KEEPING UP WITH SCIENCE

NOTES ON RECENT PROGRESS IN THE VARIOUS SCIENCES FOR UNSCIENTIFIC READERS

EDITED BY

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Jonathan Cape
Thirty Bedford Square, London

Printed in the United States of America

PREFACE

There is a fascination in watching a moving thing, especially if it is moving fast. Science is moving fast nowadays, making more progress than ever before, gaining more ground in the last quarter-century than in any previous century.

And science, unlike most human activities, is always moving on to something new, ever advancing into the unknown. The dramas of human life, as they are told to us in novels and newspapers, are based on a few simple plots, endlessly repeated from generation to generation with but slight variations. One gets to know them by heart and gets tired of them before he gets very old. Fashions in dress, arts, and customs recur in cycles.

But in the sciences and in the inventions and industries based on them there is genuine novelty and perpetual progress. The chemist makes new compounds, the biologist develops new forms of plant and animal life, such as never existed before. The astronomer discovers unknown stars. The physicist formulates new laws and strange conceptions. The scientist is always turning over a new leaf. The Book of Nature is issued only in uncut editions, and the scientist has to open its pages one by one as he reads. We cannot help him at this job. We bother him if we crowd too close and jostle his elbow. But we can look over his shoulder and follow his reading, though since it is mostly in a foreign language we may need an interpreter.

Every intelligent person likes to know something of what is going on in other fields of labor than his own. If he does not follow in a way the latest movements in art and literature, the course of events at home and abroad, the trend of thought and shifting of opinion, he feels that he is missing something—and he is. So, too, if he does not follow the progress of science he is missing something, and something that might prove interesting and possibly important to him.

But if he realizes the need of keeping up with science, as he does with other contemporary movements, he encounters a difficulty. Scientific progress is recorded in technical periodicals that he does not see, and for the most part could not read if he did, for specialization has been carried so far that each particular branch has developed a vocabulary of its own that is unintelligible except to those who are working in this field. The popular periodicals and newspapers provide the means by which one can keep well informed of what is doing in art, music, drama, and literature, they give pages to politics and other sports, but the reader does not find it so easy to get from them a clear and consecutive account of the advance of the several sciences. This is in part due to the lack of interpreters and in part to the fact that the investigator, unlike the artist, the author, and the politician, has no need for publicity for the furtherance of his work—may on the contrary be hampered by it.

The realization that the public needed better facilities to become acquainted with the results of modern science led in 1921 to the founding of Science Service at Washington. The institution was intended to serve as a liaison officer between scientific circles and the outlying public. It should act as a disinterested third party to bring together two parties who ought to know each other better. And it has been doing what it could to spread a knowledge of scientific achievements and ideals by means of newspapers, magazines, books, and motion pictures.

One of its various channels has been a fortnightly page in *The Country Gentleman,* entitled "Keeping Up with Science." It is thought that a collection of these miscellaneous scientific articles and notes, supplemented by similar scientific briefs that have appeared elsewhere, would be of interest to those who want a handy volume from which they can gather, without spending time in continuous reading, some knowledge of natural laws and human achievements that otherwise might have escaped their attention. Some of these articles I have written; more I have rewritten; others are by the staff writers of Science Service and its scattered corps of occasional contributors. So many fingers have been in some of the pies that it would be hard to tell who should be credited with them. So I have thought it best to put them all in anonymously and thereby escape the obligation of printing here the long list of those to whom I am indebted for information and criticism.

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SCIENCE AND PSEUDO-SCIENCE

Modern complex industrial life plunges every one into a scientific environment so that no one can escape the deluge of scientific terms. But he may get them wrong. Each new discovery starts a parasitic growth of pseudo-science.

There *is* a North Pole; but Cook didn't discover it.
There *is* magnetism; but not "animal magnetism."
There *is* wireless telegraphy; but that does not prove telepathy.
There *are* electrons; but "electronic" cures do not follow.

From miscellaneous reading in the papers the average layman gets a confused, composite, half digested impression to the effect that "Science Says":

People are descended from "monkeys"; the sun is made of radium; Mars is inhabited by a race of canal diggers; the ancient Mayas knew all about relativity; the earth is getting hotter; the earth is getting colder; the earth will be smashed up by running into a comet; the average mental age of Americans is thirteen; all progress comes from a superior Nordic race; mankind is losing all its teeth and hair; the world is going to starve to death from overpopulation; the world is going to die off from race suicide; Conan Doyle proved the existence of fairies; drinking sour milk or grafting goat glands will make everybody live to 150; there is no soul; everybody has two or three souls; according to Freud you must give rein to every impulse or die of a complex; all rheumatism comes from bad teeth; all diseases can be cured by manipulating the backbone; harnessing the power of the tides will replace coal as a source of power, etc., etc.

Some of these notions are false, some are hypotheses which may or may not be true, some are truths badly expressed or placed in a misleading context. The result is that the layman either becomes skeptical of all science or credulously falls victim to the first faker who can manipulate imposing catchwords.

Not only do new superstitions crop up from the soil fertilized by genuine discovery, but the old weeds still linger. Dream books, not only those based on Freud, but others of the old traditional sort, still sell in the shops. Fortune-tellers manipulate packs of cards as well as Ouija boards. Astrology numbers more followers than lived in Egypt, Chaldea and Rome. We are only three hundred years removed from witch-burning forefathers, and some would burn witches yet if the law permitted.

This is not all cause for pessimism. At least it shows that science attracts great interest and has vast prestige. "Imitation is the sincerest form of flattery." If fifty years ago legislatures did not persecute Darwinism it is because the average legislator had never heard of it. If people talk nonsense about Freudianism, hypnotism, Einstein, psychological tests, vitamins, and the like, at least they have heard of these things and want to hear more about them. All they need is some clue as to what things are so and what things are not.

Unfortunately those who trade on the name of science for profit, or who are fanatically sincere about some absurd theory, are better advertisers than the real scientists. They make more noise, assert themselves more dogmatically, make more sweeping claims and get attention first. They are not handicapped by the hesitations, uncertainties, shyness, professional caution of the true man of science. Reservations and qualifications make dull reading, and the necessary complexities of the scientific vocabulary frighten away the casual reader. Moreover, it is to be feared that some scientists are intellectual snobs and do not care whether the layman understands or not. They leave the field to pseudo-science without a struggle.

On the other hand, in the long run real science prevails over what the Bible terms "science falsely so-called" because it can prove itself by its works. "By their fruits ye shall know them," is the experimental method. Only real chemistry can provide the basis for the big industrial inventions which the public demands and appreciates. Only real medicine can in the long run lower the municipal death-rate.

There is another test of real science; its honesty. Fake science always tries to create mystery, to use long words for the purpose of creating confusion, to rely on occult forces and secret processes, because only so can it remain a profitable monopoly. Real science relies on tests and experiments that any one can duplicate and does not add artificial difficulties to the real mysteries of nature. In a word, the real scientist and the faker are both talking to the layman in unknown tongues, but the real scientist is trying to make himself understood, the faker is trying to make himself misunderstood.

√ CHEMICAL MESSENGERS

What system of government prevails in this body of ours? Is it an autocracy, the one-man rule, such as prevailed in the primitive state and still survives in the army? Or is it a democracy, the equal power of all in politics, regardless of their qualifications, such as is now regarded as the ideal? Or is it an oligarchy where the superior cells and organs manage the inferior?

Strange to say, no system of human government has yet been devised that approaches the organization of the animal organism in character—or in success. The millions of cells, the hundreds of muscles, the dozens of organs, with their infinitely varied powers and functions, are kept in harmonious activity for the good of the whole by some secret system of mutual coöperation which man has not yet learned how to apply to his artificial organism, the state.

The conscious ego cannot claim to be the dictator of the physiological realm which he calls his body. He is not even a Premier, bnt merely a Foreign Minister. He has a certain control over imports and exports, but the department of the interior is mostly beyond his jurisdiction. It is his business to keep the body out of fights with others that might result in a stab in the heart or a punch in the stomach, but he is not entrusted with such essential functions as keeping the heart pumping and the stomach digesting. For, important as the mind may think itself, it sleeps at its post for a third of the twenty-four hours and is liable to occasional fits of forgetfulness at any time. It is not the brain that mobilizes the white blood corpuscles whenever an army of microbes invades the body through a breach in the outer wall. Sight is not sharp enough to see a microbe and even if the brain suspected an invasion it would not know how to conscript the corpuscles and dispatch them to the front.

All these millions of living cells in brain or brawn or bone have to be kept supplied with food, water, and air in amounts depending on how they are working and how fast they are growing. The temperature of every part of the body has to be kept constant no matter whether the weather is cold or warm, and the ashes must not be allowed to accumulate in any cell.

Now one would think that such a marvelously complicated coördination of interdependent activities would require a strict system of bureaucratic centralized government. But on the contrary, the central government, if there is such, has little or nothing to say about most of the physiological processes. The orders to an organ come from below rather than above. For instance, if an overworked muscle needs more oxygen, it does not petition headquarters, but sends orders direct to the heart and lungs to speed up the pumping. If a gang of structural bone-workers want more lime or phosphate they do not bother the boss about it but dispatch a message straight to the supply department to import some.

How these multifarious messages could be carried was long a mystery which is now being solved. There are two ways of intercommunication in the body just as there are in the outside world, telegraph and mail. In a telegraphed message nothing travels except the electrical impulse, but in the postal service a material message, the letter, is transmitted. Inside the body signals may be sent by the nerves, which play the part of telegraph wires, but it has recently been discovered that there is another and more general system of intercommunication by means of chemical substances sent around through the blood, like letters. Professor E. H. Starling of London pointed out the importance of these eighteen years ago and named them "hormones," which is Greek for "messengers," and since then many of them have been discovered and some of them manufactured.

The two systems of transmitting orders supplement each order like telegraph and mail. For instance, a man sits down at a dinner table. The eye signals by way of the nerves, "I see food," and a minute later comes confirmation from the nose, "I smell it." At once the saliva begins to pour into the mouth and the gastric juice into the stomach to prepare for the first stages of digestion.

Sometime later when the stomach has finished its work three other digestive fluids have to be in readiness. These are secreted by three separate organs, the pancreas, the liver, and the intestinal glands, and all these have to be notified to get busy as soon as the first food passes out of the stomach.

In this case the message is conveyed by a hormone called "secretin" which, within two minutes after it has been sent into the blood stream, sets the three organs to preparing their particular digestive juices.

If we get angry or scared, the body has to be put into a state of preparedness for fight or flight, whichever the high authority decides upon. But either will require an extra supply of energy, so the suprarenal glands, without waiting for special orders from headquarters, send a chemical messenger to the heart to pump harder and to the liver to release more sugar into the blood so that no muscle shall be short of fuel in this emergency.

How the sugar is handled depends on another hormone known as "insulin" which has lately been prepared in a form that may be used by diabetics whose pancreas does not work well.

Still more recently comes the announcement of the extraction of a pure and extremely powerful form of "pituitrin," the secretion of the insignificant pituitary body, which controls the kidneys and capillaries.

The chemist is now able to make "thyroxin," which is secreted by the thyroid gland, and a minute daily dose of this may, as Dr. Starling says, effect "the conversion of a stunted, pot-bellied, slavering cretin into a pretty, attractive child."

It is these chemical messengers which in infinitesimal amounts determine whether we shall be tall or short, dark or fair, handsome or ugly, active or sluggish, alert or stupid, cheerful or melancholy, and it is the aim of the chemist to learn how to make them, or perhaps similar substances of even greater potency, so that he can acquire absolute control over the workings of the human body.

THE SMELL OF THE HIVE

The proverbial best smeller of the animal creation used to be the dog. But that was before entomologists discovered the marvelous uses that certain orders of insects make of their olfactory organs, corresponding to the nose of the higher animals. Perhaps nobody has done more to put the hound's nose out of joint (so to speak) than Dr. N. E. McIndoo, whose monograph "Recognition Among Insects" is one of the most fascinating publications ever issued by the Smithsonian Institution.

The smelling powers of insects have by no means been fully explored, but many startling facts on the subject have already come to light. Thus it is recorded that a male moth can "smell out" the only female in the neighborhood at a distance of a mile. Of course such feats seem impossible merely because they transcend human experience. A sentient being having rudimentary powers of sight might refuse to credit the everyday achievements of the human eye.

Dr. McIndoo's investigations have been made particularly among the bees. He furnishes convincing evidence that the sense of smell is the chief means of recognition among these insects and that they are able to distinguish a multiplicity of odors comparable to the multiplicity of impressions that we gain through our eyes. The investigator found from his own experience that it is possible to train the human nose to recognize many characteristic odors pertaining to bees. Just as, without training, we can distinguish the smell of a horse from that of a cow, Dr. McIndoo was able, after a few months' practice, to recognize the three castes of bees—queens, drones and workers—merely by smelling them. He was also able to detect differences of smell depending upon the age of the bees and other circumstances pertaining to their life histories. Most of his information, however, regarding the smells of bees was obtained by indirect methods, and he devised a great many ingenious experiments to show the all-important part played by odors in the lives of these insects.

Every hive or colony has its own odor, differing from that of every other hive. Then there is a "family odor" common to the offspring of any one queen; and finally each bee has an individual odor. In Dr. McIndoo's own words:

> The hive odor of a queenless colony is perhaps considerably different from that of a colony which has a queen. *The absence of a queen odor in the hive odor* probably explains why the workers in a queenless colony are irritable and never work normally. Worker bees returning to the hives from the field pass the guards unmolested because they carry the proper sign, although the hive odor that they carry is fainter than when they left the hive. Bees kept in the open air for three days *lose all the hive odor carried on their bodies, but each* bee still emits its individual odor. When a colony is divided the hive odor in each half soon changes, so that by the end of the third day the original colony possesses a hive odor very different from that of the other half.

HOW BABY PLANTS KNOW THE WAY UP

If it were not so much an everyday matter to us, it would be very remarkable that the little green shoot that comes out of a sprouting seed down an inch or two in the ground knows so infallibly just which way it must grow in order to get out into the air. Seeds are usually planted without any special care heing taken to see that all of them are right side up. It is as likely as not that the root end of the seed will be pointing upward, while the end where the green shoot will come out points downward into the earth.

Yet, as every gardener knows, the green shoot always turns around if necessary and comes straight up into the air, while the little root bends around the other way and goes downward into the soil where its particular job of supplying the young plant with food and water has to be carried out.

It is very fortunate for us that plants do know so certainly which way to grow in order to get out of the soil. If they did not, we humans would be very short of food. Many people would be inclined to let it go at that and think no more about it. But the scientists who study plants are (like other scientists) forever asking themselves "why." One of their "whys" is why *do* roots bend down in this way and why do the green shoots always bend up?

Long series of experiments in the laboratories have shown that this is because the plants are really able to perceive gravity. We humans do this by what we call the sensation of weight. We have a feeling of being pulled down towards the center of the earth; a feeling of weight in the direction of the force of gravity. If you hold out your hand it seems to be dragged down toward the ground just as though some one had hold of it. Except under such unusual conditions as being strapped into a flying airplane up above the clouds, men always know which end of them is up and which is down.

The plantlet, just as soon as it is out of the seed, knows this just as well as we do. It never mistakes "up" for "down" or "down" for "up." Though there is still one missing link in the theory, the explanation of this lies, it is believed, in a little mechanism inside the plant which, if man had invented it and used it in some machine, we would describe as extremely ingenious.

The parts of a young plant that do nearly all of the growing are its very tips: the foremost half inch or so of the green shoot and about the same distance on the tip of the root. Now these growing tips, like the rest of the body of the plant, are made up of "cells," tiny compartments or hollow granules, each one lined with a little of the living matter of the plant, the stuff that scientists call "protoplasm." Some of these tiny living cells, especially in the rapidly growing tips of root and shoot, have inside them some still tinier solid granules of starch, like the dried peas inside an old-fashioned baby rattle. These starch grains, of course, are loose and they lie on the bottom of the hollow living cell that contains them. They lie, that is, on the side of the cell which is toward the earth, whichever that side may be. If you turn the cell on its side or upside down, the little starch grains move over from one side to the other, so that they are always on the downward side.

Now these cells that contain the starch grains are trained or built somehow so that they are contented and grow normally only when the starch grains are lying on the proper side of the cell. Suppose, for instance, that the green shoot gets bent over sidewise. The starch grains in the tip cells then rest on the sides of the cells instead of their bottoms. This disturbs the cells at once. All the growing cells begin immediately to grow a little crooked, in the direction that will straighten up the shoot and turn each individual cell over so that the little starch grains in it lie on the proper side of it, the rear side, toward the body of the plant, just as they did before.

The starch grains behave a good deal like the lead ball inside the little tumbling dolls we used to have, the dolls that always come back to an upright position no matter how many times one pushes them over.

In the root the cells with starch grains in them are different, or differently trained somehow, so that the starch grains lie comfortably only on the forward or downward ends of the cells. This keeps the root always pointed downward, just as the green shoot is always pointed upward.

Just how the loose starch grains in the cells manage to alter their growth so as to bend the root or shoot around into the proper direction is the missing link in the theory. The scientists have not yet succeeded in finding out about this part of the process.

MAN SEES 6,000,000,000,000,000,000 MILES

A million light years!

Such is the estimated distance of the "new" universe recently identified by the Harvard College Observatory and known only by its star catalogue number, N. G. C. 6822.

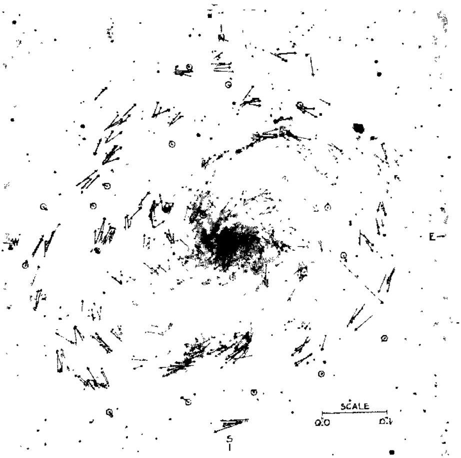
Invisible to the unaided eye, only a dim patch of light when seen through the most powerful telescopes, oval in shape with a long diameter about one-third that of the full moon, and a short diameter half as great, this misty glow in the depths of infinity has now been found to be a mighty universe.

"New" only in name. Newly identified and recognized, but in reality one of the oldest things the eye of man has ever looked at, and, so far as known, the most distant. The light that shines from it down the telescopes of the observatories to-night left home a million years ago.

And light is a speedy traveler. Nothing is faster. Einstein says nothing can be. It is the ultimate speed record, 186,000 miles a second, equaled by that of the radio waves, approached by the particles thrown off by some radio-active substances, but almost unimaginably faster than anything man has devised. More than seven times around the earth in a second; to the moon in a second and a quarter; to the sun in eight minutes; across the whole solar system in as many hours—and to this distant cluster of suns and their attendant worlds in—a million years.

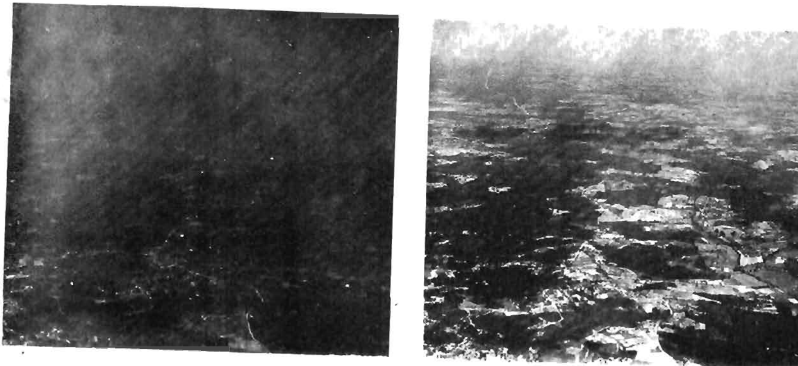
The fastest thing man has made to travel on is the racing airplane, which has attained a speed of about 260 miles an hour, more than four miles a minute. The surface of the earth at the equator travels four times as fast as this, literally as fast as "the wings of the morning" which carry the daybreak around the world in 24 hours. A rifle bullet, when it leaves the muzzle, moves at the rate of a mile in about two seconds. These are the ultimate earthly velocities so far. The fastest of them would be far too slow for a trip to the outskirts of our own solar system. The rifle bullet would require six years to reach the sun.

When we look casually up into the sky of a starry night the stars seem to be equally dis-



GIANT PIN-WHEELS IN THE HEAVENS

Internal motion in the spiral nebula Messier 33, as derived from two plates taken with 12 years' interval. The arrows indicate the directions and magnitudes of the motions during an interval of about 2,500 years, as determined by Dr. van Maanen.



MAKING THE CAMERA SEE FARTHER

Left. Photograph taken from airplane with an ordinary plate.
Right. Same scene taken at the same time with photographic plate sensitized to red rays. (Photos by U. S. Bureau of Standards, Washington.) *See* page 19.

tributed in the sky except for those hazy clouds and streamers of light across it, known from early times as the "Milky Way," or, as astronomers call it, "The Galaxy." The telescope reveals that this is a perfect mist of suns, so crowded together that to the unaided eye they seem like a haze of light. Further study reveals that along the Milky Way, and for some distance on each side of it, there are more stars than in the parts of the sky farthest removed from it. That is just what would happen if all the stars the telescope can see were a part of one immense cluster in the shape of a lens, and if we were somewhere near its central plane. Looking through edgewise we see hosts of stars, finally crowding themselves in perspective into a mere haze of light, the Milky Way, while off at right angles the stars are fewer in number, because we are looking through the narrow part of the lens.

But there are other objects in the sky besides stars. There are clusters and nebulæ of various sorts, of which the most impressive are the spiral nebulæ. Through a powerful telescope these last look like the familiar Fourth-of-July pinwheel, a bright center, and radiating from it fiery spirals trailing off into the depths of space. From our distance they seem to be motionless, and rather more like a snapshot of a pinwheel than a movie of one.

Besides the spiral nebulæ there are diffuse nebulæ and the star clouds. The diffuse nebulæ resemble the spirals in that they are immense masses of radiant matter, but they are formless. The star clouds, small hazy patches of light, such as the Magellanic Clouds which are visible south of the Equator, seem to be mixtures of diffuse nebulæ and bright stars which shine through the luminous mist like the street lights of a distant city seen through a fog glowing with the brilliancy of many reflected lights. Such a star cloud is the "new universe."

Even to astronomers it is not really new as an object in the sky, although its identification as an independent system of suns lying far beyond ours has become possible only recently through the use of the resources of stellar photography. The late E. E. Barnard saw it many years ago through a 6-inch refracting telescope. It is exceedingly faint even through a telescope, yet it shows evidences of consisting in part of diffuse nebulæ and in part of hosts of bright stars, a veritable star cloud. Its size is as yet unknown, but it is supposed to be smaller than our stellar system, and to lie far beyond it. Its location in the sky is in the constellation Sagittarius, seen low down in the southern sky in mid-summer.

MAKING THE CAMERA SEE FARTHER[1]

Amateur photographers who have taken pictures from the top of a high mountain have often been disappointed in the results. Even though taken on a clear day, giving hopes of a fine picture, the prints showed only as a confused gray blur. The valley with its towns and farms, the river, the distant mountains, all had disappeared. Evidently the camera did not see as well as the human eye.

The reason is that the scenery the camera did not see was blue; the distant mountains were bluer than the near ones; the sky was bluest of all. And thereby hangs a tale. If human eyes were less sensitive to the green light coming from the scenery and more sensitive to the blue light which was scattered from the air particles between them and the scenery they too would have seen everything as through a haze. It would have looked as it does on one of the very hazy days that often portend the end of a dry spell; and that is how it looked to the camera.

During the war this became a matter of supreme importance. Our photographers were constantly flying over the enemy's lines, but in this very important work they were often stopped by hazy weather or forced to fly so low as to put them in serious danger from hostile gun-fire.

[1] *See* illustration facing page 17.

It was known that red light is much less scattered by the air than blue light is, and that, in general, light toward the red end of the spectrum would do better for seeing through haze than light toward the blue end. The trouble was that the ordinary photograph plate or film is much more sensitive to light at the blue end.

The problem was turned over to the United States Bureau of Standards, and there, toward the end of the war, plates were produced which are much more sensitive to red light than the ordinary kind, and which can be used in hazy weather when ordinary plates would be almost useless.

The results are shown in the two accompanying pictures taken simultaneously with a two-lens camera in an airplane more than three miles high. The one on the left was taken with an ordinary plate and one would hardly guess it was meant to be a picture of the earth beneath. Now look at the other, taken on a plate sensitive to red rays, and see the difference! Everything stands out clearly. Trees and houses can be plainly seen, and if the picture were enlarged a little one could see the automobiles on the roads and even the people.

THE WARMTH OF A SNOW BLANKET

Snow is a most effective insulator and constitutes an important factor in making winter cold by hindering the escape of heat from the ground. While the snow blanket keeps the ground beneath it relatively warm, its surface becomes very cold and chills the air above it much more than does the ground under the same atmospheric conditions.

Air is one of the best insulators known. Newly fallen snow is generally about 10 parts air to one part ice; sometimes the ratio is as great as 80 to one. And ice, too, is a poor conductor. Therefore, a new snow blanket is highly efficient as an insulator, and even old snow, with only three or even two parts of air to one of ice, is fairly effective. As a consequence, by keeping in the heat, snow serves to reduce the depth to which frost penetrates the ground.

Another influence of importance in the protection of the ground from frost, though not from low temperature, under the blanket, is the fact that the soil will not freeze at 32 degrees, the freezing-point of pure water, but requires a temperature from two to nine degrees below 32, in spite of the fact that it is the water in the soil that freezes. This lowered freezing-point is owing to capillarity and salts in solution.

The extreme of frozen ground is found in the tundra of northern North America and especially in Siberia, in regions where there is little snow. There the depths of the soil never thaw, but remain a rock-hard solid mass extending down hundreds of feet. Unless the thick moss at the surface is removed, only a foot or two of melting occurs in the warm, short summer. The result is that the soil retains the surface water, which causes marsh conditions and produces terrible hordes of mosquitoes throughout the few weeks of warm weather.

The other extreme is found in the region south of Lake Superior, where the snow comes very early and covers the ground continuously until the spring thaws. The result is that the ground does not freeze. The snow keeps the heat in.

The snow surface becomes very cold because the loss of only a small amount of heat by radiation and evaporation will lower the surface temperature greatly, only a little heat being conducted through. By day the reflection, which from new snow is about 70 per cent. of sunlight, reduces heating, and melting and evaporation take much of the rest and keep the maximum temperature from rising above 32 degrees. There is, however, no such limit to the minimum. In this manner the snow blanket makes the air cold, while it keeps the ground warm. Thus banked snow about a house keeps the cellar warm, and over underground water and gas pipes keeps them from freezing.

The protective effect of the snow blanket is proved in times of extremely cold weather. On a morning in central New England, when the air three feet above the ground was 8 degrees below zero, and the temperature of the snow surface 16 degrees below, a thermometer placed four inches down in the snow registered 7 degrees above, and five inches down 10 degrees above. In the coldest weather ever recorded in Washington, D. C., in February, 1899, the lowest air temperature was 15 degrees below zero, yet at the bottom of the 13-inch snow blanket the temperature remained nearly at the freezing-point, and observations made while the temperature at the surface was still 7.5 below showed 31 degrees on the ground.

In the late winter the snow blanket allows the frost to come out of the ground beneath it, while that of the exposed ground remains solid. The accumulations of snow gradually waste away, slowly by evaporation in cold weather, and rapidly by melting on warm days. In March, 1916, a Connecticut forecaster, as the winter neared its end, knowing that the country about lay buried deep in snow, gave warning of disastrous floods to come and offered his hills as a refuge from the Connecticut river. But the snow blanket maintained cool air and high pressure over itself, deflecting the storms southward, while day by day under the warm sunshine the snow melted and its water trickled into the thawed-out ground. The pastures emerged from the snow-cover verdant with yonng grass. But there was no flood.

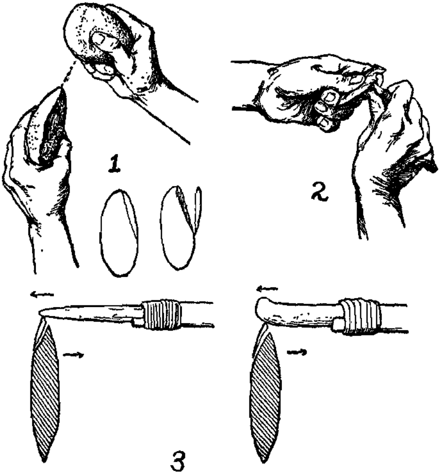
Evaporation goes on even under extremes of cold, and, if the air is dry, snow and ice evaporate. One of the Arctic explorers tells us that thin plates of ice, made in a shallow dish, suspended in the open air at exceedingly low temperatures, disappeared in a few days, and that washed clothing hung out of doors under similar conditions, frozen stiff, dried perfectly within a week. Thus it is with the snow blanket. It will give of its moisture to the atmosphere, no matter how cold it is. On sunny days, when the molecules of water are coming off the warmed surface too rapidly to stay apart in the cold air, we see roofs and sidewalks, sometimes even the snow surface itself, "steaming."

HOW ARROW-HEADS ARE MADE

Nearly every boy has at one time or another found a beautiful Indian arrow-head. Perhaps he was walking across a newly plowed field shortly after a rain and the clean-washed surface of the arrow-head caught his eye. Occasionally a spring freshet washes away the surface soil and exposes a nest of flint knives, arrow-heads and spear-points just where some redskin warrior left them hundreds of years ago.

Whether blue or black or brown or streaked or pure white, an Indian arrow-point picked up in the fields never fails to give a thrill of interest and mild excitement. It is a tie that binds the present back to that past when bears and wolves and wily red men roamed those very fields and forests. In a twinkling an arrow-head can carry a keen, imaginative boy back to the days of the "Deerslayer" and the "Leatherstocking Tales." This very bit of pointed stone a few hundred years ago was fashioned by an Indian hunter and may have been sent on its deadly mission by his strong bow, piercing the heart of the rabbit, the deer, or even the man.

Would the boy like to know how the hunter contrived to shape the little blade of stone with the two notches at the broad end which served to fasten it to the haft? He might try a hundred times with any tool or by any method known to him, without reaching a result like this. He probably wonders whether the art could be learned and will be glad to know that in recent years students have brought to light nearly all the secrets of the red man and his arts. They have examined thousands of his village sites and the shop sites where his implements were made, or where they received their final shape. They



HOW ARROW-HEADS ARE MADE

These illustrations show how arrow-heads are made. Fig. 1, showing the first step in the making of a thin blade; Fig. 2, free hand pressure chipping with a bone, and Fig. 3, positions and movements in pressure chipping. (From *Handbook of Aboriginal American Antiquities*, Part 1, by H. H. Holmes, Bulletin No. 60, Bureau of American Ethnology, Smithsonian Institution.)

have examined the quarries from which the material was obtained and where the implement forms were roughed out ready for the finishing touches. The Indian had no copper and knew nothing of iron, so that he had to make implements of stone, and by long years of practice he had become marvelously skilful. When he wanted a knife-blade, a spear-head or an arrow-point, he first had to find a boulder, pebble, or stray bit of stone of the right texture. With a boulder or rounded bit of tough stone, he roughed out the form he wanted. By a few skilful strokes he had the approximate form—a thin, somewhat leaf-shaped blade. He may have failed once, twice, or a dozen times before he had a form suited to his purpose. This is the percussion process, the free hand fracture process, Fig. 1. He was then ready for the finishing process, the pressure process, Fig. 2. With a bit of pointed bone he pressed off flakes by a quick push along the edge, giving the final pointed shape to the blade. With the same bone tool, or with a sharp-edged bit of stone, he chipped out the notches and was ready for the hafting.

When the Indian went hunting, he had his quiver filled with arrows and his bow across his shoulders, and with the cunning of long experience, he approached his intended victim. When his arrows were exhausted, he had only to find a bit of brittle stone, shape it by the tools at hand, and cut a straight slender branch for the necessary shaft, attach it by a bit of sinew or cord, and go on his way.

If the ambitious boy tries the experiment of arrow making, he will fail many times and probably give it up as impossible because it is a most difficult art requiring long practice; but that it can be done is proved not only by the vast numbers of implements scattered over the country but by the fact that some of the tribes in remote regions are found still practising the stone-shaping art.

The stone required was sometimes obtained by quarrying, and about the quarry pits are still found heaps of flakes and rejected, partly shaped fragments, and the hammer stones with which the work was done. Thousands of these quarry sites are found throughout the country, indicating the importance of the stone-shaping art and the long time that the work has been carried on.

THE HAMMERING OF STORMS

Old Norse mythology pictured Thor, the god of war, thunder, and agriculture, as destroying the giants with his magic hammer. That hammer was a good idea. And the conception of the destruction of the giants was not far-fetched, according to the theory of earthquakes advanced by Professors Ellsworth Huntington of Yale and

Stephen Fisher of Indiana University. For there are tremendous blows struck upon the earth's surface and giant mountains are shattered by them. When the barometer registers a drop of two inches, as it has been known to do in as many hours, a load of about two million tons is removed from every square mile of land affected. A two-inch rise in the barometer means that two million tons of additional pressure are thrown on the earth.

Typhoons, hurricanes, and even our lesser storms hammer on the crust of this old earth of ours. Frequent storms mean frequent hammerings. But even such a load as is hurled down by one of those tropical cyclones is slight when compared to the strength of the rock-ribbed and ancient earth-crust. As many have found out, the earth is a hard nut to crack. This Thor-like hammer of air, which may shatter mountains, merely plays a rôle very similar to that of the proverbial straw that breaks the camel's back.

The underlying cause of breaks in the earth's crust, which are frequently of such magnitude as to cause earthquakes, is the contraction of the earth itself. This contraction puts the crust under a constant strain—a strain so great that in comparison the blows of the severest storms, which we have called tremendous, are merely gentle taps.

But the earth's *contraction* is a slow-moving force and even the most brittle glass would bend if the strain were applied to it slowly enough. "But suppose," say these scientists, "that while the tension is high the glass is tapped. A gentle tap may be followed by a tiny crack. A series of little taps may be the signal for small cracks to spread in every direction. A few slightly harder taps may cause the whole sheet to hreak suddenly into many pieces. Yet even the hardest tap may be the merest trifle when compared with the strong forces which are keeping the glass in a state of strain and which would ultimately bend it if given time."

Other forces may play a part, but it is these storms which are credited with furnishing the breaks in the folding earth's crust that often make themselves felt in the form of earthquakes. Investigations by the meteorologists disclose the facts that earthquakes occur in seasons of great storm and that the great storms are most pronounced when there are the most sun-spots. So, according to their theory, spots on the sun—which are believed to be big electrical storms—result in rock-breakings and earth-tremors on this globe of ours. The Thor that wields the atmospheric hammer is the sun. But the planets which are his satellites and even the distant stars influence our light-source in some unfathomed way and cause the sun-storms which produce the earthly storms which, in turn, provoke the breakings that are earthquakes.

FRIENDLY GERMS

We usually think of microbes, if not with whiskers and claws after the manner of cartoonists, at least as unpopular disease-producing organisms to be caught in our handkerchiefs when we sneeze or smothered with antiseptics.

But no more than larger organisms can microbes escape the antagonisms which prevail among all living things. Wherever you find mice you may expect cats.

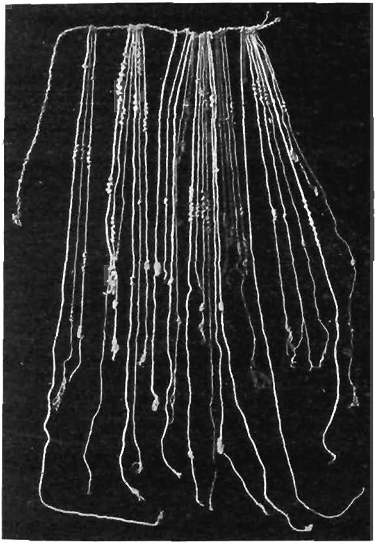
It has long been known that certain races of microbes could not grow in the presence of certain other races. Metchnikoff, the great bacteriologist of Paris, discovered that cholera could not be given readily to healthy men because the cholera bacillus could not grow in connection with certain of the micro-organisms which are commonly present in the intestine. This principle was also at the bottom of the sour milk diet of which we used to hear much. The bacteria of the sour milk inhibit the action of putrefying bacteria in the intestine.

More recently Dr. F. d'Herelle reported to the Academy of Sciences in Paris the discovery of micro-organisms which are definitely destructive of the bacteria causing certain intestinal diseases such as dysentery. Later he reported that he had isolated such bacteria-destroying organisms for two non-intestinal diseases, the Oriental plague and barbone. The latter is an epidemic disease of the East Indian buffalo.

These microbes act by generating a substance that eats up the bacteria of the disease. He calls them "bacteriophages," that is, "bacteria-eaters." They are found in those men or animals which have been exposed to one of these diseases without taking it, and in convalescents. They apparently are not present, at least in any numbers, except during epidemics. The plague, as is well known, is carried by rat-fleas and these anti-plague microbes were to be found during an epidemic in those rats which survived.

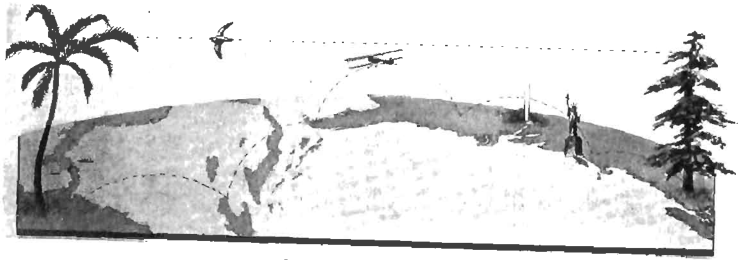
We have, then, microbes pitted against the microbes of certain diseases. The former appear in connection with epidemics and materially assist both man and beast in the maintenance of immunity and in recovery from attacks. As the bird clans gather when the grasshoppers come, so these microbes follow and prey upon the disease germs.

The discovery made by Dr. d'Herelle may be of great importance in preventive medicine, for he has succeeded in the case of barbone in collecting in the laboratory the anti-bacterial substance



MEMORY KNOTS

From a photograph of an ancient Peruvian *quipu*, showing knots with many different numbers of turns and pendent strands, the latter being of various colors. The *quipu* was a record of numerical facts. *See* page 33.



CHAMPION FLYERS

Birds can still beat the airplane. For length of long-stop flight and for economy of fuel the flying man has ot yet caught up with the feathered fowl. (Copyright by *The Country Gentleman*.) *See page 36.*

generated by the microbes. By injecting this into buffaloes he has thereby conferred upon them a resistance against the epidemic.

MEMORY KNOTS[1]

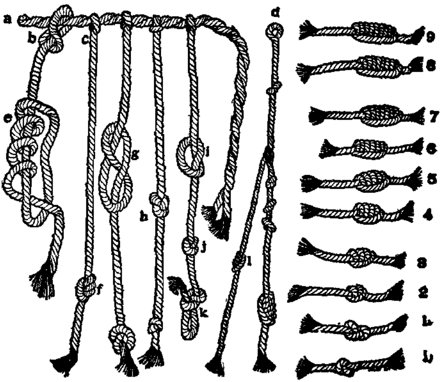
Tying a string around your finger to make you remember something is not a particularly modern trick. Knots aided the memory of the Incas and the ancient Chinese, and in the days before Columbus knotty string records were much more important than now when paper and ink are so common.

The ancient quipu or Peruvian knot record, a device which may be roughly compared to the Chinese bead counters, was used primarily for recording numbers and could hardly have been used as a conventional scheme of writing, according to L. Leland Locke, who has made a study of forty-two prehistoric specimens at the American Museum of Natural History in connection with the references to the quipu by early Spanish writers.

The use of knots in cords for the purpose of reckoning and recording numbers seems to have been as universal as the figures of the cat's cradle in the practices of primitive peoples, and both may be said to be indigenous to all lands in which the arts of spinning, weaving, and dyeing have

[1] *See* illustration facing page 32.

been cultivated. In two noteworthy cases tradition makes the knotted cord serve as letters. In China knot records are said to have preceded the knowledge of writing.



MEMORY KNOTS

Drawing illustrating manner in which the knots in the quipu were tied. It is interesting to note that no knot had more than nine turns, thus indicating the use of the decimal system.

In more recent times the most remarkable development of knot records took place among the Incas of Peru. Here is found the anomaly of a people with a highly complex civilization, particularly in governmental machinery, with a wealth of tradition, with a peculiarly rich and expressive language, but with no system of writing, either hieroglyphic or phonetic.

The specimens, which have been almost perfectly preserved in the graves of the Incas in the dry nitrous sand and otherwise, consist essentially of a main cord, varying in length from a few inches to more than a yard, to which are attached one or more pendent cords which may be eighteen or twenty inches long. The pendent cords are knotted at more or less definite intervals, the knots sometimes being simple and at other times having as many as nine twists or turns about the cord. Knots with eight twists are very frequent, but none has more than nine, indicating the use of the decimal system. The pendent cords themselves are of varying colors, green, red, yellow, blue or the natural white or buff of the wool.

The quipus were frequently used to convey messages and were carried by runners who were stationed throughout the dominion at intervals of five miles. From this and similar facts some investigators have concluded that the quipus were themselves messages, but Professor Locke regards them as having been merely used as aids in memorizing data or historical items, poems, lists of kings, much as memoria technica, or notched sticks, are used by primitive peoples to-day. Each notch in the stick represented an idea that had been memorized, and as the words were spoken the thumb-nail was passed from one notch to the next. That poems were preserved by means of quipus does not mean that the poems were written by this means. We have the direct statement by those who were in a position to know that these were transmitted by tongue.

CHAMPION FLYERS[1]

The hum of an airplane far above the fields hardly causes a neck to be craned in these days of aerial mail-carrying and international flights. We have become accustomed to the continual breaking of man's air records.

About this time of the year millions of nature's air craft quietly start on journeys that would require days of preparation and columns of newspaper space if men and airplanes were involved.

But the only regular society note on the going and coming of birds is printed on the occasion of the arrival of the first robin in the spring. Nevertheless it would be most unnatural if birds should change their millionaire habits of maintaining widely distant winter and summer homes. Migrations are thought to have begun many thousands of years ago when the semi-tropical climate that

[1] *See* illustration facing page 33.

once claimed this globe gradually gave way to changing seasons.

The champion flyer for distance among the birds is the arctic tern, which makes a round trip of 22,000 miles each year. It rivals the arctic explorer in its desire to reach the ends of the earth. Its farthest north depends upon only a place to build its nest, and it goes as far south as it can find food. No one knows its route from extreme north to extreme south.

Even the smallest of all birds, the humming bird, crosses the Gulf of Mexico without great difficulty, going 500 miles over open water in a single night. The golden plover has a non-stop record of 2,400 miles from Nova Scotia to South America, probably completed in less than 48 hours. How an airplane engineer must envy the plover! For its long flight it requires only two ounces of fuel stored conveniently away in the shape of bodily fat. The screw motion of the airplane propeller is much more efficient than the to-and-fro motion of wings, yet if an airplane could fly so economically its fuel bills would be reduced to an eighth of what they now are.

Some feathered creatures are true stay-at-homes. The grouse, quail, and cardinal, for instance, do not like to roam. Many a bobwhite rounds out its full period of existence without ever going ten miles from the nest where it was hatched. Yet what aviator who is also a hunter does not envy the speed and surprise of the take-off of the partridge?

THE STUFF THAT STARS ARE MADE OF

All the stars that feebly attempt to light the night are suns, some of them more gigantic and hotter than the flaming heavenly body that has our earth in its gravitational clutches. For our sun is a star. Stars are many, many millions of miles away; our sun is comparatively close to us, a mere 93,000,000 miles distant. Distance differentiates sun and stars.

In spite of space, man knows more about the stuff composing the most distant star than the composition of the earth a few miles below him. All the time each of these light-giving bodies is radiating news of its chemical composition. Since time began, if it had a beginning, these light messages have been broadcast. For only a moment, some sixty years to be more exact, has the astronomer been able to read them. At that time the receiving set for star and sun radiations was sufficiently perfected so that it broke up light and analyzed it. With this wonderful instrument, greatly improved, scientific students of the sky have been able to extend our knowledge of the universe.

Both sun and stars consist of the glowing vapors of many elements mingling uncombined in a free state at temperatures of thousands of degrees Fahrenheit. The spectrum of the sun, which is formed by passing its light through a glass prism—similar to those on an old chandelier—or train of prisms in the spectroscope, is made up of a band of variegated color crossed by many fine, dark lines. Similar dark lines are found also in the spectrum of some stars. These dark lines are the key to the solution of the composition of sun and stars. The rainbow band of continuous though varied color that forms the background of the spectrum tells us nothing of its source, the body or nucleus of the star. The dark lines, however, are due to the absorption of the light from the star or sun by cooler overlying vapors in its atmosphere. It is the atmosphere of a star we study with the spectroscope, not the star itself. Purely gaseous stars give a bright line spectrum, often of hydrogen or helium.

Every chemical element has a characteristic group of lines that always appear in the same relative positions in the spectrum. In the laboratory it is possible to find the position of the lines of each element in the spectrum, such as sodium, iron or calcium, by heating the element under test to incandescence and passing its light through a glass prism, which is the essential part of a spectroscope. No two elements have spectral lines in common, so once the lines of a certain element have been mapped it can be identified by its characteristic lines wherever it occurs, whether in a rock on the earth's surface or in the atmosphere of a star many trillions of miles away.

The spectroscope translates the star's answer to the astronomer's "What are you?" And to the further questions, "Where are you going?" and "Under what conditions are you laboring?", the spectroscope also gives answer.

A slight shifting of the lines of an element from their normal positions occurs if the source of light is moving with respect to the observer. If they move toward the red end of the spectrum the source is receding from the earth, and if they shift toward the blue end it is approaching. And the velocity of approach or recession can be measured by the amount of the shift. So it is that we know with what speed the stars are moving toward or away from the earth.

Any abnormal conditions in the atmosphere of a star or the sun are also revealed by the spectroscope. A gas under great pressure has its spectral lines shifted slightly toward the red. If a strong magnetic field is present a single line in the spectrum will split up into two or three lines. If a gas in the star's atmosphere temporarily becomes hotter than the surface of the star below, the dark line of the element will change temporarily to a bright line.

At the present time some forty-odd terrestrial elements have been identified in the sun and stars. The only difference between the familiar elements that exist on the surface of the earth and the same elements in sun and stars is that on the earth we find most of the elements in the form of chemical compounds while in the sun and stars they exist, with few exceptions, uncombined and in the form of incandescent gases and vapors at enormously high temperatures.

DAY-DREAMS

Day-dreams are a kind of intra-cerebral theatrical performance in which we play hero and do those extraordinary things which we are either too lazy or too impotent to accomplish in real life.

Do you remember the fable of the milkmaid who was carrying the pail of milk on her head to market? "I'll sell this milk for so much, and with the money buy a hen. The hen will lay so many eggs, worth so much, for which I will buy me a dress and cap. Then the young men will wish to dance with me, but I shall spurn them all with a toss of the head." Splash!

This is the "conquering hero" type of day-dream. The maid for the moment satisfies two natural desires—personal adornment and self-assertion. The latter—the instinctive tendency to strut around and dominate others—is undoubtedly the commoner motive. Our opportunities to dominate people and situations are generally few, whereas the instinct is very strong and finds an outlet in the imagination. The weaker the person and the more insignificant his position in life, the more frequent and magnificent are his visionary adventures.

When day-dreams are not of this "conquering hero" type they generally tend to the other extreme, and the chief actor becomes a "suffering hero." The end, however, is very much the same —to magnify his own importance. Mother scolds Mary for some little thing. Mary feels her own smallness and lack of independence, but if she could be a great martyr and suffer on a grand scale then everybody would notice her and her mother would be sorry. She proceeds to picture herself in such a situation.

Or father reproves Willy for breaking the window. Willy, not in remorse, but in anger, pictures himself driven to a life of crime and dying fiercely in the electric chair. If he is to be punished, he will have it on a grand scale.

So we see the day-dream most frequently as a "substitute reaction," as the psychologists call it, taking the place of a fight or some other act of self-assertion in direct contrast to the subject's own feeling of actual inferiority. If the milkmaid of the fable had been more popular and better dressed, so that she had actually occupied an attractive position among the young set, she would not have been so ready to toss her head at the imaginary advances of the young men.

LUNCH BASKETS FOR BABY PLANTS

To most folks seeds are merely little things which one buys in envelopes decorated with pretty pictures and plants more or less hopefully in the garden. Probably not one amateur gardener out of a hundred knows or cares what really is inside a seed. Sometimes—unfortunately—there is nothing, but we are talking about good seeds.

Take a sharp knife and carefully peel off the outer skin of an ordinary bean seed. Inside you will find two flattish oval objects, pressed together face to face, a good deal like the two halves of an old-fashioned locket. Only instead of being hinged at the side these plates inside the seed are fastened together at one end, and at this end you will find lying between the plates and partly imbedded in them a tiny white kernel which is really the essential part of the seed, the embryo, the thing which will become the new plant. When the seed sprouts it is this embryo which develops.

From one end of it comes out the root; from the other end starts the little stem which will ultimately be the stalk. But what are the two locket-halves that surround and cover the embryo?

These are the lunch basket for the baby plant. Mature plants manufacture their own food, procuring the raw materials for it from the soil and the air. But to do this a plant must have quite an equipment, including roots, green leaves and other organs. The tiny plant which is first formed when the embryo develops has none of this equipment and some days at least must pass before it will be able to produce its own food and become self-supporting. Were the little plantlet cast out into the world without food to cover this initial period it would die as surely as would a human infant similarly unprovided for. And so the mother plant puts up a lunch for it to take along. The flattened locket-halves are mainly starch, manufactured by the mother plant and stored here in the seed. As it develops the embryo feeds on this starch and obtains thereby the strength to go through its first few days of growth and construct the food-manufacturing machinery which will serve for its later life.

Practically all seeds contain similar stores of food. A grain of wheat, for instance, has a tiny embryo at one end but most of the grain is starch—again to feed the sprouting embryo. The cotton seed carries oil instead of starch. This is where we get cotton-seed oil—but the oil is baby plant food just as the starch was. And when we use the starch of wheat for flour or press the oil out of the cotton seed we are simply pilfering the lunch which mama had put up to help the baby plant get started in the world.

THE CONTINENTAL AUDITORIUM

When Whitfield, the pioneer of American evangelists, was preaching on the Philadelphia streets Benjamin Franklin was an attentive listener. But it might have been surmised by an observer that he was not interested in the gospel message, for instead of coming closer he walked away until he had found the limit of the preacher's voice. Having paced this off, Franklin proceeded to calculate how many people could stand within the circle defined by this radius. His object was to test the truth of the statements made by Greek authors as to the size of the crowd that could be reached by one man's voice.

In this Franklin had in mind as usual a political as well as a physical question. For the theory prevailed that popular government was limited to the range of the human voice; that democracy was incapable of extension beyond the limits of the Greek and Italian city or the Anglo-Saxon town meeting; that the people as a whole could only rule where they were so few and concentrated as to be capable of being brought together into one place and listening at the same time to a single speaker. When a commonwealth expanded to include other cities and remote territory it must take on a federated or imperialistic form.

Pure democracy becomes under such circumstances impossible. The community spirit is lost, and the people can no longer act directly as a body, but only through representatives who may misrepresent them and must in most cases legislate without mandate from the mass of their constituents. Government by unanimous consent, characteristic of the primitive village community, develops into government by majority, and generally into government by minority. Many of our presidents and legislators are elected by minority vote and comparatively few of the thousands of laws enacted annually are favored by, or even known to, the mass of the voters. Unanimous opinion and common action are only possible where the people can be brought under the same influences at the same time. The jury is our last surviving vestige of pure democracy, but how many unanimous verdicts would we have if six of the jurymen listened only to the evidence and arguments of the prosecution and the other six listened only to the evidence and arguments of the defense? Yet that is the way our political questions are decided, since Democrats do not as a rule read Republican papers and attend Republican meetings, and Republicans likewise confine themselves to their own party propaganda.

Mob psychology comes most effectively into play as mass action when the whole crowd is simultaneously subjected to the hypnotic influence of one orator's voice. Print is an ineffectual surrogate for the spoken word. A newspaper reaches different places at different times and is read in different ways by different people. Listening is a purely passive process while reading requires a certain amount of individual exertion and is more likely to arouse individual resistance. Reading, like eating, is a personal, not a community, function, even when it is done in public.

As our country has expanded and our population multiplied the art of oratory has declined until we read with incredulity of the effects wrought by the orators of earlier times and other lands. We can see nothing in their printed speeches to account for their known power. We have become increasingly eye-minded through reading more and listening less. This ocular disposition has been intensified through the substitution of pictured pantomime for the spoken drama as the amusement of the masses.

But now, by one of the miracles of science, the range of the human voice has suddenly been extended thousands of miles. The telephone antennæ at Arlington Heights enables any one within 1500 or 2000 miles to hear the veritable voice of the President as he speaks to Congress. Soon, perhaps, every American citizen between the two oceans can listen to the proceedings of Congress better than if he were in the gallery and can then tell whether his representative really delivered his speech or merely got leave to print it, and whether it was really interspersed with "[Applause]" and "[Laughter]" as the Congressional Record printed it.

Day and night the ether is filled with health talks and fairy tales, sermons and sports, music and market reports, broadcasted throughout the land. This, like our popular magazines and movies, contributes to the formation of uniform national mentality. It will be interesting to see how the primitive village commune will work on a continental scale.

WEATHER FALLACIES

Certain popular errors about the weather bob up serenely as often as they are knocked down by the bludgeon of science. Some of these delusions have been "exploded" again and again, apparently without impairing their vitality in the least.

The belief that the climate has changed materially within a generation or so prevails over a great part of the world. In this country the commonest manifestation of the belief relates to the "old-fashioned winter." The majority of people fancy they can remember a time when the winters were colder than they are now, and especially more productive of snow and good sleighing. Exactly the same ideas were current a century and more ago. Thomas Jefferson, writing in 1781, quotes the old people of his day as asserting that the snowfall of Virginia had greatly decreased within their recollection. It is generally believed that a "green Christmas" was once a rare event. A German writer has published a study of weather records, showing that the kind of weather depicted on Christmas cards actually occurs only about once in ten years in the neighborhood of Berlin; and this was equally true a century ago.

The moon has been credited with regulating or influencing the weather since prehistoric times. The origin of the idea is easily understood. The moon is a conspicuous celestial body which exhibits apparently erratic changes and movements. The weather seems equally erratic. Hence it was natural to suspect a connection between them, especially in the days when terrestrial matters in general were supposed to be under the influence of the heavenly bodies. Nowadays the layman's attitude on this subject is embodied in the question: "If the moon causes the tides, why shouldn't it affect the weather?" The fact is that there are tides in the atmosphere as well as in the sea, but they are utterly swamped and obliterated by the enormous atmospheric movements due to the heat of the sun—the real source of weather.

The idea that battles are the cause of rain prevailed long before the days of gunpowder. Here, again, is a fallacy that is easily explained. The movements of troops that precede a battle must generally be carried out in fair weather, since dry roads are an important factor in such movements. As these preliminaries often take several days, the end of a dry spell of average duration is quite likely to be reached by the time the engagement is fairly begun, and rain will then be due in accordance with the normal program of Nature. In modern times it is popularly believed that great explosions, whether during battles or otherwise, somehow jostle the rain out of the clouds. This is one phase of the rain-making delusion, which has cost farmers and even certain governments a great deal of money. Simple laborätory experiments prove that rain cannot be produced in any such way. During the late war all sorts of abnormal weather were attributed to the discharge of vast quantities of explosives. We sometimes hear of "sunspots" as the cause of drought, when the sun is actually freer from spots than usual!

Any storm that occurs within a couple of weeks of the vernal or autumnal equinox is likely to be described as "the" equinoctial storm. If it were called, instead, "an" equinoctial storm, the name might be as appropriate as "Easter lily" is for a lily that blooms somewhere around the time of Easter. Statistics show that there is no *maximum of storm frequency*, either in this country or in Europe, close to the date of either equinox. Neither is there any conceivable reason why the sun's "crossing the line" should cause a storm.

A certain delightful type of weather that generally prevails at intervals during the American autumn is a well-attested fact of observation. The fallacy of Indian summer consists in assuming that just one spell of such weather normally occurs each year, following a single brief spell of cold weather known as "squaw winter." Indian summer weather may prevail intermittently from the middle of September until Christmas, and, on the other hand, it may not occur at all. There is nothing regular or definite about it. The corresponding "St. Martin's summer" of England and France is associated with St. Martin's day, November 11. How very unpunctual it really is, however, may be judged from the fact that the nominal date of its occurrence was dislocated ten days by the adoption of the Gregorian calendar. This is very much as if the opening of the flower known as "four-o'clock" should be alleged to have altered its habits to conform to daylight-saving.

LETTUCE IS RICH IN IRON

To say of a man of unusual strength and vigor that he seems "made of iron" is one of those popular phrases which science has proved to have an almost literal basis of truth. Although the toughest and most enduring man has only enough iron in his entire body to make four tenpenny nails, this small amount is indispensable to life, and a material reduction in the quantity means immediate loss of strength and the onset of serious illness. For iron is the key to the door through which oxygen, without which no man can live two minutes, really enters the body. It is the basis of hemoglobin, of which the red corpuscles of the blood are composed, and these corpuscles combine with the oxygen in the lungs and then release it throughout the body wherever needed.

But people cannot eat iron although they sometimes feel hungry enough "to eat nails," and the problem therefore is to get the iron in some form of combination which the body can utilize. Nature has solved the problem by providing common vegetables which contain a large enough proportion of iron to be of service, and, what is more to the point, containing it in such a form that the body can digest it.

Lettuce is one of the more important and common of these vegetables even though it contains only one part of iron in 50,000 of the raw substance. This is a much smaller proportion of iron than that existing in the human body, yet lettuce is a valuable source of that necessary element.

The amount of iron in lettuce varies greatly in the different varieties, according to analysis by Aaron Lichtin of the Philadelphia College of Pharmacy and Science. Five of the most common varieties were analyzed. Of these May King was found to be the richest in iron and Cos the poorest. The results in detail were as follows, the percentage of iron being that in edible portions of the raw lettuce:

May King	0.00326
Grand Rapids	0.00301
Big Boston	0.00272
Iceberg	0.00189
Cos	0.00033

From the table it will be seen that while the variety richest in iron contains about ten times as much as the poorest variety there seems to be no relation between the iron content and the general type of the vegetable, for although Cos is of the Romaine type, Grand Rapids, which contains a high proportion of iron, is of the curly, leaf type, rather than of the smooth, round-headed variety. The most important commercial variety containing a large amount of iron is Big Boston, a prime favorite in all markets, while May King and Grand Rapids are only of local importance.

Doctors and chemists agree that the only practicable way to get iron is to take it as a vegetable or to follow the example of the Eskimo who cannot raise greens and so gets it from the blood of seals and walruses. The iron in medicinal preparations is in itself of little use as it combines with sulphur in the intestines to form indigestible compounds. "Medicinal" iron does have the virtue, however, of sweeping the intestines free of sulphur and thus giving the vegetable iron a chance for ready absorption, as the sulphur will also combine with the iron from lettuce or other plants.

But the way to take iron so that it may get into the red corpuscles of the blood and carry the life-giving oxygen to all the tissues of the body is to eat it in combination with things which grow. One of the handiest things of that sort is lettuce, which, coming early in the spring, brings renewed vigor to bodies needing more iron in order to combat "that tired feeling" which comes so frequently in the spring as a result of the lack, during the winter, of Nature's own tonics.

EVOLUTION WORKING BACKWARD

Once farmers planted the nubbins of their corn and the potatoes that were too small to sell. Now they know better. They cut up their finest potatoes to plant, and every grain of their seed corn is pedigreed as carefully as a Colonial Dame. The result is seen in doubled yields, in potatoes richer in starch, and corn richer in protein. Modern agriculture is fertilized by science.

The most backward branch of biology is the infant science of sociology. It is only just beginning to get its eyes open, to see things; in time, perhaps it will be able to do things, like the older sciences. But there is need of haste. The age of instinct is passing, the reign of reason has not come. Man has been pushed up to his present position. He has succeeded in slackening the pressure. Will he go forward rationally, of his own free will, or sink back until again he falls under the sway of the blind and merciless forces of the struggle for existence?

A decrease in the birthrate is not necessarily a misfortune to a country. Very likely, for instance, the British Isles have now all the population they can support in comfort under present economic conditions. The alarming thing about it is that the breeding is from the poorest stock instead of the best. Whatever objective standard one may take this is true. A statistical study of the population of Great Britain showed that in the districts where there was the most overcrowding, the cheapest type of labor, the lowest degree of culture and education, the highest percentage of pauperism and lunacy, the greatest criminality, the highest death-rate from tuberculosis and infantile diseases, there the number of children was greatest in proportion to the possibly productive wives. It is a clear case of the survival of the unfittest, the reversal of evolution. No race can maintain its efficiency and virility against such reactive forces.

The future of a country depends ultimately upon the character and ability of its people. Increase of wealth, advance of science, improvement in education, discoveries in sanitation, juster social conditions, all the achievements and hopes of the present age will be of little benefit to posterity *if there is a decline in the native quality* of the race. It would be disastrous to hand over a more perfect and complicated governmental machine to inferior engineers. One-seventh of the present generation will be the parents of one-half of the next. Therefore, two generations of selection, natural or designed, would completely transform the character of a nation. Is this seventh composed of the best men and women that we have?

This is what is going to determine whether civilization shall advance or retrograde. Galton's ideal of eugenics may be too much in advance of the age to be practical, but at least something could be done to awaken the people to the imminent dangers of dysgenics.

ARTISTS SHOULD STUDY BOTANY

The student of botany frequently finds small but amusing inconsistencies in the flowers and plants that artists paint into their pictures. Apparently the gods on high Olympus nod sometimes, even as do their lesser though better-advertised brethren at Hollywood.

One of the most interesting of these artistic anachronisms is the frequent introduction, by modern painters of scriptural subjects, of the common cactus, or prickly pear, into their compositions. It is true that this plant is found now everywhere in Palestine, and for that matter throughout the Mediterranean countries, but the joke is that it was totally unknown in the Old World until after the discovery of America. The whole cactus tribe is typically American, reaching its best development on the Mexican uplands. Introduced into Spain in the sixteenth century, it found the climate of the Mediterranean countries congenial and quickly ran wild throughout its present Old-World range. But there was no trace of it there in *Bible* times.

Other recent pictures sometimes have a similar anachronism in the kind of lilies the saints and angels carry. They are given the familiar Easter lily, which is a relatively recent importation from Japan, introduced to western Christendom not much more than fifty years ago. The white lily used (and correctly used) by the older artists, is the so-called Madonna lily, or Annunciation lily. This looks a little like the Easter lily, but has a more open flower, without the long, slender throat of the Japanese species. Sometimes, too, artists give their lilies only five petals, whereas all flowers of that family have six.

On the whole it might be safer for artists to return to the practice of the early Italian artists, who painted flowers that, for the most part, never blossomed in any earthly field or garden, but which all good botanists would be willing to admit as members of the flora of Elysium.

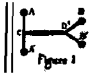
WHY KITTY LANDS BUTTER-SIDE UP

The slow motion-picture camera has enabled the scientist to solve the age-old mystery as to how a freely falling cat always manages to land on its feet even when dropped from a comparatively small height.

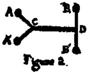
They have found that puss uses the formula $a = \frac{L \quad L}{(k)\ \Sigma\ (m\, r^2)}$, which is "the angular acceleration of a rigid body under the action of a resultant torque."

The mathematics involved is rather complicated for the layman and would probably annoy the cat somewhat also if she paused to figure it out on the way down. The whole problem, and incidentally the cat, turns on the principle that it takes more power to rotate an object through a large circle than a small one.

If one were to imagine a body—Figure 1—consisting of a rod CD, to the ends of which are hinged four weights, A and A′ and B and B′, and if by means of some machinery inside



the rod it could be made to twist, the two sets of weights would quite evidently rotate in opposite directions. Weights A and A′, being farther from the axis of rotation, would have



more leverage and would remain almost stationary, whereas B and B′ would take new positions. If A and A′ are now brought near together and B and B′ swung apart with the same twist applied, the latter two hold their positions, but the first two weights turn—Figure 2.

Figure 3

The motion picture revealed that the first part of Kitty's technic is simultaneously to extend the hindlegs and tail perpendicular to the axis of her body and to draw the forelegs close in. A twisting strain is now applied through the body and results in the closely held forequarters rotating nearly ninety in advance of the hindquarters. Then, by drawing in the hindlegs and tail, extending the forelegs and exerting another torsional stress in a direction opposite to the previous one, the hindquarters are brought around and the cat is ready to land on her feet, without using any mathematics at all.

THE VALUE OF A TRANQUIL DISPOSITION

The laboratory white rat is anything but a dull animal. It seems to have all the canniness and intelligence of its cousin, the wild, gray rat of Norway, without the latter's ferocity. A newly arrived cageful of white rats presents a ticklish problem to the novice in animal work. How extract a sample specimen from that alert group of sharp eyes and sharper teeth? But unless the rats are old bucks of uncertain temper, all the apparatus needed is a calm and assured manner. One reaches into the cage, seizes the first tail that presents itself and hauls out its owner, gently, but firmly. If the rat starts climbing up its tail with resentful squeaks toward the hand that holds it, lay it gently along your sleeve, and it presently submits to being stroked and tamed.

There is a world of difference between rats that have thus been handled and those that know man simply as a cage-cleaning, possibly dangerous, intruder. In the course of experiments involving an operation on certain glands of the neck—the thyroid and parathyroid glands—Dr. F. S. Hammett of the Wistar Institute found that this difference between tamed and untamed rats was more than skin deep. He found that the tamed rats survived the operation very much better than the others, were less tense and excited to begin with, less disturbed by the handling necessary to etherize and prepare them for operating, and apparently in general of a more tranquil disposition. Three hundred and four rats were operated on in all. Of the tamed rats, only thirteen per cent. died, while of the untamed seventy-nine per cent. died. The advantage of a tranquil attitude toward life is obvious.

It is not known just what part the parathyroid glands play in the economy of the body. Their removal, in man and the lower animals, frequently causes tetanus, convulsions and death. Apparently these little bodies secrete a substance essential for nervous balance, especially for irascible temperaments. When we become excited and angry, tense, ready to fight, certain glands pour a substance into the blood that stiffens the muscles, gets the blood into the extremities, makes our teeth clench and our eyes flash. "Hair-raising" experiences we call these episodes, and indeed the hair often does lift a bit, though man cannot accomplish as much in this direction as a dog or cat. But this "preparedness" substance, helpful at the moment of conflict or flight, may be actually a poison, and apparently the parathyroid glands are there to help the blood back to neutrality when the crisis is over.

Dr. Hammett's results seem to point to this explanation. Apparently the tamed rats, not being in the habit of flying into a temper at short intervals, miss their parathyroids less than their wilder, more irascible brethren. While normal parathyroids are probably the rule among human beings, most of us can point very easily to individuals in whom they seem not to function too well, or who, perhaps, put an undue strain upon them.

MEMORY ROOT

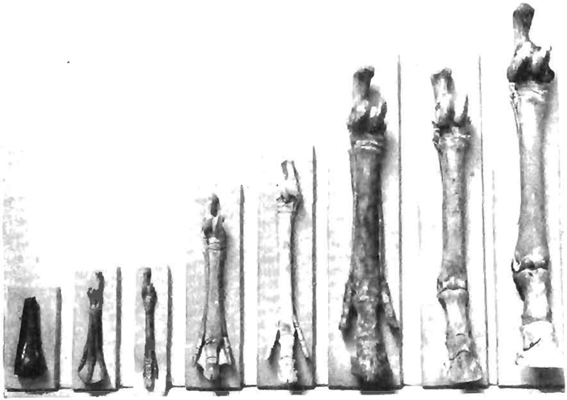
"Jack-in-the-Pulpit" is the name by which it is most familiarly known, though it is also called "Indian turnip" and "Indian peppers."

But the Indians themselves called it "memory root" and for a reason. Some of the readers of this page have doubtless had the experience of rubbing their tongues against the freshly cut surface of the "turnip" or of taking a cautious —very cautious—nibble of the same. The prickling, burning sensation, as of ten thousand little needles dipped in acid and shot into the tongue, is indeed a memory-inspiring event, and one well calculated to have quite an opposite effect from that of eating the fabled lotus.

The unpleasant effect upon the tongue is not wholly due to the actual taste of the plant, though the sap is exceedingly acrid and is even said by some authorities to be poisonous. The prickling as of a million needles is due to very real, though very tiny, glasslike needles concealed in the flesh of the root. They are microscopic, slender, pointed crystals of calcium oxalate, and botanists have given them the very appropriate name of "needle-crystals." When these are let loose upon the sensitive tissues of the tongue they lacerate it with a million microscopic stabs and cuts, and the acrid juice, entering these invisible wounds, completes the victim's discomfort. It is a repetition of the poisoned glass dagger of the Italian Renaissance, trimmed to a millionth in size and multiplied to a million in number.

The same effects may be had from the rootstocks of two or three other familiar plants. One of these, the "green dragon" of the eastern United States, is native to our woods. The other two are the callas, or arum lily, and the caladium, or "elephant's-ear" of cultivation. All belong to the "arum" family. The root of the common canna also has much of the quality of that of an aroid, although it is not in that botanical group.

Plants of this sort are much more highly developed in the tropics. Both calla and caladium have been introduced from the tropics, and there are many others, some of them growing as vines or even as small trees, that are known in the North only as greenhouse specimens. Some have increased potencies. One, the "taro" of the



THE HORSE'S LOST TOES

It took millions of years for the horse to lose his toes and grow hoofs.

See page 65.

south seas, is one of the most important food plants of the islands of the Pacific, and at the same time the source of one of the most deadly native poisons. Differing treatments of the same root may furnish forth either a banquet or a funeral.

HOW THE HORSE LOST ITS TOES

Next time you are out in the stable run your hand up and down the hind leg of a horse between the fetlock and the knee. You will find a long, slender, bony projection alongside of or behind the main bone.

This is what is left of one of the horse's toes. It is the last visible tie that links the horse to its five-toed ancestors that lived in bygone ages. We call this the splint bone.

The story of how the horse lost first one toe and then another, and how it finally developed the third or middle toe into a hoof, is a most interesting one. But unfortunately this story is written only in the rocks and in a language most of us cannot read.

Careful students have, however, studied these bones and fossils found in rocks and have translated the story for us.

This is the story as science revealed it.

Some 3,500,000 years ago a small animal, probably smaller in size than our ordinary fox, lived in swampy regions of what are now Europe and America. It is known as the Eocene horse, because its fossil remains are found in rocks of the Eocene age. It had five toes on each leg and the second, third, and fourth toes were furnished with hard hoof-like protections.

As the swamps dried up and the ground became harder, the nature of the foot of this animal changed slightly from generation to generation. Soon—that is, after perhaps a million years—the first toe disappeared entirely and the fifth was represented only by "splints" on the hind legs. Shortly after this, the fifth toe entirely disappeared on all four legs. This ancestor of the horse by that time had increased in size, being about 18 inches high.

The next ancestor, whose fossil bones are found to-day, was larger still and had four toes on the front legs and only three behind. It has been named the Orohippus—"hippus" being the Greek word for horse. Other toes were lost as time went on and the middle toe kept growing bigger and heavier until the hoof resulted.

The "splints" are found to-day only on the horse's hind legs; the last vestige of those extra toes has already left the front legs.

It is interesting to learn that while the earliest traces of the ancestors of the horse are found on the American continent there were no horses here when America was discovered.

Cortez brought the first horses with him when he entered Mexico in 1519. From these our "wild" horses of the plains developed.

Scientists believe that the early ancestors of the horse crossed from what is now Alaska to Asia in an age when these two continents were connected by land. Some 10,000 to 20,000 years ago horses about the size of the ass roamed the central plains of Asia and Europe in great numbers and were used for food. Caves that date back to the Stone Age have been found to contain great numbers of bones of horses that were evidently used for food.

THE UNCONSCIOUS

Did you ever strain for ten minutes or hours trying to recall Mr. What's-his-name or the what-in-the-world-was-it your wife told you to bring from town, but all in vain? And then next day the lost name carelessly sauntered into your consciousness when you were occupied with the price of eggs or the German indemnity.

Where was this unresponsive idea reposing over-night?

In the "unconscious," the psychologists say.

The unconscious, however, is not merely the rubbish heap of our lost wits. It is composed of those bits of past experience which cannot be recalled in ordinary memory, but whose continued existence is witnessed to in various ways such as bad dreams, hallucinations, and revival in the hypnotic trance.

The stresses, strains, and shocks of the war produced many cases of mental disturbance in the treatment of which a great deal has been learned about the unconscious, for the experiences which are suppressed into its darkness are just those unpleasant incidents of painful memory in which the war was far too prolific. Such portions of our biography are actively pushed out of consciousness by the mind because they would interfere with our happiness or health.

Soldiers, for example, have at times lost beyond voluntary recall all memory of an hour or a day in which they acquitted themselves with distinction, gave orders and directed complicated manœuvers. That such experiences were still existent in the unconscious was frequently shown by their subsequent recovery with careful treatment.

It is always an emotional experience which is suppressed, especially one tinged with fear, and such suppressions are more frequent in childhood than in adult life.

Prof. W. H. R. Rivers tells of a physician friend who had an unnatural fear of closed places such as small rooms, closets, and caves. This fear was finally discovered to be due to a suppressed childhood episode. He had been shut in a narrow hall with a dog of which he was very much afraid. The painful incident was subsequently pushed into the unconscious because of its acute unpleasantness, but it there continued to live an independent existence and make trouble for the rest of the mind.

Complete suppression of unpleasant emotions and feelings is, moreover, frequently characteristic of our behavior in the presence of danger. The aviator, while in mortal combat with an adversary in the air, is neither afraid nor angry. The fear, however, is not absent but suppressed out of the consciousness, for if the experience is reproduced again, as for example in a dream, the emotion may appear prominently.

FOOD FROM THE AIR

Plants can live on air and water! That is, a very simple and primitive plant can derive all its necessary constituents from these two sources.

Animals, including the human animal, use a great variety of foods, but all depend ultimately on plants for their body-building and energy-supplying substances. We eat the ox that lived on grass and clover or the fish that grew by devouring smaller fish. These in turn had maintained themselves on the microscopic plants abounding in the sea.

But the plants have to build up their bodies out of yet more simple foods, compounds of the four chemical elements, carbon, hydrogen, oxygen, and nitrogen. Oxygen and hydrogen are supplied abundantly in air and water, and carbon comes from the carbon-dioxide in the atmosphere, but utilizable sources of nitrogen are not so universally distributed.

There is plenty of nitrogen in the air; in fact this element constitutes about three-fourths of the air's weight, but nitrogen is a peculiarly lazy substance which refuses to combine with other things under ordinary circumstances. Hence the plants have to rely on various compounds of nitrogen which are distributed through the soil from the decayed parts of other plants and animals.

To be sure, there are bacteria which are able to build up nitrogenous compounds from the free nitrogen of the air, but these require organic matter in addition.

It is evident, however, that some kind of plant must have preceded these forms which require decayed plants and animal tissues as ultimate sources of their nitrogen, and that such a primeval organism must have been able to abstract both its carbon and nitrogen from the air.

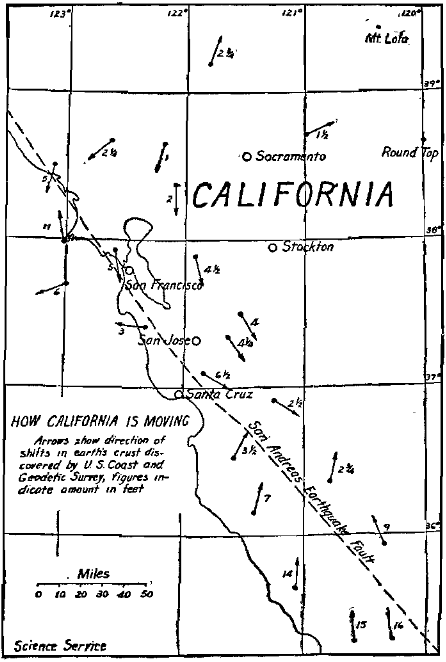
It has been maintained for many years that some higher plants still retain this power of fixing free nitrogen, but only recently has the phenomenon been demonstrated by two British biological chemists, Drs. Benjamin Moore and T. Arthur Webster.

Very primitive, one-celled, green plants were successfully grown by these investigators in complete isolation from all sources of nitrogen even for these simple plants, but the experiment shows that the four chief elements required by living things may at times be derived altogether from the atmosphere and water if the water contains the necessary mineral salts.

EARTH MOVEMENTS IN CALIFORNIA

Field parties of the United States Coast and Geodetic Survey have found irregular movements of the coastal region within 200 miles of San Francisco amounting to as much as 16 feet as compared with accurate surveys made 30 or more years before.

In 1923 the latitude and longitude of certain peaks and light-houses were redetermined by triangulation with reference to two massive peaks of the Sierras, Mount Lola and Round Top. Assuming these two points to have re-



EARTH MOVEMENTS IN CALIFORNIA

mained stationary, there seem to have been slow slippings of the earth's crust in various directions.

The movements shown bear a general relation to the famous San Andreas fault line, a slip along which was the immediate cause of the great earthquake of 1906. Points south and west of this line have, with a few notable exceptions, moved in a northerly direction; while those to the north and east of the line have nearly all moved toward the south. There is little uniformity in the amount of the movements.

For example, San José peak, about ten miles southwest of the fault line and about 40 miles inland from San Luis Obispo, has moved north 16 feet, while Santa Lucia peak, 80 miles to the northwest, has moved only 7 feet northwards.

Near San Francisco bay the differences in direction are most marked. The light-house on southeast Farallon Island has moved westward 6 feet, while Point Reyes light-house, on the mainland 18 miles away, has moved 11 feet to the north. Mt. Tamalpais has moved south about 5 feet.

Loma Prieta peak, about 50 miles southeast of San Francisco, has moved south-eastward 6½ feet, while Sierra Moreno peak, about half way to San Francisco and on the opposite side of the fault line, has shifted 3 feet to the westward.

These investigations may eventually lead to the prediction, within reasonable limits, of the time and place of earthquakes. They will certainly have great influence on geologic thought in the study of the earth's crust. The remarkable thing is that the peaks do not move the same amount for any given direction, the complicated movements seemingly indicating the action of local forces rather than one of a world-wide origin.

The results have much interest and value to the engineer, the surveyor and map-maker, the geophysicist and the geologist. It has long been known that the earth moves horizontally along a fault line, but how far back from the fault does the movement take place? These surveys found decided movements for stations 15 miles or more from the fault and the creeping of the surface probably is going on at even greater distances.

AN INDUSTRY SAVED

Science and invention are often accused of depriving men of work, as when the grain binder was perfected, or of changing the economic life of a whole people, as when synthetic indigo outdistanced the natural product of India.

But more often science saves an industry. This is sometimes through the stoppage of waste or the use of by-products. Again the principal product must be bettered or ways devised for making it return more for its cost. This was the situation confronting the use of artificial or city gas for illumination.

Time was when gas lighting was the best. Now we get wonderful results from electric lamps because science has found a way to heat to incandescence a carbon or metallic filament without its burning up in less than, say, a thousand hours.

It occurred to the scientists that perhaps gas and vapor could be made to heat a filament so that it too would glow and yet not be consumed. It was a long and tedious task. The oxides of the rare earths were found to answer. Cerium and thorium won from monazite sands serve in proportions so chosen as to give high candle power and light of the best color. To weave these metallic oxides, cotton from the Sea Islands, ramie from China, artificial silk from the laboratory and other fibers are impregnated with solutions and afterward woven into the form of the well-known Welsbach mantle. When in place where service is to be given, the fiber is burned away, leaving a network of fine ash surprising in its ability to withstand shock and rugged to a degree.

This delicate mantle gives a pleasing light only when heated very hot. The gas best suited to give light to compete with the electric lamp is the same gas that continues to be used for heating in most houses however they may be lighted. The standard becomes not the candle power but the heating power, whether it is to be used to heat a gas mantle or a pot of beans.

And so the closely adhering grains of oxides, fashioned in mantle form after many technical difficulties were overcome, add to our comfort in many a home. Besides, they have saved the gas-lighting industry and kept stacks of equipment off the junk pile.

UNCONSCIOUS SANITATION

Visitors to China always wonder why the Chinese have not all died of germ diseases long ago since they seem to disregard the laws of hygiene with impunity. But closer consideration reveals that some of their dietary habits, although quite unreasoned, are not so unreasonable as they seem.

Many of the Chinese customs, dating from the "timeless time," show interesting adaptations to sanitary necessities of an overcrowded country. These practices are of special interest in that they do not bear the force of religions laws, but are simply customs of the people, carried on from generation to generation, because, in the first place, they work, and also because "it has always been done that way."

The ancient custom of drinking tea is connected with "unconscious sanitation." Most of the inhabitants of China never drink water. Instead, they keep on hand quantities of weak tea. It is the safest method of getting drinking water in a country where every stream and canal is alive with disease-producing bacteria. The modern white man's answer to doubtful drinking water is to boil it, but boiled water tastes flat, stale, and unpalatable. The Chinese "drinking water tea," *is at least palatable, and in its preparation* it is heated sufficiently to destroy the most virulent of disease germs.

In the Chinese restaurants one can get *pe tsai* and other Chinese vegetables which have been plunged into hot fat. The surfaces are seared and brown, but so short has been their bath in the frying-kettle that the vegetables are fresh and crisp inside. For this again we find an "unreasoned reason." The intensive agriculture of the Chinese does not stop at the exploitation of the last handbreadth of ground. It includes the direct supplying of fertilizer in a manner and kind that would be highly objectionable to Western ideas. Vegetables raised in this manner would be positively dangerous if eaten raw, but the brief contact with the hot fat, at a temperature far above that of boiling water, is sufficient to give a pretty effective surface sterilization.

THE DISCOVERY OF INSULIN

Diabetes is a disease with which a million people in the United States alone are suffering and of which over 30,000 die each year. A new weapon for fighting this scourge has been found by two young Toronto scientists. It is a substance called insulin, an extract from the pancreas gland.

It has long been known that the pancreas gland, besides secreting a digestive juice into the intestine, also exercises control of the sugar-oxidizing ability of the body. It was thought probable that the normal gland secreted a substance into the blood which brought about the proper burning of sugar in the tissues, while a failure of this secretion caused diabetes.

If this were true, extracts of the gland ought to be useful in fighting the sugar disease. However, early results by many investigators were disappointing. We now know that this was because the digestive juice of the pancreas, when mixed with the internal secretion, digests the latter. In 1922 Dr. F. C. Banting and Mr. C. H. Best of the University of Toronto succeeded in preparing a solution of the active substance, insulin. When injected into diabetic animals the drug brought them to a normal condition and permitted a normal diet as long as daily injections were made.

The results on dogs were sufficiently successful to warrant human tests, and here the results have also been most promising. Difficulty was at first experienced in preparing large amounts of insulin from cow's pancreas ("sweetbreads"), but soon it was manufactured in sufficient quantities to supply the leading clinics of the country.

Since its first human use, insulin has been purified and made safer by removing extraneous and poisonous compounds. Similar substances that reduce diabetic symptoms have so been obtained from the pancreatic cells of the skate and from the tissues of clams, as well as certain vegetables such as onions and lettuce. Perhaps eventually the sea instead of the farm will yield the valuable extract, but more likely the chemist will be able to duplicate nature, as he has done many times before, and produce a better and purer compound synthetically.

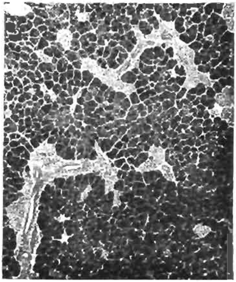
The action of insulin seems magical. A patient who has sunk into a coma from which he would probably never recover may be restored to active life in a few weeks. Like the sufferer from thyroid deficiency, who must take thyroid extract from time to time in order to be normal, so the diabetic must receive injections of insulin day after day. But he is then able to eat a normal meal, including a sufficient amount of sugar and starch.

Dietetic control is still necessary, yet the new drug saves thousands of lives and permits the sufferer an occasional indulgence in the pleasures of the table. It is too early to say whether insulin will help to cure by permitting the patient's own pancreatic gland to recover its power of functioning again. Only time and clinical experience can tell that part of the story.

The active principle of insulin is what is known as a "hormone," which means a chemical messenger sent out by one organ to do work or cause changes in another. Many of these hormones have been found to-day by medical investigators and knowledge of them often clears our understanding of obscure conditions and ills of the body. It is the hormones secreted by the ductless glands that control growth and in large measure determine character and temperament. By using such substances we are getting nearer to Nature's method of regulating bodily functions. Insulin, for instance, is not an alien drug like castor oil or quinine, which is taken to correct certain unfavorable conditions or to kill off invading microbes. An injection of insulin simply adds tc the blood one of its normal and necessary constituents which is lacking in cases of diabetes.

The discovery of insulin is one of the most dra matic incidents in the history of medicine. Dr Banting was a young and unknown country physi cian when the idea of extracting insulin came t



THE DISCOVERY OF INSULIN

Left. In this little attic room and the still smaller one beyond Banting and Best carried on their first experiments in the summer of 1921 at the University of Toronto.

Right. Three collaborators in the Discovery of Insulin. Dr. Banting in the long coat and Dr. Best in shirt sleeves. Between them is their pet dog who was inoculated with pancreatic preparation.

Below. A slice of the pancreatic gland as seen under a high-power microscope. Light patches are the Isles of Langerhans.

A SELF-GOVERNING TURBINE

This turbine water wheel has an internal mechanism that changes the angle of the wings to suit the size of the stream and so get full advantage of the flow. *See* page 89.

him, but he abandoned his practice and went at once to Toronto when the University gave him an opportunity to put his plan to the proof. A small attic room was assigned to him as a laboratory and a young chemist, Mr. Best, volunteered to devote his vacation to starting the work. A year later Dr. Banting was recognized throughout the world as one of the benefactors of the race, and to-day thousands of men, women, and children owe him their lives. The Dominion of Canada gave him a life pension of $7,500 and the Province of Ontario granted $10,000 a year to found a Banting-Best Chair of Medical Research.

In 1923 the Nobel Prize of $40,000 for the greatest discovery in physiology of the year was awarded to the discoverers of insulin.

THE PSYCHOLOGY OF AUTO-DRIVERS

All persons are not equally suited to driving a car. One man in an emergency gets and acts on an idea quickly, another slowly. The time that elapses after a danger is seen until the driver can start the movement that is required to avoid it is an important factor in safety. Slow and uncertain or wavering actions are undoubtedly the occasion of many accidents. This slowness is due in part to lack of practice and training and in part to the natural tendencies of the individual.

Both of these factors can be made matters of test.

The natural speed with which a person acts, his "reaction time," can be easily measured and the relative ability of chauffeurs in this respect could be determined. The time that it takes for a signal to reach the eye and be transmitted to the brain and for the brain to send its order down through the nerves of the arm seems instantaneous, but it can be measured by the reaction time test used in our psychological laboratories every day. A person is seated at a table with his finger on a telegraph key. As soon as he sees a given signal he presses the key. When the signal flashes, the electric current also starts a pointer marking off the fractions of a second upon a dial. When the key is pressed the current is broken and the hand on the dial stops moving. This gives a record of the time it took the person to get and act upon the idea.

Tests for driving ability can be varied according to the sort of tasks which the drivers are called upon to perform. Tests for drivers of light pleasure vehicles may be very different from tests for drivers of fast ambulances and fire appliances, and they in turn might be quite different from tests for drivers of heavy motor-trucks. High-powered fast machines obviously should not be entrusted to poor or relatively untrained chauffeurs. A specific form of test for various types of machines is good common sense and good science.

In addition to tests for mechanical expertness, knowledge of traffic regulations and automobile limitations should also be required.

Jailing reckless drivers and requiring speeders to view accident victims in the morgue are haphazard methods. Licenses to drive should not be issued to persons with such tendencies to motor manslaughter. It is perfectly possible that the psychologists will be able to work out tests to determine the moral tendencies and regard for common interests of applicants for drivers' licenses.

Careful analysis and expert thoroughgoing experimental investigation should be made of these and other problems involving the mental processes of those who use the highways. When there has been a systematic exploration of the human factor in traffic, tests can be standardized.

It is notorious that tests for drivers in one community are entirely different from tests in other communities. Licenses from different localities are quite incomparable in value. It is obvious that the same ability to drive is not required on a country road as in the city, but if the farmer is to drive into town, he must be able to handle his machine under city traffic conditions or else not be allowed to come in. Standard tests would help to remedy this situation.

Even now we should have a national black list for chauffeurs, so that those who have forfeited their licenses on account of bad driving in one state can not go over into another state and continue their homicidal practices.

THE HEAVENS 25,000 YEARS HENCE

About 9,300,000,000,000 miles. That is the distance that will be traveled in the next 25,000 years by our own particular star, the sun, and its planets, including this small world of ours, in their journey through the universe. In the meantime other stars, possibly attended by other worlds, will also have moved equal or greater distances through space in various directions.

What effect will these motions of the heavenly bodies with respect to one another have on the scenery of the heavens as we view it from our rapidly moving world? We say rapidly moving, for twelve and a half miles per second, one million miles a day, or four times the distance from the earth to the sun in a year, seems to us a pretty fair speed for the solar system to maintain century by century. Yet the majority of stars in the vicinity of the sun are traveling on the average at nearly twice this rate and a few exceptional stars are moving with velocities of between one hundred and two hundred miles per second.

It has been estimated that the average first magnitude star moves in one year about one-fourth of a second of arc across the heavens. If we multiply this by twenty-five thousand we find that the result is about one and three-fourths degrees. The angular diameter of the moon is one half of a degree, so the average first magnitude star moves a distance across the heavens equal to about three and a half times the angular diameter of the moon in twenty-five thousand years. This is of course sufficient to change appreciably the outlines of the principal constellations as they appear to us to-day. In general, however, the first magnitude stars are the nearest, and stars of fainter magnitudes are moving as a whole less rapidly across the line of sight. The average annual motion across the line of sight of a sixth magnitude star, for instance, which is the faintest star visible to the naked eye, is only one-twenty-fifth of a second. In twenty-five thousand years then, an average star of the sixth magnitude moves a little over one-half the angular diameter of the moon. The displacements of stars of the second, third, fourth and fifth magnitudes would lie on the average between the limits given for the first and sixth magnitude stars, and would be quite sufficient to modify considerably the present appearance of the principal constellations which are outlined chiefly by stars of the first four magnitudes.

In speaking of the angular motions of stars across the line of sight we have been careful to refer to the *average* stars of each magnitude, for individual stars of a certain magnitude are often exceptional in this respect. Some stars of great brilliancy, such as Canopus and Rigel, are moving very slowly across the line of sight, while others, such as Arcturus and Sirius, have sensibly changed their positions in the heavens in the past two thousand years. Also certain stars of the sixth magnitude or fainter, known as runaway stars, are moving at such high velocities across the line of sight that in twenty-five thousand years they will be many degrees from their present positions. The most noted of these stars is an eleventh magnitude star discovered by Prof. E. E. Barnard at Yerkes Observatory in 1916 that is moving across the line of sight at a rate that will carry it entirely around the heavens in a period of about 130,000 years. This star is also the second nearest star to the solar system. Very few of the stars will change appreciably in brightness in a period of 25,000 years, for the distance we travel in this time amounts to only one and a half light-years, and within a radius of fifteen light-years of the earth there are but twenty known stars. Only in the nearest of these would we note any marked change in brightness.

SUNSHINE CURES RICKETS

There is probably no condition or disease that man is heir to that has not been "treated" with sunlight. The curative effects of light have long been literally up in the air—generally on mountain tops, where sanitaria for tuberculosis, insanity and one thing and another have accumulated. But scientists have at last discovered one specific and important cure by sunlight, the cure of a very prevalent and dangerous disease of small children, rickets.

Since the War Europe has been suffering from many and fearful diseases, but none of them threatens the rising generation so much as the various complications from malnutrition. Malnutrition is simply a technical term for slow starvation, which we have only recently come to recognize as a true disease. One of its symptoms is a condition of the bones known as rickets or rachitis that occurs only in infants and small children. The bones stay soft. They grow, but they fail to harden. The hard substance, calcium, that should appear around the growing cartilage, is not deposited. If you feel the end of your nose and compare it with a tooth, you will have an idea of the difference between bone and cartilage. Naturally a cartilage skeleton cannot support the weight of the body. The ends of the bones grow lumpy and distorted; the ribs are pushed out of shape and the chest narrowed; the teeth are soft and decay readily; altogether, rickets is responsible for most of the deformities that one ordinarily meets—bow legs, badly shaped jaws, caved-in chests, and the like.

Rickets has always been puzzling to the medical profession. It is associated with an inadequate diet and it is also a "seasonal" disease, more prevalent in winter than in summer. For years cod liver oil has been used successfully as a remedy. Cod liver oil is rich in certain inorganic salts and in the mysterious vitamin A which has been found essential to normal growth. It seemed reasonable to suppose that food alone was concerned in the cause and cure of rickets.

But now we learn that while proper food can and does protect babies from rickets, sunlight can also both protect and cure them. Fresh air and sunlight have always been prescribed for children on general principles but now we learn, from Doctors Hess and Unger of New York and Dr. E. V. McCollum and others of Johns Hopkins, that direct sunlight specifically helps in the development of strong, normal bones. Sunlight may even make up, to a certain extent, for a deficient diet. It is not a substitute for food, but where the diet is inadequate and would lead to rickets, the infant can be kept normal, so far as its important skeleton is concerned, by exposure to the direct rays of the sun. The rays that protect against and cure rickets are probably the ultra-violet, invisible rays. Exposure to the rays of the mercury vapor lamp and to direct sunlight have the same effect. The ultra-violet rays cannot penetrate glass and it is therefore of the first importance that babies and young children should get sunlight out of doors. A warm, sunny nursery or kitchen is not "just as good."

A SELF-GOVERNING TURBINE [1]

The wealth of Sweden lies largely in its water-power. This amounts to about one and a fifth horse-power per capita, according to the calculations of Dr. Arrhenius, head of the Nobel Institute. Even the United States is not so rich in hydraulic resources in proportion to its population and it is not yet making as much use of what it has.

The Swedes have broken to harness one quarter of their wild waterfalls and are preparing harness for those that are still running at large. They are

[1] See illustration facing page 81.

not afraid of a coal famine, for they have always had one. From their wood and waterfalls they can get both heat and power, and they are making every effort to be as independent as possible of those countries which have inherited their wealth from the Carboniferous Epoch.

The turbine is the most efficient form of water motor. In order to secure the greatest efficiency as a power producer a turbine has to be constructed so as to run at a certain speed under a given head of water. But when the load, speed, flow or pressure changes, the turbine does not work so well as one of a different design would. To overcome this difficulty Professor Kaplan of Brünn has invented a water-wheel with adjustable blades and guide-vanes which are automatically shifted to a different angle by a sensitive governor so as to secure the greatest possible efficiency whenever the conditions change. In this turbine the blades are reduced to four or three or two and are made short and broad, being so set as to pass the water through in a continuous positive eddy without reverse currents anywhere. It looks like a ship's propeller instead of a water-wheel.

A big turbine of the Kaplan type has been constructed by the Kristinehamn works for the Royal Swedish Waterfall Board to be installed at Lilla Edet. In this a single wheel of 19 feet diameter, weighing 62 tons, gives 10,000 horse-power under a head of 22 feet, and can take an overload of twelve per cent. Its specific speed is 640.

The specific speed is the number of revolutions per minute that a similar turbine would make if of such a size as to give one horse-power under a unit head of water, which in the European system is one meter. The higher the speed the less the efficiency as a rule, but it is claimed for the Kaplan turbine that it will show an efficiency of more than eighty per cent. with a specific speed of over 800, a considerable gain over the speeds of 300 or 400 formerly customary. One installation of a Kaplan turbine shows an efficiency ranging from 84 to 86 per cent., with the horse-power varying from 57 to 99, and a specific speed of 718, the highest yet attained in Scandinavia. The conical construction of the outlet pipe, whether straight or bent, produces a suction below the wheel that adds to its power.

But its self-governing ability is most interesting. If the wheel is slowed up it adapts itself to the new condition as quickly as a gyroscope top when it is tipped. It might serve as a model to human beings who often wobble and creak badly when their equilibrium is disturbed and waste much time and energy before adjusting themselves to changed conditions of load or motive power.

AN AUTOMATIC POWER-PLANT

A great hydro-electric plant which needs no man about the place while it furnishes power to the industries of New England is located at Searsburg, Vermont, on the upper waters of the Deerfield River. Except for the occasional visit of an engineer, it operates in complete solitude, attending to its duties unassisted, even to meeting whatever emergency may arise.

It is wholly automatic in its control. If serious trouble arises in its mechanism, it shuts down and stays shut down until experts have made things right again. But if the trouble is trifling and of a sort to correct itself, the big waterwheel and generator rest for a time until conditions are again normal, and then set to work again turning out their thousands of horse-power.

Other automatic stations are in operation elsewhere; the idea has been tried out in small units, but the plant at Searsburg is the largest of its kind in the world.

The plant is the uppermost of the seven stations of the New England Power Co. on the Deerfield River. Its turbine, rotating at 360 revolutions per minute, drives a generator having a capacity of 6,500 horse-power. The only help from human beings that is required is an occasional looking over and some attention to the lubricating system, or when something needs to be remedied or the governor-mechanism is to be set to produce a given amount of power, or the turbine is to be started up at some predetermined moment.

If the company's dispatcher down in Millbury, 100 miles away in central Massachusetts, decides to tie in the Searsburg power, say at 6 o'clock the next morning, a man visits the station and sets an alarm clock for that hour. When the alarm goes off, the control circuit is closed, the gate of the huge penstock is opened, the water pours through the wheel and the generator begins to convert its power into electric current and deliver it to the high tension wires which stretch along the right of way to the distant distributing station at Millbury. Or the dispatcher, knowing the flow of water to be let down from the company's Somerset reservoir, which impounds the flow of the upper watershed, may decide that the automatic plant shall generate 2,000 or 3,000 or 4,000 horse-power, whichever may seem desirable under given conditions. In such a case a dial on the governor is set for the power determined upon, which is all that the station will generate until the setting of the dial has been changed.

These are by no means all of the human characteristics of the automatic station. If left to run at its own will, the turbine will start up when water arrives in sufficient volume and will shut down when the water falls below the efficient limit. If a bearing becomes heated the penstock gate closes, in which case the wheel stops until experts come and remedy the trouble. But when generator windings become too warm, the unit shuts down only so long as the temperature remains abnormal. When the windings cool off, turbine and generator run along merrily again.

In times of high water, when the river-flow itself is ample and storage water is not a factor, the Searsburg plant runs along all by itself, day and night, a constant, dependable source of power. It is here that another automatic function is important, the regulation of power that is generated to the load that is imposed. When the load falls off the action of the governor causes the supply of water to decrease proportionately, which means the production of a smaller amount of power.

HYPNOTIZING INSECTS

If a hen be laid on her side, with her bill down on the ground, and held quietly in that position for a short time, she may fall into a state of immovable rigidity, continuing to lie in the same position long after the hands are removed from her.

This state can be produced in many other animals, including insects. A French scientist,

M. Etienne Ribaud, who has made thousands of experiments, concludes that the rigid state which he names "reflex immobility" can be induced in all insects and in scorpions, crayfish, lobsters and all their allies.

He says that every animal as it goes about finds not only many occasions for vigorous action but also many occasions for ceasing to act and for keeping still. Reflex immobility is simply an exaggerated case of keeping still. Many animals keep very still when they are frightened; many keep very still when lying in wait for their prey.

The surface of the insect's body is richly furnished with nerves sensitive to touch, and each of these nerves, when touched, stimulates the animal to move. Touch on other nerves causes the animal to cease moving. These two sorts of nerves are grouped in separate zones on the surface of the body.

Generally speaking, touch on the hind part of the body causes the insect to run, touch on the fore part causes it to stop. This general arrangement is found probably in most animals. For instance, the horse when touched with the whip starts to run, but if pressure is put on his head, whether by drawing the reins or by other means, he stops.

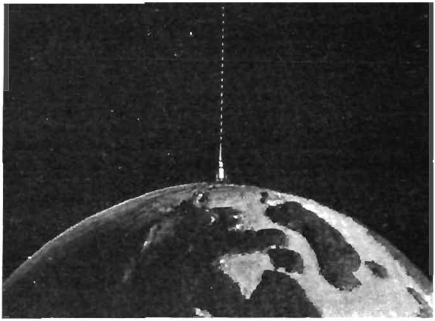
M. Ribaud found that he could in many cases put the insect into the immobile state merely by turning it on its back. As long as the insect stays upon its feet, it resists all attempts to throw it into the state of immobility.

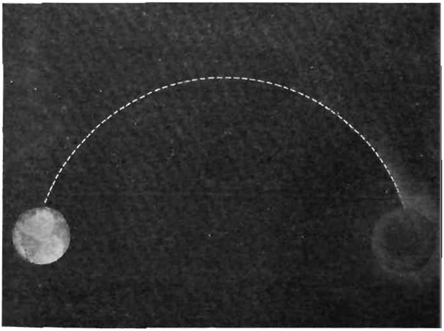
M. Ribaud, with a considerable degree of certainty, through knowledge he has gained, strokes an insect in just the right manner and it becomes as rigid as a piece of wood. Again he strokes it on other zones and it wakes from its trance and runs about again.

AN EASY EINSTEIN PROBLEM

The idea recently introduced by Albert Einstein that all things are relative, that measurements of time and space depend on the position of the observer, is commonly regarded as new and incredible. Yet some illustrations of the general idea are easy enough to understand and not at all novel. In a motion picture film made under the supervision of Einstein and shown in this country the case of a cannon ball is depicted.

Suppose a cannon is set up perpendicularly at the North Pole and fired straight up into the air. A man standing on the earth near by and watching the projectile wonld see it—if it were not too swift—go up and down in a straight line. If we assume that the gun is aimed straight upright and the projectile is well balanced and there is no





AN EASY EINSTEIN PROBLEM

Upper. The projectile from a cannon pointed perpendicularly would seem to an observer on the earth to go straight up and down.

Lower. To an observer on the sun the projectile would seem to describe a curve since the earth moves during the flight of the projectile.

wind or anything else to divert it from its course, then the projectile would fall back into the barrel, say, a minute later.

But the earth in that minute has moved forward in a curved orbit a distance of 1,110 miles. An observer stationed somewhere off in space on the sunward side, or on the sun if he had a good enough telescope, would see the course of the cannon ball not as a straight up-and-down line but as a long curve and he might marvel at the skill of the gunner who could hit a moving target more than a thousand miles away.

Now which is right, the man on the earth who sees the course of the ball as a straight line or the man on the sun who sees it as a curve?

Obviously both are right, since they are looking at the same thing. It all depends on the point of view. Motion is a matter of relativity.

THE SCHOOL-CHILD'S ENERGY

A school-child requires the energy of food to keep the human machine in good condition, just as much as an automobile must have the energy of gasoline to run properly. The amount of energy needed depends, as with the automobile, upon how big the machine is, but more especially does it depend upon how much work is done or how far the boy or automobile is to go. Every boy walks a surprising amount each day. Probably ten miles is a low estimate. All this uses the energy of food. While the automobile cannot repair itself and furnish new parts from oil or gasoline, the school-child's engine must be repaired, rebuilt, and enlarged from material coming from the food. When an automobile is not running, the engine stops and does not "idle," as do the resting child's internal organs of respiration and circulation. So with the child there is a continuous consumption energy, even if there is no external muscular movement.

A study of the heat production during quiet sleep has revealed many most interesting facts about the energy needs for running the human machine of boys and girls of varying size, weight, and age, and it has been found that the heat output of school girls and boys, while quiet and asleep, is much greater in proportion to their weight than is that of the sleeping man or woman. This fact of itself means they must have proportionately more food.

The average girl of 12 to 17 years needs about 1300 calories to sustain life for 24 hours while asleep, or at the rate of 54 calories per hour. During the school period this rises to 81 calories per hour. Perhaps the fact that a "penny" piece of candy will furnish 80 to 100 calories may partly explain frequent trips to the candy counter.

Inside the schoolroom the admonishing finger of the teacher is "sitting on the safety valve," but when school is out, there is a burst of pent-up activity that sends the heat production soaring to incredible heights. A man at moderately severe work is normally said to require about 3300 calories in a day, while a group of schoolboys at an outdoor private school showed on the average a consumption of 5000 calories per day.

EDUCATING THE AMŒBA

Even the lowly amœba, the simplest of creatures, a jelly-like one-celled animal, learns by experience. S. O. Mast and L. C. Pusch of the Johns Hopkins University have observed these tiny animals under the miscroscope and find that they shun bright light. *They learn by repeated trials* how to avoid it efficiently.

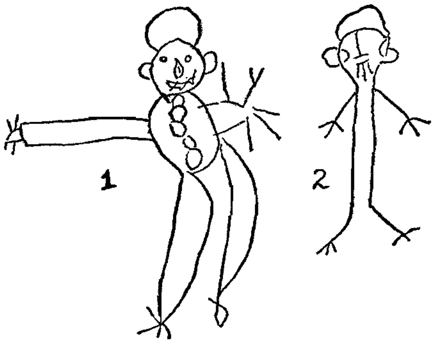
An amœba moves along by a combination of rolling and flowing. When it steps out, or rather flows out, it makes a projection which is called a "pseudopod." This projection is a sort of feeler.

"If the tip of a pseudopod of an amœba going in a given direction comes in contact with a region of high illumination, it usually stops," these scientists report. "If it does, other pseudopods one after another are usually extended in the same general direction, each one stopping when it comes in contact with the highly illuminated region, until one is extended in a different direction. The number of pseudopods produced in an individual before the direction of extension is changed decreases with the experience of the individual.

"In one series of tests consisting of eighteen trials for each of two individuals it decreased from an average of three and one-third for the first three trials to an average of one for the last three. In another series consisting of twenty-seven trials for each of five individuals it decreased from an average of one and one-fifth for the first three trials to an average of two-thirds for the last three."

CHILDREN'S DRAWINGS

In the days when we drew grotesque pictures of human bodies—a circle for a head, an egg for the trunk, crooked lines for arms and legs—we did not dream that such drawings were valuable scientific documents. Investigators tell us there is much method in the graphic madness of children's drawings. They show how the child-mind develops. At first the young artist draws only a head with perhaps a single Cyclopean eye; the head sprouts legs; a body is interpolated; arms appear. The neck arrives perhaps as a dot, like a collar-button at the top of the body. When the child notices for the first time a particular fea-



ART OF CHILDREN AND PRIMITIVE PEOPLES

The drawings of men and things made by childern bear a striking resemblance to those found in the art of primitive peoples. FIG. 1 shows a modern child's drawing, and FIG. 2, folk drawing from the Koch-Grünberg Selection.

ture he exaggerates it. Enormous ears appear, protruding noses, gigantic teeth, innumerable fingers and toes, conspicuous buttons.

The child sees no reason for confining himself to what he can see only, since he knows perfectly well much else that might be seen otherwise. Garments therefore do not hide what the child knows of human anatomy. If he draws a profile-view of a man on horseback, he will show you the rider's second leg seen through the horse. As a genius should, he refuses to confine himself to a single point of view. He can see at once from the side and from the front, and puts a full face on a body turned sideways.

Leipzig, Germany, contains the Lamprecht collection of children's drawings, composed of 100,000 drawings from European children, besides 12,000 from children of other climes. Red, yellow, and black children have contributed to the collection. From it anthropologists hope to find out whether mind develops similarly among all races or whether there exist psychologically distinct branches of the human species.

The drawings of primitive races are compared with those of children and shown to be similar in many respects. Both savage and child produce transparent drawings, in which hidden parts are represented; both celebrate the discovery of a new detail by representing it as disproportionately large; both delight in endless repetition and in hybrid figures—such as a two-headed man or a centipede-cow—both love to play with color and splash it on for its own sake; neither is troubled by theories of realism. Their art-products copy things seen by the mind's eye, not natural objects.

Both child and primitive man begin by portraying single objects; the scene develops out of his continued repetition of the same motive. Often the early artist takes the bird's-eye view, hence vertical objects appear in horizontal level. Perspective develops slowly in the drawings of both savage and child. It originates, possibly, in the tendency to diminish the size of objects in the background because of a lessened interest in them.

Curious features of the art-products of the child and primitive man reappear in the art work of the mentally diseased. The insane often display great aptitude along artistic lines, but their most artistic and finished productions may bear the stamp of a sick mind. The endless multiplication of a particular feature (stereotypy) or rigidity of figure or extravagant ornamentation tell their story to the expert. Other child-like characters appear in the transparent drawing, the drawing from a double point of view, the playful and meaningless use of color. Examples of such reversions to the infancy of the individual and the race may be seen in our modernistic and futuristic art galleries.

ANTARES, SUPERGIANT

Far over in the Southern skies, upon summer evenings, one's attention is attracted by a fiery red star in the midst of a brilliant and peculiarly shaped group of stars that bears a resemblance to a boy's kite with a long streaming tail dipping down to the southern horizon.

This is the constellation of Scorpio. The Scorpion is the brightest of all the zodiacal groups of stars through which the sun passes in its yearly circuit of the heavens, and the brilliant red star which marks the heart of the Scorpion is Antares, which means Rival of Ares (the Greek for Mars).

It bears a very close resemblance to Mars in color and in brightness, at the times when that planet is far from the earth and its splendor is somewhat dimmed. There are times too when the ruddy planet passes very close to Antares, and if Mars is at the time in the far part of its orbit the likeness of these two objects in color and brightness is very striking.

How astonished the ancients who named this star Antares would have been, however, had they known that the glorious Mars would be but an infinitesimal speck on the face of the mighty supergiant sun, Antares, in comparison with which even our own sun is a dwarf.

The results of measurements of the diameters of a number of giant stars with the interferometer show that Antares is a giant among giants and has the greatest diameter of any star yet measured, surpassing in size even the amplitudinous

Betelgeuse in Orion. The diameter of Betelgeuse is about 240,000,000 miles. The diameter of Antares is about 400,000,000 miles. To this "rival" of Mars—that tiny planet about 4,000 miles in diameter in which we take such a great interest—let us compare rather the *orbit* of the planet than the planet itself. The diameter of the orbit of Mars is about 280,000,000 miles and if we placed Antares at the center of the solar system in place of the sun its surface would be some sixty million miles beyond the orbit of Mars and beneath its surface would lie Mercury, Venus, the Earth-Moon system, Mars, and many of the asteroids.

The distance of Antares from the earth is about 360 light-years. Let us do a little computing in regard to this. A light-year is 63,000 times the distance from the earth to the sun in round numbers, and round numbers will do for this problem. Antares, then, is about 22,500,000 times further away than the sun and the distance of the sun from the earth is about 93,000,000 miles. So we can express the distance of Antares from the earth in miles if we want to do so. But what would be the use? We would obtain numbers quite beyond our comprehension. That is why the astronomer prefers to express stellar distances in terms of the light-year, the distance light travels in a year at the rate of 186,000 miles per second. Looking at it another way, then, a light-ray starting to-day from Antares will not reach this earth until 360 years have passed, and the light-rays that are now reaching us started on their journey somewhere about the year 1563.

Antares, however, is not very far away, as stellar distances go. As far as its distance is concerned there is nothing remarkable about the star unless it is its comparative nearness. What is 360 years in a universe that is probably several hundred thousand light-years in extent? Simply a stone's throw!

If we could place the sun and Antares side by side at a distance of thirty-three light-years from the earth, which is standard distance for comparing the brightness of stellar bodies, we should find that our sun would appear to us as a star of the fifth magnitude, which is a faint star just well within the range of visibility of the naked eye; but Antares would outshine Sirius, the brightest star in the heavens. Such is the relative luminosity of these two suns. The greater brightness of Antares would be due to its enormous size as compared with the sun. In surface temperature it is much cooler than the sun. In fact, these red giants have the lowest temperatures of all the stars, on the average about 3,000 degrees centigrade as compared with 6,000 degrees for the sun. Moreover, the incandescent gases of which they are composed are in an extremely rare state, the density of the red giants being less than that of the interior of a nearly perfect vacuum tube.

Antares has a small, green companion star that is nearly lost in the rays of its brilliant neighbor and cannot be found without the aid of a telescope of five or six inches diameter. What a weird system these two strongly-contrasting and mutually-revolving stars must form!

WHAT IS MATTER?

The sensations are the crude material out of which we construct a picture of the external world. Every man has to do this for himself. The philosopher, plunged suddenly into the midst of a chaos of confused sensations, begins at once to arrange them. We all have to construct a system of philosophy. The only difference is how far we carry it, whether we stop thinking as soon as we have sufficient working hypotheses to live by, or whether we are led by curiosity to extend our study to subjects not of immediate and practical importance.

This systematizing of the universe is merely a matter of convenience. We think to save the work of thinking. If a man has a lot of small objects to carry the best thing he can do is to tie them up into bundles of convenient size. In like manner we do up our sensations into bundles that we can handle called "concepts," and if we label them also before we stow them away in our memory it will help us to find them again. For example, one group of sensations which often occur together is this: a white color, a crystalline form, a gritty feeling, a sweet taste. Wrap up this group of sensations in a tidy bundle and label it "sugar." If you study sugar further you will have a lot more sensations to add to these, but "sugar" is all you will find out about it, all you ever can find out about it, all there is to find out about it.

Now is there any objection to calling this an "object" or saying it is "matter"? Not in the least, unless you ascribe other attributes to matter besides those you have just given it. Words mean what you want them to mean, just as they did to Alice in Wonderland.

If you still have a superstitious belief that matter is something besides this, tell me what it is. What sort of matter would that be that you could not touch, or taste, or see, or smell, or hear, directly or indirectly? If there were anything else there how could you know it?

Observe that this is not at all the same thing as denying the existence of matter. It is simply telling what matter is. The Greeks discovered a convincing argument against any one who denied the existence of matter and it will work to-day.

Just knock him down. He will then realize that your fist is the matter. It is a possibility of sensation.

The common crude concept of matter is useful and, so long as we do not fall down and worship it, it is a good one. It is, however, not the only possible concept, not even the best one. In modern works on physics and chemistry more is said about energy than matter. What then is energy? It is the cause of sensation, also a purely hypothetical conception, a mental construction, a means of grasping reality. We say that it is the energy of light that causes the sensation of sight, that it is the energy of motion that causes touch. We see a rolling ball, it hits against another ball, the first ball stops and the second rolls on. There is the fact, that is all we know about it, but I can say that the energy of the first ball passed into the second, and there I have a generalized statement that expresses what occurs in every other case of this kind in the universe. But it does not mean a bit more than the first statement did. It is simply another way of saying the same thing. If we begin with energy, then matter is simply energy located at a certain point. Take away energy from matter and there is nothing left.

Mass and motion make up energy. But motion is variable and, according to the latest theories, mass varies with it. No wonder that a recent exponent of these theories speaks of them as tending toward "dematerialization of matter."

FIXING NITROGEN FOR FERTILIZER

Within a year after the disastrous explosion of 1922 the great air nitrogen plant at Oppau, Germany, was again producing fertilizer at the rate of 100,000 tons per year. This reveals the revolution that has taken place since the war in the methods of securing this most necessary fertilizing material.

Four-fifths of the air we breathe is nitrogen. And it is estimated that there is above every seven acres of land as much nitrogen as the entire world now consumes annually in its principal commercial form. Yet formerly men scoured the four corners of the earth for a sufficient supply of this material to meet the needs of our growing crops.

Our merchants and traders have searched the islands of the Tropic seas and have drawn heavily upon the saltpeter deposits of far-away Chile. Our packing houses have carefully saved every bit of blood and meat scrap that contain this element. Our chemists have developed means of extracting it from coal during the coking process. Yet all the time this great weight of nitrogen in the air has hung over us, tantalizingly near but, until recently, out of practical reach.

But science has solved the problem.

No longer is there any danger that the human race may some day suffer from lack of nitrogen to produce food crops. The air supply of nitrogen is inexhaustible, and the means of separating and fixing it in usable form are well known, effective, and relatively cheap. Germany now produces somewhat more nitrogen from the air than she needs for her agricultural purposes. Norway is also a large producer and France, England, Sweden, Italy, Japan, and Canada all have their nitrogen fixation plants. The government plant at Muscle Shoals, Alabama, will be operated, no doubt, somehow and sometime and by somebody. The military importance of the nitrogen question has tended to surround it with a considerable degree of secrecy and necessitates each nation carrying on its own investigations. In this country these are centered in the Fixed Nitrogen Research Laboratory of the Department of Agriculture, located at the American University, Washington, D. C., where a staff of scientists and engineers are constantly engaged in pushing forward the frontiers of our knowledge in this domain in order to keep our government at least abreast if not in the lead of the rest of the world, both for the needs of agriculture and as against any possible emergency of warfare.

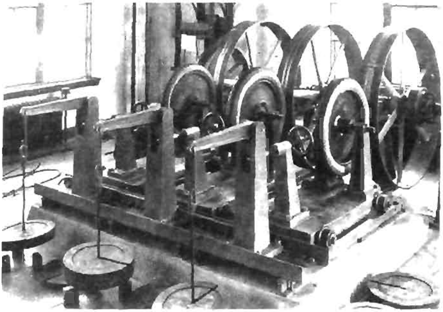
The economical production of nitrogen from the air depends at present to a large extent upon cheap electricity, and this, in turn, depends upon cheap water power. The trend of development and improvements in the processes of late years have, however, steadily reduced that portion of the cost which is chargeable to the power consumed.

Three different methods of capturing and holding this air nitrogen have been devised and commercially operated on a large scale. The method first used and to some extent still employed where hydro-electric power is very cheap, as, for instance, in Norway and Sweden, consists merely of passing air through a great electric arc flame. Very small quantities, about 1.2 per cent., of nitrogen and oxygen combine, and it is possible by further treatment to concentrate this into liquid nitric acid.

In the Haber or direct synthetic ammonia fixation process the nitrogen is produced in the form of ammonia which consists of nitrogen and hydrogen. The necessary hydrogen may be made by breaking up ordinary water into its two component gases, hydrogen and oxygen. This is done by passing an electric current through the water. The nitrogen may be prepared very simply from the air by using one-seventh of the hydrogen to burn out the oxygen, the resulting nitrogen being

NITROGEN CAN NOW BE TAKEN FROM THE AIR AND PUT INTO THE PLANT

The corn on the left has been fertilized with salts made from atmospheric nitrogen, and that on the right has received none.



A MACHINE FOR WEARING OUT TIRES

The Bureau of Standards at Washington has devised this apparatus for making comparative tests of automobile tires to see which make will last the longest and how inflation pressure affects the life of the tire. *The equipment is run day and night* until the tire begins to break down. *See* page 114.

just the right amount to combine with the remaining six-sevenths of the hydrogen to form ammonia. In larger scale plants, where more elaborate equipment is justified for the sake of greater economy of power, the nitrogen may be separated from the air by first liquefying the air and then fractionally distilling it, nitrogen boiling off first and leaving the oxygen behind. The nitrogen gas and the hydrogen gas are then brought together in strong steel chambers. There tremendous pressure and a dull red heat in the presence of a substance like porous irou, called a "catalyst," unite three volumes of hydrogen and one volume of nitrogen to form ammonia. This ammonia is a gas (the liquid you buy at the grocery is ammonia gas dissolved in 10 to 20 times its weight of water), but it can be treated with sulphuric, nitric or phosphoric acids and changed into a solid material, ammonium sulphate, ammonium nitrate, or ammonium phosphate, suitable for fertilizer.

It will be noticed that the raw materials from which ammonia is made are our two commonest materials—air and water.

In the cyanamide process the production of liquid air and separation of pure nitrogen from it is also the first step. The aim from that point on is to get the nitrogen gas changed over into a solid form. This is done by passing it over hot powdered calcium carbide, a substance made by fusing at high temperature a mixture of coke and limestone. The carbide "soaks up" the nitrogen and the resulting product is known as cyanamide. It contains about 21 per cent. of nitrogen. When treated with steam the nitrogen present changes to ammonia, and this in turn can be changed to ammonium sulphate or phosphate as described in connection with the Haber process. Of the government plants near Muscle Shoals, No. 1 is the direct ammonia process, and No. 2 is the cyanamide process. If these are used for making fertilizer the ammonia may be combined with phosphoric acid made from phosphate rock of which there is an abundance in the Southern states. Phosphoric acid is, like ammonia, an essential food for plant growth.

HOW AUTO TIRES WEAR OUT[1]

Internal friction rather than that due to the impact of the roadbed is what wears out most automobile tires. The United States Bureau of Standards has conducted exhaustive tests of the wearing qualities of tires, and its experts find that it is relatively easy to make treads thick enough to wear many thousand miles; but it is not so easy to make tires which will stand their own internal strains.

[1] *See* illustration facing page 113.

Tires are set on a wheel, fully inflated, pressed against a revolving wheel with a pressure equivalent to that of road service and kept there until they show signs of heavy wear, the equivalent distance being measured by the number of their revolutions. Few of them wear out on the treads in spite of the fact that the bearing surface of the wheel against which they revolve is studded with projections at intervals to simulate the roughness of the roads.

Every time a car goes over a bump and the tires are squeezed there is additional strain besides the usual stress due to the compression of the tire under the car's weight. This squeezing causes the layers of the tire to rub over each other, and it is this internal friction which makes tires get hot and eventually wears them out.

Tests are also being made on the loss of power due to the internal friction of the tire. A tire, revolved by a motor giving a known horse-power, is set against a wheel which turns a generator whose power output may be measured. Conditions are made to approximate those found on the road, and the loss of power between the motor and the generator is measured. This lost power is what heats the tire.

The ideal tire from a theoretical standpoint is thin and with a smooth surface. Such a one would be entirely unsuited to rough road work and would be short-lived, but if fully inflated it would deliver the engine power to the road with the least waste. The problem of the experts is to prepare specifications which will combine the highest attainable degrees of wearing quality with power efficiency.

HOW TO IMPROVE YOUR MEMORY

Have you a good memory, or does your memory play tricks on you? No matter how good or how poor it is you can improve it greatly by applying a few psychological principles. Not all persons with a marvelous memory have a really serviceable memory.

There is a man, for example, in a Middle Western State who has one of the most marvelous memories ever observed. He remembers the license numbers of every automobile which passes his window. He can promptly and without any apparent difficulty tell the exact numbers. This is no effort for him. And he is always right, for he has been checked up. This is an interesting feat of memory, but is the memory a really serviceable one? This man has a too one-sided development in his memory and has been in a State hospital for mental patients for several years.

The trouble was that he did not forget these practically unimportant license numbers. Imagine what a mess your mind would be in if you remembered every little event that took place within your range of observation. The first essential for a good memory is that the material to be remembered must be clearly perceived in order that it may be correctly and firmly fixed in your mind. You must limit your attention to a few things, not spread it out over many.

The first step in making the most of your memory is clearness of impression. When one has mastered himself so that he can go slow enough to obtain clear impressions this matter of remembering only what is worth while will largely take care of itself.

Most people do not remember names of persons because the introducer seldom gives the name clearly and distinctly. Ask him to repeat the name, and if necessary to spell it; give it your full attention. If you do this seriously you will find that a great improvement takes place in your memory for names. Make the same effort of attention to secure clearness in everything and you will soon see a general improvement.

If one really wants to retain the impression for any length of time it is essential to repeat the original impression mentally several times. Making the impression through several sensory channels has a profound effect upon the retention, which is the basis of all memory. In memorizing poetry the most efficient way is to read it aloud. By doing this the eye, the ear, and the voice are called into action and the impression is thus reinforced. All the impressions of daily life can be reinforced in this manner. If they are worth memorizing do not fail to secure this reinforcement. The practical test of a good memory is the ability to recall facts and things worth remembering. The best way to conserve and develop the memory is to use it *rationally* and use it *frequently.* All it needs is a little encouragement and assistance to bring it into greater usefulness.

WE WANT WATER

In hot weather we appreciate the fact that our bodily substance is mostly composed of water. Lucky for us that it is, for water is not only the most abundant, but the most even tempered of liquids. It is slowest to cool and, what is of more interest to us, it is slowest to heat. It is this thermal conservatism of water, otherwise known as its specific heat, that keeps us going regardless of the weather. For we can only live within the narrow range of about ten degrees Fahrenheit, and it requires a delicate adjustment of our mechanism to maintain that temperature as we roam from the equator to the pole, or as the climates of these regions alternately roam over those of us who live in the north intemperate zone.

It is water that keeps all parts of the body at the same temperature in all weathers by circulation, and then in hot weather reduces the temperature by evaporation. As a man on a pleasure excursion has to put a bill into his pocket from time to time to compensate for the sum imperceptibly evaporated in small change, so we require frequent invoices of water to keep up with the increasing retail outgo. The body in summer-time is a steam-engine, constantly taking advantage of the high rate of exchange between liquid and gas.

For water is twice blessed. It gives a blessing as it comes and as it goes—especially in the latter case, though we are not so grateful for it. We appreciate the coolness of a glass of ice water, but it does us fifteen times as much good afterward as it escapes through a million pores. A cup of hot tea may also cool us off, for it takes away with it in evaporation from the skin fifty times as much heat as it brought to us.

Water is really what is wanted, although we add various flavors, call it by various names, and charge various prices for it. And it does not matter much what its initial temperature is, it will serve its purpose just the same. The only important thing is to get enough of it at all times, before meals, after meals, between meals and at meals. One can hardly get too much of it, and one usually gets too little.

The regulation of the strength of the various fluids of the body is as nicely adjusted as the equilibrium of temperature. But both are dependent upon an abundant supply of water. An excess can be easily disposed of, but a deficiency upsets the machinery. A pound of water a day is about what the body can manufacture in its internal laboratory from the hydrogen of the food and the oxygen of the air, but this is not nearly enough to run it. The automobilist cools down his combustion cylinder by wrapping it with water and keeping this in rapid circulation. We also are propelled by an engine, using food as fuel in much the same way, and we employ the same device to prevent overheating. But we have to evaporate the water to get the full cooling effect and this tends to dry us up, to make mummies of us, to leave us stranded for want of water.

Our thirst is thus the longing of the salt that is left behind for the water that has departed. It is a sort of homesickness, a longing for an ancestral habitat. For Venus Anadyomene is a verified myth. All life sprang from the sea. And the tide that ebbs and flows through our heart is composed of much the same elements as the ocean from which it was originally dipped by the earliest of living creatures.

WATERFALLS WAR ON BOLL WEEVILS

Water has helped the boll weevil to conquer the cotton crop. Now water is to be used to help the cotton grower conquer the boll weevil. Moisture makes multiplication easy for this voracious insect. Excessive rainfall during the summer months is conducive to greater weevil activity. But now plans are being made to employ the power of many rainfalls to check the damage to America's greatest commercial crop.

A little over thirty years ago, the boll weevil crossed the international boundary at Brownsville, Texas, and the war was on. In 1903 he crossed from Texas into Louisiana. By 1907 he had obtained a foothold on the eastern side of the Mississippi. Ten years later he had advanced to the Georgia boundary.

It has been a losing fight for the farmer, losing at present to the tune of $400,000,000 a year. Many means of defense were tried, but failed. About 1918, however, a chemical warfare with calcium arsenate powder was begun. Spraying with this poison kept the weevil numbers down low enough to permit a full crop of cotton. In 1919 three million pounds of the arsenate were used.

Three million pounds used at widely scattered points was not enough. By 1920 the boll weevil entered North Carolina and completed his conquest of the great cotton belt. In 1922, thirty million pounds of the poison were employed in the fight. Airplanes were called into use to help to dust the plants. Calcium arsenate proved to be an effective weapon, but it was estimated that seven hundred million pounds a year would be required to hold the weevils in check. Where was it to come from?

The thirty million pounds used in 1922 created an acute shortage. Manufacture by chemical means could not supply the great demand. Nitric acid was used in the process, and many other industries needed that acid. This made calcium arsenate too expensive for many planters.

But now the electrical engineer has tackled the problem. By means of electrolysis the chemicals can be combined to form calcium arsenate without the use of the nitric acid. To make the 700,000,000 pounds needed, however, will require 350 million kilowatt hours of electric current annually. The water power of the South is to be called upon to supply this energy.

So the poison plants are tied up with the waterfalls, and the same rains which aid the boll weevil are also a factor in the fight to save our cotton.

A FOUR-FOOTED BIRD

We have heard frequently of the "bear that walks like a man," but the bird that walks, or rather crawls, like a beast is not so well known.

This bird, the hoactzin, does not merely use its wings as extra supports but develops during the juvenile stage genuine feet on its arms or what will be wings.

Mr. Edward M. Brigham, curator of the public school museum in Battle Creek, Michigan, discovered the young of this interesting bird while collecting on the Amazon River in South America. He was, needless to say, very much astonished when for the first time he saw one of the young hoactzins climb out of the water on to a branch on all fours. Two toes are well developed on the fore or wing limb and with the assistance of these "hands" the young birds climb out of the nest and dive into the water whenever disturbed and then clamber back again like reptiles.

These queer birds are really as out of place in our world as they seem, for they have survived from former geologic times as the sole representatives of an ancient order. Like a surrey on Fifth Avenue in 1924, the hoactzins represent a method of locomotion once in vogue but now out of fashion. They are a link with the age when wings were first worn in animal society.

The wing bones of all birds are analogous to those of the legs of four-footed animals except

THE YOUNG HOACTZIN

Four-footed birds. (From Lucas' *Animals of the Past;* courtesy of Dept. of Paleontology, U. S. National Museum.)

that certain of the wrist bones and one of the fingers are greatly elongated. Birds as a class, the paleontologists tell us, were evolved from reptiles by such a modification of the fore-limbs and other changes. The hoactzin is the most reptilelike bird that has survived in recent times.

The adult hoactzins, as might be expected, have very poor use of their wings and can fly only very short distances. They spend most of their life squatting on the leaves of an amphibious plant, the aninga, which grows by the shores of the Amazon and in other wet regions of South America.[1]

ICE A QUARTER OF A MILE THICK

A short time ago slowly moving ice-sheets covered all of Canada and most of the northeastern quarter of the United States. That is, a short time as geologists measure events. Perhaps some twenty to eighty thousand years have elapsed since the ice finally disappeared.

We know that huge continental glaciers were once with us because they plainly wrote their autographs with scratches on the rocks over which they passed. They also carried with them boulders, great and small, of kinds of rock known to come only from distant regions, and they set down these monuments to their progress here and there over the country, sometimes balanced in

[1] For history and bibliography of this strange bird see "Contribution to the Ecology of the Adult Hoactzin," by C. William Beebe, in the Smithsonian Report, 1910.

peculiar positions high up on the mountains over which they passed.

The ice-sheets also piled up at their outer edges long hills or moraines such as the range of low mounds extending the length of Long Island and elsewhere across the eastern part of the United States.

The most eastern of the sheets extended from the Labrador Peninsula out over the Great Lakes region, New York and New England, and is called, from its center of origin, the "Labrador Sheet." It solidly covered this part of the continent except for a few high mountain peaks which kept their heads above the general desolation.

Dr. A. P. Coleman, who has studied the "high ice marks" on some of these exposed points, estimates that over one region in southern Canada the ice must have been at least 1300 feet deep. In the Adirondacks of New York it extended 2800 feet up the sides of the mountains. This would be an average load of 1400 feet, twice the height of the Metropolitan Building in New York City.

The weight and hence the grinding force of this giant scraper can be appreciated when we think of it as the equivalent of a load of rock some 460 feet deep.

A NEW CORN-USING INDUSTRY

"Agricultural Bacteriology" makes a big mouthful and looks imposing on the title-pages of ponderous text-books, but just what does it mean in the life of an American farmer? Of many answers, here is one of the best; the story of newly discovered bacteria that eat a million bushels of corn a year and produce from it a valuable commodity.

The story begins back in war times when the British ministry of munitions, finding the Austrian supply of acetone, a much-needed chemical in the manufacture of cordite explosive, entirely cut off, turned to America for help. Not long before, two professors in the University of Manchester had found that a certain kind of bacteria had the power to produce acetone from the starch of Indian corn somewhat as a yeast organism produces alcohol. The mixture might be distilled and the acetone recovered.

Although never before tried outside of a laboratory, the process was put into successful operation in distilleries in Toronto and Terre Haute and acetone was produced in quantity. But after the war the market for acetone slumped and the owners of the distilleries were in a quandary. The Toronto plant went out of the business, the one in Terre Haute was taken over by private interests who continued to operate in the face of falling profits.

Another difficulty arose. A by-product of the process is what is known as butyl alcohol, a chemical for which little use had been found. Soon tons of this were piling up. Could not a use be found for it? Scientists applied themselves to the problem and found the answer.

Butyl alcohol is similar to the well-known fusel oil which has long been used as a solvent in the manufacture of varnishes and lacquers and in allied industries. But fusel oil is a mixture and differs in different lots, while butyl alcohol is a pure substance of definite composition and properties. So it was found that butyl alcohol could be used in various industrial processes for which fusel oil was not suitable. The demand increased and now it is being shipped in tank car lots and the busy bacteria are helping the farmer of the corn belt to the extent of using yearly a million bushels of his product, for corn, which is two-thirds starch, is the favorite food of these bacteria.

THE HIGHEST AND LOWEST AIR TEMPERATURES

Most people's ideas about the distribution of heat and cold over the earth are based upon the lessons of the school geographies, which divide the surface of the globe by sharp lines into the torrid, temperate, and polar zones. It is, therefore, difficult for them to realize that cold weather is not unknown in the tropics, that polar explorers often suffer from the heat, and that by far the most intemperate weather on earth is found in the so-called temperate zones.

The coldest weather experienced anywhere in the world does not occur near the North or South Pole, but in the interior of northern Siberia, close to the Arctic Circle. Here the temperature has been known to fall to 90 degrees below zero (Fahrenheit) in midwinter. The same region has, however, comparatively warm summers, the mercury sometimes climbing up into the eighties above zero. Another surprising fact is that when thermometers, attached to balloons, are sent up to test the temperatures aloft, the lowest readings are found over the equatorial regions at an altitude of about ten miles.

The greatest surprise of all was the discovery, made only a few years ago, that there is a place in the United States which has hotter weather in summer than any other known spot on the globe. At a Weather Bureau station on the edge of Death Valley in southern California, the record-breaking temperature of 134 degrees in the shade was measured with a well-tested thermometer. During the eleven years that this station has been in existence, temperatures higher than 120 have occurred every summer. The place is known as

Greenland Ranch, not in ironical allusion to its climate, but because the green alfalfa which flourishes here furnishes a striking contrast to the brown desert adjacent.

Death Valley is further celebrated for containing the lowest point of dry land in the United States, lying 276 feet below sea level.

HAS THE GULF STREAM CHANGED ITS COURSE?

If the coming winter should turn out to be very cold with a great deal of snow or very mild with very little snow, we are sure to hear that it was due to a shift in the course of the Gulf Stream. Whichever way the winter goes, there will be many people to tell us that our climate now is very different from what it was in their youth, and that this change is due to a permanent change in the course of the Gulf Stream.

Now as a matter of fact, the direct influence of the Gulf Stream on the climate of the greater part of the United States is negligible. Its effect on the climate even of places on or near the eastern coast, such as Norfolk, Baltimore, Philadelphia, New York and Boston, is quite insensible. Aside from latitude or the distance of a place from the equator, our climate depends mostly on the direction from which the winds come and the force with which they blow. And in winter our winds are prevailingly from the northwest, that is from the land toward the ocean, so that the Gulf Stream cannot affect our winters, although the westerly winds that blow over the Gulf Stream do influence the climate of the British Isles.

The Gulf Stream does change its position somewhat in accordance with the changing seasons and with changes in the velocity and direction of the winds. But these changes in its course are in response to temporary forces and are therefore of a slight and temporary character. Our knowledge of this mighty "river of the ocean" dates from the time when Ponce de León, in his search for the fabled Fountain of Youth, first felt the force of its current more than 400 years ago. And throughout all this time observations show that the Gulf Stream has kept from year to year practically the same course.

Any permanent change in an ocean current of the magnitude of the Gulf Stream could only come as the result of permanent and extensive changes in such features as the bottom of the ocean, the configuration of the coast line or the prevailing direction of the winds.

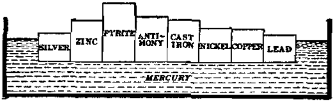
OUR UNEASY EARTH

Whenever a shake-up occurs, like that which destroyed the city of Yokohama, we take thought of our underpinnings. Is this solid earth as solid as it seems? Is not the crust likely to cave in at any time, and if so what sort of a furnace will we fall into? Will the earth open her mouth and swallow us up and our houses and our goods and close in upon us as it did upon the men of Korah who ventured to oppose Moses?

Such fears we may well have felt in our youth when we were taught that the earth was a molten mass held in by a thin solid crust. As the hot kernel of the earth cooled it would naturally shrink away from the outer shell, leaving it unsupported like the ice bridge over a dwindling stream. No, that is a highly inappropriate simile, let me say rather, like an ill-baked cake. Perhaps the basaltic dough out of which our world was molded might not have been mixed right and might collapse in the cooling with disastrous results to us animalculæ who dwell upon its upper crust.

Also we used to be told that this shrinkage of the earth caused a crumbling of the crust into mountain ranges, and the professor of geology showed us just how it was done by rumpling up the table cloth or the pages of his manuscript by shoving his hands together from both sides. We therefore lived in dread lest a new Himalaya might arise at any moment in our midst and catch us on its peak or slippery slope.

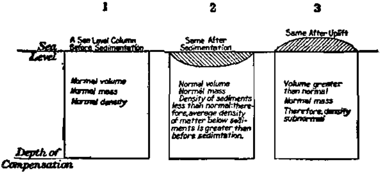
But better knowledge of the composition and character of the materials that form our globe has given us new ideas of its interior and new theories of mountain formation and earthquakes.



A SIMPLE CASE OF ISOSTATIC EQUILIBRIUM

If equal masses of different metals, each lighter than mercury, are molded to the same cross-section they will sink to the same depth when placed in mercury. Their lower surfaces will form a plane while their upper surfaces will be irregular. There will be equal pressure at the base of the different blocks. This is isostatic equilibrium in the simplest form.

It is now held that the earth is as rigid as steel to sudden shocks and as plastic as putty to long continued pressure. Do not say that this is an impossible combination of qualities, for you can easily prove it not to be so. If you give a sharp tap to an ordinary phonograph record you will knock a piece out of it. On the other hand, if you lay it on an uneven surface and pile books on it you know that the disk gradually warps out of shape. So the earth, behaving like a rigid body, will crack under a local strain and transmit the vibrations of it swiftly to all parts of the world, and yet the continents float upon its plastic mass so stably that their rise and fall is imperceptible. The pressure and heat are so great at a depth of some sixty miles that the rock will flow, and therefore each section of crust sinks to its proper level

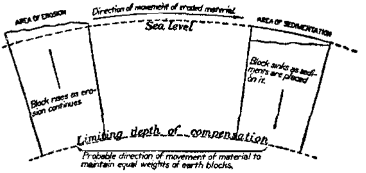


CHANGES IN DENSITIES IN THE EARTH'S CRUST

A block, with its surface at sea level, that is, in isostatic equilibrium, must have an increase in the density of its original material after heavy sedimentation. It must have a lighter density than normal after its surface has been uplifted.

and remains in perpetual balance with all the rest of it.

This is known as the "isostasy" theory and has been chiefly worked out by Messrs. Hayford and Bowie of the United States Coast and Geodetic Survey. According to Bowie, mountains are not formed by crumbling, but by swelling. As the mountains are worn away through erosion by wind and water, the sediment carried down by the rivers is deposited on the edge of the sea. This transfer of material from the mountains to the sea above ground is compensated underground by the slipping of an equivalent amount of the hot viscous material to the base of the mountain so that the mass of the mountain area and that of the



MOVEMENTS IN THE EARTH'S CRUST DUE TO ISOSTATIC ADJUSTMENT

As material is eroded from a high area and carried over the surface of the earth to a lower one and deposited as sediment, the earth block under the sediment sinks deeper into the earth. This causes a deep-seated *horizontal movement* of material from the sedimentary block towards the erosion block. Material enters the bottom of the erosion block to maintain the isostatic equilibrium, thus forcing up the material of the block under the area of erosion. The arrows show the direction of the movement.

ocean area remain the same. Mountains may therefore be pushed up from below as they are being rubbed off on top. But not at the same rate, for the material forced into the crust from below a mountain area is denser than that eroded from the surface, hence the mountain area will be gradually worn down to a low elevation.

So the material of the rocky crust of the earth contracts and expands, rises and falls, erodes and deposits. We find ocean fossils on top of the mountains, and some parts of a continent may have emerged and been submerged repeatedly in the course of time. Where the mountains are old and worn down and the land has been leveled, there is little likelihood of earthquakes, for the crust has practically reached equilibrium. But where the mountains are young and rise sharply from the sea, there are still adjustments to be made, and these cause slips and jerks comparatively slight in amount but sufficient to bring disaster upon the puny works of man.

WHICH PART OF A TREE GROWS FIRST?

A tree grows in two places each year; the topmost tips grow longer and climb a little higher into the air; at the same time the trunk grows thicker, the tree puts on another of its "annual rings," a woody growth. Which happens first? When a tree wakes up some spring morning does it first stretch out its fingers in the sunlight or does it first let out its belt another hole?

An answer comes from the experiments of Dr. D. T. MacDougal of the Carnegie Institute of Washington. The doctor has invented an instrument which takes the waist measure of the tree very accurately indeed. Even a hundredth of an inch enlargement of the tree's belt is as obvious to Dr. MacDougal and his instrument as a foot or two would be in your belt or mine. And by putting a ruler against the tree tops and his instrumental tape-measure around the belt, Dr. MacDougal finds that the tips begin to grow weeks, sometimes months, before the trunk begins to enlarge.

This is quite as it should be. Remember that trees get part of their food from air and from sunlight. They must stretch out fingers for a breakfast or two, and we all know what happens to the waist-lines of folks who eat hearty breakfasts.

FALSE AIMS AS REAL AIDS

There is a common fallacy that since the body is, like a machine, subject to the law of the conservation of energy, a certain act requires the same amount of work and produces the same degree of fatigue at one time as at another.

This is entirely false. It is not true even of simple machines. Every engineer knows that his engine will pull more at one time than at another with the same amount of coal. Tire your arm so you cannot move it and an electric current will make it act again as promptly as ever. The muscle was all right, so was the nerve thread, but the muscular nerve cells became clogged with the products of decomposition. When a telegraph line stops working it is not usually because the wires or poles are broken but rather because the battery has run down.

Now we can make the nervous system work better in many ways. In general any sense stimulation will increase the action and lessen fatigue. Fasten a weight to your finger so that it is lifted by bending it and the movement is recorded on the cylinder of the kymograph. Lift the weight till the action becomes feeble, then let some one play the Marseillaise or one of Sousa's marches. *At once you can lift more than before. If a nocturne* is played your capacity for work falls off again. A strong odor will stimulate exertion. So will a bright color, such as scarlet, flashed before the eyes. Brass bands and bright uniforms are a help to the soldier. You can do your daily dozen easier with the aid of a phonograph.

We often make fun of the boy who can play ball all the afternoon, but says he is too tired to saw wood, or the girl who dances all night but complains that she is so weak that she can't sweep the room. Now we ought not to say anything that would add to the validity of such excuses for avoiding work, but from a psychological standpoint there is a good deal of truth in them. A person *can* do more with interest and excitement than he can under humdrum conditions. He can play harder than he can work. Neither is the reaction of fatigue as great from pleasurable exercises as from drudgery requiring the same exertion.

Our best work is done when our mind is fixed on some object to be attained, not on the work itself. For that reason we devise fictitious aims in life, holding tempting baits before us like the man who put an ear of corn on a pole in front of his horse to make him travel better. That is what our honors and degrees are for. Students may think they are working for marks or degrees, but really what they want is an education. That is what games are for. It may look foolish for a man to work hard to knock a ball over a net or to move pieces of ivory over a checkered board, and so it would be were the ostensible aims the real ones, but they are not. It is physical and mental exercise that is really desired. One would think that a trained athlete would run just as fast alone as in a race, but he cannot. Even if he is running against time he has to have a pace-maker run by his side whom he can pretend to beat.

So we can constantly stimulate each other to greater exertions by competition and rewards. A man will sometimes set rewards before himself by promising some indulgence when a piece of work is done, or compete with himself by seeing how much faster he can work this time than before. Nature leads us on in this way. A man thinks he is eating because the food tastes good, but really he eats because his body needs so many ounces of protein or carbohydrates. When he gets the needed supplies, Nature stops the desire. Pleasure is the bait to life.

So we are wise when we imitate Nature in using such false aims in education. For that reason play properly arranged gives better results than the system of gymnastic instruction where a man is measured and, as a prescription for a weak muscle, is told to pull a certain weight half an hour. This is work and is most apt to be shirked, and even if persevered in, it does not do as much good as a less amount of exercise in some pleasurable form as a play devised for the express purpose of giving that muscle something to do. We may define play as "activity with a fictitious purpose." The purpose may be only thinly veiled, but we will do better work for the transparent illusion. If you will compare the ostensible motives of your actions with the real motives you will see how far-reaching this principle is.

The experimental study of fatigue has given exactness to what was formerly but dimly perceived. By experiments such as the finger instrument described above, we can get a record of fatigue. At first the action is strong and gradually falls off until it is almost impossible to move the finger. As the system reacts and a current of fresh material carried by the blood replaces the waste products, the power of action returns almost to its original degree. This is the "second wind," as the boys call it, which comes when the athlete is "all in." Fatigue again sets in sooner than before, and so the alternate strengthening and fatigue goes on in a regular rhythm. The muscle is strongest in the morning, falls off gradually until the midday meal, when it rises again, though not to its original height, to fall gradually during the afternoon.

There is no real dividing line between muscular and mental work. All work is strictly speaking mental work, and the complete exhaustion of any part of the nervous system carries with it the fatigue of the whole. A man who has done a hard day's work in manual labor cannot use his brain to advantage in the evening. The highest form of mental work can only be done by men who devote themselves to this primarily and take only so much physical exercise as is necessary to keep the body in good condition. Of course a man can get relief by a change from mental to physical labor, as he can even by a change of the form of mental work, but it is merely a change of work nevertheless and not rest. Complete rest we only get in sleep, and not always then.

THE MARVELOUS MIGRATIONS OF THE EEL

The story of the fresh-water eel is one of the most remarkable in Nature's library. For all the eels found in any of the rivers or creeks of the United States are hatched from eggs laid near Bermuda, in the southern part of the North Atlantic Ocean. Their European cousins from the waters of the countries bordering on the Atlantic Ocean and the North, the Baltic and the Mediterranean Seas also originate near this same region.

Yet the eels that go farthest up the fresh-water streams are the females of the species. The males stay in or near tidewater. Scientists think that the remote ancestors of these dwellers in our fresh-water streams stayed in the salt water. The present-day descendants, which may live several years hundreds of feet above the ocean level, once in their lifetime go back down to their old home in the sea. There they spawn at depths of about 500 fathoms and presumably die—for they are never known to come back.

But the tiny forms hatched from the eggs are very little like eels as we know them. Transparent, ribbon-like creatures only a little over a quarter of an inch long, they start on their long trip toward the distant coasts. During their migration, these young gradually change, becoming rounder, thicker, and leaf-like in shape, but remaining nearly transparent until they reach fresh or brackish water, when they become dark in color. It takes from one to three years to effect the complete transformation from the egg to the eel. In that time some of the European species have journeyed a quarter of the way around the world from their cradle in the deep to the mouth of the River Nile or up into the western Baltic. For length of time and distance covered, the larval migration of the eel is altogether unique.

The swarms of "elvers," or young eels, that reach the shores of Europe are much greater than those of the American species, and the catching of these for food is quite an industry. For this reason the European scientists have been most active in discovering the life-history of these strange fish.

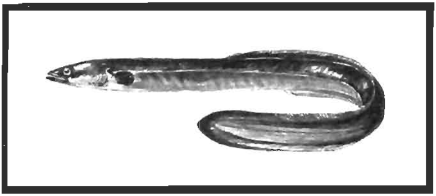
Imagine the appalling vastness of the ocean and the minuteness of these tiny eel fry, changing in size, shape, and appearance in the different parts of the sea, and you can appreciate that the expedition outfitted by Denmark and headed by Dr. Johs Schmidt had difficulty in locating the breeding-place of these creatures. And the change was not constantly in one direction either, for in changing from the full-grown larval form to the elver form, they become smaller instead of larger.

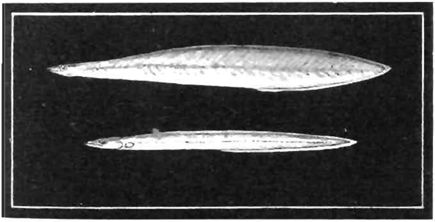
After careful, persistent work in catching and charting the regions in which the various sizes were found, the Danish expedition located the smallest form in the southern North Atlantic and only there.

There are species of fresh-water eels which inhabit the countries bordering the Indo-Pacific from the Cape of Good Hope to the Sandwich Islands, but there are none in the rivers of West Africa, South America or our own Pacific slope. The reason for this is believed to be that the ocean route that the young eel larvæ would have to follow to get to these latter rivers lies through waters that are not warm and salty enough for them. These snake-like fish, which spend most of their life far up our fresh-water streams, are creatures of some of the saltiest parts of the sea.

RETURNED FOREST EMIGRANT THREATENS PANTRY

Just because a good American was sent off traveling to foreign lands and came home with a rare and exotic disease, other good Americans in some parts of the country are going to have to do without homemade currant jelly and gooseberry pie. The exiled native was, or were, for many of him were in the party, specimens of the noble old White Pine trees, which formed so large a part of the primeval forest of the North Ameri-





THE MARVELOUS MIGRATIONS OF THE EEL

Upper. An adult eel. Though eels are found in our rivers and creeks, they are all hatched in the Atlantic Ocean near Bermuda.
Lower. Two stages of the elver, the young eel.

FOREST EMIGRANT THREATENS PANTRY

Left. Young white pine girdled by the blister rust. Note the pustules or blisters which appear white in the photo. These bear countless spores which spread the disease to currants and gooseberries.

Right. Typical damage caused by white pine blister rust. The tree is 30 years oid, 25 feet tall. The blister rust canker is 9 years old. Taken at South Deerfield, N. H.

can continent. The disease is the white pine blister rust, one of the deadliest diseases of this tree, the most used of all commercial species.

White pine trees were not native in Europe but came to be regarded by Europeans not only as a valuable forest tree, but as a curiosity for landscape gardening, and so more than a century ago seedlings were taken across the seas and propagated there. Then in the succeeding decades, when the great ambition of every American lumberman who saw a white pine tree was to cut it down, the supply in the older sections of this country began to be considerably depleted. Far-seeing lumber companies began to see the need of reforestation and there was a demand for white pine seedlings. But the nursery side of forestry was undeveloped in this country and the demand could not be supplied, so foresters went to France and Germany for the little trees, great grandchildren of the first American exiles sent over more than a century before.

But something had happened to the family while in Europe. The blister rust, a fungous disease of European pines to which those trees had developed effective resistance, attacked the little strangers from America, who, having no inherited ability to fight off the attack, succumbed or became seriously diseased. American foresters were unaware of this and so the white pine blister rust was introduced into this country early in the present century.

But the rust needs something more than white pines to live on. At one stage of its existence it must live on the leaves of either the currant or the gooseberry, and this is where the menace to the American pantry comes in. For, since it has been found that the rust may be extirpated in any region by cleaning out all currant and gooseberry bushes, both wild and tame, a campaign to this effect is now in progress in the principal white-pine-growing states where the infection has been found to be present, notably, parts of New England, New York, Washington and Oregon. Communities have sacrificed their jellies and pies for their pines.

In spite of the marked success of this remedy in localities where it has been thoroughly tried, the blister rust continues to spread and to be one of the greatest evils the American lumberman and forester has to combat. So it is probable that further sacrifices will be demanded of American palates so that American pocket-books and industry will not suffer what, if unchecked, might easily prove to be a calamitous loss.

KILLING DANGEROUS ANIMALS

In India every year several thousand persons are killed by tigers and serpents, and the Government is making great efforts for their extermination by offering rewards and calling for the assistance of sportsmen. The animals most dangerous to the human race in every country are, however, of much smaller size and much more difficult to exterminate. They are flies, fleas, and mosquitoes, which by spreading the germs of disease are slaying thousands among us every week. Is it not possible to direct against these, our real enemies, some of the ineradicated sporting instinct of man? We hunt the wolves for killing our lambs, the rabbits for girdling our trees, the crows for stealing our corn, the hawks for catching our chickens. Why not get the same fun and do more good by hunting insects? Instead of chasing the comparatively harmless fox or the still more innocent anise-seed bag, let the red-coated huntsman turn against the mosquito as game more worthy of the chase. Against such sport not even the Society for the Prevention of Cruelty to Animals would have a word to say.

As it is now, the defense of the home against these most dangerous of wild animals is left chiefly to the women, who maintain an incessant but irregular and ineffective warfare against them, shooing them out of the house with towels, poisoning or catching them with paper, sweeping them into water pails, hitting them with newspaper cudgels or wire whips or seizing them by the slow and primitive way of thumb and finger. But it is altogether improper to leave this task to the women. It is not woman's sphere. If we appeal, as all sociologists do nowadays, to prehistoric savagery, we find that man is properly the huntsman of the family and its defender against its foes. Man is the destroyer and woman the conservator. (These generalities are so handy to use in argument that it is no wonder they are so popular.)

Is there no spark of chivalry left in degenerate man which could be fanned into a flame? In every street there is an Andromeda, helpless, beauteous, and innocent, about to fall a victim to a dragon more hideous, when seen through a microscope, than that which Perseus slew. A dragon of monstrous form, with a thousand eyes, with six legs and two wings and armed with a complete set of surgical instruments, including a hypodermic inoculating syringe loaded with disease germs, is no mean antagonist for any hero. In the days of old when knights were bold the jinns, dragons and ogres, which by their magic power could become invisible or take the form of some small animal, were the most dreaded of all. Loki took the shape of a horse-fly to stop Brok's work at the forge. A fifty-foot vegetarian dinosaur from the Jurassic Period, with case-hardened scale armor, could be easily put out of commission by a modern explosive shell. And even if he were vomiting flames from his mouth, as the dragons of a later age are reported to have done, a hand grenade charged with soda water would put a stop to that without there being any need to send in a fire alarm. Far more dangerous are the dragons, large and small, that spread the plague, like the one St. George killed:

> A dreadful dragon, fierce and fell,
> Who by his poisonous breath each day
> Did many of the city slay.

Our American poets, if we have any, should sing of the deliverance of Havana and Panama from the yellow fever. A modern Raphael, if there is one, should paint Major Ross or Colonel Gorgas as a modern St. George slaying Anopheles. When we know what are our true enemies we will know who are our true heroes. Yet this evening, when some young Siegfried sitting upon the porch of the hotel kills a mosquito whose buzzing annoys the summer girl by his side, she thanks him without displacing his collar. Neither of them realizes that he may have rescued her from death as truly as if he had snatched her from the path of an automobile.

If chivalry is not a sufficient motive to rouse us for the fight, let us appeal to religion. Let us have a revival of the religion of Zoroaster, which teaches that killing a noxious insect is as meritorious as saying a prayer, and that he who drains a swamp is as he who builds a temple. Let us keep our Buddhism for the winter and be Zoroastrians all summer, swearing relentless warfare on the death-dealing Diptera. If we could get rid of all the flies, fleas, and mosquitoes, the world would be freed from its fear of cholera, bubonic plague, typhoid, malarial, and yellow fever, and other diseases too numerous to mention.

THE MECHANISM OF HEREDITY

The mill of heredity has ground very slowly indeed during the ages to bring the plant and animal world to its present state of perfection or imperfection. But how small are the parts of the mechanism by means of which heredity grinds we are only just now coming to know. So small indeed is the mechanism that it is stowed within the confines of the single cell. By means of strong magnification, assisted by other technical treatment, we are enabled not only to look at the mechanism which distributes hereditary traits but also to see the machine in action. The microscope shows us that the machine is located not only within the sex cells but that it is duplicated within each and every cell of the body. The microscope reveals to us moreover that within each cell there is a definite number of particles or bodies that take on a darker shade than their surroundings when the cell is stained. These bodies are called chromosomes—color bodies. Not only is the number of these chromosomes constant for each and every cell of the body, but it is constant for the species as well.

In order that the number of these bodies shall remain constant for parent and offspring it is necessary for the parent germ cells to get rid of half of their chromosomes, otherwise the offspring will obtain twice the number that each parent has. In fact the parent germ cells do cast out half of the chromosomes. What determines which of them shall go out and which shall remain in the cell we do not know. Perhaps the selection is made by chance; at least subsequent results seem to favor this hypothesis. However the choice is made, we know that it is done with mathematical precision and by means of an elaborate technique. We can see under the microscope that there are centres of attraction and repulsion about which or by means of which the centrosomes are moved. After each of the parent cells has got rid of half of its chromosomes the two cells unite. Then the chromosomes themselves unite for a time, each with its consort from the opposite cell. Presently they separate again and the cell has now regained its original number of chromosomes. The new individual that develops from the union of these cells and chromosomes now starts out in life with the proper number. From now on every time a cell divides to build up the tissues of the new organism, each of these bodies divides, giving off half to each of the daughter cells. Thus the number of the chromosomes is maintained constant for each and every cell of the body.

By a number of tests biologists have demonstrated that these chromosomes are really determiners of traits; determiners that are handed down by this method from parent to offspring. When each of the packets of determiners fuses with its mate in the conjugating cell an opportunity is afforded for the stronger trait, speaking from the standpoint of heredity, to dominate, get the upper hand in some way over the corresponding weaker one so that the influence of the dominating trait alone prevails in the characteristics of the new individual. The material for the weaker trait still exists within the chromosome, but it can no longer function in that individual. It must await its turn in some subsequent generation when unopposed by a dominating influence.

Moreover the biologist has proceeded far enough in his investigation to demonstrate that determiners of certain traits are located in definite chromosomes. Some of this information he has gained by hybridizing animals and plants. As we have already stated, each species of animal or plant is characterized by a definite number of chromosomes and the number usually varies with the species. By means of hybridization it is possible to unite cells with an unlike number of chromosomes so that some go unmated to the new organism. In this case the offspring inherits some of its traits from a single parent. By using each of the species in turn as father and mother a sufficient number of combinations can be made to enable the experimenter to determine in which of the chromosomes certain traits are located.

By this endless series of castiug out of the chromosomes and by recombining them so as to restore the species-number, nature is ever making all kinds of possible combinations. Some are bad, some are good, some are indifferent. Now and then something very superior is hit upon. Nature is a great experimenter, a great gambler.

HOW WE MAKE OUR MENTAL WORLD

Each of our senses gives us a world of sensations of itself entirely unlike the others, and there is no possibility of comparing them. How then do we fuse these together in a single world? Three of our senses are especially concerned with the concept of space, that is, touch, sight and hearing. How is it that the space measurements agree, so that a felt yard is the same length as a seen yard? The answer to this is, they do not agree except in so far as we find it necessary to make them. So too for all such combinations of our separate sense worlds. For example, you see a cat, you touch it, you hear it yowl. Now are there three things or one? They are not in the least alike, but economy in thinking requires that there shall be only one, so you combine together the sight, the sound, and touch into one and call it a "Cat."

Now *where* is the cat? Evidently sinee there is only one cat, the point in the visual world where the cat is seen must be the same as the point in the auditory world where the cat is heard and the same as the point in the tactual world where the cat is felt. So you pin your three different worlds of space together at that one point.

In the same way we get a common measure of distances from a single object. If the yard-stick seen is the same yard-stick felt then a certain space on the retina must equal a certain amount of muscular movement. Having obtained in this way a common unit of measurement we are able to compare the size of what we feel with what we see and to move our hands apart until the distance between them is equal to the length of an object we see.

But not very accurately. To prove that we have no absolute measure of space but merely an agreement between the senses, let us change one of them. Put on spectacles that magnify, then you will see everything larger than you have been used to, while your space by feeling is the same. Yet it could only take a few days to get used to it, so that you will without thinking raise your foot to the proper height to reach a step you see, although all your previous life you had raised your foot only half as high to reach a step that looked as high as this. You can take off these spectacles and put them on half a dozen times a day, changing the relation between tactual and visual space every time, yet it is not seriously confusing. You may wear bi-focal lenses so that part of the field of vision is magnified and the rest not, yet you soon get used to that.

It is the same with direction as with distance. If the ground that you touch is the same as the ground that you see, it must be in the same direction, that is, down. You find by experiment that you see the ground when its image strikes the upper part of the retina and you touch the ground with your feet, not with your head; therefore "down" is toward the upper part of the retina and the lower part of the body.

The fact that the image on the retina is upside down does not make a bit of difference because up and down are where we put them. Professor Stratton of California made a pair of prismatic spectacles that reversed everything and wore them altogether in the day-time. His visual world was then reversed. Yet by the end of a week he could find his way about and handle things nearly as well as if he had not moved into a topsy-turvy world.

When a student first uses a compound microscope in the laboratory he is bothered by the fact that the slide is seen reversed under the lens. If the object is too far to the right he has to shove the slide still farther to the right. But after a few days this reversal of movement seems as natural as the ordinary.

Even for the same sense magnitudes that are identical are far from seeming the same. A grain of dust in the eyes seems as big as a nut. A tooth in the mouth felt by the tongue is very much larger than it feels to the fingers or than it looks to the eye when it is taken out. Which is right, the tongue or the fingers? Both are right. That is, the size that it is felt to be by the tongue must be equal to the size that it is felt to be by the fingers because it is the same object. If the sight seems to confirm the estimate of the fingers rather than that of the tongue it is merely because we have used the tongue less and its sensations are not harmonized with the others.

All knowledge is relative, not absolute. Our "laws" and "explanations" are merely generalized statements of facts. Our philosophical principles are convenient ways of looking at the world.

WHITE COAL

A Swiss chemical company is using water power to make a new combustible which may be substituted for the solidified alcohol that is now so popular. It is called by the chemist "metaldehyde," but since that name is too long for common use the material is marketed as "Meta" or "White Coal."

It is a white crystalline powder, compressed into cakes and has the advantage over alcohol that it does not evaporate when left exposed. When lighted with a match it burns with a light blue flame giving off no smoke and leaving no ash. The flame floats above the solid substance, but without touching it, for Meta volatilizes without melting. That is, the heat of the flame is sufficient to convert the solid into an inflammable gas as it is consumed. Yet the substance is still so cool that it can be pinched by the fingers, thus putting out the flame above. Since it does not melt and run about, no special apparatus is required to burn it. A lump can be laid on a table top and simply lighted, or it may be used in any sort of pocket stove. When incompletely burned it may give off a faint odor like apples or like formaldehyde, the familiar disinfectant, which is the nearest relative of metaldehyde. But this odor may be masked by the addition of a little perfume to the product.

In making Meta in quantity the power of the Swiss waterfalls is used to generate electric current which, passed through an electric furnace containing coal and lime, converts them into calcium carbide. This when wet gives off acetylene gas, from which a liquid, acetaldehyde, a close relative of acetic acid, may be made. Four parts of acetaldehyde combine to form one part of the white solid known as metaldehyde.

The new combnstible has about the same heatiug power as alcohol. To get alcohol into a solid form it is necessary to add some jelly-like substance that will absorb it. Various substances are used as such stiffeners, soap, gelatin, agar-agar, collodion, cellulose acetate, and the like.

Meta, not being a liquid, does not need the addition of any such solidifier. It also differs from alcohol in that water does not dissolve it. In fact, it can be burned in water. So metaldehyde, which a few years ago was a mere chemical curiosity, becomes all of a sudden a commercial commodity. The chemist often springs such surprises on the world nowadays.

A JUMPING SNAIL

Locomotion in snails, slugs, whelks, and periwinkles, known to scientists under the general name of gastropods, is accomplished by a part of the animal known as the foot. The foot is that portion of the animal projecting below the shell and on which it moves with characteristic slow, gliding, creeping motion. However, one salt water gastropod, the stromb, found in Biscayne Bay, Florida, progresses by sudden and vigorous leaps. This singular step-by-step progress differentiates the stromb from all other gastropods.

Dr. G. H. Parker, of Harvard University, observed that a stromb five inches in length with a shell weighing about 175 grams could leap at a single bound a distance equal to half its length, and in so doing it raised its shell more than an inch off the ground. These forward jumps or springs of the stromb are quite a feat, when we consider the relatively small amount of musculature furnishing the energy.

The backward thrust of the foot is so vigorous that divers who are swimming to the surface with an armful of these strombs held close to the body, are said frequently to be cut on the breast.

THE LARGEST OF LIVING LIZARDS

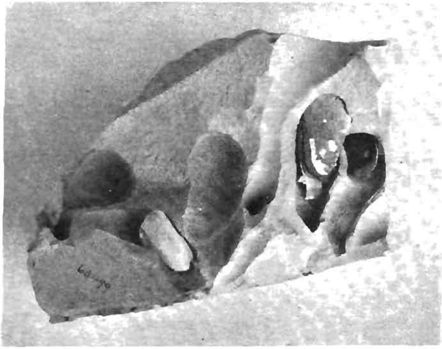
Everybody knows the funny horned toads of California and the little green, changeable lizards of Florida that are sold in the curio shops as "chameleons." They are small northern representatives of the great lizard family of iguanas, of which there are about three hundred different kinds. All are inhabitants of the warmer parts of America, North and South, except a very few species in Madagascar and the Fiji Islands. This is a most curious fact and probably indicates that in some past age the ancestors of the family were scattered over all the tropics. But their descendants have continued to exist outside of the Americas only in these two islands where they had few, if any, enemies.

In the American tropics they found conditions under which they have flourished and become diversified into a great variety of species, and have divided among themselves, as it were, the resources of the region. Some are wholly vegetarians, others live on insects, birds' eggs, etc.; one group dwells in trees, another among desert rocks, a third lives an amphibian life, and one species, about which Darwin wrote extensively, in-

THE LARGEST OF LIVING LIZARDS

Upper. Head of the heaviest of the lizard family of the present day. He gets his name of *Rhinoceros Iguana* from the spines on his nose. (Courtesy of American Museum of Natural History of New York.)

Lower. This group of natives of Central America are gloating over the iguana which will give them their next meal. Packs of hounds are trained to run down these big lizards.



A MOLLUSK ROCK BORER

The rock here broken open shows the pholads in tunnels they have quarried out as homes and tombs. *See* page 162.

habits the salt-water inlets of the Galapagos off the western coast of South America. How this last kind ever got to these distant islands is a mystery.

Nearly all these lizards are covered with strong, rough scales, and most of them are armed with tall crests of spines on head and back and tail, which make them as fearsome objects as the pictures of a Chinese dragon. This is especially true of the iguana of Central America, which no doubt owes the fact that it is very numerous in the wet jungles to its fierce aspect when it bristles up against anything alarming. As this species is often four feet long, shows a mouthful of teeth, and can put up a good fight when cornered, it is let alone by most predatory creatures. Yet it really is timid, and is easily noosed and subdued by the country folks, who are fond of its white and nutritious flesh. But its very timidity is a menace, too, for travelers say that in canoeing along the narrow jungle streams that form the principal means of travel in such regions as the Mosquito Coast, these big iguanas, which lie on the overhanging tree-branches along the stream and weigh 25 or 30 pounds apiece, may, in their fright, hurl themselves on your head or upset your frail craft.

One species in that region reaches a length of six feet. Even this, however, is outdone by the much larger and heavier rhinoceros iguana of Santo Domingo. These dragon-like reptiles, seven or eight feet long, which take their name from the horn that grows on the tip of the snout, are to be found only around the shores of Lake Enriquillo, which lies 130 feet below sea-level in a basin of the arid southwestern part of Santo Domingo. They dig burrows in dry ravine banks and come out only at night. Hence they can be taken only by the aid of dogs able to rout them out of their holes. The biggest ones will often break through a whole pack of dogs. Their white-shelled eggs are as big as hen's eggs. Underneath the surface of sandy hollows the eggs lie until the young hatch and dig out to begin life, taking to the light with them part of the shell.

A LIVING STONE DRILL[1]

You would be surprised if an oyster should bore a hole through a piece of granite. Yet there is another bivalve—whose flesh is an even more delicate morsel for the lover of sea-food than the oyster—which does just that. It is called the "pholad" and is a cousin to the destructive ship-worm.

Just as the ship-worm burrows through dock piling and ship timbers in order to make a home for himself, so this rock-drilling mollusk enters

[1] *See* illustration facing page 161.

clay and stone underneath the waters along the sea-shore.

Dr. Paul Bartsch, curator of mollusks of the Smithsonian Institution, says that it apparently makes no difference to the pholad just what kind of stone he tackles. The large animals have been found in many different kinds of rock of varying hardness. The young mollusk begins his grinding into the stone when no bigger than a pin. The opening he makes in the rock is about the diameter of a lead pencil. Once inside, however, the pholad continues to enlarge his home as he grows. When the rock is broken open, the animals with shells several inches long are frequently found. Besides this shell portion, there is a long siphon by means of which water with its oxygen and minute animal life is taken in to sustain the mollusk in its chiseled-out residence.

It is hard to see how this animated drill can work into the hard rock in which it is frequently found. When you see the delicate lime-shell with its tiny serrated edges with which the cutting is done, the wonder grows. Some scientists claim that the pholad secretes an acid which helps to disintegrate the rock. This seems questionable, since it would appear that an acid would break down the lime-shell more quickly than it would the rock into which the animal is boring.

Just as a rope may in time wear a ridge in the stone at the top of an old-fashioned well, so the persistent chiseling as the shell is moved in the burrow wears down the hard rock. The shell grows by adding on layers to the outside, and the cutting edge is renewed as the animal ages.

Yet while these mollusks have been studied and eaten since the time of Pliny and Ovid, no one seems to know how long it takes the pholad to cut into his stone house. Once inside, there he must remain, as the entrance is so very much smaller than the adult shell. Through the siphon the eggs or young are discharged into the water outside. There the young mollusk soon develops a shell and, like his ancestors, starts to chisel out a rock home.

THE HORSE AND HIS OATS

As all stockmen know, a horse fed on a heavy diet of oats has an irrepressible desire to stand on his hind legs and show the world the spirits that are in him.

We might think, of course, that he was merely letting off an excess of energy derived from his highly nutritious diet, but on the other hand it may well be that his obstreperousness is only an attack of "nerves."

Professor E. V. McCollum, the nutrition expert of Johns Hopkins University, inclines to the latter view. He thinks that the horse that "feels his oats" is displaying pathological irritability and apprehensiveness rather than a healthy activity.

Professor McCollum observed this condition in connection with the dietary experiments on rats. When the rats were fed on a restricted diet—for example, one kind of grain only—they became restless, irritable, and apprehensive. It is the difference between being "on edge" and being "full of pep." The animal that is on edge exerts itself excessively without urging, but this is not a healthy behavior.

A restricted diet of only one food, however good that food may be, lacks some of the necessary elements for complete nutrition and does not get the proper proportion of others. This results in a condition of malnutrition which may not be serious but is undesirable.

You cannot build a house out of bricks alone or a horse out of oats alone. Various foods are supplementary to one another and must be mixed in proper proportions for the best diet for either man or animal.

BLOND AND BRUNETTE ARE ALIKE

Have you accepted the statements that the blond is positive, driving, hopeful, loving, and the brunette negative, plodding, submissive, and static?

If so, you must revise your ideas, according to a study made by Prof. Donald G. Patterson and Miss Katherine E. Ludgate of the University of Minnesota. These investigators made up a mixed list of such so-called blond and brunette traits and gave this to ninety-four mature students of psychology, each of whom was requested to pick out from among his acquaintances two pronounced blonds and two pronounced brunettes, and to judge them with respect to each of the characteristics. These students were presumably not aware of any scheme of analysis based on sets of distinct traits for the blond and the brunette, and therefore were not prejudiced.

The results for the entire number of the three hundred and seventy-four individuals, half brunette and half blond show:

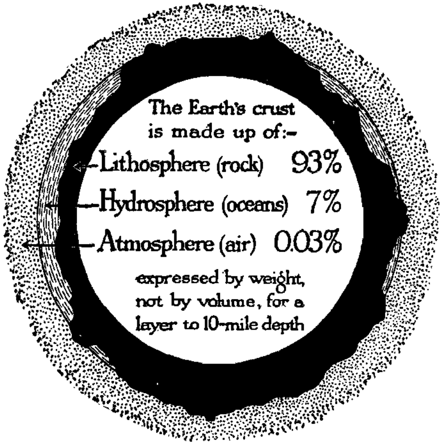
1. Brunettes were found to possess the blond traits to the same extent that blonds do.
2. Blonds were found to possess brunette traits to the same extent that brunettes do.

That is the whole story, and the results are scientific and not speculative.

THE COMPOSITION OF THE EARTH

The surface of the earth with its mountains over five miles high and its five-mile ocean depths is relatively not nearly so rough as the skin of an orange. When we climb the mountains or try to plumb the ocean depths it hardly seems that this is possible; but in comparison with the earth's total size the heights and hollows are really no greater to us than are the ridges of the orange skin to the minute bacteria which we can imagine crawling on this fruit.

Geologists call the rocky crust of the earth the lithosphere; and above it are the hydrosphere, or ocean layer, and the atmosphere. Taking these three together to a depth of 10 miles into the earth, the geologists can now figure with considerable precision the composition of the whole. Dr. Frank W. Clarke of the United States Geological Survey and Dr. Henry S. Washington of the Geophysical Laboratory have calculated the composition of the crust from thousands of chemical analyses, and they tell us that the relative masses are: Lithosphere 93 per cent., hydrosphere 7 per cent., and atmosphere (great in volume but small in relative weight) 0.03 per cent. And of the rock or solid layer nearly all, 95 per cent. to be exact, is igneous rock, formed from molten masses early in the history of this planet. Four per cent. of all is shale; while sandstone and limestone make up together the remaining one per cent., three-fourths being sandstone and one-fourth limestone. In this estimate the ores of gold,



THE EARTH'S MAKE-UP

silver, copper, lead, and other metals and all the rest of the minerals of great commercial importance have not been forgotten, for most of these are really parts of the igneous rocks, and even if separately figured the percentage of the total is very small.

It is no longer held that the interior of the earth consists of molten rock at enormously high temperatures, covered by a relatively thin solid crust on which we live, but little is yet known for sure of the composition of this internal mass. Analyses of surface rocks or even materials from the deepest mines give nothing on which to estimate the character of the earth below a depth of ten or twenty miles. The geologists, however, can now describe with considerable accuracy the average composition of the crust.

Quartz, or sand as we know it in its most common form, is the most important mineral substance of all. Its two constituents, the gas oxygen and the metal silicon, stand at the head of the list of all the elements present in the earth. These two are followed in order by aluminum, of cooking utensil fame; iron, the principal metal of commerce and industry; and the four elements, calcium, sodium, potassium, and magnesium, metals most commonly known through their compounds, as lime (calcium oxide), common salt (sodium chloride), potash (an important fertilizer), and magnesia, with which we "sweeten" baby's stomach (the oxide of the metal which we use in flash-light powders). And when we have named these eight elements we have named all that are present in the earth to the extent of one per cent. of the total. And it is only necessary to add six more—hydrogen, titanium, chlorine, phosphorus, fluorine, and manganese—to make up more than 99.5 per cent. of all the rock, ocean, and atmospheric portions of the crust.

Of the 70 or 80 other elements which chemists recognize as distinct, no single one is present to the extent of one-tenth of one per cent. But even in these small percentages there is wide variation. Sulphur, the next in order of importance, is present as an element and in the form of its compounds to the extent of about 9-100 of one per cent.; whereas the expression for the percentage of radium, that most precious of all chemical rarities, requires eleven ciphers after the decimal point before one can indicate the approximate quantity present in the earth. When one has to express its presence in terms of million-billionths parts, it no longer seems strange that this element is so costly.

WHY DOES A WOMAN CROSS THE STREET?

A chicken crosses the street to get to the other side. A human being may cross the street for almost any reason out of a multitude. Crossing the street seems to be just a simple and insignificant act, but it may give the psychopathologist a clue regarding a mental condition which may later develop into actual disease.

Such was the case with the woman who always crossed the street at a certain block in order, as she said, "to be on the shady side of the street." A skilled psychologist, however, found the real motive in the fact that once she had been frightened by a dog on the street.

The dog had barked and snapped at her after dark. She did not like to remember this fright, so it had been repressed, as the psychologist says, into her unconscious. And when she crossed the street she really thought it was to get on the shady side.

The subconscious is the great storehouse of motives for our acts and thoughts. It supplies the secret springs of conduct. And it is not known to us until after a psychologist has examined our mind and found what motives we have stored away there.

But the popular notion is that every act has been consciously willed. So fact and fancy are reconciled by figuring up some reason for the action after it has been completed. This assigning of motives to acts and opinions for which the person really has no conscious bases is termed *rationalization.*

This same woman, for example, later took an intense dislike to all dogs and attributed the reason to the fact that they carry fleas and disease and are generally unsanitary. But the real basis for this dislike lay in her subconscious and was a result of her fright and her attempts to forget it.

A little later she subconsciously symbolized her painful experience and rationalized it by not eating Frankfurters. Her rationalization was that one never knows what is put into Frankfurters. Perhaps she was right, but a careful psychological study disclosed that the real motive she had for refusing to eat these meat products was a simple symbolism of the "hot dog" name for them. This brought the fright before her subconscious in a somewhat disguised form.

When this rationalization was permitted to dominate her entire conduct she became psychopathological. Later she refused to eat Frankfurters because they were God, thus reversing the spelling of dog. And she also attributed any mild fear to the presence of God, which really, to her disordered mind, meant a fear of dogs. Such symbolization is always active in forming many of the bizarre notions of the abnormal mind.

This *mental mechanism of rationalization* is just one of many. All genuine mental disorders have their origin in the action of certain of these mechanisms. They may result in definite abnormal mental conditions or an inability to concentrate the mind for any length of time, or in constant headaches, fears, or bodily symptoms such as twitchings of certain groups of muscles or hysterical paralyses.

FRANKLIN AS A FUTURIST

Now that airships have come to be an important factor in the world it is interesting to recall that the early efforts at aerial navigation met with ridicule and contempt. Benjamin Franklin, however, was one of the few farsighted men who saw in the balloon a promising future. In 1783 he wrote thus to Sir Joseph Banks of the Royal Society of London:

> The improvement in the construction and management of the balloons has already made rapid progress, and one cannot say how far it may go. A few months since the idea of witches riding through the air upon a broomstick and that of philosophers upon a bag of smoke would have appeared equally impossible and ridiculous. These machines must always be subject to be driven by the winds. Perhaps mechanic art may find easy means to give them progressive motion in a calm and to slant them a little in the wind.

From this it seems that Franklin anticipated a semi-dirigible airship although it was not until the invention of the gasoline motor that this became practicable. He ascribes the backwardness of Englishmen in this field to their innate fear of seeming foolish:

> I am sorry this experiment is totally neglected in England, where mechanic genius is so strong. . . . Your philosophy seems to be too bashful. In this country we are not so much afraid of being laughed at. . . . It does not seem to me a good reason to decline *prosecuting a new experiment, which apparently increases* the power of man over matter, till we can see to what use that power may be applied. When we have learned to manage it, we may hope some time or other to find uses for it, as men have done for magnetism and electricity, of which the first experiments were mere matters of amusement. This experiment is by no means a trifling one. It may be attended with important consequences that no one can foresee. We should not suffer pride to prevent our progress in science.

Franklin was a neophilist, not a neophobist. He was always ready to give encouragement to a young man or a young idea. Yet he was as far as possible from being a visionary or a faddist. He was a common sense philosopher and a sharp business man.

THE NON-EXISTENCE OF COLD

"Everything has two handles, take heed that you pick it up by the right one," says Epictetus. A wise warning, for man in his haste is prone to seize hold of the wrong. The history of science proves this.

The ancients saw smoke rise and they said, "It has levity." We now know that there is no such thing as levity and that on the contrary smoke has gravity, only it has not quite so much of it as cold air and so it gets shoved up out of the way.

When the water rose under the pump valve or the mercury stood high in the barometer tube it was explained by saying that the vacuum pulled it up. How that which is nothing could pull fifteen pounds to the square inch without getting tired also required explanation, but did not get it.

Two kinds of electricity were discovered. "We will call one positive and the other negative," said the scientists to themselves, "for it may turn out that there is only one electricity after all and the other thing is the lack of it." But which was which? They had an even chance at guessing the right one, and, like a student in an examination, they shut their eyes and grabbed at a handle. And they missed their guess. Nowadays we know negative electricity well. We can catch its corpuscles and count them one by one; we can wheel them around a magnet like circus horses around a ringmaster. But nobody can discover positive electricity and we begin to suspect that it is a sort of ethereal Mrs. Harris. Matter minus electrons is what we absurdly call "positively electrified."

"Why are some things hot and some things cold?" asked the common people of the natural philosophers. And the natural philosophers got off in a quiet corner by themselves and thought about it a while and then came back and told the people, "It is because there is *caloric* in the first case and frigoric in the second." And the people went away satisfied that the matter had been explained, as they always do when one talks Greek to them. If they had been told, "There is such a thing as heat—it's a sort of molecular shiver—but cold does not exist," they would not have accepted it, for they believed in the existence of cold even more firmly than in the existence of heat. Tribes of savages have been discovered of such low moral intelligence as to have little or *no trace of a belief in the existence of a God, but* they never failed to believe in a devil. What says even our most optimistic of poets, Robert Browning?—"There may be heaven; there must be hell."

The weather being what it is in winter any of us may be pardoned for falling into this antiquated superstition of believing in the existence of cold. The very language we use drags us back into the Dark Ages. We speak of wearing clothes, of building houses "to keep out the cold." What nonsense! Nothing can keep out the cold because the cold is nothing. It is as impossible as killing a ghost. We can make walls so strong that they will keep out burglars and wolves, so tight that they will keep out snakes, mice and cockroaches, also microbes, but the cold being infinitely less than a microbe cannot be kept out. Even a Pasteur filter will *not screen out a nonentity*. A deserted house is as cold as all outdoors. No amount of clothing will keep a corpse warm. Wrapping a block of ice in burlap does not heat it up. *Ex nihilo nihil fit.*

It is not a matter of indifference which handle is chosen. When we try to explain something by nothing we always get into trouble. Debit and credit are alike to the bookkeeper. Debt is as genuine a thing to him as wealth. But that is because he deals with figures instead of realities. Minus money is a meaningless term unless there are assets, actual or potential. We cannot have a real debt unless we have real money. It is only by earning money that a man can get real debts, and it is only by earning more money that he can get rid of them. There is no other way of getting rid of debts, either real or imaginary.

It is, then, when we come to the practical application of an idea that we find out whether we have hold of the right handle. Doubtless a complete and consistent theory of thermodynamics could be worked out on the theory that frigoric is the real thing and heat merely the absence of it. But that would be misleading to us.

Defensive measures are in themselves absolutely futile in our fight against the hereditary foe of the human race, Jack Frost. To be sure in the absence of heat Jack Frost would be nonexistent. But then so would we. We can only fight him with fire. Fortifications are of value only while the garrison is active. Brick and cloth may serve in a measure to keep the heat in. But we cannot stop the leakage altogether, so we must get heat and ever more heat from within. In this struggle for existence we have only ourselves to rely upon, our fires and that central source from which comes all the heat that keeps our vital spark alive, the sun.

MARINE ENGINEERING IN THE INSECT WORLD

A meadow is a miniature world inhabited by a most interesting population, consisting of butterflies, ladybirds, tiger beetles, grasshoppers, and a host of others. These little people have problems very much like our own and solve them often by methods that are similar to our methods. One of their great problems is that of floods. For when there comes a sudden heavy rain, the rain-water fills every furrow and every little basin in the meadow, and many of the inhabitants find themselves flood-bound on tiny islands from which they must needs make their escape. If you watch their flight from the flood you will see that these Lilliputians travel across the flood by all of the three possible routes—the air, the surface, and the under-water route.

Many insects of course take the air route. They either fly from the island, as the bee, or leave it by an enormous jump, as the grasshopper.

Some insects cannot fly, but can swim. For we are told that ants, for example, make real swimming movements, rowing with their six legs as if they were six-oared boats and steering to right or left, just as the oarsman steers, by varying the strokes of the starboard and larboard oars.

But the rowboat is a slow craft, and in contrast to these slow-going ants we find insects that can actually walk and run on the surface of the water. Their tiny legs are supported on the surface film, just as an oily needle, if you lay it gently on the water in a glass, will rest on the surface film without even getting wet. Since these insects move not through the water, but over it, they encounter no resistance from it, and they can run over it very rapidly. In this respect they may be compared to our hydroplanes—broad, flat, motorboats which, when going at full speed, rise up and skim over the surface, thus avoiding the resistance of the water and shooting along at a prodigious rate.

A fourth group of insects, as some of the heavy, clumsy beetles, cannot escape from the little islands by any of the three foregoing methods. They fly but poorly or not at all, they cannot swim, and they are not built for walking on the surface of the water. These beetles boldly embark upon the submersible route. They crawl down into the water and walk along the bottom. They probably carry with them a small supply of air, in the form of bubbles on the surface of the body. At least they are able to travel a considerable distance under water before they find it necessary to crawl up on a stick or a grass blade for fresh air.

BACTERIA RUN ENGINES

In India where the elephant was first tamed for power, bacteria are now being cultivated for the same purpose. This descent in the course of centuries from the largest to the smallest of living creatures is likely to prove a gain in efficiency, for the microbe can feed on sawdust and does not even need air to breathe. The rodlet bacteria that are being colonized for the running of dynamos thrive best in dark air-tight tanks of sewer-sludge and sawdust kept at a temperature of 95 degrees Fahrenheit. Under these conditions they multiply amazingly and set about converting the septic slush into harmless and indeed useful compounds. One of the products of their activity is acetic acid which might be used for vinegar—if you did *not* know where it came from. The fermentation of the cellulose of the woody stuff also gives gases, chiefly carbon dioxide and methane. The former could be used for charging soda-water, if it were worth while. The methane is of real value, however, since it is the best of gases for motor fuel or for heating or, with a Welsbach mantle, for lighting. Natural gas from wells is about nine-tenths methane.

The method of making methane by fermentation with the aid of the airless bacteria is not new. In fact it was first found bubbling up from the decaying vegetable matter in stagnant pools and was formerly called "marsh-gas." If you look in one of the old text-books of chemistry of the days when they had space for such interesting little items, you will find a picture of a boy collecting the bubbles of the escaping gas with an inverted funnel and lighting it. But our grandfathers, being impractical and imprudent creatures, although fortunately for us curious about Nature's ways, thought of marsh-gas only as a plaything and never dreamed of setting it to work as we do nowadays.

In the Ruhr region of Germany a large municipal sewage plant has been constructed so as to save the gases given off from the fermentation of the sludge by putting concrete hoods over the digestion-tanks. This gas contains from 65 to 90 per cent. of methane and sometimes hydrogen up to ten per cent. The gas is better than the ordinary city gas. In fact, it has about twice the heating value per cubic foot of that furnished by the gas plant of Essen. From the Ruhr experience it is estimated that by employing the proper bacteria a city of 100,000 inhabitants could derive from its sewage sludge eleven million cubic feet of combustible gas a year.

A Dutch manufacturer of strawboard was much annoyed when the government issued directions that the waste liquor from the wood pulp should not be allowed to flow into the river, but should be run into storage tanks for settling and filtration. It seemed a bother and expense to the manufacturer, but he found that if the tank was inoculated with the proper bacteria and kept warm and closed, a gas could be collected from it of twice the volume of the liquid. This gas contained from 70 to 77 per cent. of methane, the rest being carbon dioxide. The methane was run into gas-holders and used in internal-combustion engines for running dynamos that furnished light and power for the works, and the surplus gas was sold to the local gas works which mixed it with 25 per cent. of coal gas and used it for the town. It has been found possible in India to get, by fermenting banana stems and skins, a gas containing 81 per cent. of methane and 14 per cent. hydrogen.

It has often happened that the government, in suppressing a public nuisance, has forced a factory to make a profit out of a waste product. So it has come to be a proverb in engineering circles that "Wherever there's a nuisance there is a waste, and wherever there's a waste there's wealth."

WHY CORN HAS SILK[1]

The farm boy sitting in the fence corner smoking his cigarette of corn-silk may merely think of these thread-like growths as a none too perfect substitute for tobacco. The girl in the kitchen preparing "corn on cob" is often inclined to think that these tender strings are merely wedged between the corn grains to give her trouble.

But a near view of the apparently smooth silks shows that they are not just what they seem to the casual observer. Seen through the microscope, the silk is a long, slightly tapering, hollow tube, the outside of which is covered with short, branched hairs. At the base of the tube is the egg-cell from which develops the individual grain

[1] See illustration facing page 192.

of corn. The silk is really part of the female organ of reproduction in the corn plant. For a corn plant is both male and female.

The male cells necessary for reproduction are supplied from the tassel which waves in the wind at the top of the stalk. From each of the small spikelets on each branch of the tassel there come tiny sacks, each of which contains about 2,500 pollen grains. From the tassel of one stalk of sugar corn it is estimated that there are 9,500,000 grains of pollen and from one tassel of field corn there may be 18,000,000 grains of pollen or more.

This pollen is the fine golden dust which may be seen flying in clouds from the tassels when they are shaken on a still morning. It has a peculiar, heavy, sweet, lasting odor. This pollen is necessary in order that kernels may form. Upon the tiny hairs of the corn silk the minute pollen grains are caught. The captured pollen grain then germinates and sends a tiny tube down through the hollow silk until the egg-cell is reached and fertilized. Unless the pollen grain reaches the silk, no kernels will be developed.

This may be clearly demonstrated by tying a clean paper bag tightly over an ear of corn before the silks develop and leaving it so covered until the silks are dried up. It takes just one grain of pollen for each silk, but Nature has been bountiful and provides anywhere from 1,000 to

6,000 grains for every strand. But there is one silk for each grain of corn produced. After fertilization takes place the silk stops growing, but if the pollen does not reach the slender green tubes, they sometimes grow from twelve to fifteen inches long.

Barren plants which produce no ears or ears without grains cause a low yield of corn. Often, also, ears are seen on which the kernels have not developed toward the tip. Corn silks do not all develop at the same time. The silks from the butt of the ear grow out first and become fertilized. The younger silks near the top of the ear sometimes find it difficult to grow through the matted older mass and for this reason may not catch the pollen grains and become fertilized. This results in ears that are poorly filled toward the tip, a condition that is often seen.

Although each plant with its tassel and silks is both male and female, the pollen would have to fall almost straight down to fertilize the silk of the same plant. So it happens that it is a rare corn kernel that knows its own father. About 95 per cent. of all corn is cross-fertilized; the silks on one plant are joined by pollen from another. In the ordinary corn-field but one parent, the mother silk, is definitely known.

Breeders of corn in developing new varieties cannot rely on the chance meeting of pollen grain with silk. They must be able to certify to the corn's pedigree. In breeding experiments the ear-shoots are bagged before any silks have appeared in order to prevent random fertilization. Then, after the silks have emerged sufficiently, pollen is collected from a known and desired source, and as a result the corn kernels are produced eugenically above reproach.

THE MAYOR AND THE MOSQUITO

"Seeing is believing" is the simple underlying principle of every scientific demonstration, whether it is a laboratory experiment with complicated apparatus or a close observation of natural events in the field. The potency of this principle was demonstrated in an amusing incident in Mexico during the Rockefeller Foundation's anti-yellow fever campaign there.

Even the rural Mexicans had by that time grasped the significance of the mosquito as a carrier of the yellow fever germ. Accordingly, when the American bacteriologist found in a little Mexican town the family cisterns swarming with mosquito larvæ, he reported the fact to the Mexican local authorities. The Mayor was interested and accompanied the Americano to view the mosquitoes. It was night, but an electric torch turned into the first barrel revealed myriads of "wrigglers." "But, my friend," said the Mayor, "those are not mosquitoes. A mosquito is a winged insect that bites. I know them well. You see, they come down from the mountains. We are in the midst of the mountains here. It is regrettable but unavoidable." The mosquito pupæ—intermediate between wrigglers and mosquitoes—were shown him with the same result. These pupæ look like old-fashioned hunting horns, curled up with two little projections, the "breathing tubes," and they resembled no mosquito the Mayor had ever seen. But he agreed to a demonstration. He would watch a number of them, carried home in a bottle for the purpose, for two hours, no longer; if they turned into mosquitoes in that time, all right!

The bacteriologist was skilful. He quickly selected the oldest pupæ, those almost ready to hatch, stoppered his bottle with cotton, and set it for observation on a table. At the end of thirty minutes, a pupa hatched. The case split and a regular, genuine mosquito climbed out and flew to the cotton stopper and looked around for some one to bite. The Mayor's excitement and admiration knew no bounds. This Americano was a true prophet. His words were verity itself, he should have unqualified support in everything he wished to undertake. The report spread quickly and the next morning every able-bodied man in town had supplied himself with a bottle of mosquito pupæ and was on his hands and knees breathlessly watching their transformation. The relation of the pupæ to the wrigglers was also quickly accepted. The theory of the mountainous origin of mosquitoes was laid on the shelf and every one turned his attention to the water-barrels, the true breeding-place of the pests.

It is not an easy matter to clean out mosquitoes in a place that derives its whole water-supply from backyard rain-barrels. These can neither be screened successfully nor oiled. The best solution has been found in little fish, an immensely prolific species of minnow, trained from their babyhood in the hatcheries to eat nothing but mosquito larvæ and *pupæ*. Three or four were presented to each householder with instructions regarding their care and introduction into the rain-barrels. Thoroughly convinced now by their own eyes, the townspeople turned joyfully to the tending of the sacred fish, with the result that yellow fever speedily diminished and finally almost disappeared from the district.

TWO KINDS OF CONSERVATION

Conservation is one of those deceptive words that have a double meaning. It is doubly danger

ous because its meaning in one case is quite the opposite of its meaning in another case.

For instance in the conservation of our natural resources. A politician with an agate-bearing tongue may say: "I am in favor of the conservation of our petroleum and water power."

Very good. But he and his audience do not always realize that contrary policies must be adopted in the two cases.

The conservation of oil means not using it, for all the oil that is used is forever lost.

The conservation of water power means using it, for all the water power that is not used is forever lost.

Oil and water do not mix. Both oil and water are limited and inadequate to our needs. But the oil supply is exhaustible while the water supply is inexhaustible. Day by day the sun pumps up water from the ocean and the winds carry it over to the mountains where it falls as rain and fills the streams.

But there is no reason to think that Providence will ever renew the supply of oil that we are so lavishly and wastefully using. Dividing the amount of petroleum left in the earth of our country, estimated at about nine billion barrels, by the amount we withdrew from deposit in 1923, 745,-000,000 barrels, we get 12 as a quotient. That means in 1935 or thereabouts, unless geologists have underestimated the supply, we will run short of the gasoline and oil that we have been getting from petroleum and that we will have to seek other sources. What those sources will be we do not know, but we may be sure that liquid fuel and lubricants will be dearer and more difficult to get in the future. We might get them from oil shale, it is true, but shale has to be mined and extracted while petroleum runs out as soon as its reservoir is tapped.

In some parts of our country we can still see the blazing beacons of natural gas burning all night from our pipes, but most of the communities which formerly have been favored by a free use of gaseous fuel have had to fall back on coal.

And there is not enough coal to go around or to last long. Three continents, Africa, South America and Australia have not enough coal to support an industrial civilization like that of modern Europe. But Europe cannot keep up its present rate of consumption of coal for many centuries. The United States and China seem to be the most favored nations in the matter of fossil fuel. They have enough coal to last several thousand years, but that is not forever and we hope it will be but a short chapter in the history of the human race.

Meantime we are wasting the greater part of our coal by inefficient combustion and by toting it back and forth across the country unnecessarily. The miner gets only one crop while the farmer gets a new crop every year. That is because the miner is using up the accumulated carbon of past ages while the farmer accumulates his carbon anew with the aid of each summer's sunshine. One is living on the capital of the world's wealth; the other on its interest. The central power-house of the solar system has been sending out its energy by radio without any perceptible diminution for some millions of years in the past and seems likely to last at least as long in the future. An impartial Providence has so arranged it that the earth revolves as a spit before the fire, so that every land receives in turn a share of the sun's rays. Furthermore, every land has been supplied with a supply of carbon and oxygen in exact proportion to its area, since these are free as air.

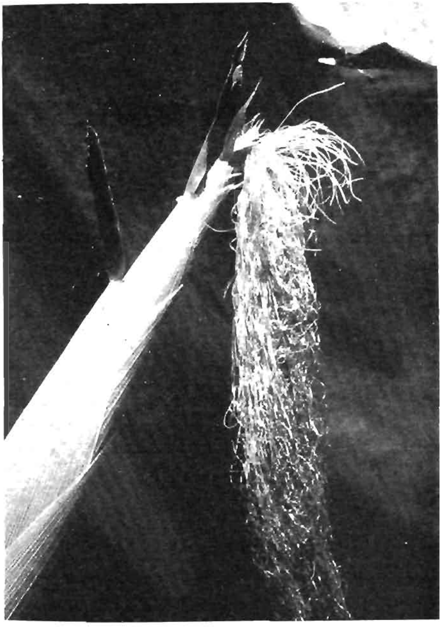
But only the plants possess the secret of economically separating carbon from oxygen and storing up the former as food and fuel for future use. And even the plants are not good at it, although they had practised the art of manufacturing carbohydrates for many millennia before man came on the scene. The green leaf wastes ninety-nine per cent. of the energy it receives from the sun. But on the one per cent. of the original solar energy that is recoverable on the combustion of the combined carbon depends all the life of the world and all the power of the machinery of man except what little he gets from waterfalls and windmills. Water power we are beginning of late to utilize, but wind power we employ less than we used to when it propelled all the ships and ran many of the mills. We have more wind than we want in some places, yet we waste most of it without a thought of conservation.

The best definition of this ambiguous word is that of Acheson: "Conservation consists in the utilization of the inexhaustible for the preservation of the exhaustible." Coal, oil, and gas are exhaustible. Water, wind, and sunshine are inexhaustible.

MEASURING THE OCEAN'S DEPTH

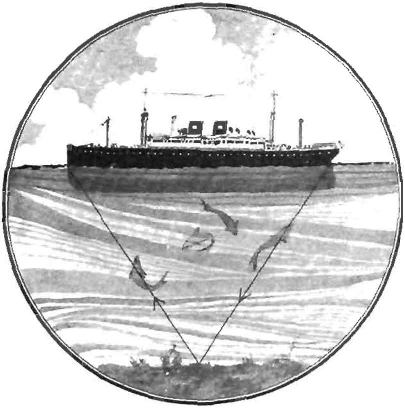
It used to be quite a job to drop a line to the bottom of the ocean and then reel it in every time a measurement was made. In some places the ocean is nearly five miles deep, and five miles of line let out from a wave-tossed boat is not the easiest thing in the world to manage, not to mention the time that is necessarily consumed.

By the use of a new device perfected by the American navy these soundings can be taken



WHY CORN HAS SILK

The silk is the feminine part of the corn plant and is useful as well as ornamental. *See* page 183.



MEASURING THE OCEAN'S DEPTH

The device uses the principle of the echo. A sound is made under water at the stern of the vessel and a delicate sound receiver at the bow records this sound after it has traveled to the bottom and has been reflected back. (Copyright by *The Country Gentleman.*)

almost instantly and without the use of a line of any kind.

The device uses the principle of the echo. A sound is made under water at one end of the vessel and a delicate sound receiver at the other end of the vessel records this sound after it has traveled to the bottom and has been reflected back.

By measuring the time taken for the sound to travel down and back it is a very simple matter, the speed of sound through water being known, to figure the distance. This machine, however, does the figuring automatically.

Since sound travels 4400 feet a second through sea-water, extreme accuracy in measuring the time is necessary. An error of only one-fifth of a second would mean a difference of seventy fathoms in depth. Stop-watch methods are entirely too slow for these measurements. Automatic electric indicators are used.

This device can also be adapted to detect the presence of icebergs by the sound reflected from the berg. It is believed that this use will prove very valuable in preventing such disasters as befell the "Titanic."

A MAGIC BATH

The Genii of the modern chemical laboratory are close competitors of the Slaves of the Ring and the Lamp who swayed romantic fancy back in the days when good Harun-al-Rashid ruled in the city of Bagdad. Take the latest dye wonder worked by scientists, for instance. If this had occurred in a less matter-of-fact age, the story of it would already be festooned with fairies and magicians. If Scheherazade could have heard about it, she might have made it the theme for the One Thousand and Second Night's Entertainment and called it "The Magic Bath."

This is what they did. They took an uncolored garment, woven from two different materials, and threw it into a kettle of dye. Then they drew it out again—a fabric of various colors. Each material in the single garment came out of the same bath with a different color.

Being, like Caliph Harun, of an inquiring mind and not easily satisfied with a supernatural explanation, as he was, you want to know right away how it was done. Perhaps you suspect there was a trick kettle like a stage magician's coffee-pot. But rest easy. There was no trick apparatus. They could have done the same thing with your own kettle, on your own stove, in your own little kitchen.

It is all a matter of the kind of dyes. Two English chemists have discovered a new sort, which they call "ionamines." These dyes come in all the various shades of yellow, orange, and red; while these colors can be further changed to such shades as browns, reds, violets, blues, and blacks by a process well known in the dye industry.

These ionamine dyes act on the fibers of the artificial product known as "acetate silk," or "cellulose acetate," or "lustron," which has heretofore given a lot of trouble in coloring and required a roundabout process to do what is now done directly, quickly, and certainly. Now this acetate silk dye is mixed with the ordinary direct dyes used to color cotton, linen, or that other artificial fiber known as "viscose."

When any of the many different kinds of cloth made of both cotton and acetate silk fibers, acetate silk and linen, or acetate silk and viscose silk are put in this bath of mixed dyes, the ionamine dye in the mixture selects the acetate silk and does not affect the cotton, while the direct dye selects the cotton and shows no affinity for the acetate silk. By this means two solid shades or two color effects can be produced as desired. If a blue direct cotton dye and a yellow ionamine dye are mixed together, the cloth immersed in the mixture will come out with the acetate silk part dyed yellow and the cotton part dyed blue.

These different colors, in cotton cloths which carry silk threads, such as men's shirts are made from, are ordinarily obtained by first dyeing the silk threads and then weaving them into the cloth and then dyeing the cloth with the cotton dye. The new method does it all in one simple process. Other fibers can be introduced to bring out an intricate design from the white fabric.

Dyeing is one of the oldest of the arts. Ancient peoples not only knew how to color cloth, but how to fix the fabric so that it would not run. They did not know about ionamine dyes, however, and they did not need to—for they did not make artificial silk, which is a comparatively new discovery, a creation of the chemist from the cellulose of cotton or wood pulp. A Boston chemist, Arthur D. Little, has proved it possible to make a "silk purse from a sow's ear," although it is not a profitable process. But it is a paying business to make silk stockings from tree trunks. In learning to dye this artificial silk by a new method science is solving one of the problems which it has itself created.

CHOPPING OFF THE HEAD CHANGES THE SEX

The problem of the determination of the sex of the individual before birth has been receiving the attention of scientists for many years. Obviously, if the sex of animals, even of human beings, can be determined by prenatal diet or drug treatment, the economic and social consequences will be tremendous. So far the work is almost altogether in the theoretical field, but some very interesting results have been reached with lower animals, and we may perhaps begin to see practical applications in a generation or two.

Almost all of the work has been done with animals, since most plants are bi-sexual; that is, they bear both pollen-producing and fruit-producing parts in the same flower, or at least on different parts of the same plant. In some cases, however, the fruit-producers are on entirely separate plants from the pollen-producers, or male elements. In growing such plants it is, of course, the object to have as many fruit-producing, or female, plants as possible, and no more than enough pollen-producing, or male, individuals than are necessary to fertilize the female flowers. The superfluous pollen-bearing plants, therefore, are commonly weeded out.

One very interesting case, where this wasteful weeding-out process is avoided by a simple method for turning male trees into female, is afforded by a semi-tropical fruit, the papaya. The papaya is a fruit somewhat resembling a small melon in appearance, much prized in the warmer countries of the world. It is borne on a small tree that looks rather like the common castor-bean of our back yards. Under normal conditions it does not branch, but bears its leaves and flowers at the top of its single stalk. The plant is bi-sexual, and only one pollen-bearing tree is required for a dozen or more fruit-bearing trees. The trouble is that it is propagated only from seed, and the seedlings come up about half-and-half, the usual sex ratio for all living things. This would therefore produce a great excess of male trees, taking up the space that might be occupied by fruit-bearing females, but for the most interesting and puzzling fact that a male of this species can be turned into a female by the simple process of cutting its head off. If the top of a pollen-bearing tree is lopped off, several branches are produced, and the flowers on these, instead of being polleniferous as before, are equipped with carpels that receive the pollen and develop into full-sized fruits.

So far as is known, this is the only organism whose sex can be controlled in this way. Certainly the more advanced feminists among the human species should not be encouraged to try similar experiments on their men folk. It won't work.

BOILING WATER AND THE WEATHER

Every one knows, though usually in a vague sort of way, that on some days water boils away more rapidly than on others, and that food cooks more slowly when boiling is rapid. But the reason is not so generally understood. The lower the temperature at which water boils the quicker it disappears in the form of steam into the atmosphere. The boiling point depends entirely upon atmospheric pressure. The higher the barometer, the higher the boiling point, the hotter the water, and hence the more efficient the cooking process; conversely, the lower the barometer the lower the boiling point. Two elements enter into this, the one the altitude above sea level, the other, which is more commonly experienced, the general condition of the atmosphere.

One usually thinks of the boiling point of water as 212 degrees Fahrenheit. But this is the temperature at sea level with the barometer, at 32 degrees Fahrenheit, standing at 29.92 inches, which is average pressure. But the barometer does not stay at 29.92 inches; a really low pressure brings with it a very considerably decreased boiling point. This temperature at sea level, say, with the barometer indicating 29 inches, is 210.4 degrees, and water steams away 3 per cent. more rapidly. A sea-level barometer reading of 30.8 *inches corresponds to a boiling point of 213.5 degrees* Fahrenheit.

Then there is the difference in altitude, which in the high levels of the earth is an all-important matter. At 32 degrees Fahrenheit pressure falls at the rate of one per cent. for each 273 feet of height, and the boiling point decreases proportionately, about one degree for each 560 feet of altitude. When water is boiling at 212 degrees at Boston or New York or Philadelphia it would be boiling at about 201 degrees on the summit of Mt. Washington, 6,300 feet up in the air, where the difference in cooking power sometimes has to be taken into serious consideration. Tea takes a long time to make, and various other items of the table are more or less affected. This condition is accentuated sharply when in addition to the low pressure produced by altitude there is the additional fall, and correspondingly still lower boiling point, produced by a low pressure in a storm.

At La Paz, nearly 12,000 feet up on the Bolivian plateau, the boiling point, compared with the 212 degrees at sea level, is about 192 degrees, and on Mt. Blanc, 15,751 feet, it is about 183 degrees. An American who lived for years on the Bolivian plateau tells of burning his mouth badly with soup the first time he went down to the coast, for on the plateau the temperature of the soup was so low that he was accustomed to take it directly from the fire, which at sea level was a dangerous undertaking. It is difficult to boil potatoes at La Paz, no matter how long they are cooked, for the heat at the low boiling point is insufficient.

The housewife may find it to her advantage to consult the barometer reading in her morning paper, or at any rate to observe weather conditions, in planning her cooking, especially if she uses a measure of time, for what would take, for instance, an hour to cook on a clear, cool day might require an appreciably longer time in a period of warm, showery weather.

THE ROAR OF THE MOUNTAIN

Dwellers in many mountain valleys are familiar with the roaring of the mountain before a coming storm, a bit of weather lore known to the ancient Greeks and Romans. But how and why mountain ranges and forests so frequently and so accurately predict in organ tones the coming of storms has been explained by one of Uncle Sam's weather experts, Dr. W. J. Humphreys of the Weather Bureau Central Office at Washington.

It is due to the howling of the wind through the trees which frequently cover the mountain ridges, and more fundamentally to the laws which govern the motions of the ocean of air at the bottom of which we live. A coming storm always sets currents in this invisible ocean, rivers of air of vast extent and often of high velocity, flowing spirally toward the center of the disturbance. For instance, when a storm is approaching the east from the Mississippi Valley, the winds set in from the east or southeast from 12 to 24 hours before the rain begins.

Most of the mountain ranges or ridges in the East run in a southwesterly and northeasterly direction, so that a wind from the southeast flows directly across them as a river flows across an obstruction in the stream, and the same thing hap-

THE ROAR OF THE MOUNTAIN

How a return current up the mountain is created. The focusing effect of the wind upon sound waves crossing the summit with the wind is also shown. *S* is the course of sound; *F* is the point beyond the mountain where it is most clearly heard. (Copyright by *The Country Gentleman.*)

pens to the air that happens to the water. Back eddies are formed around the top of the obstruction which, in the case of the wind, is the mountain ridge.

When a strong wind is blowing across a mountain it is blowing up toward the summit on both sides, on the windward side from the direct flow of the wind, on the leeward side from the back eddy. These currents blowing through the trees on the steep slopes cause a mixture of musical tones like those made by an Æolian harp, only on a vaster scale, and the roar or murmur thus produced is carried down the mountain side into the valley by the billows of air.

For just as water flowing over a fallen log breaks in a billow behind it, so air flowing over a mountain forms an invisible billow which crashes to earth somewhere along the valley floor. It is this phenomenon which causes tempest and squally conditions in certain parts of valleys during a storm while the rest of the valley may be relatively calm. Sound is nothing but a vibration of the air, and if the air which carries the vibration is moving the sound will be carried along with it. So when the wind which tells of the approaching storm eddies over the mountain top, stirring the forest to its wild music, the sound is carried down into the valley to the point where the storm-wave breaks. Here the voice of the mountain is most clearly heard, and chimneys smoke from the down draft of air and all the oldest inhabitants say, "The mountain's roaring this morning. Rain to-night."

That is the scientific explanation of a fact known as long ago as when Elijah told King Ahab to get down from Mount Carmel, "for there is the sound of abundance of rain," embodied later in many a popular proverb of weather lore, and accurately expressed by some observant dweller amid the hills in the following couplet:

When the forest murmurs and the mountain roars
Then close your windows and shut your doors.

FAT MOLECULES AND CAKE

Write this motto in your cook book: "The lazier the molecule, the lighter the cake."

Whether or not a molecule of oil in contact with a wet surface prefers to stand on its head or lie comfortably on its back would seem to be a question of possible interest only to the most inquisitive of scientists. It has, however, an important bearing on such practical things of life as the baking of sugar cookies. Recent investigation seems to indicate a close relation between the habits of molecules and the quality of cake.

For nobody knows how many centuries housewives have added oil or fat to dough to make the bread or the cake not only light, but tender; certainly since the days of the widow of Zarephath who told the prophet Elijah in the time of the famine that all she had left was a little oil and a handful of meal, with which she would bake a little cake for herself and her son, that they migh eat it and die. Probably some heedless bride in the days when cattle were first kept, upset th cream jug into the dough, was afraid to say anything about it, and then, when the lord of the household asked for a second helping and said it was even better than the kind mother used to make, was moved to repeat the experiment.

From cream it may have been but a short step to butter and then to olive oil and the fat of animals, but, however it came about, the use of "shortening" came to be practically universal. Nobody knew the reason why fats or oils made a tender bread or cake. Nobody cared until the age of machinery came and with it great bakeries and chemists anxious to know why one fat is better than another for shortening and why some other which is cheaper may not do as well.

Every good cook knows that the common shortenings differ. Excluding preferences of taste, lard is better than butter, and so is cottonseed oil. Weight for weight, they will go farther. Below butter in the scale is coconut oil, which is getting to be commonly used, and below these are the mineral oils, such as vaseline and liquid petroleum oil. It seems a nightmarish sort of idea to think of using vaseline to shorten a cake, but it can be done, even though few people would care much about eating the cake when made.

Chemists have investigated the action of shortening by examining dough with a microscope, and they have found that it acts as a sort of buffer between the other ingredients. Flour is composed chiefly of starch. It also contains gluten, which, when mixed with water, gives dough its sticky consistency. If shortening is not added the sticky layers of dough will lie close together and, except for the holes made by the leaven, will produce a bread which is stringy and tough. If it is a cake dough, to which sugar has been added, the cake will be hard, like hard candy, unless shortening is used, for the sugar will melt and mix through the mass and then harden on cooling.

But when shortening is added and well mixed into the dough a layer of fat or grease is built up around every small strand of sticky dough. On baking, the starch of the dough expands, the mass is lightened by the gas from the yeast or baking powder, but the fat is unchanged, although very finely separated, and when the bread or the cake is done it acts as a buffer between the layers of cooked starch and sugar, just as paraffin paper keeps caramels from sticking together in a box. The bread is tender, we say. It is easily broken.

Why fat acts in this way and why one fat acts more efficiently than another is the puzzle the chemists set out to solve. To do this they went back to the studies which have been made of oil films on water, and this is where the molecules come into the story. Molecules are the smallest parts into which a substance can be divided without splitting up into its original elements, or atoms. For example, a molecule of water consists of two atoms of hydrogen and one of oxygen. Fat molecules are vastly more complicated combinations of atoms of carbon, hydrogen, and oxygen.

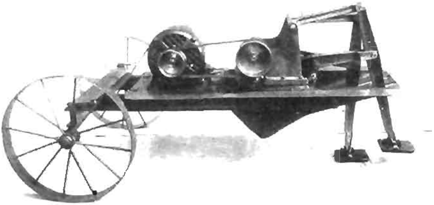
Recently we have learned something about the shape and position of molecules. A fat molecule, for instance, is a long, rangy creature, with a sort of tail of carbon atoms more or less tightly bound together. When one of these molecules is placed on water or a wet surface it may stand on its head because that is the part most attracted by the water, while its tail is more at home with the other molecules of oil. Such molecules take np little room on the water, and the fats of which they are composed are therefore poor spreaders and poor shorteners. Others are so constructed that there is a part of them about the middle which seems to be attracted to water, and when they are placed upon it they fall over and lie outstretched, take up more room and make the best shortening. Literally they go farther.

They are small things at the best. For example, a molecule of a good shortener like lard or cottonseed oil covers an area of about one 16 million-millionth of a square inch. Others are only one-fifth as large. But as the proverb has it, "It's the little things that tell," and so it happens that upon the habits of these infinitesimal and almost ultimate particles of matter depends such a practical thing as whether or not Friend Husband will like the cake to-night.

THE TRACTOR THAT WALKS LIKE A HORSE

Sometimes in the history of invention a return to nature is a step in advance. The wheel is rightly regarded as the greatest improvement that man has ever made over the mechanics of nature, yet a Swedish engineer, Fritz A. Nilsson of Stockholm, has abandoned this method of propulsion and returned to the step-by-step system that animals have been using for several millions of years. In his new Itus tractor the propelling power is applied through levers that work like legs, alternately lifting up the steel shoes and bringing them down on the ground. Different sets of shoes are provided to suit various sorts of soil. Since the feet are fixed firmly on the ground, it is not necessary to make the tractor heavy in order to get pulling power.

There being less weight to trundle about, this tractor can be run with a lighter motor and less fuel. It is claimed as a further advantage that this tractor does not press down the soil as do the tractors with wheel drives or caterpillar tread.



A TRACTOR THAT WALKS LIKE A HORSE

The Walking Tractor invented by Fritz A. Nilsson of Stockholm and exhibited at the Gothenburg Exposition.

PRIMITIVE TREPANNING

A reconstruction depicting a prehistoric surgical operation. The drawing, based on actual material and photographs of the region, represents a primitive blanket-clad shaman using the cautery in the highlands of Peru. The patient is a woman supposed to be *suffering from melancholia, for which the treatment, as judged* from the skeletal remains and from analogy with modern primitive practices, was to incise the scalp in a cruciate incision and into this open cut place the oil which is bubbling on the slow *fire in an appropriate medicine-man's jar, with the wisp of twisted* fiber lying near by. The operator has in his cheek a quid of coca leaves which he will apply to the wound to ease the patient's distress. The wound became violently infected and made a huge osseous lesion *on the woman's skull. This skull is preserved in* the American Museum of Natural History. (From *Paleopathology* by Dr. Roy L. Moodie. W. B. Saunders Company, Philadelphia.)

The Itus tractor lifts its feet daintily over clods, stones and young plants, and leaves three-fourths of the soil in the track untouched. As the foot is raised it is moved forward by the planetary gears with increasing speed until, at the top of its swing, it is traveling five times as fast as the foot on the ground. The movement of the machine is uniform, not jerky. It walks backwards as readily as forwards and, if the gearing is so adjusted, can be made to travel in a circle or any other curve. A pair of light wheels in front or behind carries half the weight of the machine.

The Itus tractor shown in the cut is a biped and is run by electricity. This is intended for gardening and does not carry a man. For plowing and farm work a quadruped is constructed, run by a gasoline motor. The movement of the four legs is so timed that two legs are always planted on the ground before one is raised.

This is the latest of many attempts made in recent years by the inventors of various countries to provide tractors with leg-motion, and it will be interesting to see what the Itus tractor will do when it really gets to work on the farm.

CURING HEADACHE WITH A CHISEL

If you are one of those who prefer "old-fashioned" remedies, you may apply to your carpenter to chisel a hole in your head the next time you suffer with a headache, as that is the most ancient of ancient "cures."

Trephining, or cutting holes in the skull, is the oldest surgical operation known. Skulls of prehistoric gentlemen with large and small perforations are dug up in many parts of the world. And what is more strange, they frequently give evidence that the victim survived the operation many years.

Such mutilations were first noticed on skeletons dating from the Stone Age, exhumed in France when archeological research was first being seriously undertaken in the middle of the last century.

It was suggested at the time that the primitive surgeons had merely removed pieces of broken bone and rough edges from heads that had collided with somebody's stone hatchet or club. Further studies, however, by Professor Lucas-Championière on specimens from the graveyards of the Incas of Peru as well as Europe and among the present-day Kabyles of the hinterland of Algeria, where the custom still survives, have shown that the operation was a remedial one calculated to relieve headache and perhaps epilepsy and other troubles of the head.

The idea is plausible; if you have a pain in your head, presumably there is something inside that ought to get out. Hence, open up the skull.

Probably the operation was successful in some instances, namely, where a similar treatment known as "decompressive craniectomy" is employed at the present day.

The surprising thing, however, is that the patient ever survived such heroic treatment with the crude and dirty technique of a savage medicine man. Yet in the American Museum of Natural History in New York City may be seen several skulls that had been cut into to let out the disease and had healed over. Professor Moodie, in his big volume on "Paleopathology," ventures to reconstruct the scene of one of these painful prehistoric operations endured by a headachy Peruvian woman of some five centuries ago.

CAT SPARKS AND EXPLOSIONS

Grain elevator fires cause millions of dollars of loss every year. Most of these are caused by explosions of the dust rising from the grain.

A dust-filled atmosphere around the whirling, grinding, or cleaning machinery, a sudden flash, a dull report, a collapse of walls, a surge of flames and about all that is left of the great towering elevator is a smoldering mountain of partly burned grain.

Threshing machines in the open field are frequently destroyed by similar explosions on a smaller scale. This is particularly true where the grain is filled with smut or is unusually dusty for other reasons.

For a long time little was known about the causes of these seemingly mysterious fires. But recent studies have not only shown the cause, but have determined the remedies.

Have you affectionately but vigorously stroked a dry cat and heard the sparks crack? Have you walked across a thickly carpeted floor on a dry winter day and seen a spark jump from your finger to the radiator? You generated static electricity, which is amusing in the parlor, but dangerous in the mill or factory. The insurance companies do not report cats as the causes of fires, but the same sort of sparks do cause them.

Moving parts of machinery on a dry day act like your hand and the cat's fur, and little sparks of static electricity do much harm in cotton gins, gasoline distilleries, powder factories, flour mills, and even dry-cleaning establishments.

Flour, grain dust, and gasoline vapor are highly flammable and an atmosphere heavily laden with them will explode like the gases in an automobile engine if the spark happens at the right time and place.

On a damp day combing your hair or the cat's does not produce the sparks because the dampness allows the electricity to leak away gradually. And putting plenty of water vapor or steam in the air is one way of preventing static electricity and its dangers. Another method is to be sure that all metal parts of machinery are substantially fastened together to themselves or the ground so that the electricity created can flow through metal easily without having to jump through the dusty air in the form of a dangerous spark.

ARRANGING YOUR MIND

Interest is largely dependent on association. Children have the greatest general acquisitiveness. They are interested in everything. But as we grow older and realize that no man can swallow the universe, we grow particular with our mental food. We pick and choose.

A child's mind is like a ball covered with glue; roll it around and it will pick up everything that it touches. A man's mind is like a magnet that will pick out a certain metal from anything that may be mixed with it. He is deaf to all sounds outside a certain range unless they are very loud. His mind is trained to a certain line of thought, and all ideas on his subject that come his way are picked up.

Let half a dozen persons read a newspaper;

they will not see the same things. Start your mind working in a certain direction and see how facts will flock to you from all sides. How often do we hear the exclamation, "Why, here is an article on the very subject we were talking about. How queer!" It is merely because you have your eyes open.

That is the explanation of the broadening effect of a college education. It lies not so much in the amount of information a man gets in the four years, but the necessity of studying in many different lines creates many points of interest, and each of these attracts information through the rest of his life. He is like a farm-house where an enterprising lightning-rod agent has got in his work. He bristles with points that draw electricity from every passing cloud. And the points are all connected and grounded in deep earth.

Then, too, a well-educated man has a more symmetrical mind. Certain important ideas that the experience of the ages has shown to be best fitted for "foundation" have been implanted in his plastic mind and he builds on these. Consequently he is less likely to become lopsided and cranky (using this word in its strict nautical sense). The library of his information is symmetrically arranged and this is better than putting the books in by chance. It is more important that we should be able to lay our hands on a given book than that we should have a large library. Or, to put it psychologically, it is better to have a good recollection than a large memory.

We can recall things best when they are arranged according to the logical laws of association. We remember best what has made the most impression on our minds, what we have been most interested in. For disconnected facts, with which we have no association, most of us have little memory. There are those, however, who have this casual memory to a high degree and are apt to retain without effort any fact that comes to their notice, a name or a date, a street sign or automobile number.

All systems of memory training that are rational are based on the laws of association. Many memory-training schemes are very crude, such as associating a nonsense word or sentence with a date. An objection often made to such schemes is that they involve learning two things instead of one, but that is not a valid criticism. For it is easier to remember two things than one if they are connected. If you don't want to lose a five-dollar gold piece wrap some worthless paper around it to make a big bundle. But the best memory systems are of course those where the association is real and logical, not arbitrary and fanciful.

BEAVER ENGINEERING

The beaver is the most famous engineer among the lower animals. Like many human beings with a big reputation, he often gets credit for things that he does not do. His press-agents have ascribed to him a sagacity in engineering which is beyond his rodent mentality. Yet he is a remarkable constructor, as his dams and canals prove. And even his burrows and lodges show architectural skill.

Some people have an idea that the beaver begins his dam by cutting trees so that they will fall across a stream, and that he then builds it out of logs. The trouble with this idea is that the trees fall in whichever direction they happen to lean or as the wind or chance directs and not according to some mysterious mathematical calculation of this industrious forester. Also, logs of any size are seldom used in the construction of the dam. The beaver cuts down trees primarily for the bark which it strips off for food and secondarily for the limbs and twigs with which it dams the stream. Many details of the life of the beaver have been revealed by investigations that are being conducted by the Roosevelt Wild Life Forest Experiment Station of the New York State College of Forestry at Syracuse.

The dam is begun by laying twigs and branches on the bottom, butt ends up stream, and then covering them with gravel, mud, or rocks dug from the up-stream side. More twigs are then laid on top and covered. Green wood is almost as heavy as water, and after being immersed a short time will stay down of its own accord, while even dry wood becomes water-logged in time. The dam is built up to the desired height in this way and then plastered with mud on top.

Some nature-fakers, judging by the shape of the beaver's flat tail, have suggested that it is used as a trowel and as a raft to carry mud and other things. Such is not the case, however. Mud is carried and plastered on by the skilful fore-paws.

The beaver dam is never finished while the pond is occupied. A large amount of labor and engineering goes into maintenance, and these master-builders are always making repairs and additions as the rising water requires. The dams vary in length from one foot to several hundred feet, and are usually less than six feet high on the down-stream side.

Even more remarkable than the actual construction of the dam, however, is the deliberate digging of a channel to transport material to the pond. For not only do the beavers dig these waterways, but they dam them to hold the water at the proper level for floating the logs and tree limbs. These ditches vary in width from one to four feet, in depth from eight inches to two feet, and in length from a few feet to over five hundred feet. The long, gradual slope of the lower face of the miniature dam makes it easy for the beaver to drag logs over it.

The beaver goes through these elaborate engineering operations in order to provide sufficient depth of water for its home. For these little social builders are more confident of themselves in the water than in their lodges. These structures must have a foundation of some sort to begin with. A small island or an elevation in the pond bottom does for a starter. A burrow is made and covered with mud and sod, on which sticks are laid much as in building the dam. The interior is kept hollowed out as the work progresses. To permit ventilation, the structure is loosely built above the one big chamber which makes up the community house. These dome-shaped piles have been found with a diameter of as much as 37 feet.

There are always at least two entrances and they are below water. The old idea that an Englishman's home is a castle to be defended is not shared by the beaver. If his home is invaded by any of his enemies, he takes the shortest way out to water. The front and back door arrangement afford an easy exit to his favorite element.

Besides a lodge a beaver colony always has one or more burrows in the banks of a pond as additional refuges. One sometimes sees piles of logs and sticks in the water over entrances to holes. These may in time develop into lodges. The burrow is not, as some have supposed, the house of a different kind of beaver from the variety which builds lodges or houses. When the bank is used and not a house, it is because the stream is too swift or affords no suitable site for the lodge.

HUMAN LEVELS

One of the most amazing little organs in your body is an automatic equilibrator and compensator. It consists of a delicate system of six little fluid-levels hidden in the bones of the inner ear. Finer than the lead in a fine lead pencil, each one is about one-half inch long. These semi-circular canals, as they are called, are set in three planes at right angles to one another, something like the spirit tubes in a carpenter's level. The human fluid-levels not only tell us when we are moved, but they also start the nerve machinery which adjusts us to each new position without a thought on our part. Quicker than we can move a finger from a red-hot stove they start the compensating muscles into action. Eyes, neck, trunk, and limbs, all receive their proper reflex impulses.

Sometimes the signals get mixed, then we become confused, lost, nauseated, or seasick. Sometimes the fluid-levels fail us completely. We get turned around in the dark, lose our way in the forest, desert, or fog. When a landlubber tries to steer a boat out of sight of land he usually gets into trouble. Without a compass or some mark in the sky it is impossible for him to keep a straight course. In the fog the land has a habit *of shifting its moorings and bobbing np in* unexpected places. Even a compass often seems to point wrongly. The airplane pilot loses his bearings in the clouds. He may even turn upside down without knowing it, in spite of the telltale strain on the straps that hold him.

Psychologists have been busy recently testing this human compensator to see how reliable it is, how slow a turn will work it, when the signals are apt to get mixed. These are critical questions for aviation. It is not enough to ask whether the prospective air-pilot has an average instrument. He must know how far his instrument is trustworthy and how to correct its errors.

It is a familiar fact that, when rotation stops, a man seems to rotate violently in the opposite direction. One can try this experimentally with a revolving chair. The confusion produced by *this illusion of stopping is very noticeable and* often most disagreeable. If one rests his forehead on a cane and revolves around it as an axis he is ordinarily quite incapable of walking in a straight line for a considerable time thereafter.

Experiments on rats by Professor C. R. Griffith, of the University of Illinois, have shown that if you rotate them long enough the automatic equilibrators cease to compensate. Young rats born of such parents are well and happy only during rotation. Professor Griffith also found that a man may become so accustomed to rotation that the compensator ceases to operate in the usual manner.

Professor Raymond Dodge, of Wesleyan University, has shown that the sensitivity of the human compensators is between one and two degrees per second. They are not entirely reliable, however, unless the angular velocity is several times greater. It is possible to start accelerated motion so slowly that it is not felt until a much greater velocity has been reached.

Slow acceleration may reach very high velocity and be continued indefinitely without nausea or vertigo. If deceleration is also slow there may be no discomfort or disturbance whatever from the experience. It is the rapid starting and stopping that are disturbing. This is a lesson that the railroads are slow to learn.

With a new instrument which was built to imitate the gradual involuntary turning of an airplane in the fog, Professor Dodge has shown that during prolonged accelerated rotation the pilot thinks he is coming to a stop. After he stops rotating he thinks he is rotating violently in the opposite direction. After he has stopped rotating for some time a series of after-images of rotation may appear, first in one direction and then in the other. Every compensation after the first would have been false, and the first compensation would have been inadequate. These experiences explain some of the disasters of aviation. They show the necessity of definite training to utilize the data from the semi-circular canals only when they are likely to be adequate, to remedy their faults and inconsistencies and to train the pilot to rely on other sense data as the mariner relies on his compass.

WHERE WATER KINDLES FIRE

Setting fire to a stick of wood by putting it into water sounds like *Alice in Wonderland* or the strange adventures to which one is sometimes subject from retiring too soon after a large piece of hot mince pie. Yet it can happen. The experiment was actually performed in the wonderful valley of the Ten Thousand Smokes in southern Alaska by Dr. Robert F. Griggs, leader of the exploration parties sent there by the National

Geographic Society after the tremendous eruption of Mt. Katmai in 1912.

The Valley of the Ten Thousand Smokes is little more than a huge lid laid over an immense red-hot cauldron of volcanic fires lying at the foot of Mt. Katmai, the volcano which blew its head off in the terrific eruption of 1912. The valley is Y-shaped, about 9 miles long and from one to two miles wide. The floor of the valley, which is the lid of the cauldron, has been perforated by the imprisoned forces in countless thousands of places through which hot steam and other gases are continuously escaping, giving the valley its descriptive name. It is something like a cafeteria or lunch counter "steam table" on a gigantic scale.

Steam at ordinary atmospheric pressure at sea-level has a temperature of only 212 degrees Fahrenheit, which is not hot enough to set fire to any ordinary substance, such as wood; but the steam of these fumaroles is something different. It has just escaped from the red-hot volcanic material, or magma, underneath the floor of the valley, and is therefore hot enough to set fire to wood shavings, although not much above atmospheric pressure.

Dr. Griggs and his companions made use of this gigantic steam kettle as a cook-stove during their explorations of the valley, but they found some of the blow-holes were altogether too hot. They would corrode the cooking utensils although nothing was coming out of them in most cases but pure, dry steam. It occurred to Dr. Griggs to see if it were not possible to set fire to a stick of wood by putting it in the steam, which of course is nothing but pure water in a gaseous state.

The end of a walking-stick was cut into a brush of shavings and thrust into a fumarole. It soon began to smoke and to char, indicating a temperature nearly if not quite that of red heat. But wood will not burn in steam. It needs oxygen for combustion, and so the smoking and charred stick was quickly pulled out into the air. It immediately burst into flame, since it had been heated to about the temperature of combustion and needed only oxygen to burn. But it was the steam that really kindled the fire, so Dr. Griggs may truthfully state that he started a bonfire by putting the kindling wood into water.

Nobody has attempted to calculate the energy which is going to waste in the Valley of Ten Thousand Smokes. Red-hot steam or even superheated steam, as steam heated above 212 degrees to only a moderate extent is called, has much more energy than steam at normal pressure. If the steam from all these fumaroles could be harnessed to engines it is probably well within the bounds of accuracy to estimate the available energy as

A LONG-RANGE LIGHT

The Signal Lamp on the top of a mountain peak, fed by a few dry cells, was seen 150 miles away. *See* page 225.

MAKING A DINOSAUR USEFUL

A Dinosaur head serves as a model for a bookend. (U. S. National Museum, Washington, D. C.) *See* page 233.

enough for all the requirements of power, light, and heat of several great cities.

Italian engineers have made use of the heat of the hot springs of Lardello and of borings on the mountain-side of Vesuvius to get steam for running engines, but such a scheme in Alaska would at the present time be quite impracticable. Aside from the immense technical difficulties, there would be no use for any power which might be harnessed, as there are no settlements in the Katmai region, and the power could not be economically transmitted to where it might profitably be used. The Valley of the Ten Thousand Smokes has been made a National Monument and will therefore remain as an unspoiled wonder of the world for years to come.

150 MILES OF LIGHT[1]

On top of a mountain peak in Arizona one night a small electric lamp stood, fed only by a few dry cells. Over 150 miles away on another peak a man was stationed. Would you imagine that that small lamp and the unaided eyes of the observer, thus widely separated, could aid in making a map for Uncle Sam?

Yet the man could see the signal light. It appeared to him a little less brilliant than the familiar star, Polaris, that shines above. Because

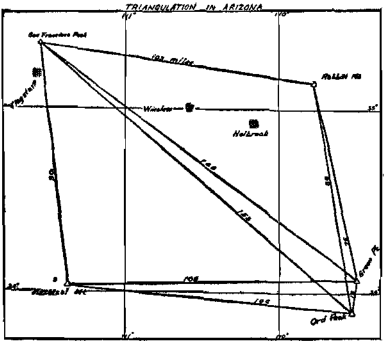
[1] See illustration facing page 224.

the rays from the lamp could span this distance, the backbones of maps of this country are being made more cheaply and accurately.

In geometry classes it is taught that if the length of one side and the size of two angles of a triangle are known, you can find out all about the triangle by simply figuring. This geometric procedure makes the construction of the map skeleton easier than would otherwise be the case. A long line is very accurately measured and from its two ends the angles to another point are measured by this small but powerful lamp. The observers at the three points of this large triangle, laid out on the surface of the earth, must be able to see objects at the lower points. The lamp provides a perfectly straight connection between the points.

Field parties of the United States Coast and Geodetic Survey are gradually spreading a great net of triangles over the entire United States, and every knot in the net becomes a known and fixed point from which mapping or surveying can start.

Over short lines it is comparatively easy for observers to sight other stations, but it becomes more difficult as the lengths of the lines are increased. Also atmospheric conditions in the daytime are not very suitable for accurate observations, and therefore most triangulation in recent years has been done at night by the use of signal lamps. Older lamps did not give sufficient light for observation over long lines, but the new lamp designed by the experts of the survey has been seen over the longest line.



THE LINES IT HELPS TO RUN

During triangulation in Arizona an observer on San Francisco Peak, an altitude of nearly 13,000 feet, saw with the unaided eye the electric signal lamps operated at the most distant stations, 153 and 147 miles away, and was able to complete the observations on them without any delays. They were very distinct objects when viewed through the telescope of the theodolite, which has a magnifying power of about sixty diameters.

The length of the 153-mile line is approximately the air-line distance from Washington to Trenton, N. J., or to Norfolk, Va. Imagine, now, a small portable lamp showing a light at Trenton or Norfolk which could be seen with the naked eye from Washington. The lights would have to be sufficiently elevated to make the two points intervisible because of the curvature of the earth. If there were mountains at Washington and Trenton, the lights would have to be on mountains roughly 3,300 feet high at both places in order that the lights at one place could be seen from the other. Or if there were a single mountain at one of the cities it would have to be 13,000 feet high in order that the light on the ground at the other end of the line might be seen.

The lamp is a simple automobile headlight with a bulb having a concentrated filament especially designed to concentrate the light as nearly as possible in one point. The theory is that with the ordinary automobile headlight reflector, a cross-section of which forms the curve of a parabola, all rays of the light are reflected in parallel lines and consequently are confined to a very small arc. For good results the lamp must be accurately focused and pointed to the distant observer.

Seven ordinary dry cells, connected in series, light the lamp with maximum efficiency.

More powerful lamps or searchlights cannot be used because, with all the necessary equipment, they are too heavy to be carried to the tops of mountains. The requirement for work of the Coast and Geodetic Survey was to get a lamp of sufficient power, yet one which was not too heavy to transport to high mountain stations. The new electric signal lamp weighs 25 pounds in the carrying case, and the full set of batteries with their carrying case weighs 63 pounds, the total weight of the lamp and equipment being 88 pounds.

THE HEAT OF A STAR

Choose a dark night, with no moon visible. Then pick out a star, anywhere you please, and with a thick canopy of clouds cover up all of the sky but the place where the star shines through. Now if you hold out your hand you will not notice that it is appreciably warmed by the radiation from the star, and yet there is enough heat falling on your hand for scientists to be able to measure it quite accurately, using a very delicate and sensitive instrument, called the thermocouple, as a detector.

It has long been known that if the ends of a wire of any metal are soldered to those of a wire of a different metal, and one soldered junction is heated hotter than the other, an electric current will flow through the wires. By making these much finer than a hair, and using a very sensitive instrument to measure the current flowing through them, it is possible to make such a thermocouple so sensitive that one can tell when one junction is a millionth of a degree hotter than the other. If the thermocouple is placed in a vacuum it becomes still more sensitive—so sensitive, in fact, that a candle miles away sends enough heat to affect it.

In some of the most delicate vacuum thermocouples used at Mount Wilson Observatory in Southern California to study the heat from stars, one wire is of bismuth and the other of a mixture of bismuth and tin. The heat from the star under observation is collected by a huge telescope and focused on one junction of the thermocouple, which is coated with a black paint so as to absorb all the radiation falling on it. Then the amount of heat which it receives from the star in a given time can be measured by observing the deflections of the delicate current-detecting galvanometer.

According to measurements made by Dr. W. W. Coblentz of the Bureau of Standards, by using a three-foot telescope it is possible to measure radiation equivalent to that given out by a candle fifty-three miles away.

If, now, we turn the telescope so that it points toward the Pole star, we find that enough radiation falls upon a square inch of the earth's surface from this star alone to bring a pint of water to a boil in a little over a billion years, provided no heat is lost once it gets into the water. Taking all the stars together, we get enough radiant energy to boil the water in a thousand centuries. And yet the sun would do it in six months running time, under the proper conditions.

In spite of the fact that our sun gives us so much more heat than any star or all of them put together, with the moon thrown in, there is hardly a single one of them that would not outweigh it in every respect. Most of them are suns larger than our own, and many of them are hotter, but they are all so very far out in space that practically all of their heat radiates away without coming anywhere near us; at any rate, only a very small portion of it ever gets caught by a telescope to warm up two tiny soldered bits of wire.

HOW OLD IS THE OCEAN?

This is not a new variation on "How old is Ann?" but a problem in geology which attacks speculative scientists now and again. And although they can not look into the ocean's mouth and read its age, they find various roundabout ways of estimating its antiquity.

The very brininess of the briny deep is the feature that is used in the computation. Common salt—such as gives the sea its taste—as every one knows, is composed of two chemical elements, sodium and chlorine. Now sodium conveniently differs from most other things that come to be dissolved in the sea water in that little or none of it is precipitated or dropped to the bottom, however long a time may elapse.

Hence, if we know how much sodium the rivers of the world annually discharge and how much sodium there is now in the ocean, it is a simple calculation to determine how long it has taken for the rivers to bring down all this sodium—i.e., what is the age of the ocean, for:

$$\frac{\text{Sodium in Ocean}}{\text{Annual Sodium in Rivers}} = \text{Age of Ocean}$$

Now there are something over 14 million million metric tons of sodium at present in the ocean, and the rivers are dumping it in at the rate of over 158 million tons annually. If we do the arithmetic we find that the age comes out at about 89 million years.

A number of corrections, such as those worked out by Dr. F. W. Clarke of the U. S. Geological

Survey, should be applied to this figure, but when all are made the total remains between 70 and 100 million years. This is on the assumption that the rate of erosion of the land has been the same as now, which is doubtful, but evidence from divers other sources indicates that the figure is somewhere near right.

MAKING A DINOSAUR USEFUL[1]

Elephants and angels, monks and monkeys, as well as various other creatures, have been used as models for book-ends, but it has been left to an ingenious geologist, Charles W. Gilmore, of the United States National Museum, to turn the head of an extinct reptile into a work of art and set it to the task of keeping a row of books from toppling over.

He has chosen for this purpose a dinosaur that lived in North America some six million years ago and is known as Triceratops because of its three horns. The monster is also distinguished by a bony frill attached to the back of the skull which must have been a good protection for his neck in a frontal fight, but here serves as the back of the book-rest. In adapting the skull for this purpose, Mr. Gilmore has reduced it from six feet to six inches and filled in the bare bones with flesh and skin of bronze. The friendly grin and the

[1] See illustration facing page 225.

twinkle in the eye give us a more favorable impression than we are apt to get of such pre-historic monsters, but nobody can say he is wrong in his restoration, for the last dinosaur was dead many million years before photography was invented.

CLIMATE IN THE COAL AGE

What kind of weather prevailed when coal was in the making? Every one knows now that coal was formed from plants; evidence, in the shape of fern-like leaf-prints and even traces of stems, can be found in almost any coal-bin. To make the quantities of coal that lie beneath the earth's surface must have required an immense quantity of plants, growing through an unimaginably long period of time. Since the climatic environment is a principal factor in determining the nature and rate of plant growth, and is also important in establishing the conditions under which the dead plants are preserved as coal, the question of the climate of the coal age has been one of the most discussed in the whole field of historical geology.

The picture of coal in the making as it is usually presented is one of immense swamps filled with huge tree ferns, gigantic horsetail rushes, and several other strange plants that have no living counterparts. The climate is commonly described as tropical, murky, and heavy. There were no broad-leaved trees, no evergreens such as we now have, no palms, no flowers. The dark and sluggish waters were thick with the fallen fronds and stems, piling ever deeper and thicker on the black muck.

This picture is partly correct, but certain details need correction in the light of modern research. For one thing, the supposed ferns were not all ferns. Recent discoveries have shown that part of them—perhaps most of them—belonged to a race of plants that existed almost entirely during the coal age, plants that had leaves like ferns, but that bore seeds; and no true fern ever bears seeds. They were, indeed, a sort of missing link between the ferns and the higher world of seed plants.

There are also certain strong reasons for believing that coal was not formed under tropical climatic conditions. The process of the formation of coal is pretty well known, and all the stages can be found to-day somewhere or other on the earth. The masses of plant material passed through successive steps, first as peat, then as lignite, then through various grades of soft coal, finally reaching anthracite. Each step involved the loss of watery, oily, and gaseous materials in the plant and the refinement of the remaining substance into purer carbon, and also the addition of pressure either through the piling on of shale and slate from the mud above or through the stress of rock-folding from below. Peat, the first of these stages, is in very active formation at the present time in several parts of the earth, notably Ireland and the "muskegs" of Canada. The notable thing about these peat-forming areas is that they are all far from the tropics, but still have relatively mild, moist climates in spite of their high latitudes. Certain kinds of palms can remain out of doors through the winter in southern Ireland, and holly and tree arbutus are native to that country. In New Zealand, which has a climate much like that of the British Isles, the finest tree-ferns of the world flourish. In the Canadian muskegs the peat-forming plants are mostly mosses, but these grow with astonishing rapidity. A tropical climate, then, is not essential for either the kind or quantity of plant life necessary for the eventual formation of coal.

Another consideration makes it improbable that the coal-plants grew under tropical conditions. Not only are all important peat-bogs of the present day in temperate regions, but practically all important deposits of coal and lignite lie outside the tropics as well. Some of the latter, to be sure, occur considerably farther south than any of the modern peat-bogs, but that is not a serious objection, for there are abundant evidences that during past geologic periods temperate-zone conditions have repeatedly advanced south and retreated north again.

Indeed, the very existence of a true bog (as distinguished from a swamp) seems to be correlated with a temperate climate. A swamp, or fen as it is called in England, is a marshy place that has surface drainage; its water therefore does not become acid or "sour," and plant material that falls into it decays completely. A bog, on the other hand, has no surface drainage, and its water becomes acid. In this acid water the bacteria and low forms of animal life that cause decay cannot thrive, and whatever falls into a bog is preserved. Corduroy roads built in Britain two thousand years ago by the Romans have been dug out of the peat, their logs still in perfect condition. It is this preservative action of acid water that makes it possible for plant remains to accumulate in bogs, forming peat, which, as has been pointed out, is the first stage in the making of coal. But while swamps exist in all parts of the earth, and reach their highest development in the tropics, true bogs can be found only in moist temperate regions. It is therefore entirely probable that during the long coal-making ages the climate of what are now the coal fields was not that of a reeking African swamp, but more nearly like the cool, misty, moderate weather of Ireland.

THE EVOLUTION OF THE USELESS

"What is the use of it?" was the question that used to be asked by an investigator when he found a strange structure or substance in a plant or animal.

He then set himself to finding out the use of it, and sometimes when he could not find out for sure what it was good for he invented a more or less plausible reason for its existence and peculiarities. It never occurred to him that the reason he had difficulty in getting an answer to this question *might be that there was no answer to get*. For if the investigator lived three generations back, in the age of the "Bridgewater Treatises," he assumed that a living creature was constructed like a machine, where every part has a purpose. If he lived two generations back he assumed that all parts and peculiarities of plant or animal were developed from the accumulation of minute favorable variations and, therefore, were, or at least had been, of value to the creature in his struggle for life. This was the theory of "pure Darwinism," but we must remember that Darwin himself was not a pure Darwinian, just as Karl Marx always refused to be classed as Marxian.

But the biologists of the present generation have given up the expectation of finding a use for everything, for they do not now assume that everything is useful in the sense of being a benefit to the creature possessing it. The characteristic under consideration may be an accidental or inevitable accompaniment of its general development. It may be a mere by-product of its life process.

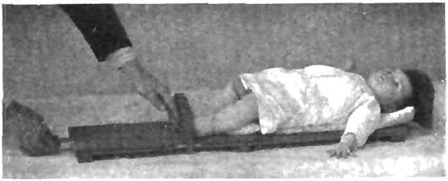
This modern point of view was expressed by A. G. Tansley, president of the Botanical section of the British Association for the Advancement of Science at the Liverpool meeting, when he said:

> An organism may produce parts which are useless or even harmful to it, provided that the whole is still able to carry on and reproduce itself in its actual conditions of life.
>
> In regard to a multitude of characters there is not only no proof but not the smallest reason to suppose that they have now, or ever did have, any survival value at all.

This view will relieve the zoölogists and botanists of a lot of the bother they have had in trying to hatch up reasons for everything. Formerly, when a plant was found to contain something poisonous or bad tasting, the botanist "explained" it by assuming that the noxious compound was put there or developed because it kept the plant from being eaten. But the compound is formed by the chemical reactions of the plant's vital processes and it may or may not be a protection to it.

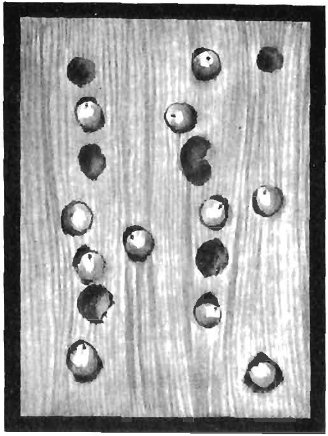
So, too, when the old-school entomologist found an insect that looked hideous to human eyes, or that gave off an odor that was disagreeable to human noses, he assumed that the bug appeared or smelled as horrible to the birds that prey on it as it did to him, and, therefore, its enemies avoided it. Perhaps that was so—and perhaps it wasn't. A skunk undoubtedly makes use of its poison gas as a weapon of defense, and it certainly is an offensive weapon. But many a poor bug may exude an odor quite as bad in proportion to his size and yet not get any benefit from it. Doubtless he has become so used to his odorous aura as to be quite unconscious of it, and often wonders why he is not more popular in society.

A scientist from Mars studying our earthly ant-hill would be quite puzzled to understand why the automobiles shot out jets of ill-smelling smoke until the happy thought occurred to him that it was for the purpose of preventing pedestrians approaching too close and perhaps climbing on behind. He would wonder why heaps of shale were stacked up around our coal mines. But he would consider the question solved when he surmised that they could serve as ramparts in case



MEASURING BABY'S LENGTH

Even a squirming baby can be accurately measured on this new board. (Bureau of Standards, Washington, D. C.)



WOODPECKER PSYCHOLOGY

A California woodpecker at work.

Acorns stored in a fence post.

See page 243.

the mine mouth were attacked by a mob of strikers.

Man may be "the measure of all things," as Protagoras said, but he is liable to mislead himself when he attempts to put his own meaning into nature.

MEASURING BABY'S LENGTH [1]

Not content with devising means of measuring accurately such different things as the electrons in a molecule, radio waves, or temperatures close to the absolute zero, the government scientists at the United States Bureau of Standards have invented a method for measuring the length of babies. It is said to be superior to those formerly used in that it almost altogether eliminates sources of error due to the squirming proclivities of infants.

Dr. Wilmer Souder designed the new measuring board at the request of the Children's Bureau of the Department of Labor, and it is to be used by that bureau and the institutions coöperating with it in a campaign for improving the health and development of the nation's children. Deviations from the normal rate of growth are indications of irregularities in health or nutrition, and consequently the more accurately they may be measured the more speedily and definitely it is possible to begin corrective measures.

[1] See illustration facing page 240.

The old-fashioned measuring board had a rigid headpiece and a movable footpiece attached to a scale. Baby was placed on the board, his head supposedly against the headpiece. Then the footpiece was shoved up against his feet, and the length of the infant measured—in theory. What frequently happened was that baby complained more or less forcibly and was propped up or jammed against the headboard, making him appear too short, or he squirmed and stretched, adding perhaps half an inch to his stature.

The new board has both end-pieces movable, and these are adjusted practically simultaneously to each end of the baby irrespective of his actual position on the board, reducing former errors by 90 per cent. When it is realized that an error of from a quarter to half an inch amounts to as much as the average thirty days' growth of the average baby, the importance of having an accurate method may be estimated.

The illustration shows a baby being measured. The system is simple, quick, and efficient from the scientist's point of view. From the point of view of the baby it seems to be painless, but uninteresting.

WOODPECKER PSYCHOLOGY [1]

Sometimes we see a young bird or animal do things without having first "learned" how. Often we regard such instinctive activity as something uncannily accurate, so much so that at times we fall into the habit of thinking of instinct as more efficient than intelligence and become confused in trying to distinguish between the two. What is intelligence? And what is *instinct?*

Take the acorn-storing habit of the California woodpecker, for instance. Here is a provident bird apparently exercising more intelligence than the man who passes by the savings-bank on pay-day. From its countless ancestors, it has acquired this apparent foresight in securing itself against the proverbial rainy day.

More astonishing still are some of the things which the scientist has observed in watching how these red-capped animated drilling machines work. For they bore the hole to fit the nut. The holes made in live-oak trees are made too small for black oak acorns. This fitting of the nut snugly in its store-house in the side of the tree protects the woodpecker's future food supply against rain and marauding animals, who might otherwise convert the acorns to their own use.

Nor are these apparently made-to-measure food containers the only wonders which the tape-line

[1] See illustration facing page 241.

and field-glass of the naturalist have revealed. Dr. William E. Ritter, of the Scripps Institution for Biological Research in California, who has studied these feathered harvesters, has found that they have regular rest periods. Once he observed a 15-minute lay-off that began at 8:45 o'clock. The birds had begun their daily drilling and harvesting at six o'clock in the morning.

These three facts alone would seem to indicate an efficiency such as the experts plan out in human factories to obtain the best results.

But Dr. Ritter and others have found that these California woodpeckers are really not very efficient after all. Supplies are laid up where they are never used or never could be recovered. Some of the nuts are placed in holes too small for them. Others slip into the holes easily, but nevertheless the woodpecker hammers them in whether they need the hammering or not.

The Bible says that when children ask for bread we shall not give them a stone, yet that is just what the foolish woodpecker does to himself. Often he places stones in the holes he has drilled instead of nuts, although the stones certainly do not look or feel like acorns.

And in doing all this there is much waste motion, a dozen little side acts which Dr. Ritter says remind him strongly of the momentary stopping of a small boy who, when running on a family errand, picks up a rock and throws it, more or less aimlessly, at a telegraph pole or any other object that may happen to be near. This wasting of time and effort, the storing of nuts which are never used, and of rocks that can never be of use, involves much loss of labor and time.

But, you ask, what has all this to do with the difference between instinct and intelligence? Just this, according to Dr. Ritter's interpretations: The wastefulness shows bad control of a valuable food-storing instinct. Intelligence is just Nature's way of controlling the instincts.

Acorns might be used as a criterion of the intelligence of those who use them. The woodpeckers, squirrels, rats, mice, and other wood folk serve their nuts in the shells without much preparation. The Indians ground the acorns into meal for bread and also used as food some of the acorn-consuming birds and animals. The white man does not directly add the fruit of the oak to his menu, since he can make the Indian's former domain yield food more profitably and more tastily. But the white farmer finds that it is good crop economics to let his hogs grow fat on acorns for a part of the year.

WHY JELLIES JELL

Epicures and dietitians alike bless the inventor of jelly, or perhaps the inventress, for it was surely some housewife puttering away at the cook-stove who discovered a quivering mass of delicious sweetness in one of her fruit pans that had been cooling outside of the window. But she and her friends, and the rest of her sex from that time on, have found out that the process of simmering, straining, boiling, and sugaring must be most carefully watched if just the right firmness is to be obtained.

Scientists have recently become much interested in just this process, and because it is their chief indoor sport to ask why, and then answer their own questions, they have looked rather deeply into this business of why jelly jells. Although there is still much to be learned, some interesting discoveries have already been made. One is that fruit juices need three substances in order to form a jelly: these are acid, sugar, and pectin.

Every jelly-maker knows that if the fruit is too ripe it will not make a stiff jelly, or perhaps not even jell at all. That is because the natural acids of the green fruit have been changed almost entirely to sugar by the ripening processes. The very simple remedy is therefore to put in a little extra acid, such as citric or tartaric, which are natural fruit acids. The second necessary ingredient, sugar, comes in part from the sugar of the ripe fruit, but often this is not enough, and a cupful of cane sugar to each pint or so of juice is used, and is added hot by the careful cook just before the final simmering of the strained juice. Finally, the pectin that is necessary comes from the fruit. Not all fruits contain enough pectin to make a jelly, and this is why apple-juice and citrus peels are often added, for these fruits contain an excess of pectin.

So jelly-making has become much more certain because the scientist had to find "why." The rules are so simple that any one who can successfully make water boil without burning it can be pretty sure of being able to turn out a good looking batch of jelly.

Jellies made with gelatin are very different from fruit jellies. For one thing, there is no pectin in them, the jellying substance being the purified gelatin itself, obtained from animal cartilage and bones, and not from fruits.

It needs neither acid nor sugar to form a jelly. The color, flavor, and sweetness are really nothing but impurities in a gelatin jelly, for this, when pure, is colorless, odorless, practically tasteless, and in addition has comparatively little food value.

The peculiar property it has of forming a jelly with water is so characteristic of it that the scientist usually spells the word "gel" instead of "jell." Just why gelatin should act the way it does is not yet fully known, but it is believed that the molecules of gelatin, which are quite big, form chains when the solution cools, which become semi-rigid, making a stiff network that holds the water in its pores. This seems at least a reasonable explanation for the really wonderful property and the ability a fruit jelly or the scientist's gel has of keeping such a large amount of water tightly held up in it.

THE MODERN THEORY OF EARTHQUAKES

Earthquakes are a natural occurrence in certain regions of the world where the mountains are alive. There are districts, like the Atlantic Coast, where they are dead, but around the Pacific and in a great belt which reaches across Asia and the Mediterranean the mountains are growing. In their growth large masses comprising many thousand cubic miles of rock are pressed against each other but are held by friction until the strain becomes too great. They then slip and an earthquake occurs.

This is the modern theory of earthquakes. It was developed through the studies of the great earthquake of 1906 which caused the fire that destroyed San Francisco, and it has been demonstrated since by observation of many minor earthquakes and by a study of the lines along which they occur.

We often speak of an earthquake plane as a fracture, but it is not really a break. It is the surface between two great masses which never have been united, but which for ages have been slipping past each other; and where this plane comes out to the surface of the earth we have a line which is sometimes called an earthquake rift. The greatest of these rifts, so far as it is known, in the United States extends through the Coast Ranges of California for a distance of six hundred miles. It passes just west of San Francisco, to the east of Los Angeles, and disappears in the Gulf of California. Along the San Andreas rift, as it is called, earthquakes have occurred at different sections. The most recent was the quake of 1906, which covered a stretch of 150 miles with San Francisco near the center. South of that stretch for some 300 miles there has been no movement since 1857, when there was a severe shock, the mark of which may be traced across the desert plains like an irrigation ditch. Still further south there have been several recent shocks, but none of great violence, although there is evidence of considerable activity in the section east and south of Los Angeles.

In view of the fact that we can thus locate certain lines along which earthquakes have occurred, we are able to speak of live earthquake rifts as we speak of live volcanoes. We know by the form of the volcano or by the occurrence of eruptions within historical time that it is potentially or actually active, and much the same may be said of earthquake rifts. They are lines of special danger on which no dam or schoolhouse or skyscraper should be located. They should also be avoided, as far as possible, by railroad lines, bridges, aqueducts, and other public works, and yet it happens that they often run through valleys where such work is suggested by the conditions of the ground. As long as we remain ignorant of their position, we run the risk of inviting destruction, but it is not difficult by proper studies to locate the lines of danger on a map and to make the information public for the benefit of engineers and others.

It may perhaps be asked of what use it is to study a phenomenon which is as sure and as inevitable as an eclipse of the sun. Since we can not stop it and probably can not predict it with certainty, what practical benefit can we hope to derive from an investigation of it? There is, of course, the answer that we wish to know; we wish to understand our earth and all its manifestations; but apart from that, as has already been pointed out, the lines along which earthquakes are likely to occur and are most dangerous may be determined, and it seems not impossible that if we can perfect our knowledge we may be able to devise methods of forestalling their disastrous effects by the selection of safer locations or by appropriate methods of construction. It is clearly recognized, for instance, that the catastrophe of San Francisco was in large measure due to the fact that its principal aqueduct followed the earthquake rift for many miles, whereas now it has been located along a mountain range which, if it moves, will move as a block and will not dislocate the pipe line.

FIFTEEN MILES OF ROOTS TO A SQUASH VINE

One little squash plant sitting in the garden row needs fifteen miles of roots to extract its daily food from the moist soil around it. Each of the waving corn stalks that dot the fields of America has roots that will total about a thousand feet in length.

The little delicate root hairs that are to be found sticking out of the root tips are largely responsible for the immense mileage of the root system. It is these nearly microscopic hairs that absorb the potassium, calcium, sulphur, magnesium, and other crude food compounds that are taken up from the soils and fertilizers by the water in the ground.

The way in which this transference of food is accomplished through the membranous walls of the tiny rootlets is known to scientists as "osmosis," otherwise "soaking through." That may not mean much to the butcher, the baker, or the candlestick maker, or even the farmer. But it means everything to the plant. If osmosis can not go on because the soil water has been made heavier or of greater density by the addition of salt, say, the plant will just wither up and die.

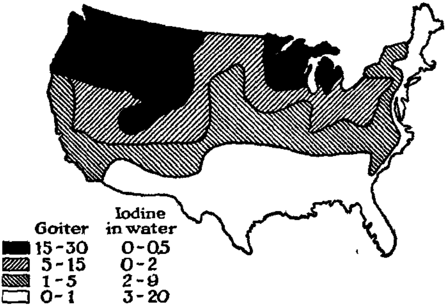
Not only does the mileage of the root system seem incredibly large in some cases, but some plants seem to be striving for the honor of being nearest the lower regions. The mesquite probably achieves farthest down, for scientists say that in the desert regions of the great southwest its roots may be found 100 feet in the ground. This long downward journey is taken in search of liquid refreshment, and the travelers, settlers, and natives of Texas and Mexico use the mesquite as a guide to the best location for wells.

IODINE AND GOITER

For a number of years it has been known that simple goiter was prevalent in certain districts while other localities were practically free from it. In the United States the Great Lakes region and the Northwest are the sections in which it is most severe, while in Europe, Switzerland and the territory bordering on this inland republic, which is shut off from the ocean breezes by the Alpine barriers, are particularly subject to it.

Recent discoveries indicate that goiter results when an insufficient supply of iodine is offered to the body. This hypothesis has been supported by the fact that the administration of small amounts of iodine compounds not only prevents the onset of this abnormal condition, but will often cure it if it already exists. Professor J. F. McClendon of the University of Minnesota showed that the amount of iodine present in water from various sections of the country is inversely proportional to the incidence of goiter in that particular locality. For example, as the map indicates, the localities in which the amount of iodine is the greatest in the water have the smallest amount of goiter and *vice versa.* While the supply of this element in the drinking water is never sufficient to meet the needs of the body, the amount present there is a rough indication of the proportion contained in the soil, which, in turn, represents an available source of this substance for animals indirectly through what is stored in the vegetables and plants which they eat.

Along the sea coasts, as is well known, instances of goiter are rare, since the sea spray, which is relatively rich in iodine, carries a supply of it for a long distance inland. Throughout the southern states, the goitrous condition is rare also, since the iodine present in the soil is much more abundant there than it is in the Great Lakes region.



IODINE AND GOITER

Map of the United States showing that goiter is most common where iodine is scarce in the drinking water.

When an insufficient amount of iodine is supplied to the body, the thyroid glands, which under usual conditions in the adult are two small organs about the size of hickory nuts, gradually enlarge in an attempt to meet this deficiency. The swelling of the neck which results is then known as goiter. Not only man but most of the higher animals are subject to this abnormal condition. Goiter is common in oxen and dogs in the Great Lakes region, while a decade and a half ago it was likewise causing large losses among Michigan sheep growers. By chance the sheep obtained iodine which was present in the salt from the newly mined salt deposits of that district and the deformity disappeared.

Hogs are also susceptible to a lack of iodine, and considerable interest was caused by the large mortality of pigs in Montana some fifteen years ago. Litters of large-necked, hairless pigs were a frequent occurrence there, most of the animals being born dead or dying soon after birth; this condition has since been rectified, however, by supplying the mothers with a small amount of iodine which was lacking in their food. Goiter was even found in the case of brook trout of certain hatcheries in Pennsylvania about 1910, where the artificial food given the young fish contained insufficient amounts of this substance. On the addition of iodine-containing foods to their diets the enlarged thyroid glands of these fish returned to normal size.

The full value of iodine in preventing goiter in human beings has been conclusively shown only recently. Dr. C. P. Kimball of Cleveland supervised the administration of sodium iodide to the children of the Akron (Ohio) public schools, the total dosage of one fifteenth of an ounce being given over a ten-day period twice each year. In this district a large percentage of the school children are goitrous. The treatment was voluntary, and about one half of a total of 5000 children studied chose to follow it. In the few years that the test has been carried out, goiter has been entirely prevented or, in cases where it already existed, markedly improved or wholly cured, when sodium iodide has been taken. On the other hand, in the group which refused the treatment, an increasing amount of goiter has appeared with augmented severity since the beginning of the test.

It is now believed that goiter, a pathological condition which is so ancient that reliable records are known of it as far back as 2000 B.C., is preventable. The simple expedient of adding a small amount of iodine in the form of an iodide to our table salt has been suggested as a preventive measure. If this or some other effective means is applied for supplying the needs of man and animals for iodine in the districts where an insufficient amount of this substance is found in the foods and the water for normal requirements, goiter in the future may become an almost unheard-of ailment.

THE LONG RULE OF A SHORT THUMB

The race is not always to the swift nor the battle to the tall, to paraphrase Scripture slightly. That length of days and length of stature by no means run parallel is strikingly illustrated by the death as late as 1921 of that tiny celebrity, the Countess Magri, better known all over the world as Mrs. Tom Thumb, wife of the equally famous dwarf, General Tom Thumb.

As the Countess died in her seventy-eighth year and was only thirty-two inches high, she attained almost two and a half times as many years as she did inches, at which rate the average of us would live a century and a half and the fortunate six-footers nearly two centuries. This is a span of life which not even the most enthusiastic of health reformers and life extensionists hope to reach.

Moreover, this wonderful little lady excelled the average of us in proportion to stature in brains as much as she did in length of life. For fifty-five years she was a brilliant success as an entertainer, traveling half over the civilized globe and retiring with a world-wide reputation and a handsome fortune which she conserved and managed until the day of her death.

The interesting feature about her success is that it is not exceptional but rather according to the rule. In spite of the fact that we all long to be tall, if we were compelled to choose between the two extremes of human stature, it would be safer to choose the short. The average dwarf who comes before the public is longer-lived, keener-witted and more successful in life than the average exhibition giant. Indeed it is hardly too much to say that the giants are almost as short-lived as they are long-bodied, so that our prayers ought to stop short at six feet. A series of twenty exhibited giants and giantesses whose histories were studied showed an average age at death of about 24 years.

Curiously enough, both these extremes of stature appear to be associated with changes in the same gland, the pituitary, a little rounded body lying at the base of the brain. In many giants this is found strikingly enlarged, often from thirty to forty times its natural bulk, while in some dwarfs it is shriveled, part of it being turned into fibrous substance. Moreover, if an extract of this gland is fed to young animals it produces a remarkable effect upon their growth.

Another type of dwarfism, known as cretinism, is due to under-development of another gland, the thyroid. This is the gland lying in the front of the neck on either side of the wind-pipe the enlargement of which makes the well-known goiter, or "big neck." Unfortunately, in this type of dwarf, mental growth is checked even more than bodily and though great improvement can be produced in these cretins by feeding them with the extract of the thyroid gland of the sheep, they can never be brought up to anything like full mental vigor.

The contrast between these two forms of dwarfism is further shown by the fact that cretinism is strongly hereditary, while healthy, intelligent dwarfism is scarcely so at all, most of the type being born of parents of normal height, as was illustrated in the case of Mrs. Tom Thumb and both her husbands. Her parents and several brothers and sisters were of average height, though she had one sister, Minnie Warren, who was even shorter than she was and who used to travel with her on exhibition tours. Her second diminutive husband, Count Magri, had one sister who was also a midget.

Exceptional cases of this sort backed by experimental studies in the laboratory are rapidly increasing our knowledge of the uses of the so-called ductless glands and of the secrets of human growth and development. This has already yielded remedies of great value in the control of disease conditions and especially greater power over arrests of development of various sorts.

The time may not be far distant when, by the use of these literal "nature's own remedies," combined with scientific feeding, we may be able to control growth and stature, within healthy limits, almost at will.

HOW LONG CAN AN ANIMAL LIVE WITHOUT FOOD?

Knowledge which has been gained from carefully planned and supervised experiments demonstrates beyond a doubt the fallacy of the ingrained popular belief that life may be quickly endangered through fasting. Of course, whenever men have been exposed to starvation through the hazards of their occupations, as for instance shipwrecked sailors and buried miners, their suffering has been extreme and intense. It should, however, be borne in mind that under such circumstances the suffering has been due less to actual privation than to other causes: exposure to cold, poor air, and above all the mental agony of the suspense between life and death.

There are many authentic records of human beings who voluntarily have endured complete abstention from food for periods of sixty or seventy days. The Shravaks, a sect of religious mystics in India, undergo yearly a fast of about thirty days, and in our own country a number of persons have fasted for periods of fifty days and longer either by way of protest against some injustice they were otherwise powerless to avenge, or out of sheer bravado, or with the idea of regaining lost health.

Since a highly developed organism like that of a human being can subsist without food for a long time, it is not surprising to find that among the lower animals existence under inanition may extend over incredibly protracted periods. Scorpions are known to have starved for 368 days, and spiders have survived starvation for seventeen months. The larvæ of small beetles have been known to live through more than five years without food, their body mass being reduced in this time to only one-six-hundredth of what it was at the start. There is a unique record of a fresh-water fish, Amia Calva, which fasted twenty months and even then had not yet apparently reached the end of the rope but was killed. Frogs survive starvation for sixteen months, and snakes remain alive even after two years of fasting. The longest recorded fast endured by a dog was 117 days, or nearly four months. Of course, in all these instances of starvation the animal, deprived of income, must draw upon its capital to cover the expenses of subsistence. Life will endure as long as the reserve capital lasts.

THE MOTH AND THE FLAME

Why does the moth turn towards the flame?

We used to say that it was "attracted" by the light just as the human moth is lured to the "white lights," but more careful observation has shown that the insect's response is most rigid and mechanical. The moth is a slave of the lamp which directs its movements and compels it to turn automatically.

When light is thrown sidewise on the insect it tends to turn until its two eyes are equally illuminated. If beams are thrown from each side simultaneously so that one strikes one eye and the other the other eye, the insect will not move in the direction of either light but rather along a line midway between them. Its movement is like that of a little sailboat in a tub with two children blowing equally from either side. If one of the boys blows harder than the other, the boat will travel off at an angle which could be calculated beforehand providing the relative strength of the two "blows" was known. Similarly, in the case of insects illuminated by two lights of different, measured intensities thrown from opposite sides, the path the animal will travel can be mathematically determined. This experiment has been performed with the larvæ of the blow-fly by Dr. Bradley M. Patten.

Dr. Jacques Loeb, the noted physiologist of the Rockefeller Foundation, would have explained this reaction of insects after the manner of what the physiologists call "forced movements," and classified it as a "phototropism."

The muscles of the body are always in a state of tension or tautness, thereby maintaining the proper bodily position. If one side of the brain is damaged, the muscles on the opposite side of the body will lose their tension. When an animal in this condition starts to walk it will, so to speak, push harder on one side than on the other and hence move in a circle.

The effect of light falling sideways on an insect is to start chemical changes in one of its eyes. This photo-chemical change affects one side of the brain, thereby reducing the tension of the muscles on one side of the body so that, like the animal with the damaged brain, when the insect moves it turns to one side until it reaches a position where both eyes are equally in the light.

That the process is actually one of reduced tension was shown by painting one eye of an insect black so that no light could enter it. In this condition the tension of the muscles of one side of the body was permanently reduced and the insect stood lopsided or walked in a circle.

LIFE IN THE OCEAN

The lands of the earth are covered with a vast amount of living matter, both animal and plant. And with respect to the highest form of life on earth, that of the human race, there are already cries of too great congestion and overpopulation in many places. So at first thought it would seem as if the amount of living matter on the land must greatly exceed the quantity of living matter in the waters. As a matter of fact, it is just the reverse.

In the first place, the ocean covers about two and one half times as much surface as the land. But what is even of greater importance, life is found throughout the whole extent of the ocean, from the equator to the poles and from the surface down to the very bottom; while on dry land living beings do not rise very high above or penetrate very deep below the surface. In other words, on dry land life is practically confined to two dimensions, length and breadth; but in the ocean living matter is found in all three dimensions, length, breadth, and depth. These two factors—the greater extent of the surface of the ocean and the added dimension of depth—have led the scientist to conclude that the total quantity of life in the ocean greatly exceeds that on the land.

The rule that holds for life on land—that all animal life is dependent directly or indirectly on plant life—holds also for life in the ocean. But plant life in the ocean does not extend more than 4,000 feet below the surface, for that is the limit to which sunlight penetrates. Within that depth however, plant life is well distributed, either attached to the bottom of the shallower parts of the ocean or floating free. Some of these plants, as the seaweeds, are of great size, sometimes 700 or 800 feet long; but the great majority are very small, forming frequently vast floating meadows of minute plant life which furnish food for many of the animals living in the ocean.

Animal life in the ocean is found from the surface to the bottom; and the bottom in the deepest part of the ocean is six miles from the surface. Below a depth of 4,000 feet there is no sunlight and the temperature of the water is low; but even here we find many varieties of animal life, which find their nourishment either in the form of small animals on which they prey, or in the form of small particles of organic matter that fall down from the upper ocean regions.

It is a very fortunate thing that the ocean can sustain so large an amount of living matter. For with the continued increase in population there will come a time when the earth alone will not be able to furnish sufficient food. The ocean will then be used as a source of increasing food supply and in time it will be as carefully farmed as the land.

TAKING THE EARTH'S TEMPERATURE

Not all the explorations of the earth are carried on upon its surface or in the thin blanket of air covering it. While some hardy climbers are struggling to reach the top of its highest peak and others are going still higher in their planes, curiosity-filled scientists are searching into the secrets that lie in the other direction. One thing we already know about this region underfoot which may serve to make us very thankful for the thin crust of soil and rock on which we live. That is that only a little way below us the rocks are so hot that human beings would find it quite impossible to exist among them.

Just how far beneath us these hot rocks are we do not know with certainty, but that they are very close, as earth distances go, we have first-hand evidence. Down in South America, in one of the primitive mountain sections, there is the deepest hole which men have yet dug into the ground. It is not the deepest hole they have actually made, for drills have gone much farther, but it is deeper than any other shaft in which men can themselves descend and work. It is the St. John del Rey gold mine, near the settlement of Morro Velho in Brazil. The lowest working level is 6,726 feet below the surface. The rock temperature at this level is around 117 degrees Fahrenheit, and the normal temperature of the air, as a result of the increased pressure alone at that great depth, is only a few degrees less. The miners work in artificially cooled air.

This same rapid increase in heat with depth has occurred in mines all over the world, although the rate of increase is not the same in all of them as in the St. John del Rey. Indeed the reports from the localities where digging or drilling have been going on show that there is wide variation in this rate. In some places it takes only twenty-five or thirty feet of depth to raise the mercury in a Fahrenheit thermometer one degree. In others it takes two hundred feet and more. In volcanic regions the heat may grow very fast as the drill descends. One principle seems to be pretty well established, and that is that the older a region is the cooler are its rocks. In the Appalachian section, for instance, where thousands of feet of sedimentary rock attest to the millions of years through which the land has passed, the rocks show a much more gradual rise in temperature with increasing depth than in the younger rocks of Arizona and other Western states.

The deepest hole which men have ever made in the earth is in West Virginia, about eight miles from Fairmont. It was put down in the search for oil and gas sands, and the drill did not stop biting its way into the rock until the measuring marks showed a depth of 7,579 feet—just 341 feet short of a mile and a half. The world's second deepest well is also in West Virginia and goes down almost as far as the first, 7,386 feet. In each of these wells tests showed an average increase in heat of about one degree for each 70 feet, but this was not a uniform rate all the way down. For part of the distance the increase was greater than 70 feet and then it grew less and then greater again.

These surface scratchings of course do not tell us anything about the heat of the earth's interior. Probing a mile and a half into the earth's crust is about like probing a distance of one-third of the diameter of a pin-head into the surface of a globe ten feet in diameter. But everything that has been learned in these scratchings is quite in line with the generally accepted theory that the earth's interior is very hot indeed. It is also pretty well accepted that this heated interior is not like liquid lava but that it is much denser than steel. Our situation indeed seems to be not unlike that of some very tiny microbes clinging to the surface of a hot cannon ball shooting through space and covered, fortunately, with an extremely thin film of soft chalk, wet for the most part.

HOW SEEDS BREATHE

So far as we know every living thing in the world has to breathe very much as we do. Even the seeds of plants breathe all the time. The packets of seeds lying quietly on the shelf waiting for you to plant them in the garden are breathing. If you should seal them up in a tight bottle so that they could get no air at all they would die just as surely as you would, though not so quickly.

Breathing, you remember, consists of taking some oxygen gas out of the air and putting back into the air, in place of this oxygen, some of another gas called carbon dioxide. This is what humans do when they breathe. Some oxygen is taken up by our lungs and some carbon dioxide gas is breathed out.

Scientists who have been studying seeds find that all the seeds do exactly this same thing. Of course seeds have no chests that expand and contract as ours do, nor do they have anything corresponding to our lungs, but the substance of the seed itself, the living matter inside it, is continually taking up oxygen and giving out carbon dioxide gas in just this way.

Of course the quantity of oxygen used up by a seed is very small. Dry seeds, like those in a seed store, use up so little of it that you need the most delicate and complicated chemical apparatus to make sure that it is being used at all. But always, no matter how dry the seed is or how small or how old, there is always a little oxygen being used up by it so long as it is alive and retains the power of growth. Scientists have used this fact, even, as an extremely delicate and quite certain test to tell whether important samples of seeds are still alive or whether they have accidentally died.

When seeds have been planted in the ground and are getting ready to grow they use up more oxygen and breathe a great deal faster than when they are dry and are merely resting between seasons. This is why it is so necessary for air to penetrate into the pores of the soil before seeds will wake up and sprout in the spring. When they begin their real job of starting a new living plant they have to breathe faster, just as we grow short of breath and begin to breathe more deeply when we work our muscles harder than usual.

Seeds swell, too, when they begin to wake up. Of course this is really because they are soaking up water, but when we think of this and of their faster breathing at the same time, we might almost say that the sleepy seed stretched itself and took a few deep breaths when it first got up in the morning, just as we do.

This faster breathing when they begin to grow applies to all ordinary kinds of seeds. They will not get up in the spring until they have had a few good deep breaths, until there is plenty of air in the soil. But a Japanese scientist, Dr. Takahashi, discovered some years ago that there is one kind of seed that does not need air in order to wake up. This is the seed of rice. The ordinary rice grains of the stores are merely the inside of these rice seeds, with their yellowish husks or coats scraped off by machinery and thrown away.

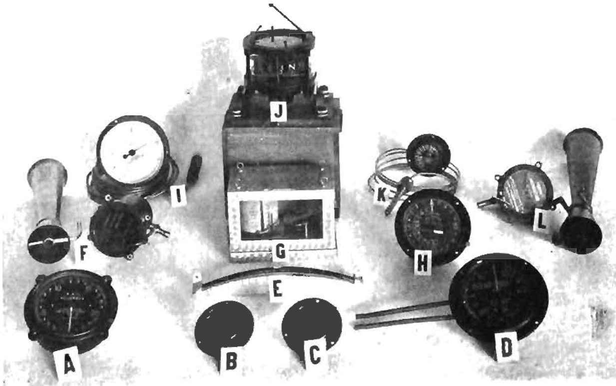
Rice seeds, Dr. Takahashi found, will start growing even inside a sealed bottle where there is no air at all, provided only that the seeds are wet enough and warm enough. Recently Drs. W. A. Cannon and E. E. Free found another kind of seed that will do the same thing. It is the seed of a kind of wild grass that grows as a weed in the rice fields of California. These two kinds of seeds are the only ones known to have this extraordinary ability to start off in the spring without needing any breath of air.

But this does not mean that these seeds can really live and grow without breathing. They do breathe, but they are able, strangely enough, to breathe *water*. Water, you know, is a chemical compound of oxygen and hydrogen. What the rice seeds do, it is believed, is to break up some of the water into its chemical elements, just as the chemist can decompose water with an electric current in the laboratory. Then the clever little rice seed breathes this oxygen that it has made for itself out of water, so that it does not need to get any from the air as all the other seeds have to do.

CONQUERING THE AIR

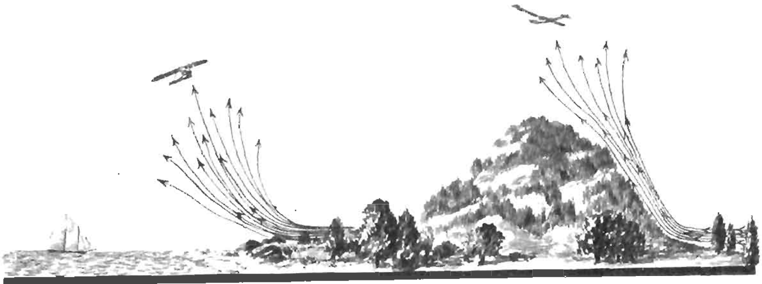
"Oh, for the wings of a dove," sang the psalmist of old, a cry echoed by many generations of poets and dreamers. To-day we fly, but not on the wings of birds, nor by wings alone, for one of the first discoveries made by men when the attempt to fly was seriously made, was that wings are not enough. As the old saying put it, it was easy enough to make a machine which would fly—at least a short distance—but the difficulty was to make one which would alight gracefully and safely. Wings are indispensable, but even the bird has more than wings to fly with.

It has a flying sense, a knack of coördinating its keen impressions. It knows how to keep right side up, to maintain a given direction even at night, to tell how high it is, and perhaps how fast it is going. When man took to the air he was handicapped by the lack of these hereditary abilities, but man's whole history has been that of beating the animals at their own game and, once getting the means of flying, he proceeded to build artificial sense organs of flight.



CONQUERING THE AIR

The twelve extra sense organs of the aviator. *A*, tachometer; *B*, oil pressure gage; *C*, air pressure gage; *D*, air speed indicator; *E*, bubble inclinometer; *F*, gyroscopic pitching indicator; *G*, barograph; *H*, altimeter; *I*, strut thermometer; *J*, compass; *K*, radiation thermometer; *L*, gyroscopic turn indicator. (Bureau of Standards, Washington.)



HOW AIRPLANES MAY RISE WITHOUT MOTORS

How two kinds of rising air currents are formed. Surface winds strike hill or mountain sides and are deflected upward. Where sea and land meet there are decided differences in the rates at which *surface air* is heated and the cooler sea air pushes the lighter heated air upward. (Copyright by *The Country Gentleman.*)

The result of his efforts to date may be seen in the aircraft department of the Bureau of Standards at Washington, where there is a collection of aircraft instruments whose use gives to man most if not all of the "flying sense" of the bird. About all that is lacking is the sense of coordination possessed instinctively by the feathered aviator and acquired by man only through practice.

For the mysterious sense of direction which guides the birds on long flights or migrations the aviator has the compass and the turn indicator. The first instrument is an adaptation of the familiar mariner's compass, the second is based on the gyroscope. When a gyroscope is set spinning it tends to hold its axis in the same position. If the aircraft is turned, a pressure on the axis ensues, and this is used to turn a dial hand indicating to the aviator which way he has turned.

This is a substitute for the semi-circular canals in the ear of the bird which, like those in man, give the sense of equilibrium. But those in birds are naturally more sensitive than those in man, which, though well adapted for land, are apt to fail him in the air.

Whether or not birds are able to realize just how fast they are flying is an unsolved problem in bird psychology. Men when flying can tell how fast they are traveling through the air, and if the ground is visible their velocity with respect to the ground can also be determined. With reference to the air, the problem is solved by various devices which record the pressure of the air, from which the speed of the machine through it may be easily calculated and read off on the dial.

One of the perils of human aviation, when flying in clouds or where the earth and sky are both invisible, is that of turning partly or completely over. The bird avoids this accident through some instinctive adjustment. The aviator uses the inclinometer, which is either a gyroscope or a device resembling a spirit level that tells him if his plane is tipping greatly sideways or fore and aft.

Birds usually fly at something like a uniform height, depending upon the species, the eagle being one of the highest flyers. Probably each species instinctively knows when it is high enough from the effect upon its breathing and from the increased difficulty of flight. Men do not notice the difference of the quality of the atmosphere until they are more than a mile high. Altitudes are hard to determine with accuracy without the use of the altimeter, a modified aneroid barometer. The barometer ordinarily displays the pressure of the atmosphere, which at the surface averages that of 30 inches of mercury, or 15 pounds to the square inch, falling to about half of that at an altitude of some three miles. In the altimeter the barometer shows the altitude directly without calculation, being set at zero when leaving the ground.

Finally, there is the mysterious homing instinct of the bird which, in the case of the homing pigeon, guides him across hundreds of miles of unfamiliar land or sea. To equal this, man has called to his aid the radio. Aircraft can carry radio direction-finders which in connection with signals sent from the home or other airdrome can guide the flying man as unerringly to it as instinct guides the flying bird to its nest.

So man has almost equaled the birds in their accuracy of flight while surpassing them in speed and endurance. Almost, for conscious effort of coördination is required for man while instinctive reflex action serves for birds, and conscious activity is never as quick as reflex and seldom as well applied or as accurate. In every plane there is a small electric power plant that actuates some of the instruments. This may be compared to the central nervous system of the bird with the important difference that the nervous system of the bird interprets itself and is automatic, while in the plane its findings must be interpreted by man.

But in spite of this still unsurmounted handicap man has practically equaled the sensitiveness of the sense organs of the bird. Through the use of his mind and his trained hand he can see farther and hear farther than the bird, and can feel his way through the pathless air with almost equal facility. He is not in his natural element when in the air, but he has subdued it, for *nothing* is "unnatural" to him who, as the philosopher said, "is one world, and hath another to attend him."

HOW THE BULLDOG GOT HIS JAW

The bulldog's jaw is a delicate subject—if investigated without the coöperation of the dog. But having obtained formal introduction you may become quite chummy and easily examine this natural wonder, for a bull's evil disposition is chiefly in his reputation and his looks.

You will notice that the lower jaw protrudes considerably beyond the upper; not merely the fleshy part of the lips but the bone itself is set forward as much as an inch or even more, making an elongated vise, well adapted for hanging on to trouser seats and the like.

The bulldog's blue blood antedates the War of the Roses and extends back into the mists of the Thirteenth Century. He is obviously an artificial product of the animal breeder as are our horses, sheep, cows, and chickens, and he was apparently cultivated for animal baiting: hence the name "bulldog"—a dog for baiting bulls.

For that sport a dog was required with a mighty grip and indefatigable persistence, ferocious courage and considerable weight.

The breeders did not break two dogs' jaws, stretch them and then find that the dogs' children had longer jaws than most of their kind.

A start was made by breeding together the great English mastiff with the large pugdog from southeastern Asia. This union was probably at first merely an accident, but the progeny were noticeable for large dogs with somewhat longer and heavier underjaws than usual.

Among these hybrid dogs some had longer underjaws than others. By breeding together the dogs with the longest jaws, then selecting from their litters those with still longer jaws and so on, the bulldog's facial characteristics were finally perfected.

SIX SORTS OF SMELLS

Most people are familiar with the fact that there are but four elementary taste qualities—sweet, salt, bitter and sour—and that the so-called tastes of our foods are various combinations of these qualities in conjunction with smell.

Of odors, however, there seems to be a vaguely indefinite number. Our noses are in some ways very delicate sense organs. Mercaptan, a peculiarly disgusting odor, can be detected by most people if there is little more than one trillionth (0.0000000000014) of an ounce to a quart of air.

On the other hand, we discriminate among odors so little, or they play such a small part in our mental processes, that our language is practically lacking in names for the different kinds of smells. The colors and the tastes have their own proper designations, but the odors have never been christened and hence are called after the things from which they most commonly arise, as roses, goats, and vanilla.

Recently, however, a German psychologist, Dr. Hans Henning, has shown that the odors can be reduced to six elementary qualities or classes. Just as there are four tastes, so there are six odors.

These are:

1. Spicy, typified by the odor of nutmeg.
2. Flowery, typified by the odor of violets.
3. Fruity, typified by the odor of lemons.
4. Resinous, typified by the odor of frankincense.
5. Foul, typified by the odor of hydrogen sulfide (rotten eggs).
6. Scorched, typified by the odor of tar.

Other odors are blends of these elementary types, as the odor of geraniums, which is a compound of flowery and fruity, and of mint, a compound of fruity and spicy.

Dr. Henning experimented with 415 "chemically pure" scents, carefully selected to represent the whole range of odors, as well as with the common or kitchen variety. His classification of scents by the nose is also supported by chemical evidence, for substances giving rise to the same type of odor show similarity of molecular structure.

WERE THE CAVE MAN'S EYES BETTER THAN OURS?

Many thousands of years ago when some of our ancestors lived in caves and caverns among the rocks they amused themselves by drawing pictures on the stone walls of their domiciles. Or perhaps they were trying to write books and leave permanent records of the knowledge they had gleaned. At any rate, some of these pictures in protected caves have been preserved down to the present day.

Some of the things they frequently pictured were certain well-known groups of stars, notably the group known as the Pleiades. As we look up at the Pleiades at night, even on the clearest of nights, we can see but seven stars in this group. Yet the cave pictures all show ten. And there *are* ten stars in this group or, rather, eleven fairly large ones, but we have to use a telescope to see the other four.

How did the cave man see the three stars that our eyes will not reveal?

Astronomers do not believe these stars to be less bright now than when our hairy, skin-clad ancestors gazed up at them perhaps ten thousand to twenty thousand years ago. The atmosphere is clearer in some parts of the world than in others, it is true, but even in the clearest atmosphere our unaided eyes are incapable of seeing these three faint stars except under one condition. From the tops of high mountains they become visible to the naked eye.

So we must conclude either that these early people traveled to high mountains to study the stars or else that their eyes were capable of seeing things that ours are not.

THE SKELETON IN THE SALAD DRESSING

To inquisitive people mayonnaise salad dressing ought to be extremely surprising. What in the world makes it hard? Neither oil nor water is remarkable for rigidity, and the egg and lemon juice or vinegar are equally unreliable as structural materials. Yet the mixture of them, when we are lucky, is a firm and lasting solid, uniform in texture, and far harder than any of the things which go to make it up.

The explanation of this household curiosity comes not from cooks but from the research workers who have founded the new science of colloidal chemistry. They have discovered that hard salad dressings have the structure of a honeycomb. The vinegar or lemon juice and the egg, if you use it, form a complicated water solution which takes the place of the wax of the honeycomb. The oil corresponds to the honey. The oil-filled cells are very tiny, far too small to be seen without a powerful microscope.

The hardness of the dressing is due to the network of vinegar films, which are stretched against the force known as surface-tension—the force which draws a falling drop of water together and makes it round instead of square or oblong. The stretching of these films sets up pulls in them and these pulls provide the strength necessary for firmness and hardness. Just why this is so is not obvious without some study of the mechanical theory, but this theory is well known and is not unlike that which engineers use to design the beam-network of bridges or steel-frame buildings.

And what have the chemists to say about the times when salad dressings fail? This, they say, happens when the forces of the surface-tension are not great enough or are too great. The pulls in the network of vinegar films are either too weak to hold the mass together or so strong that they pull apart the films themselves. In either case the structure collapses as does the steel frame of a bridge if one member is either weakened or shortened—that is pulled—too much. Variation of temperature, the presence of foreign substances in oil or vinegar, slight, accidental differences in the chemical composition of either of the materials, may cause these changes in the surface-tension pulls. This is why dressings occasionally fail to harden.

DON'T QUARREL AT MEAL-TIME

If you must quarrel, don't do so at the dinner-table or immediately following the meal. This is advice from the doctor, not the preacher. The latter would probably tell you not to quarrel at all, but, assuming that you cannot deny yourself that pleasure, do not indulge your anger on a full stomach.

The why and the wherefore of this maxim are very simple; when you start a fight, your stomach stops working to watch the fun!! The intestine also joins in this recess and the whole business of digestion is held up.

This phenomenon may be observed directly by means of the X-rays. X-rays will pass through the body and register on a plate, but they will not pass through some other substances, such as metals, which accordingly cast a shadow. A key in your pocket will take jet black in an X-ray photograph.

Now the physiologist cannot feed you a stew of carpet tacks and steel wool and then photograph your stomach while the wife presents her millinery bill to you. He may, however, induce a friendly cat to eat a good meal of barium sulphate, a substance opaque to X-rays. While the cat is contentedly digesting this meal the X-ray picture will show the rhythmical churning movements of the stomach and intestine. Then, while the cat is held immovable, the experimenter introduces into the room a noisy dog. Immediately the activity of the cat's stomach is seen to cease, and it does not start again for a quarter of an hour.

This reaction of the digestive system has a definite function in animal economy. Only with man is anger an indoor sport; the lower animals (and man under some circumstances) become angry when the situation calls for a fight. To fight effectively the animal needs all its energy, so all other diversions in the body must cease and let the combat muscles have complete sway.

You can talk and digest your food, but you can't fight and do so, for fighting may be a life and death matter, and in such matters Nature takes no chances.

RELIEVING YOUR MIND

One of the labor-saving devices of psychology is to let the unconscious and automatic part of your mind do all it can and so free your consciousness of drudgery that it can take up operations requiring initiative and will power. A voluntary act is one in which our consciousness is concerned. It is one that "we" do, to use the word by which we ordinarily distinguish what was done consciously from the workings of our unconscious mentality.

A new thought is probably always a conscious one. It is consciousness alone that has the power of striking out in new paths. But as change is a necessary condition of consciousness the repeated thought becomes more and more unconscious, and as the disturbing originality of consciousness drops off it becomes more and more regular and mechanical. We may compare it to the breaking of a new road across the country, which is an exciting experience, while after the road has been well traveled and rutted the driver goes to sleep.

The speculation that some metaphysicians have indulged in, that all our unconscious acts, our instincts and reflex actions were once conscious and voluntary, has at least a solid starting point and is further supported by the modern theory of biology that the function makes the organ, that use perfects the instrument, that thinking forms the brain.

What is of practical importance is the lesson that we ought to turn over as much as possible of our mental work to this unconscious self. This, for two reasons: one is to save our own time for new and important matters and the other is because the unconscious self can carry on habitual actions better than we can. The man who is learning to write may have as good and just as complete voluntary control of his muscles as the practised penman. The reason why his writing is shaky and irregular is because he is doing consciously what the habitual writer does unconsciously. Why is it that when you can walk a board easily on the ground you stagger when it is raised a foot from the ground? Not because you become dizzy but because when you manage your legs consciously you cannot walk so straight.

Awkwardness is self-consciousness, that is, the consciousness interferes with the work of the lower centers, just as the head of a department sometimes upsets the work of his clerks by telling them just how to do their work, or an ignorant mistress goes into the kitchen to superintend the cook. Movements directed by the unconscious centers are more apt to be graceful. Gracefulness is obvious adjustment of means to an end. Gracefulness in a person is the manifest coördination of the whole body in one motion, a unification of all possible movements. It is most complete when the object of the movement occupies the attention to the exclusion of everything else and all the work of adaptation is done by the lower centers.

Look at the athlete. His whole attention is concentrated on the ball or the goal, and his body is a perfect expression of his desires, not a muscle is out of place. He is the embodiment of grace. But look at him a moment later when the excitement is passed and he is receiving the congratulations of the grandstand. He is awkward then simply because he is self-conscious; he is trying to put his hands and feet into their proper positions and doesn't know how.

That is the fault of many systems of calisthenics or physical culture. They try to teach one how to hold one's limbs and body instead of concentrating the attention on the act itself. As a consequence the unhappy victim grows more self-conscious instead of less, and his movements acquire the grace of a jumping-jack. Military drill is conducted in this way, but its avowed object is to make man mechanical.

Our unconscious mind is far superior to our conscious in controlling actions. How could a musician play on the piano if his fingers all received their orders from headquarters? The musician knows better than that. He is like a wise general who requires of his officers certain results and for the most part lets them choose their own methods. Consider what a tennis player has to do when he returns a ball to a certain part of his opponent's court. The data he has to work on are nothing more than some ten circles on his retina of different size and position. Now all the conditions of his problem may be known; the laws of light by which these images of the ball are received, the elasticity of the ball and racket, the angle at which the ball rebounds from the ground and racket, but it would take an expert mathematician a year to calculate what must be the position and force of the racket. Yet the player solves the problem within a second. There is no comparison in the amount of work required by the two methods. One is the hardest kind of labor, the other is a recreation.

TIME-TELLING BY STONE ICICLES

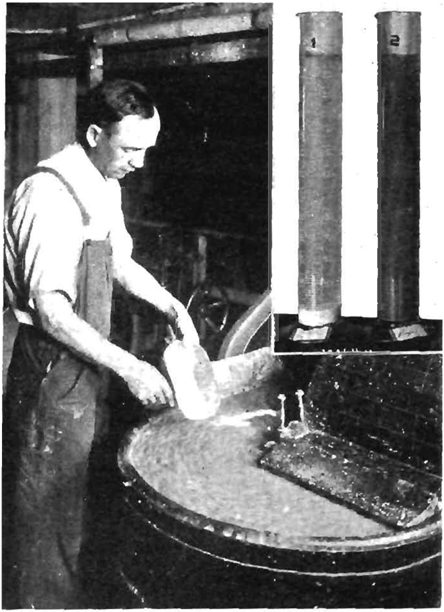
The icicles which hang from the eaves of houses on cold mornings do not last long. Yet in the making of these transient icicles there is duplicated a process which gives the geological detective a clue to many age secrets in the prehistoric past.

These pendants of ice are sometimes smooth and sometimes rough, sometimes thick and sometimes thin. On these differences hangs the story. Whenever you see a smooth, even-growing icicle, you can be sure that the rate of the drip of water has been the same from the start and the temperature has been about the same all the time. When you see a rough uneven growing icicle you may know that the drip and air temperature have changed back and forth during its life. A thick icicle is formed when the drip is so slow and the temperature so low that the water freezes before it has time to drop. The thin icicle is produced by the fast drip of water before it has time to freeze.

If the drip is too large for all the water to freeze upon the hanging icicle, part of it drops to the ground and freezes and builds up a post-like or mound-like icicle. If too much water reaches the post-like form to freeze, it spreads out until enough cold air can get to it to freeze it—it cannot drop off as it did from the hanging icicle, and so icicles on the ground are generally much thicker than the hanging kind.

Now Dr. Vernon C. Allison, of the U. S. Bureau of Mines, says that those icicle-like forms in stone found in many of our limestone and other caves

LOUIS PASTEUR



HOW NEWSPAPERS ARE RENEWED

Putting powdered Bentonite, which solved the problem of de-inking newspapers, into a beater full of the latter at the United States Forest Products Laboratory. The left-hand tube in the insert shows the sediment of English china clay after twenty-four hours' suspension in water. No sediment is visible in the right-hand tube, which contains Bentonite. *See* page 296.

and caverns grow in every way like water icicles. Water which slowly seeps through decaying vegetable-matter acquires the power of dissolving limestone. When this water slowly trickles through the limestone, it dissolves all it can, and when it reaches the roof or ceiling of the cavern, the fastness or slowness of the drip, the high or low temperature and the air circulation, all conspire to force the limestone solution to give up its limestone and build these icicle-like forms. A hanging limestone icicle is called a "stalactite," and the mound-like mass of limestone forming on the ground beneath the drip is called a "stalagmite."

As in the case of icicles, if the stalactite or stalagmite is uniform and symmetrical, we have evidence that it grew during its whole life at the same rate. Dr. Allison has found that knowledge of the size, the rate of drip, the temperature, the air movement, and the material of which the stalactite or stalagmite is made make it possible to tell how fast the stalactite is growing now. By this method he has determined that the gigantic stalagmite called the "Pillar of the Constitution" in Wyandotte Cave, Indiana, which is 71 feet around and about 30 feet high, is 30,500 years old.

There is a further check on this method of figuring the age of the pendants of stone, for each year may leave its finger-print, as it were, to help the geological detective get a very good idea not only of the age of the stalactite but the kind of climate it enjoyed during its past life. If it grows in a place where the outside air can get to it easily, each year may leave a "yearly cap" or "yearly layer" because there will be more dust in the air in the drier part of the year and less in the wetter part. This dust settling on the moist face of the stalactite or stalagmite leaves its mark in the form of a slightly darker layer than that formed during the less dusty season. If the stalagmite or stalactite is cut through the middle, from top to bottom, and polished on this cut surface, these yearly layers can be counted.

In many caverns in Europe and this country bones and crude stone, bone and wooden tools, are found within and around stalagmites. Their position determines their age. Stone icicles formed while man and animals evolved will in this way give us dated exhibits of the past.

A HUNDRED YEARS OF PASTEUR

A century ago, on December 27, 1822, there was born of a peasant family in a small village in France a child who was to revolutionize our world by discovering another. To-day we drink our milk without fear of disease, we understand why bread rises and cider becomes vinegar, we have ceased to attribute epidemics to the "wrath of God," and we no longer fear many diseases because we can prevent them. It is hard to imagine only sixty years ago—a time when the microscopic world was hardly known and when the leading men of science held that living things commonly came into being spontaneously.

Millions of our people unconsciously use the name of Louis Pasteur every day when they talk about pasteurizing some liquid, and yet many do not realize that this process of sterilization was only a by-product of his wider work.

For there is hardly a branch of science that does not owe a debt to Pasteur. A chemist by training and inclination, he was the first bacteriologist. His discoveries of disease germs, his conquest of chicken cholera, anthrax, rabies, and other diseases, his introduction of antiseptics and sterilization in surgery, have made him the father of modern medicine. He saved both the silk and the grape industry of his native land from destruction, and the manufacture of wines, beers, and vinegar was placed on a scientific basis through his personal work. Hardly an industry could afford to be deprived of the knowledge that Pasteur and his followers have furnished. And agriculture, being concerned with living things, has been immensely influenced by Pasteur's mind and vision.

Pasteur was led to his great field of work by a study of the crystal shapes of tartaric acid. In the laboratory he could make two forms, the kind that occurred in nature and another, a mirror image of the other, that is never found in nature. Because he found that a ferment would eat up the crystal shape that occurred in nature and leave the laboratory form alone, Pasteur was led to a study of fermentation.

For thousands of years people had used ferments to make wine, vinegar, bread, and cheese, and no one stopped to wonder what made the material "work." Of course they did not dream of living organisms. Yet this is what Pasteur's patient work revealed. Not only did he watch these queer little cells under the microscope and see them grow and, by budding, form new creatures of the same race, but he learned how they live and what they eat. He learned that there is no other mystery about fermentation than that it is caused by the efforts of an organism to break down the sugar or other compound on which it feeds so as to get the material into a form that it can use. And Pasteur proved that vegetable substances are not necessary for the growth of a ferment, for he succeeded in cultivating yeast in entirely artificial mixtures.

Still other kinds of minute living cells were discovered by Pasteur during these studies, with quite opposite characteristics to those of the yeasts, for while yeasts have to consume air in order to live, just as we do, this new sort will die if any air comes in contact with it. Since there is so much air everywhere, those anaërobic, or airless creatures, could not survive if they did not make a sort of partnership with the air-using organisms. But they do this, and so are able to exist. They play a large part in the putrefaction of animal substances, causing the production of the bad-smelling hydrogen sulphide gas which decaying things give off.

The fact that any living creature could get along without air was a surprising discovery. But a greater one followed. Some organisms which are naturally aërobes can, if deprived of air, live as anaërobes as well—at the expense, of course, of the substance from which they draw their nourishment. Many diseases are due to exactly this circumstance.

In opening up this new world of minute organisms all about us Pasteur became involved in a discussion of theories that was being waged hotly at that time over "spontaneous generation" of living things out of inert matter. We know now that this does not occur among visible creatures; that bees, for instance, do not come into existence miraculously from the entrails of a dead bull, but at that time—only sixty years ago, remember—

many believed such things to be possible. That this idea is commonly recognized as a superstition, so that we laugh at children when they watch a horse-hair in water to see it turn into a snake, is due almost entirely to Pasteur. He showed that the forms which we see come into existence have developed out of eggs or smaller forms which we cannot see, but that we have no right to claim that a thing does not exist because it is too small for our eyes to distinguish it. His microscope revealed a world of unknown creatures living out their full and complex lives in a drop of water, or on a dust particle in the air.

But do not imagine for a moment that Pasteur's life was devoted only to laboratory work and scientific discussions. Just as many scientists today are fighting very real battles with disease, Pasteur made his greatest conquests in practical combats with the unhappy side of nature. For six years he worked hard to save France's silkworm industry from disease and he succeeded. And when the dread anthrax was sweeping over Europe killing sheep and often men, he identified the bacillus which caused it, proved that it is the sole cause of the disease and showed how the bacillus protects itself from unfavorable conditions by forming spores which may be found in the ground near where an animal that died of anthrax has been buried. These spores caused the "cursed fields" in which no animal could be pastured without taking the disease.

While Pasteur discovered many more disease germs, he was not content with these achievements. He wondered why some animals took anthrax and others did not. Body temperature was one reason, but when he was studying chicken cholera he discovered by accident that old cultures of the germs that were highly attenuated only made the chickens slightly sick. And fowls treated in this way were immune to later inoculations with virulent germs. He had discovered a vaccine for chicken cholera, and he was able to vaccinate against this disease just as Jenner had discovered how to protect people against smallpox. Pasteur did not lose much time in preparing a virus against anthrax that proved to be a sure protection.

But then, as now, old ideas died hard. Every one would not believe in Pasteur and his discoveries. Boldly the great scientist agreed to a dramatic public trial of his own work. Farmers, veterinarians, doctors, and the merely curious assembled and followed the experiments. Healthy sheep and cows were vaccinated one day and then later they, and some unprotected animals, were infected with anthrax. A few days later when the vaccinated animals were all well and the others were dead or dying, many who came to scoff went away convinced.

The crowning achievement of Pasteur's life was his work on the dreadful disease, rabies. Even to-day a popular superstition attributes this disease to the effect of the heat, lack of water, or the position of the stars. But before Pasteur it was known that this disease is transmitted from animal to animal and from animal to men by bite or scratch. Using the methods that had conquered anthrax, Pasteur and his co-workers made the cure of rabies so certain that now no one need die of this disease, which had formerly been regarded as fatal.

The great French scientist lived to have his work rewarded with all the honors that a grateful world could bestow. A great research institution bearing his name was built for him and his disciples. He saw his ideas and investigations influence the thought and action of the whole world. If greatness be measured by the extent of the good done to one's fellow-men, his name will stand high for all time.

NEWSPAPERS RENEWED[1]

Forests of spruce wood now being used annually in the making of newspapers may be saved

[1] See illustration facing page 289.

by the method of de-inking news print discovered at the United States Forest Products Laboratory. This process, amazingly simple in its operation, is calculated to cut the cost of news print $15 a ton—28⅓ per cent.—and so result in the annual saving of the cut on 275,000 acres of 100-year-old spruce wood, if de-inking mills are established in the metropolitan centers of newspaper production.

In Chicago alone, it is estimated, 325 tons of waste newspapers could be collected daily and converted into 260 tons of clean paper, able to compete on the market with standard news print. If this were done, 97 acres of spruce wood that took 100 years to grow could be saved every day.

The de-inking and re-use of old magazines has been practised for some time, but it had never heretofore been possible to utilize repulped newspapers for printing again because the only processes known for taking the ink from paper during the process of repulping it required such strong alkalies that the paper was discolored in the process, since news print is made from groundwood. The use of Bentonite clay, however, with its high colloidal powers, solved the problem. Bentonite is a fine, creamy-white, soft clay found in large deposits in Wyoming. This clay occurs in finer particles than any other mineral substance, and will go into colloidal suspension in water without the aid of strong alkalies.

When the paper is being repulped, soda ash and Bentonite are added to the water in the pulp beater. *The alkali loosens the ink, and the fine particles of Bentonite attract the loosened particles of carbon and carry them off through the washing screen.* Before the discovery of Bentonite, nothing had been found which could keep the heavy printer's ink from gathering in masses on the washing screen or in the fibers of the pulp. Bentonite, however, washes the pulp fibers clean and leaves them ready to be run into paper again, paper only slightly deteriorated and quite able to meet the requirements of the modern press.

The advantage of the de-inking process lies, furthermore, in the fact that the source of supply of the materials and the market for the de-inked paper are identical. Mills erected in the large cities can produce the de-inked paper for the newspapers published in those cities, thus saving much in freight.

"To make the most of the de-inking process," say the experts at the laboratory, "it is absolutely necessary that the mill be independent of the periodical manipulation of the waste-paper market. A large part of the mill's supplies could be collected by its own force from the neighboring territory, thereby cutting out the profits of at least three middlemen. In stabilizing the supply of waste papers the publishers can be of enormous assistance, since the supply is directly dependent on the amount of paper saved by the average householder. With proper newspaper campaigns, such as were carried on during the war, the supply of waste newspapers could be doubled without much effort."

The Forest Products Laboratory de-inks and uses again most of the paper from its own wastebaskets, as a practical demonstration of the economy and the success of the discovery.

HOW THE 'POSSUM GETS INTO THE POUCH

The great marsupial mystery has been solved. In the annual report of the Smithsonian Institution for 1921, Dr. Carl Hartman, zoölogist of the University of Texas, tells how the new-born Virginia opossum gets into its mother's pouch. Incidentally, he upsets the fascinating theories which old woodsmen and nature students have fabricated to explain this puzzling phenomenon.

Throughout the country, among whites and negroes, there has been a conflict of explanations. The more credulous have held that the young are born directly into the pouch which serves as their incubator during the first several weeks of their lives. Others have maintained that the mother seizes the baby 'possum with her mouth and thrusts it into the pouch herself. Dr. Hartman is one of the few who can claim to have actually seen what really happens. He was lucky enough to watch the birth of a litter of eighteen. The process is as simple as it is remarkable.

The new-born 'possum just climbs hand over hand up into the pouch without the aid of the mother. The coördination of nerves and muscles necessary to find the pouch in a maze of hair and attach themselves for their two months' stay at this haven of food and shelter is little less than marvelous. Dr. Hartman found that the opossum has an extremely early birth, the entire development of the embryo within the mother's body being only about eleven days.

A MOTHER FISH

Fishes as a class are notorious for the fact that they give little or no attention to the welfare of their progeny. Most animals at least see to it that their young come into the world under favorable and protecting surroundings, but fishes, for the most part, cast their eggs upon the waters and hence must provide for the survival of their kinds by the production of millions, only a comparatively few of which escape the destructive forces encompassing them.

Among certain species, however, especially sharks, skates, and rays, the young are born alive, and M. Raphael Dubois has reported to the Academy of Sciences in Paris an instance of maternal care displayed by an electric ray.

The electric rays, as they are commonly called, possess powerful electric generators on either side of the head which can give a sufficiently strong shock to repel many animals, including men. These electric organs are bundles of muscles, modified in ways not well understood to serve as defensive weapons with which the ray drives off its enemies.

M. Dubois placed in his laboratory a torpedo about to give birth to young, and it there continued to generate strong electric discharges.

During the night seven rays were born. When the family was examined in the morning the mother was with her children, but she had shut off her electric generators and gave out no discharges as long as her young were near by.

That the shocks would be harmful to the little fishes was in some way or other appreciated, and so, *contrary to her usual habits*, she inhibited the discharges. This is one of the very few instances in which a fish has been observed to show any consideration whatsoever for its infants.

HEALTH AND FINANCIAL PANICS

Many indeed are the causes to which periods of business depression and financial panics have been attributed. Everything from bad crops to sun spots has been blamed for the occurrence of "hard times." Dr. Ellsworth Huntington, research associate in geography in Yale University, presents statistical facts tending to show that the most fundamental cause is a condition of general ill-health.

We would expect, without further examination, to find that hard times were accompanied and followed by a notable increase in disease and a consequent rise in the death-rate, for at such times people are more poorly fed and under greater nervous strain.

But contrary to our expectations, Dr. Huntington finds that hard times are not only accompanied but *preceded* by an increased death-rate and that business recovery is in turn preceded by a bettering of the general health.

Specifically, even the long period fluctations in New York Clearing House receipts are preceded by a rise and fall in the death-rate, and this applies also to National Bank Deposits, immigration, and general prices.

These facts tend to show that the panicky state of the public mind, necessary for the precipita-

tion of a financial crisis, is the result of the weakening forces of ill-health and that business recovery waits upon a return to normal vitality.

The causes of periodic fluctuations in the general health of the people, however, are not easy to determine.

THE MOST EFFICIENT INCANDESCENT LIGHT

When you turn on the electric light the bulb becomes hot, but the heat is of no use to you; it is altogether wasted energy. Nevertheless you have to pay for it in your monthly light bill. The lamp is not 100 per cent. efficient. As a machine for transforming electrical energy into light it wastes part of the energy in the form of useless heat.

The firefly, on the other hand, has an almost perfect lighting plant; it gives practically 100 per cent. light without heat.

The firefly is not unique in this respect, however, for throughout all of the major divisions of the animal kingdom are found species which carry their own lanterns. This is especially true in the sea which is inhabited from the surface to the deep abysmal darkness by many light-producing animals.

These luminous creatures have stimulated the investigations of the curious since time immemorial, but only in recent years have biologists and chemists succeeded in extracting some of the inner secrets of the lighting process.

The process is essentially chemical and is due, in part at least, to the oxidation of certain substances. Oxidation, or the combination of a substance with oxygen, is a familiar enough phenomenon, illustrated in the burning or rotting of wood. In this case the carbon of the wood combines with the oxygen of the air and heat is produced. The light which appears is not the immediate result of the oxidation but is caused by unburned particles of carbon becoming heated until they glow.

The oxidation occurring in the luminous organ of the firefly gives exactly the other extreme, all light and no heat.

There are two substances secreted by the firefly, according to Dr. E. Newton Harvey of Princeton University, for use as fuel in its lantern. These he calls luciferin and luciferase, respectively. The former is the material which is oxidized in the production of light, whereas the luciferase is a sort of enzyme or ferment which inaugurates the process and keeps it going like the enzyme from yeast which maintains the chemical process causing bread to rise.

WHY THE NIGHTMARE GALLOPS

The nightmare is a testy mustang, as most of us well know, whose capers are second to none, not excepting the "movies."

Not only nightmares but dreams as a class are characterized by their erratic, irrational and extreme emotional content, extreme either in mildness or intensity. We cold-bloodedly slit our neighbor's throat in a dream without the least chagrin, while on the other hand we sometimes experience genuine and lasting horror in connection with some relatively trivial dream-incident. The force of the emotion which is felt in the nightmare is not infrequently of a degree such as is never experienced in waking life.

Dr. W. H. R. Rivers, the noted psychologist of Cambridge University, England, has called attention to the nightmare as an example of a psychological phenomenon observed in many mental diseases and stresses.

In these instances, according to Dr. Rivers, the mind tends to drop back into juvenile, infantile, or even animal stages of instinctive behavior. The patient loses certain of the habits of control over his instinctive conduct, habits which he has acquired through growth and experience, and behaves as a child in certain respects.

One of the characteristics of primitive instinc-

tive behavior is its tendency to extremes in expression and emotional feeling. When the very young child becomes afraid, he is terror-stricken without discrimination as to the relative degree of danger, and when anything arouses his anger, be it great or trivial, he flies into a rage.

Those instincts which protect us from danger, as flight and fighting, with their emotions of fear and anger, are very deep-seated in the mind and very powerful indeed.

When we go to sleep the higher brain centers, whose function it is to regulate and control, are put out of commission in great part. That the *mind is not altogether non-functioning*, however, is evident from the fact that breathing and other life processes go on, that the neighbor's wailing infant does not awaken us, whereas our own does, and that we dream under certain conditions.

But when we dream we clothe our uncontrolled and irrational thoughts with a feeling of reality such as the child seems to show toward fictions of his own imagination. He creates the myth of a bogy behind the piano and then becomes afraid of approaching the spot.

When among the fictions of our dreams the danger instincts are turned loose they appear free from the inhibitions and rational controls which have been developed in the higher regions of the mind and rage in all their *primeval ferocity.*

With the nightmare we feel terror because we fall back into a condition analogous to a primitive stage of our mental evolution.

ATMOSPHERIC DUST

Dust-free air is attainable in the laboratory by means of certain filtering devices, but it does not exist anywhere in Nature. From the earth's surface up to the highest atmospheric levels—scores or probably hundreds of miles above the loftiest clouds—every cubic foot of air contains dust-motes. Near the earth the dust is mostly blown up by the winds. Far aloft the millions of meteors that enter the earth's atmosphere every day contribute their quota of fine solid matter. Finally, every great explosive volcanic eruption spouts up enormous quantities of dust to great heights.

All kinds of dust are heavier than air. Therefore, contrary to popular belief, dust never really "floats" in the atmosphere. In still air it always settles more or less rapidly toward the ground, its rate of fall depending upon its specific gravity and the size and shape of the dust particles. Other things being equal, the finest particles fall most slowly. Tiny fragments of meteors and dust particles from volcanoes take years to reach the ground from a height of ten miles or more.

Winds charge the atmosphere with billions of tons of dust every year, and it is often carried to great distances before it settles to the earth. Some parts of China are covered to a depth of hundreds and even thousands of feet with a fine yellowish earth, called "loess," which is supposed to have been blown thither by the winds from the deserts of Central Asia. Less extensive deposits of similar wind-borne material are found in our Mississippi Valley and elsewhere. A single storm, which occurred in northern Africa March 8-10, 1901, raised a cloud of dust that spread as far as 2,500 miles from its place of origin. Reports on the deposits of dust from this cloud, collected from hundreds of observers, indicate that not less than 1,800,000 tons fell over the continent of Europe. On the African coast itself the deposit is supposed to have amounted to 150,000,000 tons. A reddish haze, due to dust blown from the Sahara Desert, is frequently encountered by vessels in the region between the Canaries and the Cape Verde Islands. This haze probably explains that old legend of a "Sea of Darkness," reported by the early navigators of the Atlantic.

Much atmospheric dust is always brought down by rain. When it consists of fine powdery sand, the rain sometimes acquires a brownish or reddish tinge, staining objects on which it falls and constituting the so-called "showers of blood" that have been recorded all over the world from the earliest times. Pollen, chiefly from pine trees, is responsible for showers of so-called "sulphur."

Volcanic eruptions sometimes spread a veil of dust over the greater part of the globe. After the eruption of Krakatao, in 1883, the dust from the volcano hung in the upper atmosphere for three or four years, producing gorgeous sunset glows and other striking optical phenomena.

Volcanic dust veils are believed to be responsible for cool weather, and it has been suggested by W. J. Humphreys and others that prolonged periods of intense volcanic activity in the remote past may have been the cause (or one of the causes) of Ice Ages. According to this hypothesis, the fine grains of dust are much more effective in barring the passage of the short waves of solar radiation than that of the long heat-waves radiated outward from the earth. Thus the normal balance between in-coming and out-going radiation is disturbed, and the lower air gradually grows cooler. The famous "year without a summer" (1816) followed the gigantic outbreak of Mount Tomboro, in the Sunda Islands, in 1815. Periods of low temperature and reduced sunshine were observed after the eruptions of Mount Pelée, in 1902, and Mount Katmai, Alaska, in 1912.

THE SMALLEST THING IN THE WORLD

There is nothing better known, and nothing more important to all human beings, than the smallest thing in the world. Yet it is doubtful if the average American citizen could tell, off-hand, just what it is, much less how small it is, and how much—or rather, how little—it weighs.

Well, the smallest thing known to science is an *electron,* and the diameter of one of these "corpuscles," considered as a sphere, is about one five-thousand-billionth of an inch. In other words, it would require 5,000,000,000,000 (five trillions) of these tiny particles, placed side by side, to cover the distance of one inch.

It is these infinitesimal corpuscles that constitute what we know as an "electric current"—i. e., they are the individual "specks," which, following one another at a speed comparable to that of light, constitute the electric current. Each electron "weighs" about one eleven-octillionth of an ounce. Professor Fournier D'Albe calculated that the number of electrons in the human body is—just write 10 and follow it with 30 zeroes, and that's how many!

Now, electrons have not only been weighed and measured, but they have been counted in their swift flight along conductors; and, thanks to Professor Robert A. Millikan, we know how many electrons a second are required to give us the amount of light obtained from a common 16-candle-power electric lamp. To state the number in figures is futile, for, as a matter of fact, no human mind can really think of even one million of anything, in the sense that it visualizes a hundred, or a few thousands, of objects.

Realizing this fact, Professor Millikan put it this way: the quantity of electricity which courses through such an electric lamp *every second* is so large that if two and a half million persons were to begin to count out these electrons, and were to keep on counting them out, each at the rate of two a second, and if no one of the counters were ever to stop to eat, sleep, or die, it would take them just 20,000 years to finish the task!

Thus the electron, of which all the atoms, molecules, and substances in the universe are composed (with a nucleus, in each atom, of positive electricity), is not only the smallest thing in the world, but also the entity possessing the greatest velocity—in some cases nearly 186,000 miles a second, the speed of light.

THE HIGHEST TIDE IN THE WORLD

It is in American waters that the greatest tide in the world is found. Just above the line that separates Canada from the State of Maine, in the upper part of the Bay of Fundy, the tide twice each day rises and falls through a height of about fifty feet. For six hours the water rises and in the following six hours it falls; and during this time there are periods when the water rises or falls twelve feet or more in one hour.

Until recently it was believed that this great tide was brought about by the shallowing bottom and funnel shape of the bay, which at its mouth is about 300 feet deep and 80 miles wide, while at its head it is reduced to a few small shallow streams. It was thought that the tide wave, coming in from the ocean, was cooped up as it advanced up the bay, becoming higher and higher as the channel became narrower and shallower.

Recent investigations, however, have shown that the rise and fall of the water in the Bay of Fundy behaves, not as if a tide wave entered from the ocean and progressed up-stream, but rather like the rocking of the whole body of water in the bay after the manner of the alternate swashing from one end to the other of water in a box. Following this up, it has been discovered that when the water in a bay is disturbed, it rocks from mouth to head, the rise and fall being very small near the mouth, but increasing gradually to the head where the rise and fall is greatest. It has been found further, that the time taken for the water in a bay to rock back and forth depends on the length of bay and on the depth of the water, and when these quantities are known for any bay, the time required for the water to oscillate back and forth can be calculated. For the Bay of Fundy this period is about 12½ hours.

In pushing a child in a swing, we know that a slight force repeated at regular intervals that coincide with the period of the swing, will finally be sufficient to maintain a very vigorous swing. Just so in the rocking of the bay, a slight force applied at regular intervals that coincide with the period of oscillation of the bay will be sufficient to maintain a vigorous oscillation of the water in the bay. And in nature we have such a periodic force in the ocean tides, the period of which is 12½ hours.

The explanation of the great tides in the Bay of Fundy is that the waters of the bay have been put into oscillation by the disturbing force of the tides, and since the period of the tide coincides with the period of oscillation of the bay, this oscillating motion has finally reached its most vigorous stage, and it is steadily maintained by the ocean tide.

WHO KILLED THE DINOSAURS?[1]

Everybody nowadays knows what dinosaurs looked like, and everybody knows that (happily

[1] See illustration facing page 320.

for the rest of us) they are quite extinct, and have been so for a comfortingly long time. To be sure, the impression prevails in some quarters that our ancestors back in the Old Stone Age had these huge lizards to contend with, but (happily for them) this idea must be exploded. The last of the dinosaurs laid him down to die in his primeval swamp many long ages before the first man appeared on earth, popular romancers and comic artists to the contrary notwithstanding.

But why did the dinosaurs disappear? Why should a creature as huge as a house, often armored with horny plates inches thick and well equipped with claws and teeth for the survival-struggle, be compelled to relinquish his overlordship of creation? Probably we shall never know. It all happened such untold ages ago, and the records of the rocks are hard to decipher. We murmur something about "changing conditions—unfavorable climate," and let it go at that. Another suggestion is that the race was wiped out by some epidemic of a disease against which they had no immunity. Probably the major reasons for the extinction of the dinosaurs do lie hidden in this vague fog of undetermined causes, but that need not prevent speculative ventures that often turn up something interesting.

One very suggestive coincidence is that the dinosaurs disappeared at about the time when the first mammals came into being. All through the Mesozoic Period—the Middle Ages of geologic time—the dinosaurs had held undisputed sway like armored barons, but upon the appearance of the newcomer they suddenly—that is, in a few hundreds of thousands of years—and completely disappeared. The natural inference is, therefore, that the mammal might have been at least a partial cause of the disappearance.

A glance at the fossil remains of one of these earliest mammals makes such a theory appear at first ridiculous, for they were only about as big as a good-sized cat; and a saurian no larger than an elephant was a very modest saurian indeed. Yet Puss-in-Boots among the ogres was able to do by adroitness what he could not accomplish by force. A modern instance gives us a hint. The most destructive enemy of the present-day crocodiles in Egypt is a small, weasel-like animal called the Ichneumon. Scarcely large enough to make a decent mouthful for a crocodile, this little hunter wipes out whole colonies of the great reptiles by burrowing into the sand where their eggs are hidden and sucking the whole batch.

Something of the same sort may have happened to the dinosaurs. They were egg-laying animals, like all reptiles, and their eggs were probably small compared with the vast bulk of the adult. Furthermore, the jawbones of the arch-ancestral mammal show an equipment of carnivorous teeth. It is quite possible that this nobody-knows-how-many-times-removed grandparent of ours gained a handsome living for herself and at the same time made the world safe for Mammalia by literally undermining the tottering saurian dynasties.

THE NERVES OF AN ANIMALCULE

Do the one-celled microscopic animals ever get attacks of nerves? As to that we cannot be sure, but anyway they have the nerves, says Professor C. A. Kofoid of the University of California who, together with his students, has been investigating the internal economy of these little organisms for many years.

Some of these little animals beat their way about the world (they live in the water or other fluids) by means of a covering of minute, hair-like processes or cilia which work like the long tiers of oarsmen on an ancient Roman ship. Others swim with a long whip or flagellum which acts somewhat as does the tail of a fish.

But the animal has to respond to jolts from different sides of its body, turn in one direction at one time and in another for a different stimulus. To effect this control it has a system of fine fibers running from a central body to the surface.

These function in somewhat the same way as the nervous system of higher animals. If you burn your finger, the nerves carry the impulse from the skin to your brain and back again to the muscles of your arm, and you draw the finger away from the hot body and put it in your mouth. So the animalcule's fiber system assists it in getting away from or towards something before or behind or on the side.

This system was discovered back in 1880 by a German scientist, but its function was only demonstrated with certainty in Professor Kofoid's laboratory through the perfection of an unusually fine technique in micro-dissection. With fine quartz needles—glass would not do because it is too springy when so fine—the scientists cut separate fibers in living micro-organisms under the oil-immersion lens, the highest power of the miscroscope. By this means they demonstrated the part played by individual fibers and groups of fibers.

This type of neuro-muscular system, although similar to that of higher animals, is not a structure from which the later was evolved. It is restricted entirely to the protozoans or one-celled animals. It is interesting to learn, however, that the lowest animals are not so simple as they superficially appear, but contain in their protoplasmic mass a complication of structure and division of labor comparable to that of their many-celled descendants.

THE QUICKEST THING YOU DO

What is the quickest movement you can make in response to a signal or stimulus?

Probably you think first of the elevation of your anatomy when you sit on a tack or the summary *dropping of a hot lamp chimney. Most people* would imagine that they got off the tack or dropped the hot object instantaneously.

But the physiologists, with their electrical timing instruments, tell us that such reactions are relatively slow, taking nearly two-tenths of a second at the best.

Another suggestion might come from the common expression, "quick as a wink," and in fact the "lid reflex," or closing of the eye when something comes toward it, is very rapid, about five-hundredths of a second.

But the most rapid reaction of all is a leg movement (jazz artists please note), namely, the familiar "knee jerk." If you cross one leg over the other and then strike sharply the freely hanging leg just below the knee, the lower leg will be raised by contraction of the muscles of the thigh. This jerk is remarkably sudden, only a little more than *five-thousandths* of a second elapsing between the blow and the muscular contraction. Even then the nerve current has to travel all the way to the spinal cord and back again, but it enjoys a clear run without switches.

This phenomenon may seem a useless perfection of human efficiency, but on the contrary it is really an indication of a very important function. It is only the peculiar situation in which we test the reaction that makes it appear as a mere physiological curiosity. A similar response is found in connection with other joints and serves in other positions than that of crossed legs to prevent any *sudden* strain falling on the ligaments from the contraction or increased tension of attached muscles.

By means of the extraordinarily rapid mechanism of the "tendon reflex," any sudden muscular strain on the tendons (which are inelastic and might rupture) is offset by an equally sudden contraction of an opposing set which saves the joint without the individual ever feeling the strain.

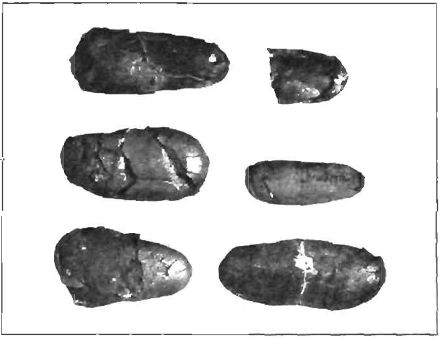
JIMSON WEEDS AND EYE-GLASSES

The next time your eyes are examined for glasses you may have reason to be thankful for Jimson weeds and for science that has found a way to use them. Belladonna is often used to dilate the pupils and this mydriatic action is due to the alkaloid atropin which is the active principle of the plant, *atropa belladonna*. The extraction of alkaloids from plants is a costly, tedious process so that in times past only those plants with a high alkaloid content were worth using.

The usual method for the preparation of atropin is to air-dry the plant, grind it finely and then percolate it with cold 90% alcohol. If seeds are used the oil is first removed by dissolving it out with petroleum ether. Most of the alcohol is removed by distillation and the residue treated with dilute sulphuric or hydrochloric acid under slight vacuum which removes the alkaloid. Then follows a chloroform treatment to remove traces of oil, chlorophyll or other soluble non-basic substances. Next dilute ammonia is added to make the solution just alkaline and then the alkaloid is extracted with chloroform.

It is still impure and may be a mixture of alkaloids which much be separated by crystallization and recrystallization from alcohol by the addition of water. The whole process requires much care and quantities of expensive chemicals.

One day an investigator found that when he filtered a solution containing atropin through anhydrous aluminum silicate, commonly known as fuller's earth, there was no alkaloid in the filtrate. It had all been taken up by the fuller's earth. Now

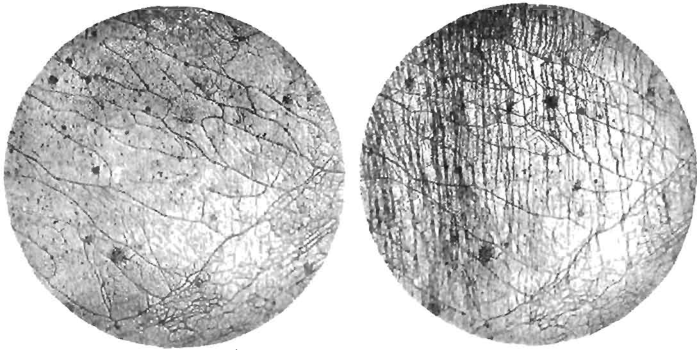


DINOSAUR EGGS

It has always been assumed that the saurians of prehistoric times laid eggs like modern reptiles, but it was not until 1923 that this surmise was confirmed through the discovery of twenty-five fossilized eggs in Mongolia by the Third Asiatic Expedition of the American Museum of Natural History. The eggs are about six inches long. One of them contains the bones of an unhatched dinosaur chick. *See* page 313.

PROTOCERATOPS AND HER PLAYFUL PROGENY

A family group of dinosaurs, living in Mongolia some ten million years ago, as depicted by E. M. Fulda of the American Museum of Natural History. (Photos from American Museum of Natural History.) *See* page 313.



WHY METALS GET TIRED

Left. Microphotograph of a *piece of iron before* being bent.
Right. The same part of the same piece of iron *shown on the left after* being bent back and forth about 400 times. Note the cracks spreading through the metal. These would be invisible to the naked eye.

this is a very simple procedure which eliminates so much of the cost in the separation of alkaloids from the first solutions made from the plants that plants carrying but a small percentage can be treated commercially.

Now about the time this technique was being perfected it became difficult to obtain enough *atropa belladonna,* which is largely imported to meet our needs. But for the new process we certainly would have suffered much inconvenience, if nothing worse. Then it was found that the much *despised Jimson weed contains some atropin and* in some localities it became a source of revenue. It can be treated profitably by the fuller's earth process but not by the older method.

There is still another advantage, for an alkaloid like ipecac is not ordinarily tolerated in the stomach. When it is absorbed by fuller's earth it is tolerated and can therefore be administered in tablet form. Science still has much to do before we can subscribe to the belief that everything in nature is useful, but at any rate Jimson weed has been transferred from the liabilities to the assets.

WHY METALS GET TIRED

Many who drive automobiles have had the inconvenient experience of a spring breaking. In most cases the spring breaks suddenly and without apparent cause; the spring has withstood hard usage, heavy loads, and hard bumps, and then one day, as the car is running along with an ordinary load on a good road, the spring suddenly snaps without giving any warning of its intention to do so. The garage man looks wisely at the broken spring and says it has "crystallized," or failed by "fatigue." But what does he mean by such terms, and how can springs be made and used so that they will not fail in this disconcerting way?

Auto springs are not the only things which show this sort of failure. The blades and the wheels of steam turbines once in a while "let go," sometimes with disastrous results, bolts on engine parts snap in two, shafting breaks short off, and other parts of swiftly moving machinery have sudden failures. Not that these failures occur in all machines, or in any very large number of machines, but they do occur often enough to cause machine designers and metallurgists and machine-owners a good deal of worry. It seems as if under repeated loading steel and other metals may become tired out and suffer a sort of nervous breakdown—hence the name "fatigue" of metals.

This fatigue of metals, especially of iron and steel, has been the subject of study for about three-quarters of a century, and scientists have found out a good deal about the nature of it by examining metals under a microscope as specimens of the metal were bent back and forth. In Figure 1 is shown the appearance of a piece of iron before it had been bent back and forth. The metal is made up of irregular crystalline grains; it is already "crystallized" as are all structural metals. Figure 2 shows the way the iron looks through the microscope after it has been bent back and forth several hundred times. Minute cracks, invisible to the naked eye, can be seen working their way into the metal. When they have spread far enough the remaining uninjured metal is unable any longer to carry the load and the whole piece suddenly gives way.

Now to return to the auto spring. The hard bumps it had withstood without breaking had started these minute cracks, and then the cracks kept on spreading, very slowly, but still spreading, under *light* bumps as well as under heavy bumps, until finally there was no longer enough sound metal left to stand ordinary service, and the spring snapped, not because the metal had "crystallized" under repeated loads, but because it had been subjected to a progressive cracking of the crystals of the steel.

Now how can steel, or other metal, be so made and so tempered that it will be reasonably "proof" against the starting and the spreading of these fatigue cracks? The complete answer to this question has not yet been obtained. But in a general way, the suitability of steel for resisting fatigue is determined by tests of samples in a machine which vibrates them back and forth, determining the violence of vibration which the steel can stand for, say, ten million times without failure.

One test, devised by a British engineer, uses a very delicate electric thermometer on the steel. If under a given load the steel does not heat up appreciably as a specimen is "wobbled," it is not developing fatigue cracks; if the fatigue cracks are developing and spreading the specimen develops a fever, and in a few minutes a small but measurable rise of temperature occurs.

The problem of fatigue of metals, especially in airplane parts, became so acute during the war that an extensive investigation of the subject was organized under the joint auspices of the National Research Council, Engineering Foundation, the General Electric Company, and the University of Illinois, with Prof. H. F. Moore, of the University of Illinois, in charge. Another extensive investigation was organized by the United States Navy at Annapolis. Valuable results are being published by both investigations, and by the British National Physical Laboratory, but much yet remains to be learned about fatigue of metals. However, to-day, it is possible for steel makers and steel temperers to produce steel highly resistant to fatigue.

One factor particularly influences the resistance of metal to fatigue. Fatigue cracks start very easily at notches, nicks, or rough surfaces on a piece of steel. Remember how easily a wire can be broken by bending if it is nicked with a file. For this reason it is good insurance to keep rust spots from the surfaces of your springs and shafts and steering knuckles, and not to let the garage man leave file and chisel marks on parts which, in service, tend to bend or twist.

CLOTHES AND VENTILATION

Those people who are "always chilly," sensitive to the slightest draught, are paradoxically generally those who are overclad. Only the underfed and the under-exercised feel the need of very warm clothing to conserve the body heat and keep out air currents, just as only those who are well nourished and healthy can afford to regard clothes mainly in the light of ornament, or "*fashion.*" Darwin describes the natives of Tierra del Fuego, a hardy race that practises infanticide in order to keep down its numbers to the possibilities of the food supply, as practically naked in the sleet and snow of winter. The long hair of the women is their main protection; the men wear at most an otter skin, the size of a handkerchief, laced across the chest and shifted to the side struck by the icy wind. Not a comfortable picture, but the Tierra del Fuegians appear to suffer less from cold than an English curate described in contrast by Dr. Leonard Hill in his monograph on "The Science of Ventilation and Open Air Treatment." The curate, in mild winter weather, complained that he "always felt the cold." His clothing is enumerated by Dr. Hill: "He wore a thick llama wool vest, a thick woolen shirt, a wool-lined waistcoat, a cardigan jacket with long sleeves, a tweed suit and a wool-lined motor overcoat. Why should this guardian of men's souls thus induce the perfect heat-regulating mechanism of his body to atrophy from disuse? Nursery training had instilled into him the fear of cold, draught, and wet feet."

Too heavy clothing, and particularly ill-ventilated clothing, defeats its own end. It provokes excessive sweating and exhausts the skin by keeping it unduly active. Clothing must be permeable to moving air currents in order to be serviceable. It must be porous and have air-holding and water-evaporating power. For this reason the method of weaving cloth is more important than the nature of the material; by proper weaving the same results can be obtained with cotton, linen, and wool. Dry flannelette is as warm as flannel and a shirt of fine linen woven as thick as a woolen shirt is as warm as wool.

The heat-retaining power of cloth, fur, feathers, etc., depends not upon their thickness or weight but upon the air immobilized in the pores and between the layers of the material. The motionless air imprisoned in the material acts as a non-conductor of heat, helps the body to hold its own against the cold air outside. The porosity and water-evaporating power permit the skin to breathe, to react to moving air currents and keep fit by giving off excessive moisture. Only for protection against high winds, tropical sunlight and rain or snow are non-porous, impermeable garments like water-proofs, wind-proof silk, etc., useful. For exercising in wet weather, woolen clothing is preferable to rubber on account of its greater permeability. Wet clothing cannot chill the body so long as one keeps warm by exercising.

Over-warm, ill-ventilated clothing readily becomes a habit as the skin loses more and more its original power as a natural heat-regulating device. The result is a greater sensitivity to draughts, chills, and colds, and possibly a lowered resistance to such infectious diseases as pneumonia and tuberculosis.

MONOLITHIC ARCHITECTURE[1]

Ever since man left his cave temples hewn out of the solid rock his buildings have almost always been put together of small pieces. He has worked as a child plays with blocks, piling brick on brick or stone on stone, and fastening together sticks and steel. Now he is experimenting with a new material, reinforced concrete, combining the strength of steel with the solidity of stone, and he can construct a building as he conceives it, in its entirety, not as an accumulation of insignificant components. The house is a whole, one solid block of stone, hollowed with convenient chambers. If it tips over on one side by the subsidence of its foundation, it is simply set up again.

It will be interesting to see what the architects will do with this new and plastic material that has been thrust into their hands. They have been freed from their old formulas. They are no longer bound to pillar and beam. Their structural ornamentation becomes ridiculous when the structure to be accentuated no longer exists. So long as they had merely a steel upright to deal with they could surround it with a veneer of marble or plaster veined like marble, and pretend that it was nothing new and alarming, nothing but a Greek pillar which nobody could deny was good art. So did the Greek architects in their

[1] See Illustration facing page 336.

day, imitating woodwork in stone and making their pillars like tree trunks.

For architects are timid creatures. When they progress it is by walking backward, keeping their eyes fixed on the past. When they have an opportunity to do something new they dodge it and cling to the old and familiar. In the most expensive of our public buildings, we may see a huge bronze electrolier that is a bundle of anachronisms. The electric bulbs, instead of hanging down as they should, are stuck on top of imitation candles made of porcelain; these are mounted on globes, obviously pseudo kerosene oil reservoirs, and connected by coiled tubes, originally designed for gas, while below the support projects the handle of the primitive torch. It constitutes a complete history of the art of illumination from the earliest times to the present, but it is fit for nowhere but an archeological museum. It is because of this atavistic obsession that architects make us libraries with no places to store books or to deliver them, churches where we cannot hear or see the minister, and post offices where the clerks work in the dark and handle the mails by the touch system.

Now we do not want to have to wear hand-me-downs forever, so we welcome this new material, which may effect a revolution in architecture if it can be kept under the influence of utilitarianism long enough to develop its own natural forms. If the academician gets his hands on it he will spoil its fair façade by sticking on fake pilasters and arches. The great advantage of concrete from the artistic point of view is, as we have already said, that it is not composed of little pieces, yet we see already walls where fake mortar lines are carefully marked in to simulate blocks of stone.

The true aim, on the contrary, should be to give the impression of unity, to show that the edifice was cast, not built up. The decoration should be of the same character: molded cornices and belts, glazed tiles and mosaics of colored clay. It was such surfaces that inspired the Byzantine and Moorish architects to develop their inlaid work and low relief. The forms or molds into which the concrete is poured can be ornamented or plain surfaced, and the tiles to be embedded in the wall can be pasted on the inside of the forms arranged in the desired design. Instead of chiseled stone, prepared by long and expensive handwork, we have molded stone, more sensitive to the artist's will. Who knows but we may get an American school of Della Robbias?

The cheapness and ease with which decoration with sculptural forms can be secured in concrete will doubtless lead to grotesque exuberance in some cases, but it will be a welcome reaction from the commonplace and conventional to which we have been tied. So far even the hastily and economically constructed factories and warehouses are a delight to the eye, because of the simple lines, massive surfaces and neutral gray tints, following more nearly than any other the Mission style, as they should, for this was of adobe derivation.

Reinforced concrete is a partnership of surprising suitability. Thin steel rods or bands, twisted or notched, are stretched through the boxes into which the concrete is poured, and the two together are stronger than the sum of their separate strengths, for to the compression strength of the cement is added the tensile strength of the steel. The two materials expand and contract together, so there is no breaking by change of temperature. It is startling to our eyes, accustomed to wood and stone, to see the thin floors stretching from wall to wall with no beams beneath, sheer pent roofs without brackets or pillars, and balconies with no visible means of support.

From an artistic as well as a utilitarian point of view its chief advantage is its adaptability. A building should be designed from the inside outward. Instead of putting up an ancient or medieval edifice and housing in it more or less comfortably a modern institution or industry, this should first form its own commodious apartments, and then the consequent exterior should be made as attractive as possible. It is better to be a clam, forming its own shell, than a hermit crab borrowing a misfit lodging.

COCKTAILS FOR PLANTS

The best way to cure many a sick man is to give him poison.

This is not intended as a feebly jocular reference to the well-known remedy once prosecuted in the form of the guillotine for the ills of the French aristocracy. Nor is it any other kind of a joke, feeble or robust. It is an exact fact.

For instance, what does the doctor do when he thinks you need a heart stimulant? He gives you *strychnine* or perhaps *digitalis* or *nitroglycerine*, all of them violent poisons. But the point is that he gives you a small dose. A sixteenth of a grain of strychnine is stimulating. A large dose, say half a grain, is poisonous. This is a very common circumstance. Many poisons, perhaps most of them, are stimulating if given in small doses. Even John Barleycorn furnishes a case in point.

All of this is common knowledge. What is not common knowledge, what indeed has only recently been discovered, is that exactly the same thing is true of plants. The scientists, who are investigating the conditions under which plants grow well or poorly, discovered a long time ago that when a considerable quantity of copper sulphate or blue vitriol is mixed with the soil in which plant roots are grown, the roots are killed. The copper sulphate poisons them. Suppose, however, that we put into the soil only a very small quantity of copper sulphate. If we get the quantity just right the plant is not poisoned. Indeed, it sometimes grows faster, it is stimulated.

It is necessary to be extremely careful in interpreting such experiments. Unlike a human patient the plant cannot tell us when it has a headache or when it feels fine. One must judge by the rate of growth, the weight of the tops or roots produced in a given time, or the like.

In very precise experiments we cannot use soil but must grow the plants with their roots in water to which have been added the exact amounts of food materials or medicines which we wish the plants to have. As doctors do with human patients, we put our plants on a liquid diet. Many careful experiments have been carried out in this fashion on the effects of copper and other poisonous elements on wheat plants, barley, peas, and others. The conclusion is that in many cases, perhaps in all, small doses of the poison are stimulating, just as are small doses of strychnine to animals. The plants are more active, they grow faster. As there are for the human body many stimulant poisons besides strychnine, so there are many substances which act in this way on plants.

Will these effects ever be used practically? Will science give us presently highballs for plants, spring tonics for tired vegetables? Who knows? Naturally the plant physiologists are uncertain of details and cautious in making prophecies The medical profession did not come all in a minute to the use of strychnine. But it is worth while to remember that John Watt's tea-kettle has had some rather important descendants and science probably has not finished obtaining large results from small beginnings. "Dope" for plants has interesting implications. Imagine, for instance, a cabbage with the cocaine habit!

THE IRREPRESSIBLE DANDELION

Nobody disputes that the dandelion is a great success—at least from the point of view of the dandelion. Adaptable to pretty nearly all kinds of soil and climate, triumphant in its competition with other plants, defying the knife of the exasperated householder, prolific in its offspring, is certainly among the "fittest," if survival is an indication of fitness.

In the manner of bringing its seed into existence it has taken a most unfair advantage of its neighbors. As every one knows, the rule among plants is that seeds cannot develop until they have been fertilized with pollen. This makes most flowers dependent on weather conditions, the visits of insects, the presence of other plants, and a number of other factors that help or hinder in the scattering of the pollen. The dandelion escapes all this handicap simply by developing its seeds without waiting for them to be fertilized. It is simply production of offspring with a mother but no father—a kind of vegetable virgin birth. Scientists have given this process a Greek name —"parthenogenesis"—which in plain English means exactly that.

This natural virgin birth is no uncommon thing among certain orders of insects and other lower animals. It is the common mode of reproduction, and it is frequent also in certain plants other than the dandelion. Bnt the dandelion is the most common plant that produces its seeds in this way.

The discovery of this fatherless-seed habit in the dandelion is of only recent date. The flower has all the parts that other flowers have for producing pollen and effecting pollination, and even goes through a somewhat complicated process as though it actually did use the pollen, so that for a long time it was thought that it was like all other flowers in this respect, only more efficient. Then it occurred to an enterprising botanist to cut the tops off the buds, removing the pollen-bearing and pollen-receiving organs before they were unfolded, but leaving the unfertilized seeds. These went right ahead and ripened as though nothing had happened. Later, more detailed investigation showed that this was the normal course of events anyway, and that the development of the seeds always started before the flower opened, and therefore before there was any chance for pollination at all.

Why the dandelion still goes to the trouble of producing pollen and repeating the performances that usually accompany fertilization, is an unanswered riddle. Most botanists think of it simply as an evolutional relic—something that once served a purpose and is now carried on just from sheer force of habit.

But about this the dandelion is not concerned. "Get there," is its motto, and its seeds, unfathered though they are, certainly do get there, as any harassed suburban householder can testify.

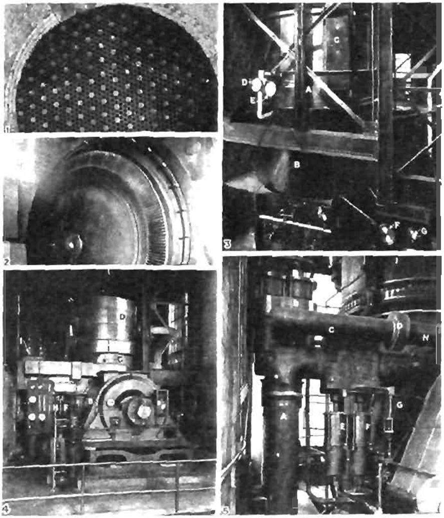
VISIBLE SOUND WAVES

One afternoon in April, 1906, Professor Frank A. Perret, the American volcanologist, was flirt-

MONOLITHIC ARCHITECTURE

Upper. A concrete bridge is like a single stone laid across a stream.

Lower. A concrete house is like the chamber hollowed out of a solid rock such as the primitive cave-man lived in. (Photos from Portland Cement Association, Chicago.) *See* page 328.



THE NEW MERCURY ENGINE

1.—Bottom of mercury boiler from bottom of furnace, showing hexagonal cross-section of lower end of the tubes. The tubes are slightly conical and one in seven is omitted to permit circulation of the mercury.

2.—Blading of turbine runner.

3.—*Mercury boiler. A, boiler; B, furnace casing; C, flue casing,* inclosing vapor pipe; *D*, mercury-level gage; *E*, mercury-pressure gage; *F*, steam-pressure gage; *G*, vacuum gage.

4.—Mercury turbo-generator set, condenser and condenser boiler. *A*, generator; *B*, turbine; *C*, mercury condenser; *D*, condenser steam boiler; *E*, flyball governor; *F*, electrically controlled governing valve and throttle; *H*, electrically controlled emergency valve; *I*, *mercury safety valve.*

5.—Safety, emergency, and governing valves. *A* vapor pipe from boiler; *B*, safety valve; *C*, by-pass from safety valve direct into condenser; *D*, accordion expansion joint; *E* electrically controlled emergency valve; *F*, electrically controlled governing valve; *G*, turbine; *H*, condenser; *I*, condenser steam boiler.

See page 339

ing with death upon the flanks of Vesuvius, then in active eruption. Discharges of lava and crumbled rock occurred every few seconds and each discharge was accompanied by a sharp detonation. Watching the cloud of smoke and dust, Professor Perret witnessed a curious spectacle. At each explosion a thin luminous ring was seen to flash upward and outward from the crater and disappear in space. The movement of the rings was much more rapid than that of the material ejected from the volcano. Attempts were made to photograph them, but without success. In 1910, during an eruption of Etna, Professor Perret again saw the strange rings of light. He named them "flashing arcs" and explained them as visible sound waves.

These observations acquired fresh interest during the World War, when numerous reports came from the front of mysterious curved bands of light and shade seen sweeping across the sky or the ground near places where cannon were being fired. They were described as resembling the concentric ripples produced by dropping a pebble in the water. These were also identified with sound waves. In fact, one observer told of hearing the explosion of a distant gun at the precise instant when the moving arc reached his feet.

How do sounds become visible in these cases? An explosion suddenly pushes the air away in all directions from the point of disturbance and *sets up what is scientifically called a "wave,"* though it bears little similarity to the waves of the ocean. This sound wave, which is really a steadily expanding spherical shell of condensation followed by a shell of rarefaction, spreads out from the source at a speed of a little more than a thousand feet a second. When the wave reaches our ears, the vibration that it imparts to our ear-drums enables us to hear the explosion.

These spreading spherical shells in the air are made visible by their effects upon the paths of light-rays coming through the air to our eyes. We commonly say that air is invisible, but it would be more correct to say that it is merely more or less transparent, just as a window pane is transparent. If the glass of the pane contains little irregularities in texture—such as the "bubbles" found in glass of inferior quality—these are easily seen because the light comes through them at various angles as compared with its general direction through the pane. So it is with air.

The power of air to "refract" or bend light rays varies with its density. In the case of the optical effect seen over a hot stove contrasts of density arise from contrasts of temperature; the mingled streams and currents of warmer and cooler air keep altering the paths of the light, concentrating the beams in one place and spreading them apart in another. In the case of the sound wave we have a uniform disturbance of the light rays along a curved line, corresponding to the cross section of the moving shell above mentioned. The sound wave may be aptly compared to a soap bubble in process of blowing, and Professor Perret's "flashing arcs" to the circular outline of the bubble.

A MERCURY ENGINE [1]

The first mercury engine in the world for the production of power in commercial quantity was put in operation in the plant of the Hartford Electric Light Company in September, 1923. The invention is essentially a turbine engine run by mercury vapor, instead of water vapor, that is, steam. The mercury vapor driving the engine is at a pressure of 35 pounds to the square inch above atmospheric pressure and at a temperature of 850 degrees Fahrenheit.

The Hartford installation delivers 3,500 kilowatts of current, of which 1,400 comes from the mercury turbine and the rest from the attached steam turbine. About 7 pounds of mercury per kilowatt are now used, but this is expected to be reduced by half in new designs.

The mercury vapor exhausted by expansion in the turbine is sent to a condenser where it is

[1] *See illustration facing page 337.*

cooled by water, just as in any ordinary power system. But the mercury vapor is so hot that the "cooling water" is turned into high-pressure steam. This steam is not wasted, but is sent to a steam turbine from which additional power is obtained. This still further increases the efficiency of the system. The new engine uses only about a quarter of the coal previously used for the same amount of power.

It is the object of making such installations in the future to replace the steam boilers in the large modern plants by a mercury boiler which will give nearly double the output in the same space. Consequently, no general re-design of a station will be necessary to obtain the benefit of better economy.

The process was invented and designed by Dr. W. L. R. Emmet, of the General Electric Company. As the characteristics of mercury vapor had never been thoroughly studied by other scientists, it was necessary for him to go into this general subject in great detail. It was found that no form of packing of the joints would resist the mercury vapor, and a system of arc and acetylene welded joints was therefore developed.

WORRY AS AN INDOOR SPORT

Why worry?

That question is more frequently asked than answered. Worry is always a useless waste of nervous energy and utterly unnecessary from the point of view of the other person.

The Freudians tell us that worry is but a cloak for a desire which you will not acknowledge, even to yourself. When you worry lest somebody get hurt, it is because down in your "Unconscious" somewhere you would really like to see him hung or anyhow something happen to him.

Possibly this may be true in certain pathological cases, but we would scarcely say that a student worries over an impending examination because he really wishes to fail in it. On the contrary, he worries over the examination because there is nothing else he can do about it and it continues to occupy his attention. The worry is a sort of substitute reaction which he indulges in when no effective action is within his power.

But, as Professor R. W. Woodworth points out, "worry may also be something of an indoor sport as well." For example, a mother habitually worries over her child. When he is late getting home from school, she imagines that he has fallen into a pond or been hit by an automobile. In reality, she does not think anything of the kind has happened. If she did, she would run to the pond or the street and not sit contemplating visions.

By conjuring up these imaginary dangers she is really making the child's home-coming something of an event instead of a mere matter of routine. She is mentally enjoying a mild danger like a person shooting the chutes or playing poker. In the latter cases we create a danger which we know we can escape and the experience gives us a thrill. So the mother, by imagining a hazardous home-coming for her infant, experiences a pleasant feeling of relief when he comes strolling in, as she all the while expected he would.

AN ANIMAL WITH FIFTY STOMACHS

Ordinarily one stomach causes enough inconvenience to an individual and we rarely think of the possibility of an animal having more than one, unless perhaps in the ruminants where the stomach is divided into several compartments. Yet there are some water-dwelling protozoa, tiny, single-celled animals, either invisible or scarcely visible to the unaided eye, which have their digestive system centered in numerous little spherical bodies known as "improvised stomachs" or food vacuoles. The paramecium is a microscopic animal which has such a digestive apparatus.

The food, consisting of bacteria and other small plant and animal forms, is taken into the interior of the paramecium, and at the point of entry the food is pinched off into vacuoles about ten or fifteen twenty-five thousandths of an inch in diameter; this is the average size although larger ones are sometimes formed if the animal be very hungry. It is quite an ordinary occurrence to see ten or twenty food vacuoles in one animal; if the medium in which the protozoa are living contains an abundance of food, fifty vacuoles may be formed; and as many as ninety-five have occasionally been seen in a single paramecium.

These microscopic gastric vacuoles are to all intents and purposes "stomachs," because digestion of the food takes place here. Under the microscope, these vacuoles can be seen to circulate in a certain fashion through the substance of the animal. While this circulation is in progress, fluids are poured into the "stomach" to help to digest the food material. By means of delicate chemical indicators, these fluids have been shown to be comparable to the gastric juices of higher animals.

A NEW KIND OF COMPASS

When an airplane takes up an ordinary compass, with its needle of magnetized steel, and starts to make rapid turns of any kind, the compass becomes air-sick and the needle whirls round and round and points every which way for north. To add to its troubles it is usually placed in very close proximity to a large steel engine, and a compass simply cannot tell the truth when there is an engine around.

The gyroscopic compass has been used with success on water craft, but it also is subject to air-sickness in addition to being undesirably heavy.

Now Dr. L. J. Briggs and Dr. P. R. Heyl of the Bureau of Standards have invented a compass that overcomes these defects and furnishes a reliable instrument for use in aircraft. For this device Dr. Briggs and Dr. Heyl were awarded the Magellanic Gold Medal for inventions useful to navigation, the first time it has been awarded for anything pertaining directly to air navigation. This medal was established in 1786 by John Hyacinth de Magellan, a descendant of the famous navigator, and is awarded by the American Philosophical Society.

The new direction-finder is called the "earth inductor compass." The essential principle on which it is based is much the same as that of the electric generator. A coil of wire revolving in a magnetic field has an electromotive force, or voltage, induced in it. In the ordinary generator the magnetic field is furnished by a powerful electro-magnet, and the revolving coils of wire are connected to a series of copper bars called a commutator, which revolve with the coils and successively come in contact with two fixed brushes over which the current is carried to the outside lines.

It is found that if the position of these brushes is changed with respect to the field the voltage generated is also changed. It would therefore be possible to tell the relative position of field and brushes by measuring the voltage.

In this type of compass the magnetic field is furnished by the earth itself. This field, of course, remains stationary no matter what the airplane does. The brushes, being attached to the machine, turn with it, so that a reading of the voltage would tell the direction in which the machine was pointed.

Actually it is not quite so simple as this. In practice it is necessary to have two pairs of brushes instead of one, and these are so arranged that a turn which increases the voltage of one pair will decrease the voltage on the other pair. The direction will then be measured by balancing these two voltages against each other.

It has been found best to do this by means of an instrument which is set for a given course. As long as the airplane follows this course the instrument reads zero, but it promptly shows a turn.

In the picture the four coils of wire form a cross just above the weight at the bottom; the brushes are just above them; and at the top is a wind-wheel for driving the rotating parts. The whole device is mounted in the tail of the machine away from the engine and is connected with cockpit and the reading instrument by four wires.

Ships on the sea as well as in the air will benefit from this new sort of compass born of aerial necessity. For so well does it guide airships that it is being applied to our ships at sea as a rival to the magnetic needle.

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