making it ready to enter the engine. If gasoline is sprayed into the air, no liquid will be seen. It immediately vaporizes and mxies with the air. The oxygen of the air is needed in burning the gasoline, and in the right proportion an explosive charge is produced. If too much gasoline be present or if too much air be present, the mixture will not explode. The carburetor requires rather delicate adjustment in order to produce a proper explosive charge. The explosive charge passes from the mixing chamber or intake manifold of the carburetor through an inlet valve into the engine cylinder at the proper time.



The carburetor.

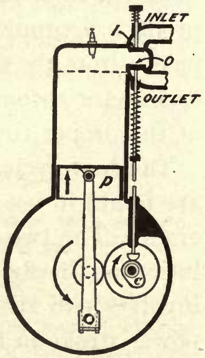
The four-cycle gasoline engine. — Two forms of engines are found in use. These are two-cycle and four-cycle engines. The two-cycle has one power stroke for each revolution of the fly wheel. Each revolution of the fly wheel involves two strokes of the piston, hence there is but one power stroke in two strokes of the piston. The four-cycle engine is the simpler of the two and is the one in common use. The operation of the four-cycle engine will be explained below by describing what happens in each of the four strokes. A careful study of the diagrams showing four different strokes will help us to understand how this engine works.

The suction stroke or charging stroke. — Let us start with the piston in the cylinder (see *A*) just starting to move out. As the crank revolves through half a circle the piston will move downward. During this stroke valve *I* is open but valve *O* remains closed. A mixture of air and gasoline vapor, sometimes called "the charge," is brought into the cylinder from the mixing chamber of the carburetor by "suction." Is it pulled or pushed in? At the end of this stroke valve *I* closes and we have the condition shown in (*B*), the cylinder being filled with an explosive charge of air and gasoline.



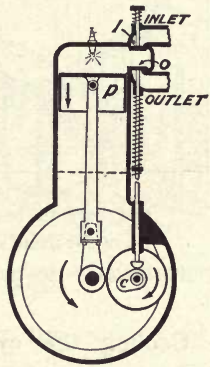
A. Suction stroke.

The compression stroke. — During the next half revolution of the crank, the piston is moving into the cylinder. Both valves *I* and *O* are closed. The charge is compressed into the clearance space above the dotted line. As the volume of the gas decreases its pressure rises. Its temperature also increases. The pressure at the end of the compression stroke may be as high as 100 to 200 pounds per square inch and its temperature 300° to 700° F.



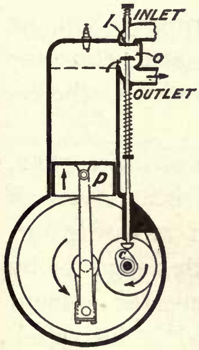
B. Compression stroke.

The expansion stroke or power stroke. — When the gas is under this high pressure and the piston is just ready to start outward again, an electric spark ignites the charge. The fuel now explodes and great heat results. The temperature is raised to over 3000° F. The heat tends to cause expansion, but in the confined space effects tremendous pressure. This pressure, amounting to 300 to 700 pounds per square inch, is exerted during the entire stroke. This is often called the power stroke because it is the only stroke which receives power from the fuel.



C. Power stroke.

Exhaust stroke. — At the end of the expansion stroke the cylinder is full of burned gases. As the piston starts back valve *O* opens, allowing the burned gases to be forced out. At the end of this stroke valve *O* closes while *I* opens, and the engine is ready to begin the suction stroke again.



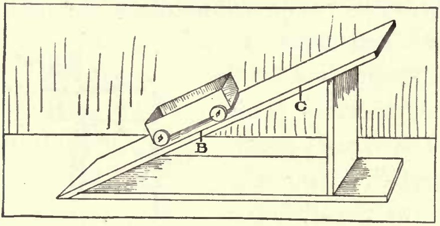
D. Exhaust stroke.

Use of fly wheel. — Since force is exerted upon the piston during but one of its four strokes, we would have very jerky motion were it not possible to carry some of this energy over to the other strokes. The force is communicated to a heavy fly wheel which is set in motion. The momentum thus given to the fly wheel makes it a storehouse of energy for the other three strokes.

Experiment. — To explain momentum.

Materials: A small heavy cart. A 3-foot board. A light wheel (may be wood or cardboard) arranged to revolve on an axle. A heavy wheel (may be lead or iron) arranged to revolve on an axle.

Method: (1) Support the board to make an angle of 30° with the table. Place the car first at *B* and then at *C*, and release it. Note how far it runs on the table in each case before it stops.



(2) Take hold of the light wheel and give it a whirl. Note how many seconds it continues to turn. Repeat with the heavy wheel.

Results and Conclusions: Compare results in (1) and explain reason for the difference.

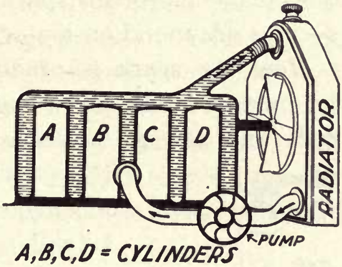
Compare results in (2) and explain reason for the difference.

Application: How is this principle made use of in engines?

Cooling the cylinder. — Much of the heat resulting from compression and from combustion of the charge is absorbed by the cylinders. Unless this heat can be taken away as fast as it is received and the cylinders kept at some temperature below that at which the gas will burn. there will be a premature explosion or " back firing." Suppose the charge were ignited by a hot cylinder just before the end of the compression stroke. What would be the result?

Air-cooled engines. — There are two systems of cooling, — by air and by water. The amount of heat given off by a hot body increases with the area of radiating surface. By making gas engine cylinders with flanges or by studding the surface with metal projections, the amount of heat conducted to the air and radiated is increased. By bringing in colder air and driving the warmed air away faster than it would circulate in natural circulation, cooling is hastened. This is done in air-cooled automobiles by means of a fan.

Water-cooled engines. — When water is used for cooling, a water jacket surrounds the explosion chamber of the engine. Through this, water is kept in circulation sometimes by gravity, but better by means of a pump driven by the engine. In the automobile the hot water leaving the water jacket is carried through a radiator where it is cooled rapidly. A fan helps circulate the air around the passages of the radiator. By this means a relatively small amount of water is sufficient to keep the engine cool.



Water-cooling system of an automobile engine.

How the charge is ignited. — In practically all gas engines to-day an electric spark sets off the charge in the cylinder. There are two systems of ignition: the "jump-spark" and the "make-and-break."

Experiment. — To see the difference in method of producing the "jump" spark and the "make-and-break" spark.

Materials: A spark coil. An induction coil. A spark plug. A key or switch.

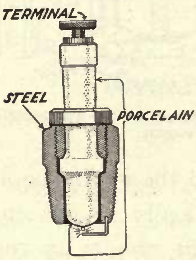
Method and Results: (1) Connect poles of secondary coil of the induction coil to the spark plug. Send a momentary current from 2 dry cells into the primary coil of the induction coil. This shows the "jump" spark.

(2) Connect 2 dry cells in series with a spark coil, leaving a gap in the circuit. Bring the two wires at this gap as close together as possible without touching. Is there any spark? Touch the two wires and break the circuit instantly. Is there any spark? This results from a "self-induced" current. Can you find out what this means?

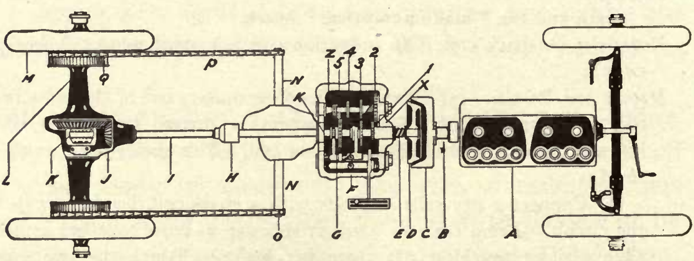
Application: Can you see any advantage in the "jump" spark for automobile use?

The jump spark is used in high speed engines such as are found in the automobile and airplanes. The spark jumps the gap between the wires at the end of the spark plug which is screwed on to one end of the engine cylinder. The make-and-break spark is used in low speed engines such as are found on motor boats.

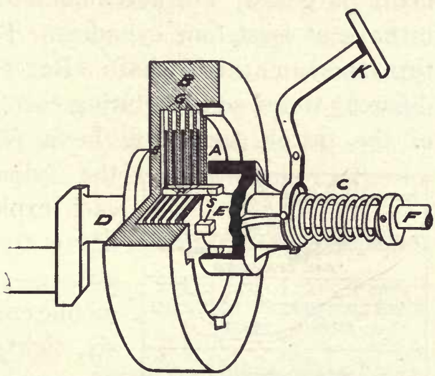
How the spark is produced. — An electric spark can be produced only by a high voltage current. Both dry cells and storage batteries give a low voltage current. It is possible to "step up" a low voltage to a high voltage by means of a *spark coil.* It will make an interesting project for some of you to find out how the *induction coil* changes a low to a high voltage for the jump spark use; also to learn how a single coil such as is used for gas lamp-lighters and for the make-and-break spark changes the voltage. In some cases a magneto is used. This produces a high voltage current and it replaces both batteries and coils.



A spark plug.


Automobile transmission systems.

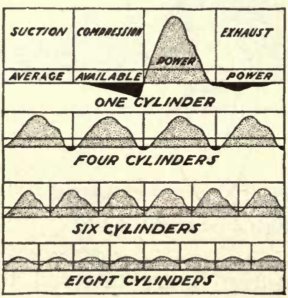
Transmission. — Before an automobile can move, the power developed in the engine must be transmitted to the wheels. This is usually done by what is called the "*shaft drive,*" but sometimes, particularly in trucks, by the "*chain drive.*" The differences in methods employed in the two types are shown in the illustration. The fly wheel of the engine (*C* in figure) is the outside or driving member of the clutch. This revolves when the engine is running. When the clutch spring (*E*) is released, the inner member of the clutch is pushed into *C* so tightly that both *C* and *D* revolve together. A shaft from *D* passes into the transmission case *F*, where by various gears, different powers or speeds may be applied to the propeller shaft which runs from the transmission case to the rear axle. Here the power is given to the driving wheel. If a "chain drive" is used the propeller shaft (*I*) and differential (*K*) will be replaced by the chain, axle, and differential indicated by *O*, *N*, *P* in the diagram. Many automobiles use a *multiple drive clutch* instead of a *cone clutch* shown in the figure referred to above. This type of clutch is shown in the accompanying figure. Attached to the inside of the fly wheel (*B*) are a number of driving disks; alternating with these are driven disks which communicate the power by means of the shaft *F* to the transmission gears. Can you explain why pressure on the clutch pedal (*K*) allows the engine to run free?



The multiple drive or disk clutch.

The muffler. — As the burned gas leaves the engine cylinder, it is at a pressure much above that of the atmosphere. If allowed to discharge directly into the air at this high pressure it gives a very loud and objectionable explosive sound. The muffler is a device to reduce the noise. By leading the gases from the engine into a series of chambers, each one larger than the one previously occupied by the gas, the gas expands gradually and finally escapes at a pressure but little above that of the atmosphere.

Engines of many cylinders. — A single large cylinder used with a heavy fly wheel will do satisfactory work for many purposes. For automobiles, however, it is desirable to have at least four cylinders. The four piston rods all turn the same main shaft. But the explosions occur at different times, so that during each one of the four strokes of the piston there will be a power stroke in one of the cylinders. By this means each explosion is smaller and a lighter fly wheel may be used to give a steady motion. Automobile engines are built with four, six, eight, and twelve cylinders. The power may or may not increase with the number of cylinders, but the greater evenness obtained from the twelve cylinder engine is of but little advantage over that obtained from the six cylinders, since there are so many more parts to move.

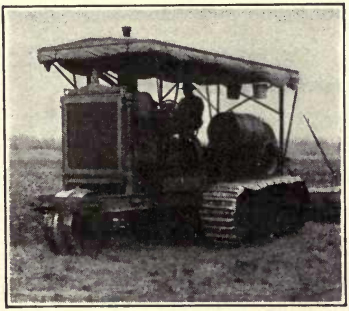


Showing the greater evenness of power distribution as the number of cylinders is increased.

Use of kerosene in gas engines. — The rapid increase in gasoline engines has resulted in a greatly increased consumption of gasoline. This has caused the price of gasoline to double in the last few years. Kerosene is now cheaper than gasoline and with suitable device for changing it to gas it gives satisfactory results in low speed engines. Kerosene has a higher fuel value than gasoline, but it does not burn so rapidly and is not therefore so well adapted to high speeds. A kerosene engine is usually started on gasoline and when the engine gets warmed up, a turn of a lever shifts over to the kerosene fuel. Kerosene is being used successfully in stationary engines and tractors.

An age of automobiles. — Thanks to the low-priced and excellent engines now on the market, a person need not be wealthy to own a motor cycle or a motor car. Millions of pleasure cars are now operated, while commercial cars and especially motor trucks have come into much greater use since the World War. A period of activity in the construction of good roads is favorable to the increased use of automobiles.

Tractors and their uses. — In late years the gas engine



The caterpillar tractor is useful in peace and in war.

has come into prominence on the farm, where it does better and more economically the work of cultivation, reaping, binding, and thrashing, formerly done by horses. Most large farms now use the gasoline engine in many ways. The war, too, made use of tractors, not only in dragging heavy guns and supplies, but also in that interesting development of modern warfare known as the tank. The tank or so-called caterpillar tractor became an important weapon of offense not only to go over the roughest kind of ground, but also to tear up barbed wire entanglements and even to go through heavy embankments and walls of masonry.

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CHAPTER XXIII

TRANSPORTATION THROUGH AIR

Problems. — 1. *To learn of the development of aërial flight.*

2. *To understand the principles underlying balloon ascension.*

3. *To learn the advantages of airships over the balloon.*

4. *To understand the principle by which heavier-than-air machines can remain in the air.*

5. *To learn something of the stability and method of control of airplanes.*

Experiments. — 1. To discover what common gases are lighter than air.

2. To study action of soap bubble balloons.

3. To show the principle of the glider.

Project I. — To make an air craft scrap book.

Collect pictures showing various types of air craft — machines and aviators who are of interest in history or who have made flight records. Also show different advantages of air craft. News clippings about important air craft events.

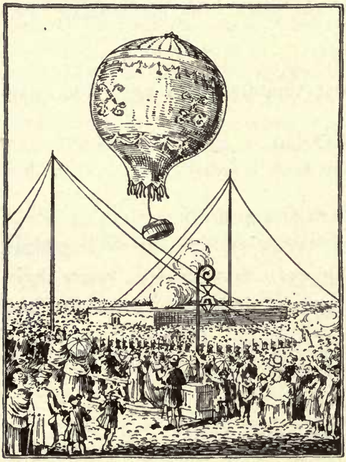
Project II. — To make a fire balloon.

Project III. — To make a box kite.

Project IV. — To make a model airplane.

Through the air. — To fly as on the wings of a bird has become an actuality at last. While air transportation was slowly coming into its own, the World War suddenly threw it into prominence, and as successful warfare depended largely on the knowledge of the movements of the enemy, so the airplanes, dirigibles, and balloons became the eyes of the army, and went a long way toward winning the war for the ollies. Man has produced machines in which he can fly as well as birds, and can also perform trick movements which birds do not even attempt. Transportation through the air, the dream of centuries, has now become a reality. There are two classes of machines now in use in the service, known as lighter-than-air machines and heavier-than-air machines. Their names indicate exactly what they are.

Earlier lighter-than-air machines. — The French were the pioneers in developing balloons. The earliest balloons were made by the Montgolfier brothers in 1783, and were called fire balloons, because a straw fire was built under the gas bag to supply hot air which caused them to rise. In that same year, hydrogen, which, as you know, is a gas many times lighter than air, was used. In the next fifty years numerous ascents were made by adventurous spirits, and so knowledge of the envelope of air surrounding the earth was very greatly enlarged. Some daring balloonists reached an altitude of seven miles above the earth, and although they nearly lost their lives in this hazardous flight they found that there



One of Montgolfier brothers' fire balloons.

was only one-fourth as much air there as there was at sea level, so we have been able to estimate pretty clearly that if this ratio were kept up, there would be little if any air left one hundred miles above the surface of the earth. Indeed, at a height of twenty-three miles, which has been reached by some exploring balloons sent up with weather instruments in them, it has been found that only one three-hundredths of the air was left above the balloon.

Why balloons rise and float. — A balloon rises because it is pushed up by air which is denser than the gas in the balloon. Since only those gases which are lighter than air can be used in balloons, it may interest you to find out experimentally some of the common gases which are suitable for balloons.

The higher one goes in the atmosphere, the rarer it becomes and the less lifting power, because its density decreases as one ascends. When a balloon has risen until its total weight just equals the air it displaces, it ceases to rise, and becomes a floating body, very much as we have seen in the case of boats. A balloon from which ballast is dropped will rise, while if gas is allowed to escape, the balloon will sink to a lower level. Why?

Experiment. — To discover what common gases are lighter than air.

Materials: Collect two test tubes each of carbon dioxide, oxygen, hydrogen, and illuminating gas.

Method: Hold one tube of each gas mouth down for 3 minutes and apply test for the presence of the gas. Hold another tube of each gas mouth up for 3 minutes and apply test for the presence of the gas. Which gases are lighter?

Method of Collecting Gases: 1. *Carbon dioxide.* Put marble or washing soda in the generator (*A*); add dilute hydrochloric acid. Close and collect gas by water displacement.

2. *Oxygen.* Drop a small lump of oxone into water in the generator
3. *Hydrogen.* Put zinc into dilute sulphuric acid in generator.
4. *Illuminating gas.* Connect rubber tube to gas cock and collect as in other cases over water.

Buoyancy of air holds up objects in the sea of air just as water holds up objects which weigh less than the amount of water displaced. One thousand cubic feet of air weigh eighty pounds, and one thousand cubic feet of hydrogen weigh only five and one-half pounds. A balloon carrying 200,000 cubic feet of hydrogen will then have a lifting power of $74\frac{1}{2}$ times 200 or 14,900 pounds. Part of this lifting power would be used to hold up the material of the bag and balloon car, and the rest would be used for ballast and passengers.

Experiment. — To study action of soap bubble balloons.

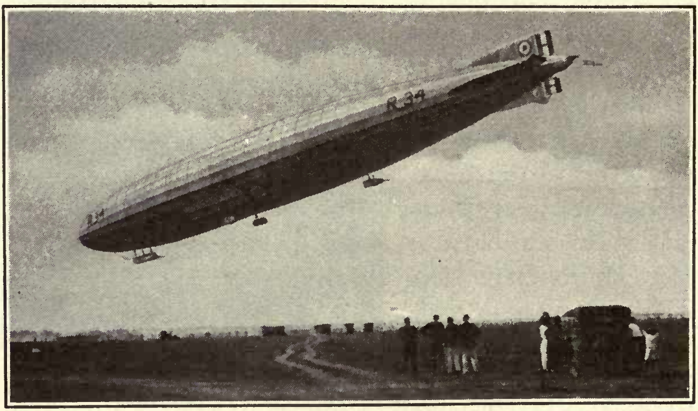
Make a thick soap solution with which you can blow large bubbles. Attach a glass tube with smooth fire polished edge by means of a rubber tube to the gas jet. By pressure on the rubber tube the flow of gas may be regulated.

Blow bubbles with the gas. Shake off. Observe: (1) Some rise directly. Explain why. (2) Others sink at first, and then rise. Watch these carefully. Try to discover the cause of this action. How does this illustrate the practice of throwing out ballast?

Uses of balloons. — Balloons, as we have already seen, would not be of much value for transportation, as one would have to depend entirely upon the wind currents. A skilled balloonist is able by shifting the altitude of his balloon to take advantage of winds moving in different directions. We have seen their use in scientific experiments. The captive balloon at the front lines of the armies in the World War proved of very great value indeed, as they were enabled to direct the fire of artillery, prevented surprise movements of troops, and gave signals in case of attack of hostile airplanes. These balloons were held to earth by a long cable attached to a windlass, which allowed them to go to the height of two or three thousand feet. In case of attack by enemy airplanes, they were drawn down quickly, thus preventing the loss of many balloons on each side.

An army observation balloon.

The dirigible. — For a great many years people worked on some plan to steer balloons. In 1850 a Frenchman by the name of Giffard built a cigar-shaped gas bag under which he placed a car containing a steam engine. This was not very successful, but later gasoline engines were used. Captain Renard of the French army in 1885 was the first man to bring his cigar-shaped balloon back to its starting point. Santos Dumont in 1901 won a $20,000 prize for steering his dirigible around Eiffel Tower and coming back to his starting point, a distance of three or four miles. It is interesting to remember that he used an automobile engine, so that the automobile helped in the development of the dirigible. The first part of the war brought into great prominence the rigid dirigibles of Count Zeppelin of Germany. These great machines were made of a large number of sections, each of which was a distinct balloon by itself, and the entire lifting body of the balloon was made rigid by means of aluminum bars and rings, so that it looked like a great silver cigar as it moved through the air. Although some of these airships were over 500 feet in length, and could lift a load of many tons, yet they did not do the damage they were expected to do. They made many long trips without stops, frequently penetrating the countries of the allies, but were soon found to be at the mercy of the faster airplanes. In these times, however, the commercial possibilities of airships seem to be

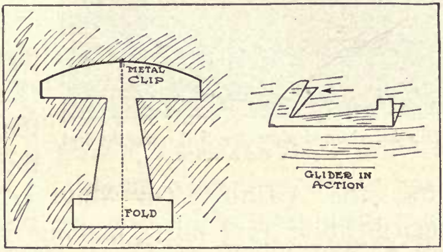


The English dirigible which made the first round trip across the Atlantic, landing on Long Island, N. Y.

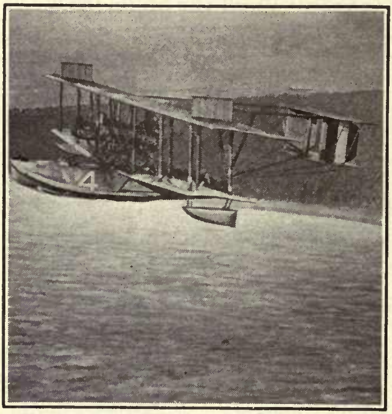
very great. The English dirigible, R 34, in July, 1919, made the first round trip between Europe and America, the return trip, with favoring winds, taking only a little over seventy-two hours.

Forerunners of the airplane. — Every boy knows how to fly a kite. He also knows that the stronger the wind, the better his kite will fly. When a wind blows against the surface at right angles it exerts a pressure which tends to push the surface in the direction of the wind. When a wind blows against the surface at some other angle, it tends to move the body at an angle to the wind direction. We all know how wind striking at an angle against the pin wheel causes it to revolve rapidly, while it causes the kite to rise to a higher level. This is due to the fact that the wind upon striking the kite is deflected, but reacts to push the kite in a direction which depends upon the angle between the kite and wind direction. From the box kite, which has been used for a great many years in England to raise observers above the ground, to the glider is only a step. The glider is only a huge box kite arranged to hold an operator.

Experiment. — To show the principle of the glider: Fold a piece of stiff paper 7 inches square in the middle in order to cut the two sides of the glider just alike. Cut out the glider in the form suggested in the diagram which is approximately to scale. Slip a metal clip over the front edge at the center to give greater stability. With a little practice you can make this travel across the room. Remember that in starting the glider you give it a thrust forward, pointing it slightly upward. Make a diagram by which you can explain why it stays up so long.



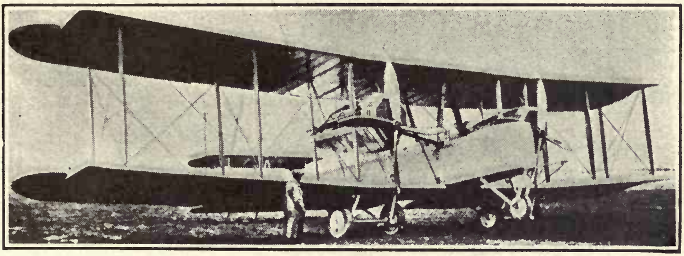
The invention of the airplane.—Like so many other great inventions, the airplane is not the work of any one man, although Americans have had a prominent place in its development. Professor Langley succeeded in making a model airplane run by a small steam engine fly out over the Potomac for 900 yards at the rate of about 25 miles an hour. The Wright brothers experimented with gliders, and learned much about the laws of flight. In 1903 they were able to place a gasoline engine on their glider, and made exhibition flights of a whole minute in duration. Think of the rapidity with which improvements have been made, for to-day non-stop flights of over twenty-four hours are taken, hydroplane and airplane have successfully flown across the Atlantic, and an airplane trip half around the world, from England to Australia, was successfully made in 1920 by Sir Ross Smith.



This American airplane, the N-C 4, was the first to cross the Atlantic.

The first transatlantic flight. — The N–C 4 (Navy-Curtiss No. 4) has the distinction of being the first airplane to cross the Atlantic. On May 31, 1919, it completed this flight of 4513 miles, making five stops on the way. The longest flight on the trip was 1380 miles from Newfoundland to the Azores. The airplane with load weighed 14 tons. The commander was Lieutenant Commander Albert Cushing Reed of the United States Navy. The trip was begun at Rockaway, Long Island, and ended at Plymouth, England. The first non-stop flight was made June 14, 1919, from Newfoundland to Ireland, a distance of 1890 miles, by the Vickers-Vimy airplane piloted by

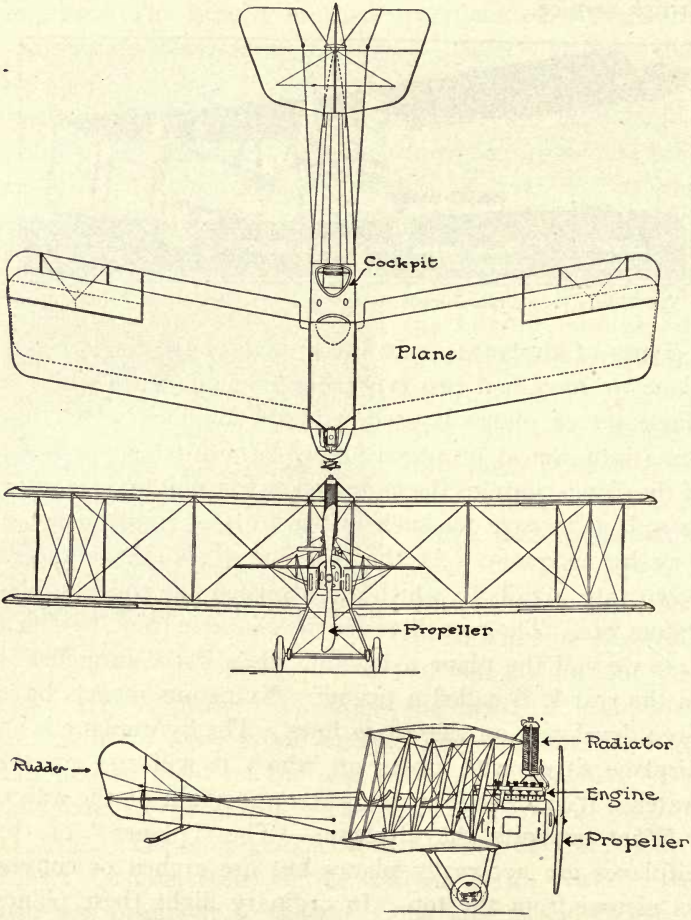
Captain John Alcock of the British Army, and navigated by Lieutenant Arthur W. Brown, an American in the British service.



The Vickers-Vimy airplane made the first non-stop flight across the Atlantic.

Types of airplanes. — In the growth of the modern airplane we have had two types, the monoplane, in which a single set of planes is used, and the biplane, which has come into almost universal favor. The fuselage, or body of the plane, contains the motor, room for pilot and operator as well as storage for such instruments or implements as may be necessary. At the rear end the fuselage tapers down into a tail, to which are attached the rudders, elevators, etc. The propellers may be placed in front, in which case we call the plane a tractor, while if the propeller is in the rear it is called a pusher. Numerous models have been developed on these two lines. The hydroplane is an airplane fitted with floats on which it will rest on the water. It can rise from the water and alight on the water.

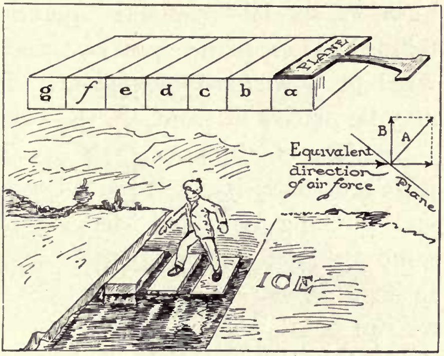
What supports the airplane. — The "planes" of the airplanes are not really planes but are arched or convex as viewed from the top. In ordinary flight these planes are tilted about eight degrees from horizontal, and as the propeller pushes back the air the planes are pushed forward. Because of this motion air strikes against the concave side of the plane with considerable force. One result of this is the lifting effect which counterbalances



Showing general features of the tractor airplane.

the effect of gravity, which is always pulling downward on the machine.

The support of the airplane is somewhat similar to that of the man who crosses the river on floating logs or on loose blocks of ice. One block of ice, of the size usually cut in ice harvesting, would sink if the man were to stand on it, but he may step on it, and before it has time to sink, step to another block, and then still another. In this way he can travel any distance on blocks of ice which individually are too small to support his weight. He makes use of the "inertia of rest." It takes time to set the block of ice into motion and before it sinks he has passed on to another block.



Why the airplane does not fall (see text). A more scientific explanation involves resolution of forces as suggested by diagram at right. *A* at right angles to the plane is one component of the air force acting upon the plane. *B* is that component of *A* which lifts the plane.

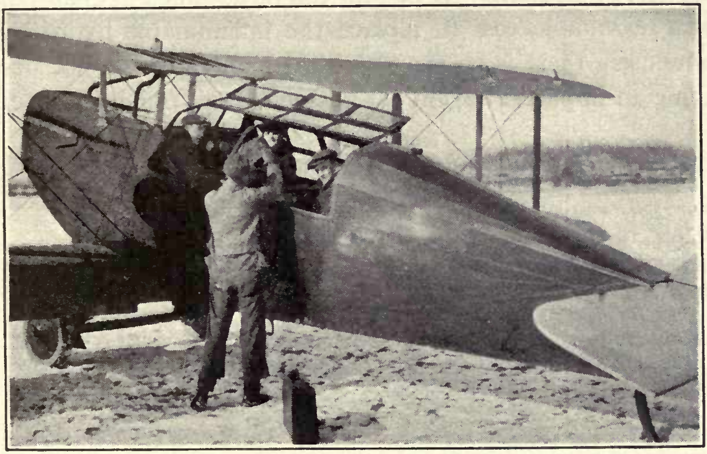
Can you think of the air being composed of blocks of air? The airplane rests on one block of air for an instant, but before that air can sink, it passes on to the next block, and so on. The airplane must travel faster in air than the man on ice blocks, because air can be moved faster than ice, and because the airplane is heavier than the man.

Lifting force, speed, and power. — The air support depends upon the area of the plane. Double the plane area will give double the supporting force. The air support also depends upon the speed; double the speed will give four times the lifting force. It is thus seen that the lifting power of an airplane increases directly as the surface area of the plane and directly as the square of the speed. In order to double the speed of an airplane the power must be increased eight times.

How to rise and fall. — By driving at a high speed, the planes being slightly inclined, the air exerts an upward pressure sufficient to lift the airplane to a higher level. At a slower speed the airplane will fall. For ordinary flight, however, special "elevator" planes are used for rising and falling. These planes may be tilted at will, causing an upward or downward movement. The "elevator" planes may be placed in front, at the sides, or in the rear.

Stability of airplanes. — Boats in water are often subjected to disturbance, such as rocking from side to side and pitching bow and stern. Airplanes experience this same trouble, but in greater degree. The water tends to keep a boat on even keel to a greater extent than the air can hold an airplane. Gravity is pulling the machine down, the pressure of the air is pushing it up. The pilot's seat is directly over the center of gravity of the airplane. If the center of upward pressure is not at the same place as the center of gravity, a turning effect will result. The greater the distance between these two centers, the greater will be the tendency to upset. When one is rising or falling or when the speed is being changed, the center of pressure will change. The pilot can change the center of pressure by use of the elevator planes and he tries to keep the two centers in the same position. There are automatic devices, too, which assist him, but none as yet can replace the alertness of the pilot, who must acquire the habit of instinctively doing the right thing at the right time.

Present and future. — The airplane is a prime necessity of modern warfare. Scout planes are built which can travel one hundred and fifty miles per hour. Regular airplane service is now established for mail delivery between distant cities in the United States. Passenger planes can carry fifty passengers. The airplane can travel for hours without a stop and can fly in any wind except a gale.



Air travel. Passengers getting aboard.

Transportation in air may never compete to any great extent with land and water transportation, but its usefulness has already been established. Boat traffic is often seriously interrupted between the mainland and islands off the coast in the winter. Ice packs are no hindrances to air service. We may confidently expect the establishment of an air line between America and Europe, and between Europe and Asia, since the feats of American and British fliers have proved such service entirely feasible.

Scientific study of conditions in the upper air has been made possible by the balloon and airplane, the balloon with passengers having reached an altitude of 30,000 feet, while on September 28, 1921, Lieutenant Macready of the United States Army ascended in an airplane to a height of 40,000 feet at Dayton, Ohio.

The development of the airship has been hindered by numerous disasters. If helium can be obtained in quantity at a reasonable cost to replace the inflammable hydrogen now used, there is no reason why the airship may not become an important agent for passenger and freight service.

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CHAPTER XXIV

MEANS OF COMMUNICATION

Problems. — 1. *To see how means of communication have developed.*

2. *To understand different methods of signaling.*

3. *To appreciate the value of mail service.*

4. *To understand how communication is possible by telegraph.*

5. *To understand the working of the telephone.*

6. *To realize what an important part newspapers and other printed matter play in the world to-day.*

Experiments. — 1. To see how the electric telegraph works.

2. To study the action of the telephone receiver.

3. To study the action of the telephone transmitter.

4. To demonstrate the principle of wireless telegraphy.

Project I. — To become expert in "wigwag" signaling.

Project II. — To learn the significance of railroad signals and how they are operated.

Project III. — To install a telegraph line between two houses.

Project IV. — To set up a wireless and learn to use the international code.

When we were babies our means of communication were very limited. A baby can cry and make some of his wants known, largely by signs and facial expression. Language must have been in existence for a great many centuries, for all people seem to have this means of communication.

How we make sounds. — Perhaps you know how difficult it is for a young child to learn to talk; you have seen little children struggle with the formation of new words. We make sounds by means of the use of the voice box or *larynx*. This is located in the region we call the "Adam's apple." It is at the upper end of a tube which leads downward into the lungs. This voice box is made of cartilage and contains two cords of elastic tissue, the *vocal cords*. These cords are held in place by muscles so that when air is forced through the tube the cords vibrate. Stretching or loosening these cords, their vibration rates are changed and hence different tones are produced. By means of forming the lips or the walls of the mouth in different positions and causing these vocal cords to vibrate speech is made possible. Of course it takes much practice to control this delicate organ, hence the slow learning to talk on the part of little children.

Early communication by means of signals. — Signs and signals have been in use perhaps as long as words, and they find as important place in the world to-day as they did in the world of our ancestors. In communicating by signals two of our senses are made use of, hearing and seeing. From earliest recorded time people have had means of signaling, the simplest being the flaming torch or bonfire by night. The Romans maintained fires on the coast headlands to guide their triremes of war and commerce. The Greeks developed an elaborate method of torch signal communication. By using a screen to hide the torches not in use, they could signal all the letters of the Greek alphabet (see figure). The American Indians sent daylight messages by covering the fire for a short time with a blanket and quickly uncovering it, thus rings of smoke were sent up which could be seen 20 miles away. The Eskimo finds it more difficult to use fire and does his signaling with his arms. He stands, when possible, on a hill against the sky facing his observer. By moving his arms up and down at the sides he gives his message. The Eskimo seems to have been the forerunner of the semaphore now so common in the railroad train signaling as well as in the navy and army signaling.

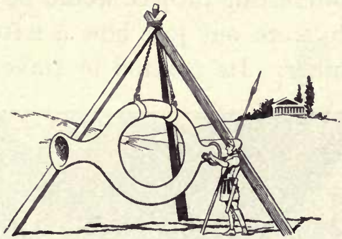
Torch signals used by the Greeks.

The use of light in signaling. — Beacon Hill in Boston derived its name from the fact that a beacon light there warned the colonists of the approach of hostile Indians. Lantern light gave Paul Revere the information that started him on his famous midnight ride. In 1870 the first plan to use flags and lanterns to transmit messages by a practical code was evolved. This was soon improved so that hundreds of different messages were possible. This led to the wigwag system of the United States army. Our lighthouses with numbered flashes tell the mariner his location. Rockets, from the flaming arrow of the Indian to the brilliant colored rockets used in the World War, have been a common and important means of signaling. What boy or girl does not know the use of a small mirror in throwing a beam of sunlight. Heliograph messages are usually limited to 100 miles, but in exceptional cases have been sent nearly 200 miles. The heliograph is an important instrument in the national forests, being used for communication from one station to another.

Sending a message by heliograph.

Ear signals. — Signaling by sound requires a medium, usually air, to conduct the waves from their source to the ear. You may remember that sounds are vibrations of matter within such limits of frequency (sixteen to forty thousand a second) as will affect the organ of hearing. When a sound wave enters the passage of the external ear it beats upon the drum membrane, which is stretched between the outer and middle ear. In the middle ear, three small bones transfer the sound energy to the inner ear, which contains a fluid and thousands of tiny fibers of varying length. These fibers are sensitive to particular sounds and transmit the sensations to the nerve which carries them on to the brain.

Ear signals are perhaps less important than eye signals, and yet they serve many conditions where eye signals would fail. Crude drums and trumpets have been used by many tribes for signaling, and it is said that a huge megaphone was used in the army of Alexander the Great. The fog horn, automobile horn, and fire alarm are examples of the usefulness of ear signals. The door bell, telephone bell, church, and school bells, and the factory whistle all give their message to the ear. But all methods of distance communication devised in thousands of years by man, are clumsy and inefficient indeed when compared with the telegraph, cable, telephone, and the wireless, which have all been developed within the memory of your parents or grandparents.

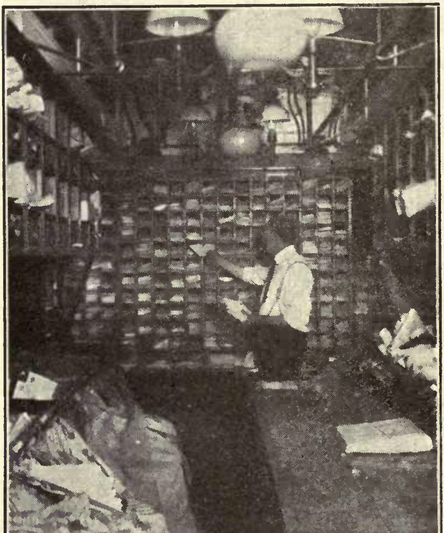


Army megaphone of Alexander the Great.

Speaking tubes. — Speaking tubes, once quite common in apartment houses, schools, and commercial buildings, are now almost entirely replaced by telephone equipment. Speaking tubes are metal tubes, between one and two inches in diameter, which confine the sound waves, forcing the vibrations to move in one long path rather than allowing them to spread out and lose strength as they do in an unconfined air space.

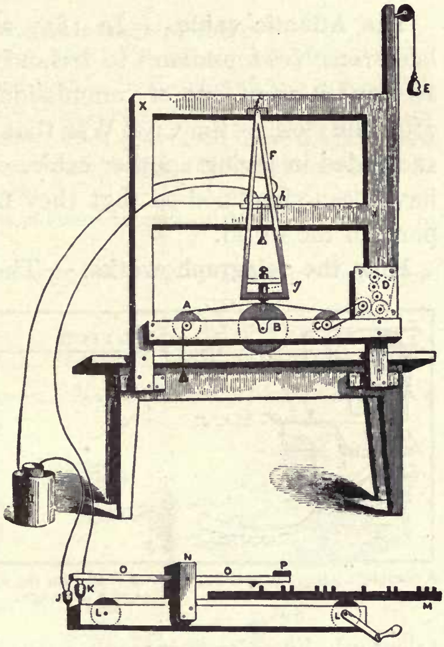
Mail service. — An invaluable service to commerce, business, and household is performed by the mail delivery. Even the distant rural population receives and sends written messages at small cost and at frequent intervals of time. United States mail carriers have the right of way over all other traffic, except in emergencies such as fire or hospital services. To increase the speed of delivery, air service has already been established between some large cities, and in the future this will undoubtedly form an important branch of the mail service.

How letters are delivered to their destination. — An interesting project would be for some member of the class to work out just how a letter gets from one place to another. Its method of travel would certainly be interesting. After mail is collected from the letter box it is taken to the post office, where it is roughly sorted and put on a mail car going north, east, south, or west. On this car are postal clerks whose business it is to sort out the letters going to certain cities or areas of distribution. Before the mail train reaches the destination of your letter, it has been re-sorted with all the other first-class mail for that locality and placed in another bag, to be put off at the proper station. From that point it is taken to the post office and is either put into its proper box or sent out by the city carrier or the rural free delivery carrier to be finally delivered to the person to whom it is addressed.



Interior of a mail car.

The telegraph. — As early as 1831, Joseph Henry, who was a pioneer in work with electromagnets, was able to produce sounds at a distance by means of electromagnets. The system devised by Samuel F. B. Morse in 1832 and perfected in 1843 is the one, however, which has been generally used, and is known to-day as the electric telegraph. Much experimental work and many improvements were made before the telegraph became commercially possible, but on the 24th day of May, 1844, the first message ever sent over a commercial telegraph was sent from Washington to Baltimore. The message was in the code of "dots and dashes," but when transcribed into letters and words read "What hath God wrought!" When we compare the state of affairs in 1844 with the conditions to-day and realize that almost every hamlet, no matter how remote, is connected by telegraph with its neighbors, and that almost 250,000 miles of

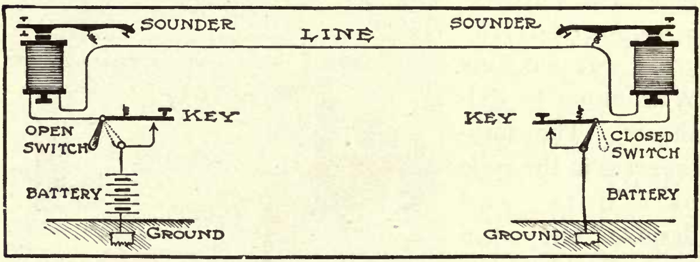


Morse's first telegraph instrument. When *M* is moved under *O* each contact of projecting points lifts *P* and lowers *JK* into mercury cups, thus closing an electric circuit. An electromagnet (*h*) acts upon a pendulum (*F*) which holds a pencil (*g*) in contact with a strip of paper which is constantly being drawn across the drum (*B*) by clock work. Each time the circuit is closed, the electromagnet pulls the pendulum, to which a soft iron armature is attached, and a mark is drawn across the strip of paper.

telegraph lines exist in this country we can see what an important place it has in our lives. It is estimated that there are about 200,000,000 telegrams sent every year, or practically two for every man, woman, and child in the United States.

The Atlantic cable. — In 1857 a submarine cable was laid from Newfoundland to Ireland, but after working for 18 days it went out of commission and it was not until after the close of the Civil War that Cyrus W. Field finally succeeded in laying another cable. Since that time cables have been simplified so that they now connect almost all parts of the world.

How the telegraph works. — The essentials of a short



A complete telegraph system. Shown ready for the operator at the station at the left to send a message.

telegraph line for connecting the houses of two boys are wire, a battery, a key, and a sounder. The double wire line well insulated is best, but a one wire line may be used if connected to a water pipe which, with the ground, makes a return circuit to replace the second wire. The battery should consist of two or more gravity cells joined in series. The key is a device for opening and closing the circuit. The interruption in the flow of the current produces a signal in the sounder at the other end of the line.

When no message is being sent, the switch attached to the key is closed. The current always flows through the entire circuit except for the interruption during the sending of the message.

Experiment. — To see how the electric telegraph works.

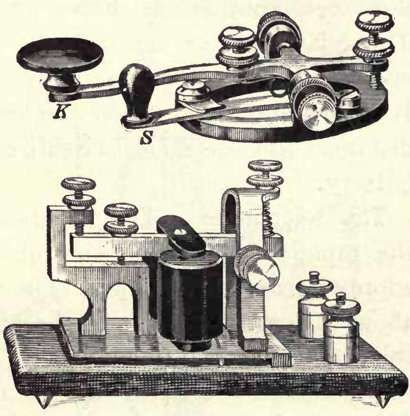
Materials: Telegraph sounder. Key. Two gravity cells. Wire.

Method: Connect a key and sounder in circuit with two gravity cells joined in series. Trace the wires through the instrument. Learn the names of the different parts. Open the switch; close it again; open the switch again and close and open the key. Hold it closed for a short and for a long period of time.

Results: Explain the results obtained in each of these trials. Learn to make dots and dashes.

When through with the apparatus leave with circuit closed. How can you do this?

How the message is received. — The sounder consists of an electromagnet. An armature is attached to a strip of brass pivoted at one end. The free end of the strip of brass may be moved up and down within a yoke against which it strikes to make the sound. When at rest, the armature is held close to the electromagnet. If the switch is open, the current stops. There is no longer any magnetism to hold the armature and it is raised by a spring. Upon pressing the key the current flows, magnetism is produced, the ar-



Telegraph key and sounder. Name the essential parts shown.

mature is drawn down, and the blow on the yoke results in a loud click. The interval of time between successive clicks is determined by the length of time the key is kept closed. A short interval makes a "dot," and a long interval makes a "dash." Dots and dashes in different combinations stand for the letters of the alphabet. A short space of time follows each letter and a longer one follows each word. The following is the Morse Telegraph Code:

A .-	H	O . .	U ..-
B -...	I ..	P	V ...-
C .. .	J -.-.	Q ..-.	W .--
D -..	K -.-	R . ..	X .-..
E .	L —	S ...	Y .. ..
F .-.	M --	T -	Z ... .
G --.	N -.		

In commercial lines where messages must be sent long distances, another instrument, the relay, must be used. The relay is more sensitive than the sounder, and will operate on a current too weak to operate the sounder. It is therefore used when the message comes from long distances to close a local circuit containing a sounder and battery.

The telephone. — The telephone offers an example of the rapidity with which useful scientific inventions are adopted in modern times. The telephone was invented about fifty years ago; it has been in commercial use about thirty years, and to-day there are over eleven million telephones in use involving the use of nearly 30,000,000 miles of wire. People in San Francisco and New York can carry on conversation with each other with as much ease as if they were sitting in adjoining chairs, and by wireless telephone conversation can be carried on between an airplane high in the air and the ground, or between Europe and America.

Experiment. — To study the action of the telephone transmitter.

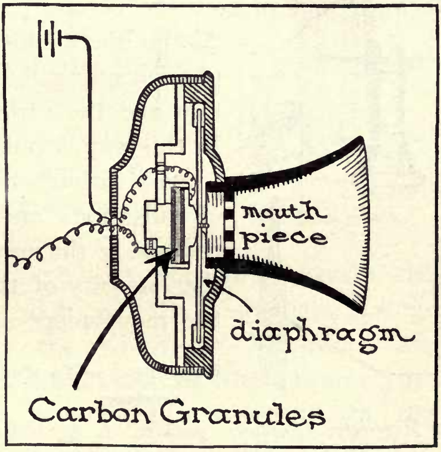
Materials: Telephone transmitter. Four dry cells. Two electric light carbons. Wires. Ammeter reading to 10 amperes.

Method and Results: Connect the ammeter in series with four dry cells and transmitter in one circuit. Read the ammeter. Press the diaphragm of the transmitter in, read the ammeter again. Release the diaphragm. Result? Disconnect.

Replace the transmitter with the two carbon pencils and use two instead of four cells; make good contact by winding the bare ends of the connecting wires tightly around the ends of the carbons. The circuit is closed and broken by bringing the two carbons together and separating them. Touch the carbons lightly, read the ammeter. Press the two carbons firmly together making better contact. Result?

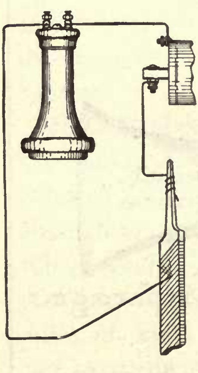
Conclusion: Inside the transmitter is a little box of carbon granules through which the current must pass. Explain how the fluctuating current is produced in the telephone circuit when one talks into the transmitter.

How the telephone transmits sound. — The ordinary telephone system is very complicated, and yet it is possible for us to understand the simple, physical principles underlying its use. We must first of all recall what sound is, how the voice is produced, and picture the sound waves as vibrations of the air traveling to the transmitter. There,



Telephone transmitter

contrary to popular belief, the sound stops. *No sound* passes over the telephone wire. Just what is transmitted will be very soon understood. Let us see what we can learn by a study of the transmitter. We learn from the experiment that there is a little box filled with carbon granules in the transmitter. These grains of carbon form a part of an electric circuit, but offer a rather high resistance to the flow of current. If the carbon particles are pressed closer together, resistance is decreased and more current flows. When they separate, less current flows through them. If we were to compress and release the walls of the box alternately, a variable current increasing with pressure and decreasing with absence of pressure would pass through the circuit. One wall of this carbon box is attached to a thin diaphragm just inside the mouthpiece of the transmitter. Sound waves are vibrations, the air becoming first more and then less dense in rapid succession. Each compression pushes the diaphragm forward and presses the carbon particles closer together.



As the air becomes less dense the diaphragm springs back to its natural position and the carbon particles separate. In this way, a pulsating current is made to pass through the wire. The number of pulsations and their intensity correspond to the number of vibrations and the intensity of the sound produced in the mouthpiece of the transmitter.

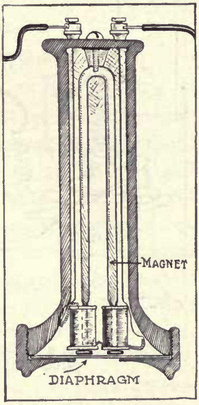
Experiment. — To study the action of a telephone receiver.

Materials: Telephone receiver. A dry cell. Wire. A coarse file. A fine file.

Method and Results: Connect one pole of the cell to one binding post of the receiver and the other to one end of a coarse file. Join a wire to the other binding post of the receiver, leaving the other end free. Hold the receiver to the ear. Run the free end of wire along the smooth surface of the file near the end. Result? Run the free end of the wire along the rough surface of the file. Result? What different effect is noticed if a fine file is used? If the speed of drawing the wire along the file is increased?

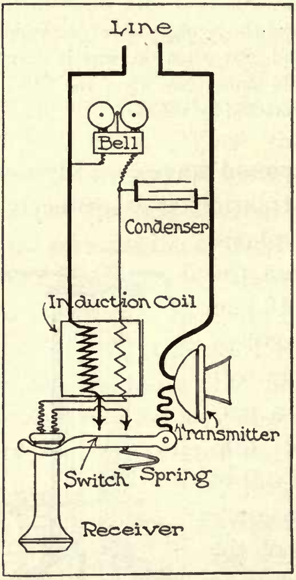
Conclusion: Unscrew the cap on the end of the receiver to see the inside structure of the receiver. Bear in mind that when the wire is drawn over the file ridges electrical contact is made only when the wire is touching a ridge. Explain the result detected by the ear.

How the receiver gives us the sound waves. — Suppose the electric circuit in which the transmitter is connected also includes at a distance a telephone receiver. What will happen when the pulsating current comes to it? If you should unscrew the cap at the end of the receiver you would find a thin soft iron diaphragm held in place by a permanent magnet. Remove the diaphragm and you will find a small coil of wire around the end of the magnet. This coil of wire forms the part of the electric circuit which carries the pulsating electric current. Every time the current is increased the magnetism is made stronger and the diaphragm is drawn closer to it. Every time the current decreases the magnetism becomes weaker and the diaphragm springs back. This completes the vibration. Vibrations are made as often as the pulsations of the electric current occur and these, you recall, correspond to the number of vibrations of the voice in the transmitter



Telephone receiver.

mouthpiece. The vibrating diaphragm of the receiver sets up sound waves in the air which are duplicates of those given to the transmitter. Thus it is that speech is reproduced at the other end of a telephone line with no sound, but only pulsations of electric current being transmitted over the wires. In order to strengthen the loudness and decrease the loss of electricity along the line, an induction coil is used in the telephone instrument to "step up" the voltage.

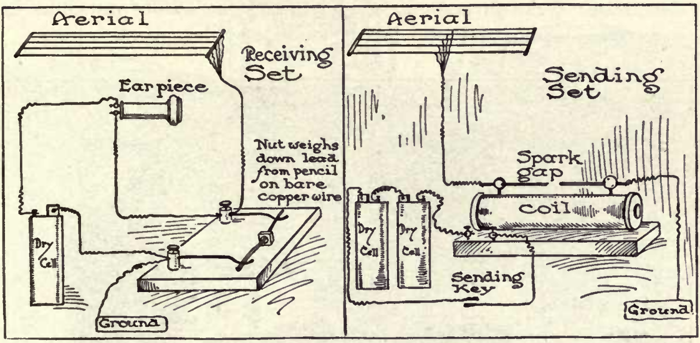


Instruments in a subscriber's telephone set.

Wireless. — Whenever an electric spark is produced an electric wave through the *ether* results. When a crystal of silicon, galena, or some other so-called "detector" is in loose contact with a metal and forms a part of an electric circuit there is high resistance at the point of contact, but when an electric ether wave passes across this contact point, the resistance is decreased and a stronger current flows. This strong current is detected by listening with a telephone receiver in circuit. This, in brief, is the principle underlying wireless telegraphy. In practice, the instruments with their adjustment and operation are rather complicated. The explanation of how a wireless set works will make an excellent project for those particularly interested. The following experiment illustrates in a simple way how a message may be sent and received.

Experiment. — To demonstrate the principle of wireless telegraphy.

Materials: An ordinary telephone receiver. Dry cell. Two screw binding posts. Copper wire. Graphite from "lead" pencil. An iron bolt nut. Two pieces of sheet metal. A small static machine or an induction coil.



Apparatus for demonstrating wireless.

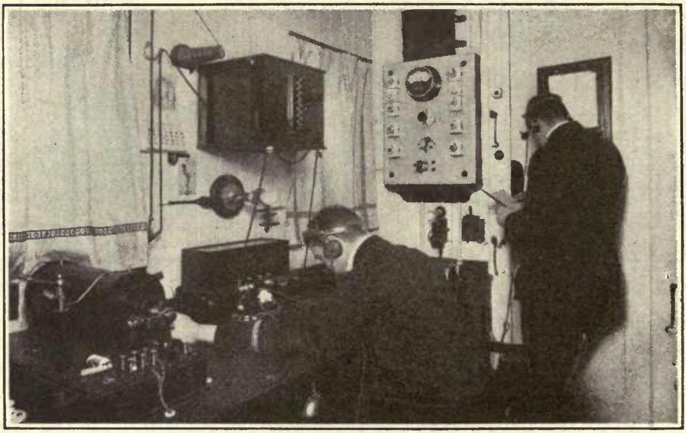
Method. Receiving end: Screw the two binding posts into a block of wood $1\frac{1}{2}''$ apart. Put a 3-inch length of No. 16 bare copper wire through the holes of each binding post so that they lie horizontally and about parallel to each other. Strip the wood from the graphite in a soft "lead" pencil to obtain a 2 to 3-inch length of graphite. Tie the bolt nut to the center of this and lay it across the two bare copper wires. The weight of the nut makes good electrical contact between the copper and the graphite. This device is the *detector*. Connect a dry cell and the telephone receiver in circuit with the detector. Also connect wires to the binding posts of the detector; one to a metal sheet (aërial) fastened high in the room and the other to the ground. The ground is easily secured by connecting to a water or gas pipe or to a steam pipe.

Sending end: In a distant room or a different building near by, set up the sending apparatus. This may be a static machine. If so, connect one pole to the ground and the other to a metal plate (the aërial), as was done in the receiving apparatus. Draw the pole pieces about $\frac{1}{2}$ inch apart and generate electricity. When a spark passes, a listener in the telephone receiver will hear a slight click or crackle of the telephone diaphragm.

If an induction coil is used in place of the static machine, adjust the spark gap to give a "fat" spark. Use the ground and aërial as in the other case. Each spark produced by closing the key will make an audible sound in the telephone receiver at a considerable distance away.

The detector may need some adjustment such as moving along to a new position on the copper wires or in bending the copper wires to change the distance between them.

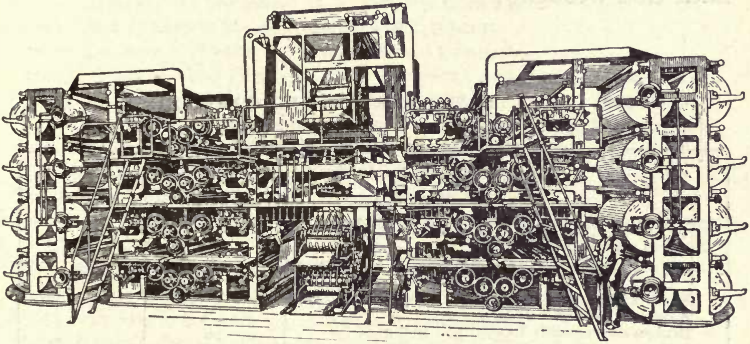
Conclusion: Write an account which explains the science principles involved in sending and receiving the message by the apparatus used.



A well-equipped wireless station.

Wireless has come to be considered an essential equipment for steamships and air craft. It is also used in commercial life for carrying messages across the ocean between many different countries. Not only can messages be sent by code signals but actual conversation can be carried on by parties thousands of miles apart. This is done by means of the wireless telephone.

The newspaper. — Perhaps no medium of communication exerts a wider influence upon our thoughts and actions than the newspapers and periodicals. It is a far cry from the crude press of Gutenberg which would give half a dozen single sheets an hour, to the modern Hoe press which turns out our newspapers with almost lightning rapidity. The gathering of news, the editing, the typesetting, the plate making, the printing and delivering of



Our newspapers are printed by means of very complicated machines.

the paper so that one can buy a paper containing a printed account of the various happenings within a few hours after they occur make up one of the marvels of modern achievements. It is said that half an hour after the death of Queen Victoria newspapers telling of her death were being sold on the streets of New York.

Sending pictures and writing by wire. — Several successful devices have been invented by which pictures can be sent over telegraph lines. The processes are too complicated for description here. The telewriter is a modern instrument by which a person can write a message and have it written instantly in his own handwriting hundreds of miles away. Telegrams and drawings are as easily reproduced as the writing. The telewriter depends in its action upon a properly adjusted system of resistances and electromagnets. The copy made by the receiving instrument is done with a pen which goes through the actual operations of a similar pen in the hand of the sender. One cannot read of all these marvels without thinking of the first message sent over the telegraph by Morse: "What hath God wrought!"

SCORE CARD. TRANSPORTATION AND COMMUNICATION

	Perfect Score	My Score
Streets and Roads Surface of type well adapted to location and kind of traffic (5) Roadway of ample width and lined with trees (5) Kept in good repair and clean (5) Bridges conveniently located and well kept (5)	20	
Railway One or more railway lines in the community, with local and express trains (5) A freight depot in the town (5) House express collection and delivery (5)	15	
Street Conveyances Frequent street car or jitney service locally and to near-by towns (5) Cars or jitneys adequate for traffic without overcrowding (5) Cost of travel in proportion to distance (5) Satisfactory bus or taxi service (5)	20	
Water Transportation A good harbor for ocean traffic (5) Lake or river transportation for fifty or more miles (2½) Canal extensively used (2½)	10	
Mail Service and Newspapers At least two collections and deliveries daily (5) Daily paper published in town (10); within 10 miles (5)	15	
Telegraph Day service (5) Night service (5)	10	
Telephone and Signal Service. Local and long distance telephone (5) Fire alarm box signal system (2½) Police signal service (2½)	10	
TOTAL	100	

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PART VI. HOW LIFE ON THE EARTH HAS IMPROVED

CHAPTER XXV

HOW PLANTS AND ANIMALS HAVE BEEN IMPROVED

Problems. — 1. *To understand how life comes from life.*

2. *To learn how pollination is brought about in flowers.*

3. *To find out what results from pollination.*

4. *To understand the meaning of the terms heredity and variation.*

5. *To understand the meaning of the work done by some great investigators in heredity.*

6. *To know something of Gregor Mendel and his law of inheritance.*

7. *To learn something of the work of the Department of Agriculture.*

Experiments. — 1. To learn about the structure and work of the parts of a flower.

2. To study cross-pollination in flowers.

3. To study the structure and growth of pollen.

4. To determine if there is individual variation in any one measurement of the members of my class.

5. To understand how artificial selection is made.

6. To show how hybridizing is accomplished.

Project I. — TO SEE HOW PLANTS ARE IMPROVED IN YOUR COMMUNITY.

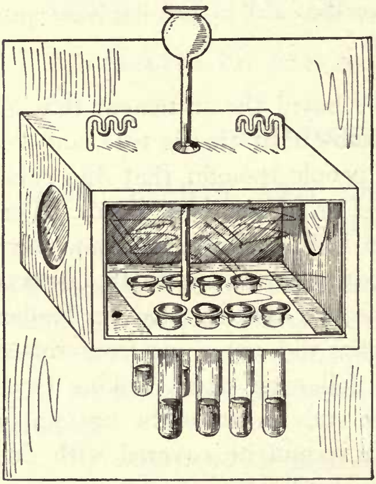
1. To make a study of the part played by different agents in cross-pollination of garden and other crops in your vicinity.

2. To learn what methods of plant improvement are practiced by the farmers or florists in your neighborhood.

3. To make a study of the processes used in breeding some particular plant in your own garden.

Life from life. — We have heard the statement that all life comes from life. We know that this is true, and yet not so many centuries ago people thought that flies came from rotted meat and frogs from scum on ponds. Persons are heard to say, even to-day, that toads rain down and that some insects are formed from the earth. It was not until the middle of the last century that an Italian named Redi proved that flies did not come from rotted meat. He did this in the following way. Taking three deep dishes he placed some stale meat in the bottom of each. One he left open, a second he covered with fine netting, and a third he covered with parchment paper so that no odor could pass out. He observed after a short time that maggots appeared in the open dish, but in neither of the others. He then examined the netting carefully and found the eggs of flies on it. We can reason from this experiment, knowing what we do about the habits of flies, that they were attracted by the decayed meat, laid their eggs in the meat in the first dish, laid their eggs as near to it as they could in the netting in the second dish, but were not attracted to the third dish at all because there was no odor from it.

Tyndall's experiment. — As late as 1876 many people believed that germs came spontaneously from water or certain decayed substances. Professor Tyndall, by means of the apparatus shown in the diagram, convinced scientists that there was no such thing as *spontaneous generation* of life. He made a box which had a false bottom through which test tubes of various sterile substances could be placed. This box had two glass sides through which rays of light could pass. The inside of the box was carefully covered with oil or vaseline so that dust in the air inside the box would stick to the sides. Air was admitted into the box through small, curved glass tubes. These tubes were also greased on the inside and were so made that no dust could find its way into the box. When the air within the box was entirely free from dust there was never any growth of bacteria in the substances in the test tubes. This proved conclusively that bacteria were introduced into substances in the tubes by means of dust in the air. Different experiments by Louis Pasteur proved that the small organisms called bacteria did not come into existence without previously coming from other living germs of the same kind.

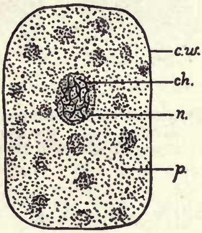


Tyndall's apparatus.

Structure of living things. — We have already spoken of the growth of bacteria. We found that these little plants, much too small to be seen with the naked eye, are in reality individual organisms. These structures, which we call cells, are the units out of which living matter is formed.

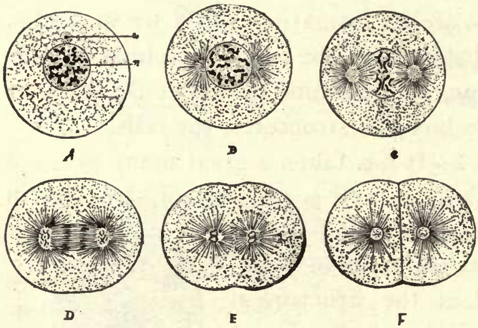
When we look at a distant brick building, we can only see that it is red. But if we focus a field glass or a telescope upon it, we can see the individual bricks out of which it is made. In the same way if we look at a large plant or animal we cannot see its formation, but if we were able to cut a very small slice from the plant or animal, mount it under a microscope, and examine it, we would see that it was made of little box-like structures, the cells.

Structure of cells. — It has taken a great many years of study to discover that the cell is the unit of structure in both plants and animals. Cells in all kinds of living things are made of *protoplasm.* As we look at the structure of a plant we find this living matter is not so evident as in the cells of living animals because the plant cells have thick walls of cellulose. If the contents of the cell be carefully stained with certain dyes, we find it invariably contains a small darker stained body called the *nucleus*, within which are found certain tiny bodies which color deeply and hence are called *chromosomes* (color-bearing bodies).



A cell; *c.w.*, cell wall; *n*, nucleus; *ch.*, chromosomes; *p.*, protoplasm.

Asexual reproduction. — When cells multiply, the nucleus divides, half of the chromosomes go into one of the new nuclei and half into the other. The cell body separates and two cells are formed out of the original one. This method of reproduction of living organisms is called *asexual* and occurs only in very simple forms of life. Likewise, the growth of a plant or a tree or a frog or a baby is always dependent upon the multiplication of cells making up the body of the living thing. This growth depends upon the nutrition of the individual plant or animal. If it is well nourished, if plenty of food is absorbed by the cells, and if they change this food into living matter, then the cells will grow rapidly and the body will increase in weight. It is a matter of common knowledge that if one's digestion is not good or if for some reason the cells of the body do not get enough nourishment, then their growth is slow and a person does not gain and may even lose weight.



Stages in the division of one cell into two. The nucleus divides first; the chromosomes split and the parts go in equal numbers to each of the new cells.

Sexual reproduction. — But there is another method by which living things reproduce. Not all plants are produced by planting slips or buds nor by fission as explained above. As a matter of fact most plants that we know of come from seeds. In most animals the young do not bud or break off from the parents, but as in the case of the frogs or birds the young develop from eggs. Let us see how this kind of reproduction, which is called *sexual*, is brought about.

The relation of bees to flowers. — We have all watched a bee as it visited some bright flower, and perhaps have noticed just what happened. The bee lights on the flower and, standing upon some one of the outer parts, sticks its head down into the middle of the flower. Its head bears a long beak or proboscis, and if we watch the little animal carefully we find it is trying to get some liquid matter that is stored within the flower, or that it is engaged in gathering yellow masses of dust from certain parts of the flower. Let us now examine a similar flower carefully to see just what the bee is after.

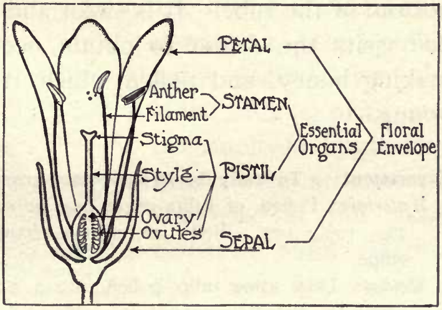
Experiment. — To learn about the structure and work of the parts of a flower.

Materials: Any large flower, preferably a simple flower. Hand lens.

Method: Carefully examine parts of flower.

Observations: Notice that the flower is built with the parts in circles. How many parts in the out-most circle? Of what color? They are called *sepals*. Collectively they make up the *calyx*. The parts in the next circle are called *petals*. How many parts did you find? Do they have color? Together they form the *corolla*. Notice the little knobbed structures next in order. They are called *stamens*. The *stalk* is called the *filament;* the knob, the *anther*. The yellow dust is called *pollen*. Use a lens and see how the *pollen* gets out of the *anther*.

The middle part of the flower is called the *pistil*. The enlarged base is the *ovary;* the stalk is the *style;* the tip, which is sticky, is the *stigma*. Pollen will grow on the stigma. How can pollen get from the *stamens* to the *ovule?* Cut a cross-section through the *ovary*. The little structures we see inside are called ovules. Within each ovule is an *egg cell* which is too small to be seen without a microscope. This egg cell under certain conditions will develop into a baby plant.



Parts of a flower.

Conclusions: Which parts of the flower are essential for the production of seeds? What then are the *essential organs* of the flower?

Structure of a simple flower. — If you examine almost any large flower, you will find as you look at it from above that it seems to be in circles or whorls. Outside are some green, leaf-like structures which we call *sepals*. Within this is found another circle of parts, usually brightly colored and sometimes quite irregular in shape. These are called *petals*, or, taken together they form the *corolla*. Still farther within the flower are a number of little stalks bearing at the end tiny boxes which contain the *pollen* or yellow dust just spoken of. These structures are called the *stamens*, the stalk is the *filament*, the box holding the pollen, the *anther*. In the very center of the flower is a structure shaped somewhat like an Indian club with the big portion at the bottom of the flower. This structure is called the *pistil*. We shall see later it is a very important part of a flower. Many flowers get along without the sepals and petals, having only the essential organs, the stamens and pistils.

What the bee is after. — If we should examine the lower part of the cup of the flower with a hand lens we would find little glistening drops of moisture. We have all pulled a honeysuckle and sucked this liquid from the bottom of the tube. It is sweet and is called *nectar*. The bee visits the flower to obtain nectar which it uses in making honey, and pollen which it uses in feeding the young.

Experiment. — To study the structure and growth of pollen.

Materials: Pollen of tulip, sweet pea, or nasturtium. Sugar solution, 3%, 10%, 15%. Bell jar, sponge, hand lens, compound microscope.

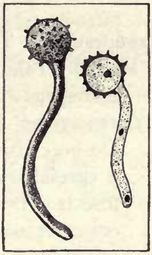
Method: Dust some tulip pollen into a 3% sugar solution, a drop of which has first been placed on a glass slide. Do the same with sweet pea or nasturtium, and a 10% and 15% sugar solution. Place slides and a moistened sponge under a small bell jar. Examine every twenty-four hours with low power lens of compound microscope.

Observations: Notice the small tube-like structures growing out of pollen grains. These are the pollen tubes and contain sperm cells.

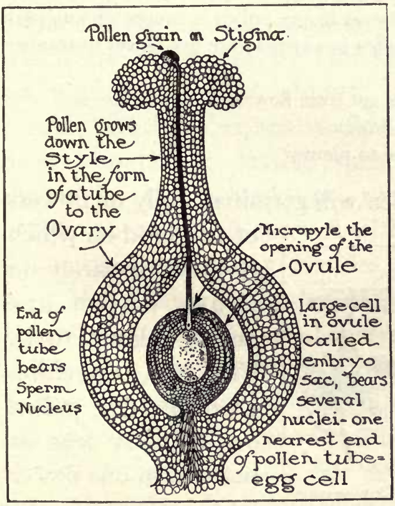
Conclusions: 1. What made the pollen tube grow?

2. Under what natural conditions might pollen tubes grow?

What the pollen does. — If we were to examine the grains of pollen under a microscope we would find that they contained one or more cells, depending upon the age of the pollen grains. Some of these pollen grains when placed in a weak solution of sugar and water will sprout, giving rise to little tubes looking very much like root hairs. These *pollen tubes* contain cells, one of which is known as a *sperm* cell. Examination of the top of the pistil shows the surface to be moist and sticky. It evidently throws out a fluid somewhat like a sirup. If a pollen grain lights upon this sticky surface called the *stigma*, it will usually germinate, the pollen tube going down the stalk of the pistil and eventually finding its way into a little structure in the base of the pistil, called the *ovule*. Within this ovule are found a number of cells, one of which is an *egg* cell. As the pollen tube grows



Pollen grain and tube. Section on right shows sperm cell passing down the tube.



Fertilization of a flower.

downward it takes with it a single *sperm* nucleus which under favorable conditions unites with the egg nucleus. This union is called *fertilization*. The ovule grows rapidly larger, the basal part of the pistil containing it becomes thicker, and the cells multiply rapidly and thus a *seed* is formed. This seed is usually contained within the thickened part of the pistil which goes to form a *fruit*.

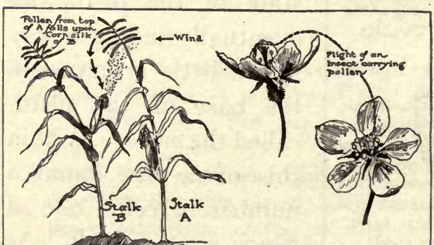
Experiment. — To study cross-pollination in flowers.

Method: Take a field trip where flowers are abundant and notice the following:

Observations: Are flowers being visited by insects? If so, what insects? Do bees visit flowers of one sort or of different sorts in order? Make a careful study of this with the bee. With the butterfly, or other insects. Do insects seem to know color? Do they seem to prefer one color to another? Can you discover any means by which the flowers might attract an insect? Insects can probably smell and taste as well as see. Do you find any peculiar shapes in flowers which seem to offer a resting place for insects? If so, does the pollen from such flowers become attached to any part of the insect? Catch two or three different insects. Use a hand lens to see if any pollen is caught on any part of their bodies. Could this pollen be carried from one flower to another of the same kind?

Conclusions: 1. What do insects get from flowers?
2. What do insects give to flowers?
3. How might this be of use to plants?

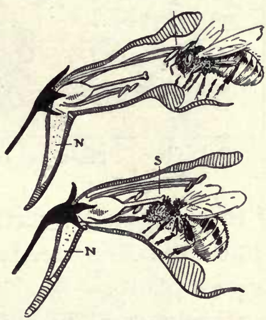
Cross-pollination. — Pollen will germinate only on flowers of the kind on which it grew, or rarely on those which are nearly related to it. The bee, therefore, when it takes pollen on its hairy legs or body from one flower to another of the



Cross-pollination.

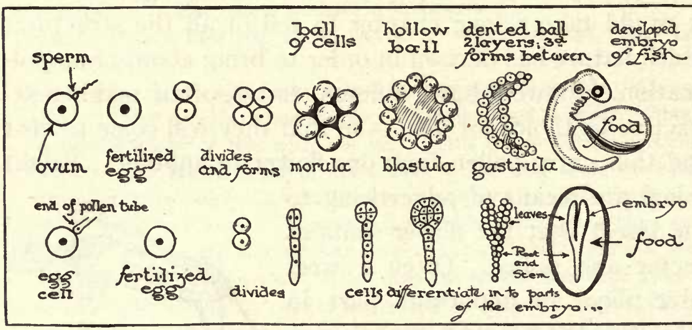
same kind transfers the pollen grains to a place where they can germinate. This process is called *cross-pollination.* It has been found by biologists that plants are usually healthier and stronger if they grow from seeds developed in flowers which have been fertilized by grains of pollen brought from anthers of one flower to the pistil of another flower of the same kind.

Some ways in which cross-pollination is brought about. — It would take a long chapter to tell of all the structures which nature has devised in order to bring about cross-pollination. Flowers have different forms, often making attractive footholds for insects so that they will come to visit and thus carry pollen from one flower to another. Bright colors are means of advertising to the insect that the flower contains nectar and pollen. Often a sweet odor plays an important part in attracting the bee, and some flowers which are pollinated by flies have an unpleasant odor almost like rotting meat. Frequently flowers have remarkable devices such as shown in the illustration, which enable them to be sure of either self- or cross-pollination. Besides, insects, birds, the wind, water, or man himself may be a means of carrying pollen from one flower to another.



Notice that the bee's head rubs against the anthers (*A*) and later against the stigma (*S*) as he presses forward to secure the nectar (*N*). How may this aid in self-pollination? If the bee visits other flowers of the same kind, might cross-pollination result? Explain.

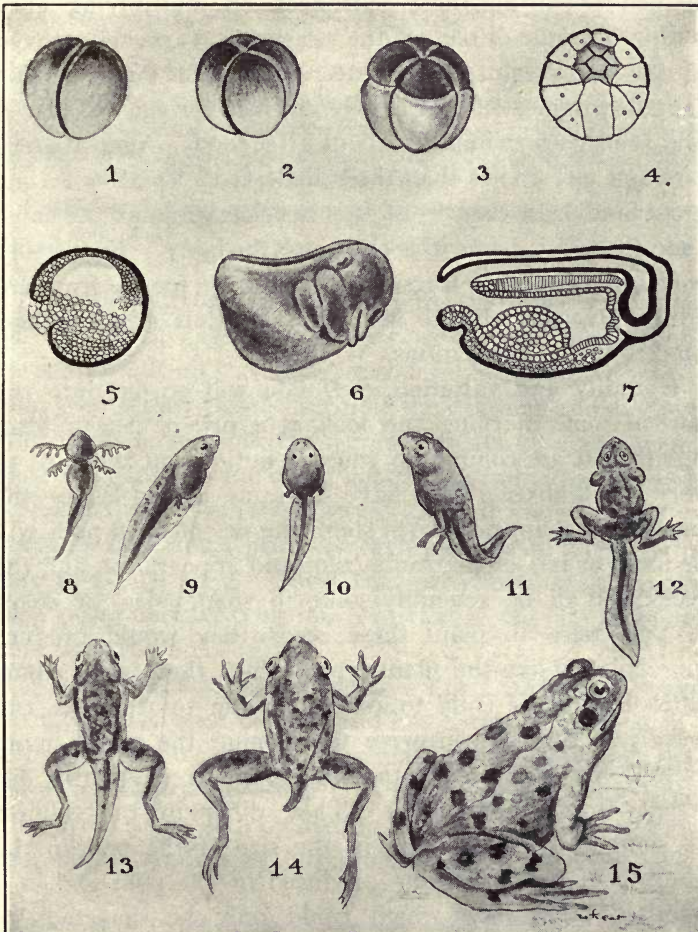
The development of an embryo. — After the egg cell has united with the sperm cell a single cell is formed, but almost immediately this cell divides into two, then these two into four, four into eight, and so on, until within the seed a little baby plant or *embryo* is formed. This embryo remains dormant until such time as the seed is placed in favorable conditions for germination or growth. We know that plants in the garden require a certain amount of warmth, water, and soil. Under such conditions the baby plant within the seed is awakened to activity and starts to grow. Eventually it will produce flowers, and



Plants and animals both develop into embryos.

if the egg cells are fertilized these flowers will then produce fruits containing seeds. These seeds in turn will give rise to new plants.

Development in animals. — Nearly every boy and girl has seen a mass of freshly laid frog's eggs. These eggs are laid in water in the early spring by the female frog. The male frog then places some sperm cells on the eggs. If a sperm cell unites with an egg cell then that fertilized egg cell will develop into a little tadpole or baby frog. If you will examine a mass of frog's eggs laid in the early spring, you will doubtless see that these eggs are in the process of division. Just as in the flower, the fertilized egg divides first into two, then into four, then into eight, then



Development of a frog. 1, two-cell stage; 2, four-cell stage; 3, 8 cells are formed, notice the upper cells are smaller; in (4) the lower cells are seen to be much larger because of the yolk; 5, the egg has continued to divide and has formed a gastrula; 6, 7, the body is lengthening, head is seen at the right-hand end; 8, the young tadpole with external gills; 9, 10, the gills are internal, hind legs beginning to form; 11, the hind legs show plainly; 12, 13, 14, later stages in development; 15, the adult frog. Figures 1, 2, 3, 4, 5, 6, and 7 are very much enlarged. (Drawn after Leukart and Kny.)

sixteen cells. So these cells keep on multiplying until within a couple of days if the weather is warm the embryo of the frog begins to elongate. In another day the little tadpole wriggles out of the jelly in which the egg was placed and soon goes swimming about after food. Almost every boy and girl knows that these little tadpoles after a time grow hind legs, then front legs develop while at the same time the tail is being absorbed into the body. Eventually we have the young frogs. Not until the female frogs are adults are they able to lay eggs and thus pass on their kind to future generations.

Heredity and variation. — If you will go out into the garden some morning and look at a row of pea or bean plants that are coming up you will notice that they are all very much alike. They have the same shaped leaves, the same general appearance of stem, the pea or bean pods will be more or less of the same color and appearance, and the seeds will all be generally alike in shape, size, or color. If you were to plant these seeds they would produce more plants like the plants from which these seeds came. This likeness of child to parent is due to what we call *heredity*. But if you were to examine the plants more closely you would find that every plant is slightly different from its neighbor. They differ in the tallness or shortness of the stem, in the size of the pod, in the number of peas or beans produced in the pod, and in a hundred other ways which could only be detected by fine measurements. These plants have the same conditions of soil, moisture, and air. The factors of their environment may be the same, and yet the plants differ. This tendency to differ among plants and animals is called *variation*.

Experiment. — To determine if there is individual variation of any one measurement of the members of my class.

Materials: String. Rule.

Method: With the string carefully measure the circumference of the right wrist of a member of the class and let him measure yours.

Observations: Hand your measurement in inches on a piece of paper to one member of the class who will tabulate the figures on the board. Make a graph showing the individual variations.

Conclusion: Is there variation in this measurement among the members of your class?

Variation in the classroom. — In the same way if we observe the members of the class we see that the boys and girls are built on the same general model, and no doubt in many ways they closely resemble their fathers and mothers, and in some respects their grandparents or great grandparents. But on the other hand, each individual member varies in many different ways. We all know that if we were to take finger prints of each member of the class no two would be alike. These two great factors of heredity and variation have done much to change the life of plants and animals on the earth.

Variation and its use to men. — For a good many years variation has been noticed and has been made use of in a practical way by plant and animal breeders although they have not known any exact laws with which to work. Yet they have succeeded, by mating plants or animals with certain desired variations, in producing better offspring.

Experiment. — To understand how artificial selection is made.

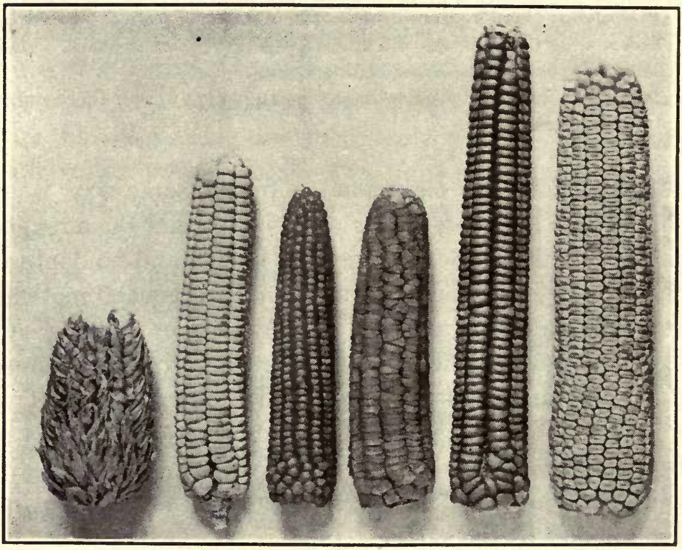
Materials: Corn on the ear. Shallow box and sawdust.

Observations: Compare several different ears of corn and select one ear which has the most even rows, largest kernels. Suppose this ear came from a plant bearing but few ears; would you select it for planting? Now select one of the poorest ears, judging by the same standards as above. Place equal number of kernels from each ear in planting box.

Note the percentage which grow. The appearance of corn plants on the average of two, three, and four weeks.

Conclusions: 1. How would you select corn seed for planting?

2. Do these experiments give sufficient evidence for selection?



Types of corn. From left to right: pod corn, soft corn, pop corn, sweet corn, flint corn, dent corn. (After Moore and Halligan.)

Charles Darwin. — In the middle of the last century, a great Englishman, Charles Darwin, was one of the first to realize the practical uses of variation and heredity. He knew that although plants and animals were like their ancestors they also varied from them. In nature the variations which seem to fit a plant or animal for its own environment were the ones that were handed down to another generation. Darwin thought if nature thus seized upon favorable variations, then man could *select* favorable variations, and by care could breed for the characters that he desired. Such artificial selection is seen in everyday farming. The boy and girl who belongs to a corn club and who selects the best corn for planting by means of testing is practicing artificial selection. By means of selective planting such as this the farmers have put millions of dollars each year into their pockets and have made the cereal crops of this country known the world over.

Mutations. — Rather recently a Dutchman named Hugo de Vries, while working with primroses, discovered that in breeding these plants certain ones were produced which differed widely from the parent plant. The seeds of these primroses when planted produced plants exactly like the parents. Plants which thus arise are called *mutants*. In 1862 a Mr. Fultz of Philadelphia, while passing through a field of wheat, found three heads of wheat which had no chaff. He was a plant breeder and recognized the value of these three beardless wheat heads. He took the grains out carefully, sowed them by themselves, and as a result produced a strain of beardless wheat now known as the Fultz wheat. This is an example of how a mutant can be used in ordinary agricultural work. It should be the ambition of every boy and girl interested in agriculture to watch carefully for such favorable variations, to preserve them carefully and to plant the seeds from these plants in hopes that the desirable quality may be preserved.

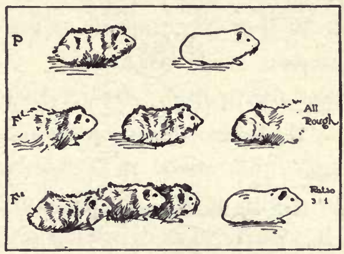
What causes plants and animals to breed true. — We have already seen that plants and animals are made of cells. We have furthermore seen that these cells are of two kinds, the ordinary cells of the body which give rise to stems and leaves and roots of plants and the flesh and blood of animals, and another kind of cell known as the *sex* or *germ* cells. These germ cells are set apart at a very early stage in the life of the plant or animal and are the bearers of *heredity*. It has been pretty well determined by means of careful experiments that the tiny structures we call *chromosomes* within the *nucleus* of the cell contain the *determiners* of the qualities which may be passed from parent plant to offspring or from animal to animal.

Germ cells. — It has also been found that in preparing for the process we call fertilization half of the chromosomes of the male cell and half of the chromosomes of the female cell are eliminated, so that when the two cells combine to form a fertilized egg it contains the whole number of chromosomes for that particular plant or animal. If the chromosomes carried the determiners of the characteristics which are inheritable, then it is easy to see that a fertilized egg would contain determiners from both parents. In this way each of us has received the determiners which give us certain characteristics which have been handed down from mother or father, grandmother or grandfather, or even from some far distant ancestor. This subject is of vital importance to all of us, and you will study more about it when you take up the subject of biology later in your school course.

Gregor Mendel. — About fifty years ago there lived in an Austrian monastery a monk named Gregor Mendel. He worked in his little monastery garden for a good many years breeding peas. For a long time his work was unknown, but a little more than twenty years ago it was suddenly called into prominence by work done in this country and in Europe, which indicated that he had discovered a law by which heredity works.

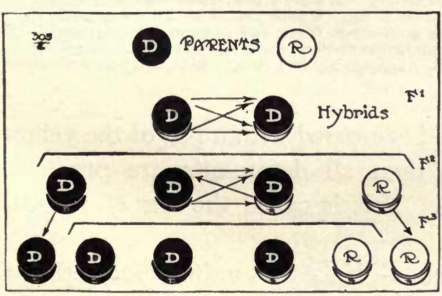
The law of unit characters. — He found first of all that the plants with which he worked handed down certain fixed characteristics such as the color of the peas, the shape of the pods, the tallness or shortness of the bodies. This gave rise to what is known as the *law of unit characters*, for it appears that our heredity is made up of unit characters, and that when we are like both our fathers and our mothers we have received certain unit characteristics from each of them and not a blend of the two.

The law of dominance. — He also found that if he crossed peas containing two characters, such as the yellowness and greenness of the peas in a pod, one character always dominated over the other and would appear in the offspring. The other character, in this case the greenness of the peas, would not be lost, but would appear in a later generation. This is called the *law of dominance.*



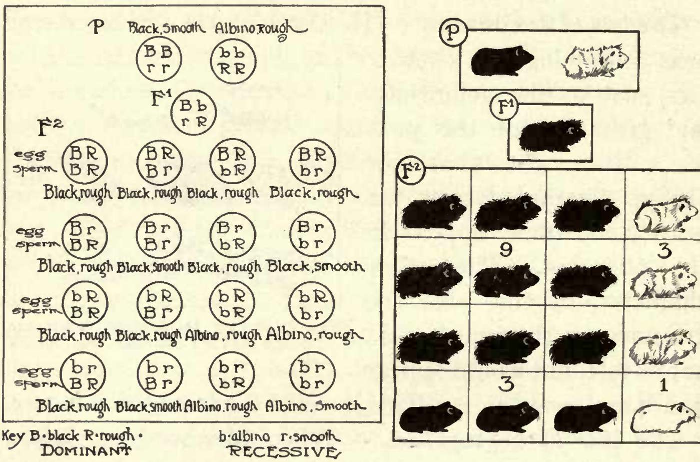
This illustrates the law of dominance. Rough coat is a dominant characteristic.

The law of segregation. — When Mendel bred yellow and green peas he found the offspring all had yellow peas in the pod. These peas were really hybrids, that is, they were the offspring of two parents which differed in respect to a certain unit character. If these hybrids were bred



This illustrates the law of segregation. Follow out the crossings of the D hybrids to the F^3 generation. The proportion of hybrid to pure recessive is 3: 1. Pure recessives will always breed recessives and dominants will breed dominants.

each with another hybrid of the same kind, then in the next generation the offspring would be produced in the ratio of about three yellow to one green, or three dominant to one recessive. If the hybrid peas were bred with a green pea (a pure recessive), then the offspring would be produced at the rate of about two dominant and two



The inheritance of contrasted characters. Mendel's law shows that unit characters are handed down from parent to offspring. Notice that if we cross a smooth, black guinea pig with a rough, white guinea pig, black and roughness of coat are dominant characters. In the F^2 generation we find these unit characters sorted out in the proportion of 9 rough black, 3 smooth black, 3 rough white, and 1 smooth white

recessive. If the hybrid is crossed with a pea of the yellow variety (a dominant) then all dominants are produced in the next generation. This is called the *law of segregation.*

Use of this knowledge. — Since it is quite evident that a knowledge of these laws is of very great importance to plant and animal breeders, hundreds of biologists are trying to find out new dominant and recessive characteristics in plants and in animals, for it is only by a knowledge of these characteristics that intelligent breeding of plants and animals can take place. Much can be done with selection, but by means of a knowledge of Mendel's law it is quite possible for those who are trying to make better plants and animals to breed for exactly the qualities that they wish. And so the dairyman breeds for greater milk and cream production, the hog raiser for heavier hogs, the sheep grower for more and better wool, and the florist for new and more beautiful flowers. Heritable traits in man as well as in plants and animals seem to be subject to these natural laws. One may therefore predict with some degree of accuracy the characteristics of children. Thus we see that the application of all this knowledge is of tremendous consequence to the future of the human race. The following tables show some of the characteristics that have already been discovered in plants and animals.

INHERITED CHARACTERISTICS OF PLANTS

Plant	Dominant Character	Recessive Character
Barley	Beardless	Bearded
Corn (Indian corn)	Round seed	Wrinkled seed
"	Yellow grain	White grain
Cotton	Colored lint	White lint
Garden pea	Tallness	Dwarf habit
"	Round seed	Wrinkled seed
"	Colored seed coat	White seed coat
"	Yellow albumin in cotyledon	Green albumin in cotyledon
Sunflower	Branching stem	Non-branching stem
Sweet pea	Purple flowers	White flowers
"	Long pollen	Round pollen
Thorn apple	Prickly fruit	Smooth fruit
Tomato	Two-celled fruit	Many-celled fruit
Wheat	Beardless	Bearded
"	Late ripening	Early ripening

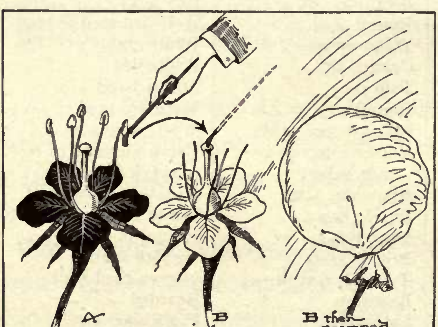
INHERITED CHARACTERISTICS OF ANIMALS

Animal	Dominant Character	Recessive Character
Canary	Crested head	Plain head
Cattle	Polled (hornless)	Horned
Fowl	Rose comb	Single comb
“	Rumpless	Rump
“ white leghorn	White	Colored
“ another race	Colored	White
Fruit fly	Red eyes	White eyes
“	Beaded wings	Normal wings
“	Long wings	Vestigial wings
Guinea pig	Colored	White
“	Rough coat	Smooth coat
Horse	Bay coat	Chestnut coat
Mouse	Normal movement	Waltzing movement
“	Colored	White
Rabbit	Short hair	Long hair (Angora)
Silkworm	Yellow cocoon	White cocoon

Experiment. — To show how hybridizing is accomplished.

Materials: Plants bearing flowers. A manila bag. A camel's hair brush.

Method: Tie a manila bag over a flower that is about to open. Find another flower that is about to open, on a plant of the same family though another variety or preferably another species, and from that flower remove all the stamens. Tie a bag over it also. Why?



Transfer of pollen in hybridization.

When the flower in the first bag opens transfer by means of a small camel's hair brush some of the pollen to the stigma of the flower without the stamens. Put the bag again over the second flower, placing a label on it. Give all of your data.

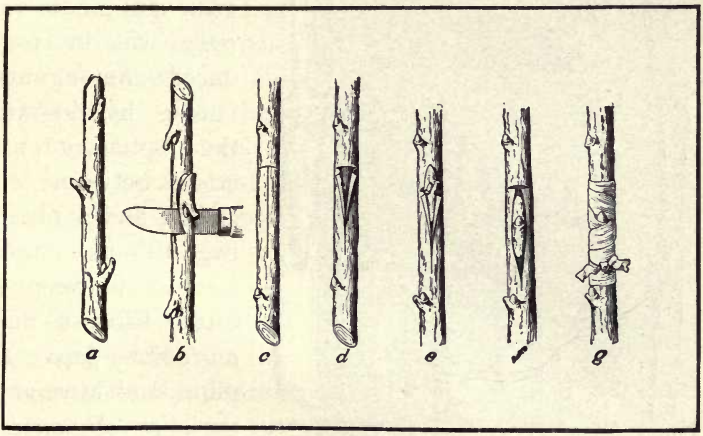
Observations: Why do we take so much care in covering the flower?

Why such care in the transfer of pollen?

Remember that as a result of this transfer the sperm cell of one flower may unite with the egg cell of another having quite different qualities.

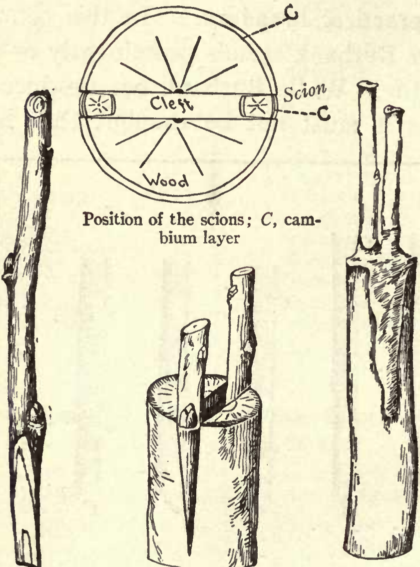
Conclusions: What is the use of hybridization?

The work of some practical breeders. — In this country the name of Luther Burbank stands prominently as a great creator of plant life. While Burbank has produced many wonderful plants it must not be thought that he



Steps in budding. *a*, **twig having suitable buds to use:** *b*, **method of cutting out bud;** *c*, **how bark is cut;** *d*, **how the bark is opened;** *e*, **inserting the bud;** *f*, **the bud in place;** *g*, **the bud properly bound in place.**

has produced any new unit characters. He really selects from a great number of plants a few that have varied in such a way as to display prominently some unit character or combination of unit characters which he is desirous of perpetuating. He destroys tens of thousands of plants which do not have the desired characters. Another method used by Burbank is that of artificial hybridizing. By this method he carefully covers a flower on some plant which he wishes to experiment with, and at the proper time cuts off the stamens before the pollen is produced. Then he carefully dusts the stigma of the pistil with pollen from another plant which contains the qualities he wishes to cross with the first plant. If these two plants are near relatives then it is likely that the pollen will grow and a new variety will be produced. Among such famous hybrids are the "plumcot" a cross between an apricot and a plum, the "Climax" plum, a cross between a bitter Chinese and an edible Japanese plum, and his many varieties of berries, particularly the "Lawton" blackberry and the loganberry. Another new cross is the spineless cactus, which promises to be a wonderful food plant for cattle in the desert regions where grass cannot be grown. Most of Burbank's varieties thus produced will *not* grow from seeds, but are produced *asexually*, by grafting or budding, as illustrated in the diagrams (pages 407, 408).



Position of the scions; *C*, cambium layer

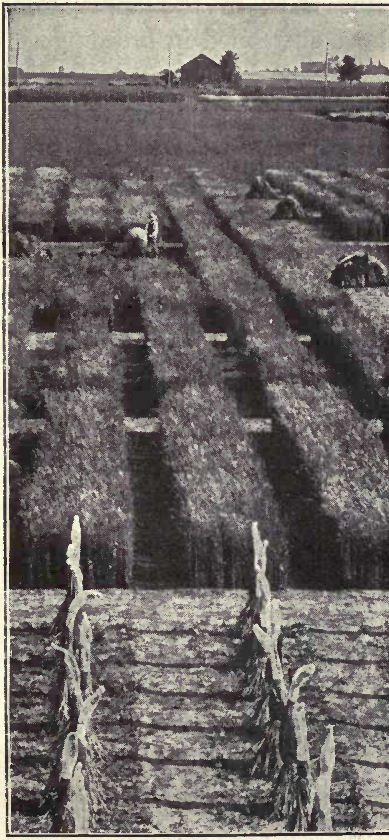
Scion

Scions in the cleft

Cleft graft complete

Grafting. The scion is taken from a tree having the kind of fruit desired and placed in a tree of the same species as suggested above.

The work of the Department of Agriculture. — One of the greatest factors in the production of more and better crops in this country is the Department of Agriculture. Not only are they doing wonderful work with methods such as have been described, but they have perfected new ways of grafting and budding. If a tree, for example, produces a kind of fruit which is of excellent quality, it is quite possible to insert a bud from this tree into another strong tree of the same species that is not a good fruit producer, and thus get the desired fruit. A T-shaped incision is cut in the bark, a bud from the tree bearing the desired fruit is placed in the cut and bound in place. When this bud grows later its branches will bear the desired fruit.



Experimental breeding plots.

In somewhat the same way grafting is done. In this case a small portion of the stem of a tree is fastened into another tree of the same species so that the barks of both come together. This allows the food to pass from the tree into the grafted stem, and thus the stem is nourished.

The Department of Agriculture is also doing remarkable work in the application of Mendel's law. They have succeeded in breeding wheat with certain unit characters which enable it to resist cold, frost, and rust. Many cattle are now being bred for immunity against certain diseases. This work of the Department of Agriculture bids fair to be the most successful and important that it has yet done. The state departments of agriculture also have developed greatly and in many states are the chief sources of help to the farmer. They are developed in connection with the state agricultural schools and universities and do, by means of their experimental farms, much to make plant and animal products more useful to man.

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CHAPTER XXVI

HOW THE HUMAN RACE HAS PROGRESSED

Problems. — 1. *To learn how man handed down knowledge.*

2. *To understand the meaning of the triangle of life.*

3. *To learn the meaning of feeble-mindedness.*

4. *To understand why " blood will tell."*

5. *To understand the meaning of eugenics and euthenics.*

Experiment. — 1. To determine some means of bettering the human race physically and mentally.

Project I. — TO MAKE A STUDY OF THE HEREDITY OF MY OWN FAMILY.

a. Obtain from the laboratory of the Carnegie Institute, Cold Spring Harbor, New York, material for the study of your own family history.

b. Get all the data you can from parent, grandparent, and other relatives and construct a chart such as is shown in some of the illustrations in this chapter.

c. Prepare a report of the findings.

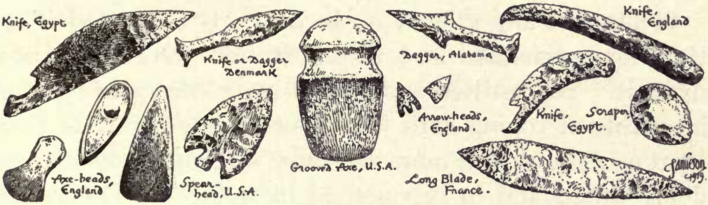
Project II. — TO MAKE A STUDY OF ALL THE CONTROLLABLE FACTORS IN MY ENVIRONMENT WHICH WILL HELP OR HINDER ME IN LIFE.

The beginning of civilization. — We have already told the story of man's early life on the earth. It is indeed a far cry from the cave man living by the strength of his arm and spear to the civilized man of to-day. We have progressed greatly and the civilized earth is a much better place for habitation than it was in the days when man wandered without a fixed abode. It is also a much safer place than in the days of Greece and Rome with all their vaunted civilization. How is it that man has improved so greatly?

Man learns from experience. — Man differs greatly from the lower animals in one respect. They can learn from experience but they cannot tell others. A little chick, for example, just out of the shell, picks at a badly tasting worm and gets an impression that lasts it through its life. It will probably never pick up such a worm again. But all other chicks will have to learn all this over again by themselves. On the other hand, man learns not only to profit by experience but to teach what he has learned to others and thus hand the knowledge down to the next generation. We cannot hand down by heredity the knowledge we have gained in this life, but we can teach others and they can pass on the information they have acquired.

This shows how an Australian native kindles a fire. Our remote ancestors used similar methods. Some American Boy Scouts can kindle a fire in this way.

Knowledge that concerned the making of fire. — The making of fire was so important a process that it was doubtless considered in the relation of a religious rite or ceremony, and by such means it was impressed upon the youths of the tribe. The boys of the tribe learned from their fathers how to make spears, bows and arrows, and nets with which to catch fish. Women in primitive life doubtless did all of the household work. They planted and tilled little fields in order to keep body and soul together when the hunting and fishing gave no return. Necessity doubtless prompted them to make vessels of



Primitive stone tools and weapons

soapstone or other soft stone in which they could cook. They learned to use fibers and weave them into rude clothes when skins were not obtainable. They raised their children and taught the girls the same things that they had learned to do.

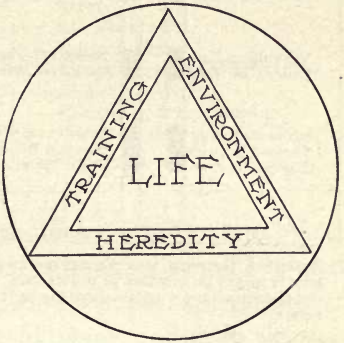
Primitive "household" work.

How civilized life has developed. — Early in the life of man the clan or tribe played an important part. Gradually people began to live together in communities for mutual protection. Inhabitable areas began to be used by more and more people. Regions of fertility came to be seized upon by clans or tribes. Wars thus developed for the possession of these areas or in defense of them by the people who lived there. All this led to strong tribal feeling. It also led to another development — that of the strong man in the tribe as leader or chief, and from this came the further one, that the son of the chief ought to continue in power. Thus government by a few rather than by many developed.

Civilization and science. — In the early days of civilization, communication and transportation were crude and difficult. Superstition and lack of knowledge made people incapable of coping with famine or disease. But as time went on man became more and more scientific in his way of doing things and in his method of thought. To-day we live in an age of science. The World War in spite of its evil has shown a good side since it has drawn men and women the civilized world over towards scientific thinking in the solution of their problems. It has also led to coöperation rather than antagonism. Witness the work done during the World War by Catholic and Protestant together, by the Red Cross at home and abroad, and by the Hoover committee for the relief first of the Belgians and then for the saving of lives in other afflicted parts of Europe.

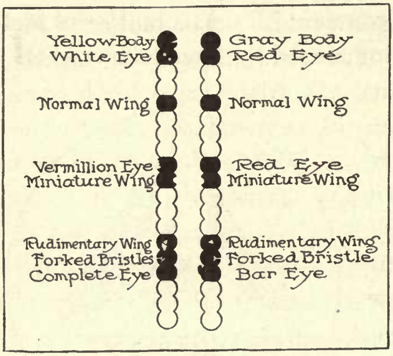
In life, however, we must have competition to stimulate us as well as coöperation to make growth possible. Science is showing how competition and coöperation may go hand in hand. It is directing the work in great factories, making working conditions there safer and better, and increasing the output by means of improved machinery. Science is helping man through coöperation in the saving of human lives, in better sanitation and hygiene in the home and in the community. It is showing us better methods of work in the hospitals and in the sanatoria. It is giving us better prisons and methods of dealing with prisoners. It is making our teachers and physicians better equipped and more capable of coping with problems based on science; it is becoming a part of the working knowledge of every boy and girl, as well as father and mother, thus to be passed along to the next generation.

Triangle of life. — A good deal has been said and written upon the question, "Which is the more important for a person, his heredity or his environment?" As a matter of fact the life of each one of us is influenced by three great factors; these are *heredity* or what we are, *environment* or what we have, and *training* or what we do. We have shown in the previous chapters of this book how important our environment is and how much is being done to improve it. In the first part of this chapter we have seen how important training has been and still is in the lives of people. Let us now ask ourselves the question, "What part does heredity play in our lives?" Knowledge that the race is gradually changing, that there is a constant growth or evolution makes us ask, "Can these laws of heredity of which we learned in the last chapter be applied to the human race?"



The triangle of life.

Heredity in man. — We have already seen that the chromosomes which are believed to be the bearers of the determiners of the heredity qualities are present in the cells of certain flowers and of frogs. Are they present in the cells of man as well? It has been found that chromosomes are present in the germ cells of *all* plants and animals and differ in number in different species. In the little worm called *ascaris* and in the fruit fly, there are four chromosomes in one germ cell. In the mosquito (*culex*) there are six, in the rat sixteen, in the frog twenty-four, in man forty-seven, and in woman forty-eight. In certain crustaceans there are over one hundred and fifty, while in one tiny animal there are believed to be as many as sixteen hundred. It is therefore reasonable to believe that the chromosomes in the human animal are similar in structure and in function to those of lower animals. Professor Morgan at Columbia University came to believe, as a result of his studies with a tiny fruit fly, that the chromosomes actually were made up of unit characters and that these characters were often linked together in the same sex and were handed on together. This suggests a makeup of chromosomes as is shown in the diagram above.



This section through two chromosomes shows how it might be possible to prove that different chromosomes contain separate unit characters.

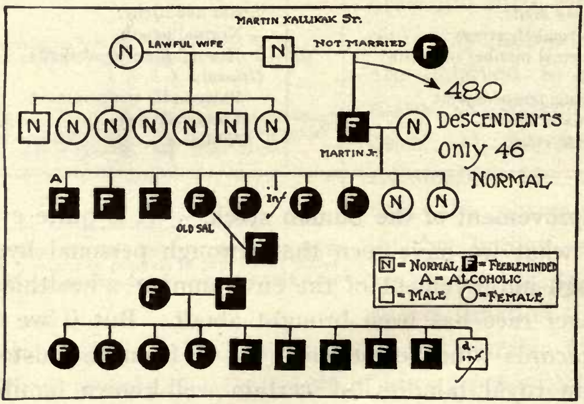
It can easily be seen that with forty-eight chromosomes it would be a very difficult matter for us to follow up just which traits or structures were dominant and which recessive, since so many different combinations of characters are possible. However, a number of characteristics have been determined already, as the following table shows.

INHERITED CHARACTERISTICS OF MAN

Dominant Character	Recessive Character
Eyes:	*Eyes:*
Brown	Blue
"Night-blinded"	Normal sight at dusk
Pigmented iris	No pigment in iris
Hair:	*Hair:*
Beaded	Even
Curly	Straight
Dark	Light
Limbs and digits:	*Limbs and digits:*
Abnormal shortness	Normal length
Abnormal number of digits	Normal number of digits
General:	*General:*
Nervous temperament	Phlegmatic temperament
Normal-minded	Feeble-minded
Normal color	Albinism

Improvement of the human stock. — It is quite evident from what we have seen that through personal hygiene, through improvement of the environment, a healthier and stronger race has been brought about. But if we study the records which come down to us from the history of certain royal families, of certain well-known families in this country and Europe, and in studies made of other families which through misfortune have become a burden on society, we find that *breeding* in man must be taken into account as well as in plants and animals.

The heredity of civilized man. — A number of years ago there lived in an isolated part of New York state a family of ne'er-do-wells. This family, known as the Jukes, has been carefully studied. Up to 1915 there were 2094 members. Of this number 1600 living at present are feeble-minded or epileptic. There have been 310 paupers; over 300 immoral women; 140 criminals, of whom 7 were murderers. Not a soldier has appeared in the family and no one of them has had a common school education. Only 20 have learned a trade and 10 of these learned it while in prison. The family has cost society over $2,500,000 up to the present time. And why? Because the original stock was feeble-minded and intermarriages have handed down the feeble-mindedness to other generations. Another case is that of the Kallikak family.



The family pedigree of the "Kallikak" family. Is feeble-mindedness handed down by heredity?

This family has been traced back to the time of the War of the Revolution when a soldier named Martin Kallikak had a feeble-minded son by a feeble-minded girl. Up to the present time there have been 480 descendants from this boy. Of these 33 were sexually immoral, 24 confirmed drunkards, 3 epileptics, and 143 feeble-minded. The young man who started this terrible line of immorality and feeble-mindedness later married a normal Quaker girl of good family. From this couple a line of 496 descendants have come in which there are no cases of feeble-mindedness. Feeble-mindedness is thus seen to act as a recessive Mendelian characteristic, and, as a study of the diagram shows, if one feeble-minded person marries another all their offspring are sure to be feeble-minded.

Parasitism and its cost to society. — If this were but one case it would be bad enough, but there are over 200,000 feeble-minded persons in the United States to-day. These persons spread disease, crime, and immorality in all parts of the country, principally because they know no better. Just as certain plants or animals become parasitic on others so these people have become parasites on society. Largely for them the asylum and the poorhouse exist. They take from society but they give nothing in return. In the valley of Aosta a few years ago there existed a number of idiotic folk known as cretins. Probably over fifty per cent of the inhabitants of this little mountain valley were so affected. But thanks to wise planning these idiots were segregated, the males in one asylum and the females in another. Since that time the race of cretins has gradually died out and one scarcely ever sees any of them now. This is the only means by which feeble-mindedness can be eventually blotted out from the earth.

Experiment. — To determine some means of bettering the human race physically and mentally.

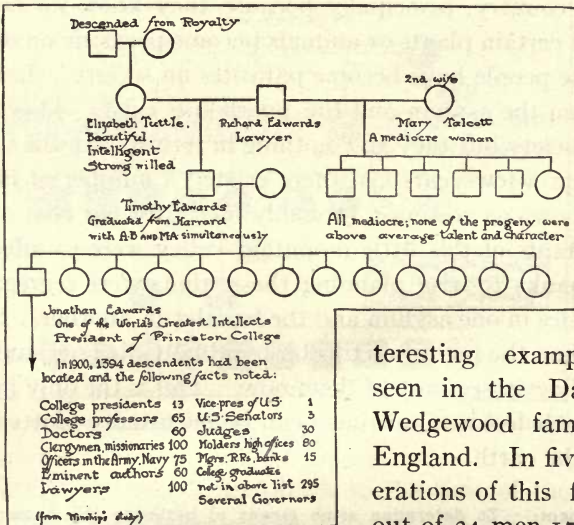
Materials: Charts adapted from Davenport, Goddard, or other authors showing the heredity of genius, mental traits, feeble-mindedness, epilepsy, etc.

Method: Make a careful study of the charts to answer the following questions.

Observations: Are mental traits handed down from one generation to another? Is artistic ability handed down? Is musical ability handed down? If one party to a marriage is feeble-minded are any of the children likely to be feeble-minded? If both parties to the marriage are feeble-minded what is the probability of feeble-minded children? Does feeble-mindedness seem to be a dominant or recessive character? Explain.

Conclusions: 1. Is it possible to better heredity through careful mating?
2. Should feeble-minded persons be allowed to marry?

The inheritance of moral and mental characteristics. — Fortunately, the bad side of heredity is not the only one. A study of certain notable families has proved that genius and mental traits are also handed down. An interesting example is seen in the Darwin-Wedgewood family in England. In five generations of this family out of 24 men 17 have been noted in science or in letters. In this country the Jonathan Edwards family has been a notable example. Out of 1394 descendants there have been 13 college presidents, 75 army officers, 100 lawyers and ministers, more than 60 authors, 60 physicians, 295 college graduates, and not a single pauper. The following extract is taken from Davenport's "Heredity in Relation to Eugenics." In 1667 Elizabeth Tuttle, "of strong



The family pedigree of the Edwards family will, and of extreme intellectual vigor, married Richard Edwards of Hartford, Conn., a man of high repute and great erudition. From their one son descended another son, Jonathan Edwards, a noted divine, and president of Princeton College. Of the descendants of Jonathan Edwards much has been written; a brief catalogue must suffice: Jonathan Edwards, Jr., president of Union College; Timothy Dwight, president of Yale; Sereno Edwards Dwight, president of Hamilton College; Theodore Dwight Woolsey, for twenty-five years president of Yale College; Sarah, wife of Tapping Reeve, founder of Litchfield Law school, herself no mean lawyer; Daniel Tyler, a general in the Civil War and founder of the iron industries of North Alabama; Timothy Dwight, second, president of Yale University from 1886 to 1898; Theodore William Dwight, founder and for thirty-three years warden of Columbia Law School; Henrietta Frances, wife of Eli Whitney, inventor of the cotton gin, who, burning the midnight oil by the side of her ingenious husband, helped him to his enduring fame; Merrill Edwards Cates, president of Amherst College; Catherine Maria Sedgwick, of graceful pen; Charles Sedgwick Minot, authority on biology and embryology in the Harvard Medical School; Edith Kermit Carow, wife of Theodore Roosevelt; and Winston Churchill, the author of "Coniston" and other well-known novels."

The meaning of eugenics. — The above paragraphs show us that blood will tell or rather, to put it scientifically, "that the chromosomes will tell the story." It is evident that if the race is to be improved, we must improve the stock. This is to be done in the same way that we would work on animals or plants, that is, we must check the reproduction of the poorest strains and mate the individuals of the strongest stock. *Eugenics* is the science of improving the human race by better heredity.

The meaning of euthenics. — People to-day all over the civilized world have a much better chance than those of a few years ago. The housing conditions as late as 1850 in London and other large cities were disgraceful but are now being gradually remedied. For example, a report by Dr. Havelock Ellis tells us that in one of the slums of London, a part called Bethnal Green, in 1848 many of the workmen's homes were mere huts, small houses or sheds never intended for human habitation. There were thirty-three miles of streets and more than one hundred of by-ways, only a few miles of which were paved. There were few if any sewers. Refuse and filth were dumped into the street and accumulated there, for the entire street-cleaning department of this part of London consisted of thirteen worn-out old men who could just about cover the territory every three months. It goes without saying that with such conditions pestilence and death stalked hand in hand. A few years ago child labor was permitted everywhere. It amounted indeed to virtual slavery in many places. Children worked long hours under conditions which were unfit even for pigs. But to-day laws have been made which prevent any such unfair treatment of children. Civilized society would not permit the conditions which formerly existed in the London slums. A city which allows foul tenements, narrow streets, and crowded slums to exist will spend more than its share for police protection, for charity, and for hospitals. *Euthenics* is the science of the betterment of the environment. It is another factor in the making of a stronger and healthier race. The world is growing better in spite of what pessimists believe. It is gradually becoming a safer and healthier place to live in. The lives of children are now safeguarded by purer milk and better housing, by means of public nurses and dispensaries. Our schools are more useful and more adaptable. Our laws on child labor are more comprehensive and helpful. Above all, both children and parents are becoming better educated in the duties of good citizenship and healthier living. May this book do its part toward helping in this great work.

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