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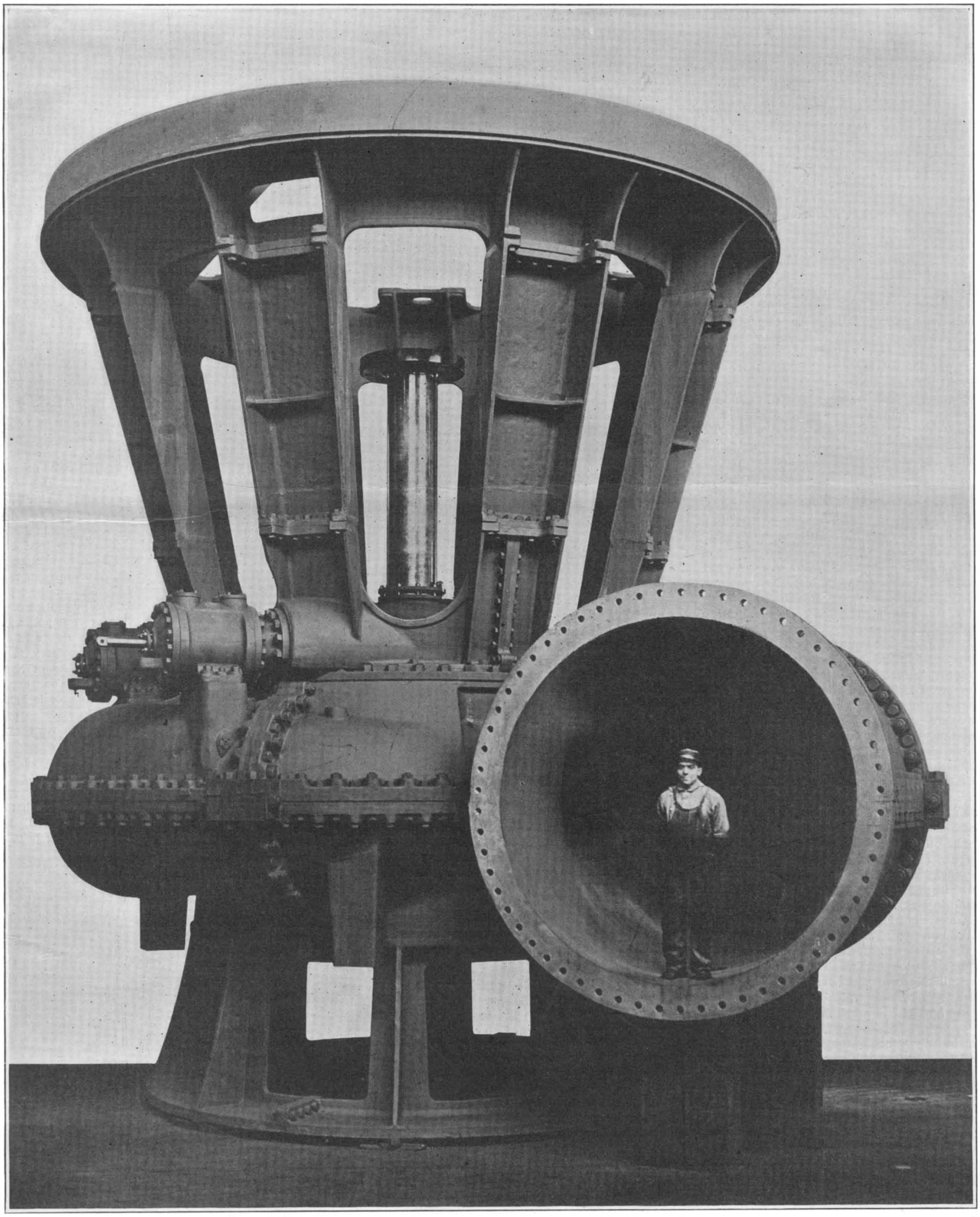


One of a number of water-motors that will furnish power for the electrically operated section of the Chicago, Milwaukee & St. Paul R. R. in Montana.

A 15,000 HORSE-POWER TURBINE.—[See page 133.]

Perpetual Motion*

The One Phenomenon Which Is Universal and Constant

By Charles E. Benham

It seems at first sight a little extraordinary that science should insist upon the practical impossibility of the one phenomenon which is universal and constant, and more in evidence than any other in the whole universe.

From nebulæ and suns down to atoms and electrons there is nothing but perpetual motion in every created thing, great and small—animal, vegetable, mineral, solid, liquid, gaseous, ethereal—and yet we are assured that perpetual motion is immutably barred by the law of the conservation of energy. It is well known that every molecule of the densest rocks of the globe is a congeries of rapidly vibrating atoms; that every particle of the ocean is similarly agitated in its component ultimates; that air and vapor particles dart incessantly with incredible and unceasing velocity through their appointed orbits; and that the all-permeating ether fulfils the "law of exchanges" in a ceaseless ripple of infinitesimal waves; and yet we are assured that perpetual motion is impossible. When we point to the incessant movements of rotation and revolution of the globe on which we live, and to the orbits of the very sun and stars—to say nothing of the inner tremulations of their component atoms and electrons—we are told that all these things are but temporary; that they will "have their day, and cease to be"; that the mighty movements of these huge masses will ultimately ripple away in heat vibrations, and sink into a final repose of complete quiescence. When we ask for evidence of this tremendous surmise we are referred to the doctrine of the conservation of energy; in short, we are told that it must be so because perpetual motion is impossible. It seems very like arguing in a vicious circle. We start our proposition with the enunciation that perpetual motion is impossible; we turn to facts and find it in every particle of matter, and then we infer that all that movement must necessarily cease because perpetual motion is impossible. Q. E. D.

Perhaps it may be answered that some evidence of the decay of planetary motion is to be found in the life-history of our dead moon, which has already so far altered that she is supposed to be no longer capable of supporting life; and we may be told of other observations of change in the province of astronomy, and also of calculations that have been made as to the past and future careers of suns and planets; but at best these are necessarily conjectures, founded for the most part on the assumption of the truth of the very point we are considering—the impossibility of perpetual motion. What is it, after all, but surmise that the moon was once a world of life, and is now but a dead planet, or, even if that is granted, that she must gradually cease to revolve and rotate; and, *a fortiori*, what an enormous leap to assume positively that, therefore, even the sun's great cycle of revolution will in aeons of time dwindle into inaction and repose; or, to take the other end of the scale, that every quivering molecule, atom, and electron is wearing itself out with its energies, and must one day sink down, tired out, in everlasting sleep? Considering that we have not even a glimmering knowledge of the causes of atomic or electronic vibration, or even of the more patent Brownian movements, that we can watch with our eyes under the microscope, what vanity it seems to dogmatise upon the causes that must finally arrest those inexplicable oscillations, and to assert positively that there is no possible replenishment of spent forces, the origin of which we admit is beyond our investigation!

We may fully concede the truth of the doctrine, supported by abundant evidence, that all energy tends to ultimate in heat vibrations, and we may accept to the full the doctrine of the conservation of energy; but the case is not met by these admissions. Granted that all the forces of the universe tend to resolve themselves into undulations of heat, we have no assurance that they are not renewed; and, while their source and origin are inscrutable, we can claim no right to deny the possibility of their replenishment. The mystery of creation, if it implies anything, rather implies a possbility of re-creaton than the opposite. While there are so many cosmic energies that have sources of origin that we have no means of exploring, we may justly keep an open mind as to the question of whether they may be capable of eternal replenishment. In so doing we do not in the least impugn the doctrine of the conservation of energy. We may be sure that from a purse that is being constantly opened the contents will gradually disappear, but we cannot say that the purse will become empty unless we know how and whence it is supplied, and whether the supplies are or are not inexhaustible.

In the same way, without disputing the calculated life-periods of the radio-actives, without denying that in time their energy may be expended, we must not hastily assume that all atomic and electronic motions will expire. It may be that there is a simultaneous replenishment provided for in the economy of the universe, making good the loss. In the recesses of ancient rocks have been found liquid films embedded in quartz, and containing minute particles of matter in suspension, which show under the microscope an activity of movement that has undoubtedly gone on for aeons of time before human or any life existed on this planet. What set them in motion we do not know, nor why they continue to move. Dare we presume to assert with any degree of confidence that these movements, the cause of which the wisest philosopher knows no more about than the child, must necessarily some day come to a standstill, because, forsooth, we have agreed among ourselves that it is impossible that they should do otherwise? The philosophers of the Middle Ages used to reason that because it ought to be, therefore it is; which was very ridiculous. Some modern men of science sometimes argue that it cannot be, and, therefore, it is not; which is not much better.

The fact is that perpetual motion, in its widest sense, is far from proven to be impossible, and there is not even any reason why science should not one day discover means of enslaving the unflagging energies of nature in such a way as to produce an actual perpetual-motion machine of real practical value, and this without infringing any of the canons of orthodoxy. What is impossible is the unscientific attempt to arrive at perpetual motion by devices which overlook certain unknown and unquestionable laws of matter and force. It is impossible, for example, to construct a hydraulic ram which shall work in unceasing cycle by the force of the water which it itself has raised. It is impossible to make a wheel revolve by means of falling weights which shall themselves be raised with it to repeat the cycle. This type of quest for perpetual motion is the one that is based on pseudo-scientific principles, and carries its own condemnation; but it is different altogether in kind from that of which we are here speaking.

Yet so subtle are Nature's ways, and so delusive some of her paradoxes, that along this false track of pseudo-scientific research a whole procession of would-be discoverers has wandered restlessly for hundreds of years, wasting many lives and fortunes in the hopeless pursuit of the obviously unattainable. A fallacy is always latent in their devices, but Nature conceals it from their eyes with such whimsical spells that hundreds and thousands have been deceived by her cunning semblances, and lured on to seek what ever eludes them, and ever seems all but within their grasp.

It would be impossible in the scope of a short essay to outline even the principal examples of this futile province of fallacious research, nor would it be very profitable to do so, though the subject is not without its psychological interest, even if it is tedious to the better-informed mechanical expert, to whom the fallacies involved are patent at a glance. One early example may, however, be noticed as illustrating the long-lived character of this *ignis fatuus* of inventive genius.

As early as the year 1269 Peter Peregrinus wrote a famous epistle on the magnet in camp at the siege of Lucera. It is a wonderful fragment, whether we consider the uncongenial conditions under which it was written, or the really remarkable precision of the work. It is perhaps the first literary example of experimental scientific research, long anticipating that of those two pioneers of inductive science, William Gilberd and Francis Bacon. One flaw alone mars the truly scientific character of the little treatise—the last chapter, in which the writer takes up the quest for the *perpetuum mobile*, which he alludes to as a pursuit in which many had "wandered about wearied with manifold toil." This shows at least that the problem is one which has engaged attention from an early period. He attempts to solve the problem himself by a very simple device, in which a toothed iron wheel was to respond to a magnet in such wise that, after each tooth had been drawn to the loadstone, it went on a little way by its impetus, and was then subjected to repulsion from the magnet—it is not easy to see why—and thus a continuous rotation of the wheel was to be secured. Needless to say, the machine was not ever made by Peregrinus, or he would have found out its futility. Its conception was founded on a fallacy which is, perhaps, the most common one in all the innumerable perpetual-motion devices—this reliance upon impetus to carry the movement over the crucial gap that always renders the cycle otherwise incomplete.

Delusive as the aims and hopes of the seekers after perpetual motion are, when the quest is based upon an attempt to circumvent the conservation of energy principle it is impossible to restrain sympathy with the tyro in science, who is misled into expectations of success; for the playful way in which Nature presents us with phenomena that sometimes seem as if they were cunningly devised to lure and entrap the human mind into a belief in the possibility of achieving this unattainable result by the simplest means is truly remarkable. These cynical snares of Dame Nature need not be detailed, but a typical example may be given to show how deceptive they may be. It is well known that water will rise, for some unaccountable reason (which we veil under the title of "capillary attraction"), to a considerable height above the level of the vessel containing it. A tube of the fiftieth of an inch in diameter will effect an ascent of an inch above the level of the water. Now, what more natural than to imagine that with the tubule protruding half an inch above the water the raised column would flow out at the top and back to the vessel, thus affording us a continual cycle of movement? Yet nothing of the sort happens. The liquid rises promptly to the top of the shortened tube, but there it remains, and shows no tendency to flow further. This is one of the whimsicalities of Nature, which has led astray many a hopeful young explorer in the domain of physics, and the example is but one of many more that could be quoted in evidence of the tantalising lures which are presented in some of the paradoxical phenomena of science.

It may safely be said that the *perpetuum mobile* will never be found on lines that seek to circumvent the doctrine of the conservation of energy. Neither gravitation nor magnetism will ever supply energy that will repair its own loss. But that is not to say that the perpetual-motion machine, based upon other principles altogether, is impossible.

Impossible of course it is, if we take into account the fact that the machine must itself wear out as time goes on. Even the most sanguine seekers after the self-moving machine were not blind to this qualification, but had their expectations been realisable in every particular except wear and tear it would be readily conceeded that they had practically solved the problem. Their fallacies were quite apart from this factor, which by common consent need not be taken into account, because it is rather concerned with the perpetuity of the machine than that of its motion *per se*.

Waiving the inevitable wear and tear difficulty, is it possible that a *perpetuum mobile* could be established, and, if so, on what principles? The answer is that if the thing is to be done at all the motive power must depend upon the various forms of perpetual energy that do, as a matter of fact, exist all around us, to which allusion has already been made. We have but to harness these to our chariot and the problem is solved without the least transgression of the laws of Nature, for it is those laws that we shall call to our aid.

As a matter of fact, the problem has already been solved more than once, and by more than one device.

Strutt's so-called "radium clock" can hardly be

*From *Knowledge*.

quoted as an example, for this cannot be strictly called a perpetual-motion machine if the calculations which have fixed its extended life-period are to be trusted. According to these estimates it will have sacrificed half its energy in a couple of thousand years; but it must be remembered that this life-period is still but a theoretical computation, and, though probably reliable, is not, of course, proved experimentally as yet. Nature often belies the hypotheses of the philosophers, and we must wait a few centuries before we pronounce quite positively as to the decline of radio-active forces, however reasonable our expectation of it. The radium clock is of very simple construction. A leaf of aluminum foil is enclosed in a glass bulb, from which the air has, as far as possible, been exhausted, to prevent the "ionisation," which would render the experiment impracticable. Charged electrically by means of a small quantity of radium within the bulb, the aluminum leaf is repelled from its support until its free end stretches out far enough to make contact with an earthing plate, which discharges it, and the cycle recommences.

The electric dry pile is a close rival of the radium clock for prolonged electric activity. What its life-period may be it is impossible to say, and no attempt seems to have been made to dogmatise on the subject; but a celebrated example, made by Singer seventy-five years ago, has been continuously tinkling its little chime bell at Oxford for the whole of that long period of time; and though its vigor (for some unaccountable reason) occasionally varies, it shows no sign at present of any actual diminution of energy. And, minute as that energy must be per second, the amount which these tiny oscillations for seventy-five years without cessation represent would perhaps already make an appreciable total in foot-pounds, while the apparatus has by no means exhausted its store of latent potentiality.

But, apart from these mere approximations, the actual perpetual-motion machine—setting aside wear and tear of machinery—was practically accomplished many years ago, and the mechanism, of which full details are available, is one that could be reconstructed at any time.

The story of the original is an interesting one. In the latter half of the eighteenth century there was an ingenious jeweler in Shoe Lane named James Cox, and among the many marvellous contrivances of his genius was a clock, which was cleverly rendered self-winding by a barometer attachment arranged to actuate a cog-wheel in such a manner that, whether the mercury rose or fell, the wheel always revolved in the same direction, and kept the clock weight always wound up. Slight as the changes of atmospheric pressure occasionally are, Cox's difficulty was not by any means their insufficiency to keep pace with the descending clock weight. On the contrary, the chief trouble was to guard against overwinding. This was ingeniously obviated by a device which caused the cog-wheel to throw itself out of gear when the weight was nearly wound to the top.

Cox's Museum in London, where this surprising mechanism was exhibited, together with many other ingenious contrivances, was a treasure-house of fascinating wonders. Some of his other marvels of workmanship will be found described in the "Annual Register" for 1765. In 1773 Cox obtained Royal Assent to an Act of Parliament enabling him to dispose of his museum. His clock was introduced the following year, but he was very chary of making public the details of its construction, contenting himself with vague generalities about the "philosophical and mechanical principles" on which it was based, and the clock remained a mystery to the public until James Ferguson, after a close inspection, openly divulged the secret, at the same time testifying, in a signed memorandum, as follows:

"I have examined the above-described clock, which is kept constantly going by the rising and falling of quicksilver in a most extraordinary barometer, and there is no danger of its ever failing to go, for there is always such a quantity of moving power accumulated as would keep the clock going for a year, even if the barometer should be taken quite away from it; and, eed, on examining the whole contrivance and construction, I must with truth say that it is the most ingenious piece of mechanism I ever saw in my life.

"James Ferguson.

"Bolt Court, Fleet Street.

January 28th, 1774."

Hardly less remarkable than the clock itself is the dramatic sequel of its subsequent history, incidentally brought to light in a work, entitled "Travels in China," by John Barrow, private secretary to Earl Macartney. From this volume it appears that among the presents "carried by the late Dutch Ambassador" were two grand pieces of mechanism from the Cox Museum, one of which was the perpetual clock. In the course of the long journey of the Dutch Embassy from Canton to Pekin both machines suffered some slight damage, and an endeavor was made to have them repaired at Pekin. On leaving the capital, however, it was discovered that the wily Chinese Prime Minister, Ho-tchang-tong, had taken a fancy to the wonderful timepiece, and had substituted an ordinary clock in its place. It was believed that he purloined the instrument with a view to ingratiating himself by making a personal gift of it to his emperor. Whether it ever reached the Imperial Palace can now never be known, for there is no light upon its subsequent history. Possibly it is still patiently recording the passing hours somewhere in China; possibly it has returned with other loot to London, and reposes as a Chinese antique in some marine store dealer's warehouse in the metropolis. Happily the exact and detailed drawings and the descriptions made by James Ferguson still exist, so that a replica could easily be made.

About the same period a perpetual clock was exhibited in Paris, which was similarly devised, except that the self-winding was effected by thermometric instead of barometric means. The expansion of a silver rod with the diurnal rise of temperature was employed, and it is said that seven or eight degrees of difference in temperature per day sufficed to keep the clock fully wound. Instances of kindred contrivances could be multiplied.

Of the greater powers of the universe, which seem available as perpetual servants of man, the three most important are the incessant variations of atmospheric pressure, the constant changes of temperature, and the unending sway of the ocean tides. These are all of them mighty storehouses of practically unbounded energy, and all the problem that rests with man is the harnessing of them for his purposes.

The most amenable of the three would seem to be the tidal ebb and flow. Round the shores of this island is more than enough power—running to waste, as it were, year in, year out—to produce all the lighting and motive energy required for the whole of our industrial enterprises. The fact has been frequently referred to by some of our most distinguished men of science, but the problem still awaits practical solution. Within a century or two it will almost certainly have been solved, and with it a new era of economy will commence.

In speaking of the tides as a perpetual source of energy, we must not, of course, forget that, according to prevailing theories, they, too, are destined to cease, and with their cessation is predicted a slackening of the rotation of the earth itself. The friction of the tides, we are told, is gradually diminishing the speed of the earth's daily rotation, and will go on doing so until our days, like those of the moon, are twenty-eight times their present length, and our globe will be exposed to alternations of about six hundred and seventy-two hours of sunshine and six hundred and seventy-two hours of darkness. All life will disappear, all vegetation will be destroyed, and the evaporated oceans will reveal the awful tragedies of their depths —the "Titanics," the "Lusitanias," and many another crime or disaster of the high seas. The moon, it is surmised, has already passed through this ordeal. The tidal influence of our greater globe has won the primary victory against the satellite, and only time will achieve the Nemesis of lunar reprisal. All this is plausible enough conjecture, but in the technical sense it still remains "hypothesis" rather than "theory." It is founded upon the assumption that the energies of the universe are incapable of replenishment—a fundamental postulate which is far from being demonstrated —and until it is, we are fully justified in looking at tidal energy as a *perpetuum mobile.* Even with that far-off ultimate vision of "the wars of elements, the wreck of matter, and the crush of worlds," the ebb and flow of the ocean still remain for all practical purposes a source of perpetual energy.

But, while these huge forces are those to which attention is most naturally directed in our quest for an unfailing supply of power, the lesser movements of palpitating nature are not to be despised. What they lack in individual might the infinitesimals make up for in the prodigious number of their energy-bearing units. To take one example only, the Brownian movement already briefly referred to. The term by which it is popularly known has a misleading suggestion of some social settlement scheme, and it is more scientifically named "pedesis," the original name of Brownian movement being merely a title associated with the discoverer, Dr. Robert Brown, who first observed it, about 1827, in the case of the minute contents of pollen grains, which he found when microscopically examined in a liquid menstruum were in a state of perpetual rotary and oscillatory, as well as even translatory movement, looking for all the world as if they were alive. That it is not life as we understand the term is clear from the fact that the movement is common to small particles of any substance, and it perseveres unaffected by vacuum, hermetical sealing, boiling, or any of the life-destroying conditions; while, as already stated, there are good geological evidences that it can keep up its energy for the countless millions of years that separate us from the early epochs of the world's history.

One of the most fascinating ways of preserving the phenomenon is to rub up a little gamboge (a gum resin which breaks up in water into exceedingly minute round particles). Dipping a fine flattened capillary glass tube into the solution a thin layer of it is drawn in. The tubule has its two ends hermetically sealed by momentary application of flame, and is then mounted in Canada balsam, and viewed as a microscopic object. Under a power of not less than a quarter-inch objective, the circling dance within the watery glass prism is beautifully seen; and, if only the slide is kept safe from German bombs and other dangers of this mad age, it may be taken from the cabinet at leisure every century or so and re-examined, without exhibiting any apparent diminution in the play of movement.

Any other minute particles may be similarly treated, and will give similar effects, with modifications, according to the specific gravity of the particles and the nature of the liquid employed. It is theorized that electricity has some share in the phenomenon from the fact that substances which increase the conductive power of water (salts and acids) are said to diminish the rate of movement; while gum and other substances that decrease the conductive power accelerate the particles. But this is not confirmed by all experimenters, and of the cause and origin of pedesis no man knows anything with certainty.

Three principal theories—all mutually contradictory —have been put forward to explain the Brownian movement. The electric theory has little evidence in its support, and, in any case, does not go far to elucidate the mystery. A theory of "thermo-dynamic origin of the Brownian motions" was published in *The Monthly Microscopical Journal* of July, 1877, by the Rev. Joseph Desaulx, S.J., and seems plausible. It attributes the movements to the molecular vibrations which constitute heat. In the case of minute gas bubbles it is supposed that their minuteness enables the pressure of the molecules to vary upon the different points of their envelope. In the case of solid particles it is suggested that the molecules of the liquid in which they are suspended are bombarding them irregularly with force sufficient to cause them to oscillate, and calculations are given showing that the dimensions of the particles and the length of the molecules' path are appropriate to the fulfilment of the theory. In the same number of *The Journal* is a different theory altogether, by W. N. Hartley, F.R.S.E., who attributes the movement to variations in surface tension consequent upon variations in temperature of the surrounding liquid. This theory also appears to be confirmed by the experiments quoted by the author, but it fails to explain the fact that the movement is active in cases where there is no liquid, such as smoke particles in air. On the whole, Desaulx's hypothesis seems the most reasonable, though, of course, it still leaves unsolved the mystery of the perpetuity of movement, merely transferring it from the solid particles to the molecules of the liquid.

Still, the phenomenon itself is indisputable, and the practical possibilities of even such infinitesimal energies as these are not so contemptible as they might seem to be when we consider the trillions of combined activities which even an ounce bottle of gamboge solution may comprise; and, further, the enduring character of the movement. If time be taken into account, there may be measurable foot-pounds of energy represented in the expenditure of even those few tiny geological captives which have been beating the quartz walls of their cells since the days when the primaeval rocks were formed.

Professor Ames, of Johns Hopkins University, in Baltimore, amuses himself and his audience by an annual experiment, which may give us a hint of what our gamboge particles might do for the world if only they were properly trained and marshalled. His experiment consists in making a pailful of water boil from the heat generated in it by stirring it with a wooden paddle. Surprising as it may seem, the water by this simple expedient is actually raised to boiling-point by a continuous paddling executed by the Professor's assistants (working in shifts) for a period of five consecutive hours—a tedious experiment, but it comes off successfully.

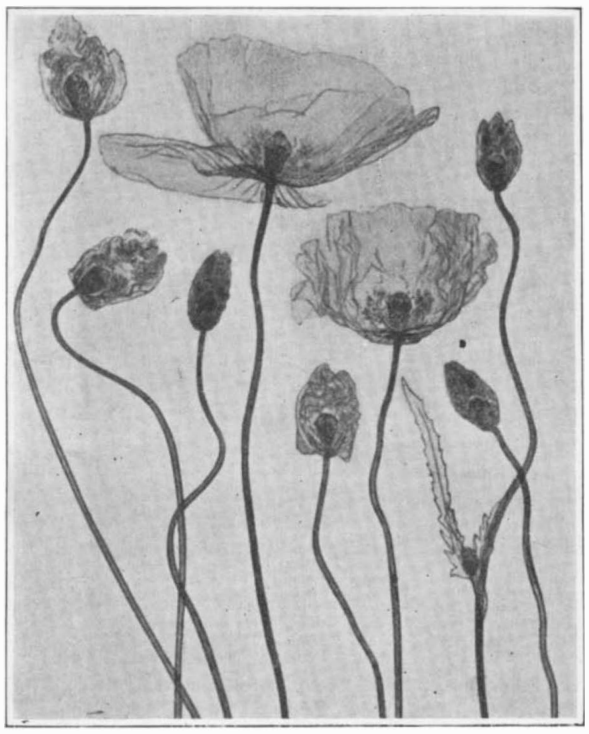


Fig. 1.—Poppy (Papaver Rhoeas).

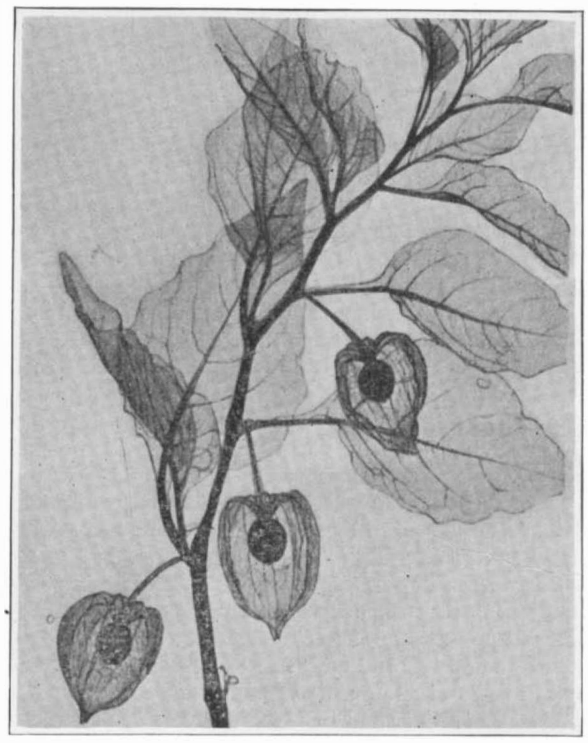


Fig. 2.—Chinese Lantern plant (Physalis Franchettii).

Fig. 3.—Bluebells (Campanula).

X-Ray Pictures of Living Plants

A Valuable Method to Assist the Botanist in Studying Vital Processes

For several years X-ray photographs of the human body have been of incalculable use to the surgeon and physician, not merely in locating foreign bodies such as bullets, shrapnel, pins, needles, buttons, or fragments of rock and metal in cases of injury by explosion or other accident, but for studying the organs and tissues themselves. Recent experiments with Roentgenographs of plants show that the botanist also possesses a valuable method therein for studying various vital processes, such as blossoming, fertilization, the rise of sap, etc. Moreover, the beautiful pictures in which flowers and seeds are represented, not merely by outline, but plastically, may well prove a source of inspiration to artists in general and decorative designers in particular. Since the various parts of a plant, root, stem, leaf, flower, fruit, and seed vary greatly in the amount and composition of their mineral elements there is a very great difference in the degree in which they are susceptible of penetration by the Roentgen rays.

The beautiful pictures which accompany this article are taken from a recent article in *Umschau* (Berlin) to which we are also indebted for a summary of the text by Dr. H. Rieder.

Besides oxygen, hydrogen, and carbon, from whose combination the elaborate organic compounds are formed, the minerals potassium, sodium, iron, sulphur, phosphorus, silicium, calcium, chlorine, and magnesium are found in considerable quantity. Seeds generally contain much phosphorus, much lime and silicic acid are found in leaves, stems, and the envelopes of fruit, iron is present in the chlorophyl of leaves, while flowers usually are distinguished by a low content of lime. The fact that even the tenderest and most delicate tissues of plants are perceptible in the X-ray photograph proves that even they, though apparently quite permeable by these rays, in reality absorb them to a certain extent, determined by their consistence and thickness, their content of sap and of air, and their chemical composition.

A matter of technical importance is that for the making of Roentgenographs of delicate vegetable tissues only the long-waved rays can be made use of, that is, those which proceed either from a Roentgen tube evacuated to a low degree, or from one provided with the so-called Lindemann glass which is also quite permeable to very long-waved rays. In this kind of glass the constituents sodium, calcium, and silicon, which possess a relatively high molecular weight, are replaced with a lower molecular weight, i. e., by lithium, beryllium, and boron.

The simplest method of investigation, which is amply sufficient for ordinary purposes, is to have the photographic kit made of thin, black paper on which the separate plants are laid as flat as possible and then illuminated, after which the plates are developed. Luxuriant garden plants and tropical growths are in general easier to photograph by the Roentgen ray than are delicate wild domestic plants. Freshly plucked, juicy specimens give better results than those which have been longer picked and are therefore, perhaps, partly dried. Among the cryptogams the larger fungi are more suitable, while lichens and algæ are unfit because of their small size. The phanerogams naturally afford much better subjects. In these the vascular bundles in the stems and leaf-veins are defined with particular clearness, as are also the air-filled, hollow spaces of stems and leaf-stalks, as well as the fruit-envelops and the seed-kernels.

As has been noted, results are particularly satisfactory with plants in flower, since the various stages may be observed from the forming of the bud to its full development and unfolding. Even in the bud, whether it is still in the sheath or has emerged, it is possible to see the petals of the corolla, the stamens, and the pistil. The various stages of the blossom itself can also be admirably observed. Very instructive pictures of the fruit in its shell or husk can be obtained.

The accompanying illustrations are reproduced from drawings carefully prepared from the Roentgen plates. Fig. 5 depicts the familiar wild flower *Cypripedium calceolus*, or lady-slipper, one of the most beautiful native orchids. In the poppy, *Papaver somniferum* and *Papaver Rhoeas* (Fig. 1), the long dentate foliage leaves surrounding the stalk and the flower buds are visible. In the latter we recognize the rough calyx leaves, the stamens standing in a ring about the bottom of the flower, the crumpled petals of the corolla, which look quite smooth in the open flower, folded into the narrow bud like the thinnest paper, and the seed-bud with its disk-formed stigma. In the *Arum maculatum* (Fig. 4) we see both in the closed and the open flowers the spill-shaped, vertically striped spathe surrounding the spadix, which ends in a pestle-like structure. The female flowers are at the base of the spadix, the male flowers forming a smaller group above them, while still higher are a few sterile blossoms. Sharply and plastically defined against their surroundings are the pike-shaped, singularly twisted and rolled or curved-over foliage leaves, with their strongly developed ribs. In the *Campanula* (blue-bell) the handsome bell-shaped blossoms are strikingly plastic in appearance. The stamens spring from the flower axis and surround the tall projecting pistil. In the well-known "Jew-cherry" or winter cherry, *Physalis Franchettii*, we see how the seed-containing berry is surrounded by the persistent and completely closed calyx. Note here the sharply defined ribs of the partially superimposed foliage leaves.

Valuable and interesting X-ray pictures of the wood of various trees are also easy to obtain. Thus one can see clearly indicated the structure and grain of the species of various sorts of trees, as the ash, elder, beech, fir, pine, maple, etc. On account of its greater density the hard inner core can be readily distinguished from the exterior sap-wood. The annual rings can also be seen quite clearly.

As we have said, not only the morphology of plants can thus be studied, but vital processes of nutrition, fertilization, etc. Peculiarly noteworthy are the pictures of the latter in ears of grain, the various degrees of development being easy to follow. Highly useful too are the Roentgenograms of germinating seeds, such as peas and beans. Another use of these pictures to the scientific agriculturist is the detection of animal and vegetable parasites and the observation of tissue changes due to their depredations. It is obvious that such pictures, too, will be invaluable in agricultural schools.

Finally, since the Roentgenograms of plants give an absolutely faithful portrayal, since their architectonic and ornamental structure is well reproduced, Roentgenography may lay claim to a place in the realm of art beside that of the photography long in use. Such pictures may inspire craftsmen in search of decorative patterns for the ornamentation of dress-goods, tapestries, laces, jewelers' wares, etc.; though lacking the beauty of color, possess that of form and pattern in an eminent degree.

Concrete Purifiers

Anything approaching a bold departure in the principles of gas-making is not frequently attempted in the gasworks of this country; consequently, experiences with concrete purifiers as erected at Romford were listened to with a good deal of curiosity at a recent meeting of the Southern District Gas Association.

Cast iron has for years been the recognized material from which the purifying boxes should be constructed. Naturally, the size of the vessels renders them decidedly costly, so that they may account for as much as 8 per cent of the total capital outlay on the works; and, although no definite figures can be given for the concrete boxes, it seems fairly evident that in the case of large installations some appreciable saving may be effected by their adoption. If concrete is to be made use of for the purpose it would seem that the most suitable structure would be obtained by employing some recognized system of reinforcement. At Romford, however, the sides of the vessels were built up from special rectangular blocks molded from a suitable mixture of clinker, breeze, sand, and cement. The tops of the walls so formed were afterwards covered with special cast-iron coping plates designed with the inner edge turned upward in such a manner as to form a continuous bearing for the wrought iron dry-lute covers. The chief concern with vessels made from a porous substance is the question of making them perfectly gas-tight and of keeping them so. In the case of Romford the whole of the interior surfaces were dressed with a solution of "Ironite," which appears to consist of the finest iron dust, separated from borings by means of an air-blast, and mixed with salammoniac, on th lines of the well-known rust joint. Some doubt was expressed as to the ability of this material to withstand chemical reaction when foul gas is admitted to the vessel, a point which will be cleared up by experience alone. No doubt, the success of the new departure depends almost solely on the possibility of obtaining and retaining gas-tightness; but there are alternative methods available, among which may be mentioned the insertion in the main walls of a fine sheet wall of pitch.—*Engineering Supplement of the London Times.*

Fig. 4.—Wake Robin (Arvm maculatum).

A 15,000 Horse Power Vertical Turbine

In the various articles that have been published describing the great electrification plans of the Puget Sound lines of the St. Paul Railway, reference has been made to the great system of power houses that will supply the current necessary for the operation of these lines, and the illustration on the first page of this issue of the Supplement shows one of the great turbine water wheels that will be used for generating the electricity at one of the principal stations of the Montana Power Company, which has undertaken to supply the road with power.

The transmission lines of the Montana Power Company form a network that covers the greater part of Montana and a portion of Idaho, supplying electric power not only for the 440 miles of railway that is being electrified, and a large portion of which is now in operation, but also furnishing power for many mining enterprises. For this work the power company has twelve power stations, either already developed or projected, and by a complete system of interconnections a constant supply of power is insured, for if for any reason one station temporarily fails, other stations are immediately ready to take up the load.

These stations, which will have an ultimate capacity of 243,890 kilowatts, supply alternating current at 100,000 volts, which at the points where it is used is stepped down to the required point. In the case of the railway the current is utilized at 2,300 volts by motor-generators, which furnish a direct current of 3,000 volts to the trolley wires of the road.

One of the smaller power stations is operated by steam turbines, but all of the rest depend on water power, and to supply this a number of reservoirs have been established in different places. The largest reservoir, at Hebgen, has a storage capacity of 300,000 acre-feet, located at the headwaters of the Madison River, and this can supply in turn the several installations on the Madison and Missouri rivers, so that the same storage water is used a number of times, giving an available storage capacity considerably greater than the above figure would indicate. Besides this great reservoir there are several auxiliary reservoirs at various points that bring up the total available capacity to 418,000 acre-feet.

The largest of this great system of power plants is at Great Falls, Montana, where the large turbine illustrated is located, and it is one of six similar motors at this station, each rated at 15,000 shaft horse-power, that will give a combined output of 90,000 horse-power. In addition to these large main turbines there are being stalled two similar units of 850 horse-power each for driving the exciters for the large generators.

The big turbine shown has a single runner working in a cast iron scroll case, and operating under a head of 150 feet, and its size may be judged by the fact that the intake is eight feet in diameter. It will be noted that the shaft of this turbine is located vertically, and the moving parts of both the turbine and the electric generator are suspended from a thrust bearing located on top of the generator.

Electricity has demonstrated many advantages over steam in numerous cases, not only for railway operation but for power purposes generally, and it is particularly valuable throughout a large portion of our western country, where no suitable coal for steam power is produced, and where the supplies of coal are liable to interruption by the heavy snows of winter; and it is particularly fortunate that in these regions the water power resources are so widely distributed and abundant. In time it is probable that electricity generated by water will be the sole power employed throughout the great northwestern country.

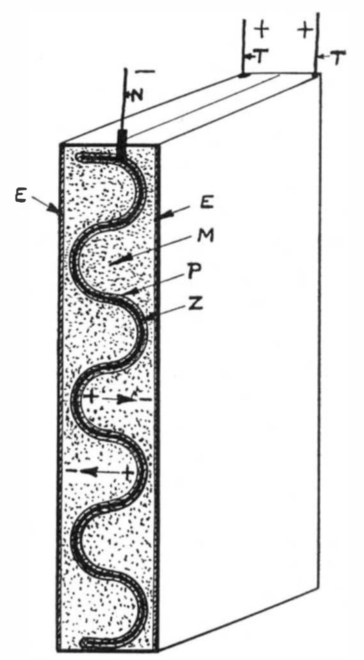
An Improved Dry Cell Battery

By H. R. Palmer

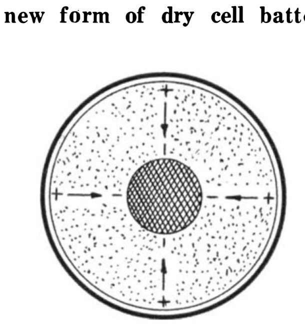
The modern dry cell is a development of the old Gasner Leclanché type, rendered more efficient by reduction of internal resistance and increase of the depolarizing effect, together with the incorporation and retention of a greater percentage of electrolytic solution. The careful selection of pure ingredients has also been an important factor.

Realizing that an inherent change in the construction of dry cells was necessary in order to attain any further marked improvement, the writer devised an entirely new method of construction, abandoning the familiar round type of zinc container and adopting a flat type similar to the lead plate construction of the storage cell.

The positive element consists of a zinc sheet *Z*, encased in a porous envelope *P*, completely surrounding the same, and imbedded in the electrolytic and depolarizing material, technically known as the mix *M*. Next to the mix lies the negative elements or electrodes *E E*, which, taken as a unit, form the container of the cell. Thus the current generated on the zinc element has two paths through the mix (as shown by arrows) to the electrodes, which act merely as non-corrosive collectors, and emerges at the terminals *T T* which, connected together, form the positive pole of the cell, the zinc terminal *N* being the negative pole.



A new form of dry cell battery.



Section of an ordinary round cell.

It will be seen that this is a reversal of the common round cell, in which the carbon rod electrode is the center and the zinc the outside container.

The greatest difficulty to be overcome in the production of the flat cell type was the formation of the flat type electrodes *E E*. Carbon plates were found to be prohibitive, owing to high first cost and the fragile nature of the material. The comparatively high resistance of carbon also caused an uneven distribution of current, the portions nearer the poles *T T* supplying much more current than the diagonally opposite corners. The electrodes as now constructed in this cell are of such a low resistance (considerably under 1/1000 of an ohm) as to give a uniform current distribution. They are flexible, unbreakable and non-corrosive and very thin, about 1/32 inch.

Since the distance separating the zinc element from its container remains constant, the output of the cell varies directly as its area and weight, whereas, in the round cell, the increased size of can in diameter increases the resistance and amount of material in a much greater ratio than the output. For instance, the 8-inch round cell weighs 250% more than the 6-inch, but is only about 50% stronger electrically. This new flat cell 7 inches by 9 inches by 1 inch weighs 300% more than the 4¼ inches by 5 inches by 1 inch, and is exactly 300% stronger. Another great advantage of this cell lies in the greater depolarizing power of the mix, owing to the greater contact area of the zinc element with the depolarizer. This is a corrugated sheet and presents 40% more area than the equivalent round cell. The current density of the dry cell should not exceed 0.013 ampere per square inch of zinc depolarizing surface to obtain economical service. The life of a dry cell does not vary in a direct ratio with this current density, but approaches more nearly the law of inverse squares, i. e. the life of a given cell supplying 0.013 ampere current density would be nearly four times longer than the same cell supplying 0.026 ampere current density. Following the above law an increase of 40% area means an increase of life of about 96% which accords approximately with the results found under test.

Fig. 5.—Lady Slipper (Cypripedium calceolus).

These cells at present are manufactured in unit batteries of 2, 3, 4, 5, 6, 7, 8 cells connected in series and sealed under pressure in waterproof non-corrosive containers and occupy much less space than an equivalent number of round cells, and have only two connecting posts, regardless of the number of cells in a battery. They occupy much less space, weigh less and will not deteriorate under moisture. In fact, will operate equally well in the air or submerged in water.

Owing to the lower internal resistance, the short circuit test shows about 75 amperes. The voltage is the same as the round cell as the electro-chemical reactions are identical.

The round cell container being zinc, which is the fuel supplying the electrical energy, becomes thinner with use and will eventually be eaten through in spots. The cell is then rendered useless and the remaining zinc and other materials become waste product. Whereas in the new flat type, the zinc sheet can be entirely consumed and will deliver current up to the last, the cell on dissection showing no zinc whatever within the porous envelope. The cell, owing to its greater depolarizing area, maintains a higher voltage under load than the round cell, thus rendering better service as well as longer life.

Golfer's Foot

For practically every occupation and recreation that has attracted any general public attention, the doctors have produced a corresponding disease. Many will remember the dread "kyphosis biclarum" of the wheeling days, and more recently the "automobile knee;" and now we have the "golfer's foot." This is described as an acute condition due to distortion of the foot as a result of broken arch in the anterior metatarsal curved area, and results from an improper position of the feet while playing, which throws undue stresses on certain portions of the foot. Besides its discomfort, this trouble is said to be very frequently responsible for the annoying and, hitherto, unexplainable periods of "off play."

The Elements*

What They Are; Their Fundamental Attributes, and the Atomic Theory

By Theodore W. Richards, Chem. D., M.D., Ph.D., Sc.D., L.L.D., Harvard University

As the title on the programme indicates, my pleasant duty now is to speak to you on the fundamental properties of the elements, which have formed the chief subject of my chemical and physical studies. At the outset one may well ask: What are the elements, and what shall we designate as their fundamental properties? In these iconoclastic days several of our old scientific idols seem to have been shattered. If uranium and radium are only transitory, may not the other so-called "elements" also be slowly decomposing? In this case, ought we to count them as elements at all? Moreover, if as some suppose, the atom is made up of nothing but electrons (positive and negative), what has become of the old atomic theory?

These questions, disturbing although they may seem to be, are easily answered. Perhaps, from a philosophical and etymological point of view, the chemical atom no longer deserves its name; but the fact remains that in all the ordinary affairs of life our relations with the chemical elements primarily concerning us are unchanged by all the fascinating new knowledge. These same old elements remain as permanent as they ever were; and the only satisfactory explanation of the definite proportions by weight in which they combine is now, as of yore, the assumption of ultimate, undestroyed (if not indestructible) particles or chemical "atoms." The atomic theory is indeed even more convincing to-day with regard to mundane chemical affairs than it was before the dawn of radio-activity.

Of course, no one pretends nowadays that the chemical elements are to be considered as absolutely incapable of decomposition. Even supposing, however, that in the hottest stars some of them disintegrate, on earth, at least, they are amazingly permanent. It is concerning the earthly chemical elements, therefore—the old-fashioned kind of half a century ago—that I have to speak.

These elementary chemical substances build up everything about us, as well as our own bodies. It has always seemed to me, therefore, that the fundamental attributes which determine their behavior are worthy of very careful scrutiny.

Among the most fundamental of attributes, if not the most significant of all, is the tendency possessed by the elements to combine in definite proportions by weight. This we explain, as already stated, by the assumption that all matter is made up of atoms. One cannot believe that these atoms should have anything so important as their weight decided by mere chance or accident. Therefore, I chose the study of the atomic weights as the first of the fundamental properties to be investigated, and perhaps half of my time during the last thirty years has been devoted to this subject.

Great accuracy in the work was sought for several reasons, the most important of which was an earnest desire to find if possible the suspected mathematical relationship between these fundamental quantities. Such a relationship, if discovered, would greatly deepen our insight; and if it is to be found, the data to be compared must be determined as accurately as possible.

Another reason for taking great pains in determining atomic weights is the fact that these figures are used by chemists throughout the world in their daily work oftener than any other series of data. All the manifold happenings of Nature occur in material built up of these same atoms. If we are to analyze or synthesize, or in any way have to do with the quantitative relations of reacting chemical substances under any circumstances, we must ultimately turn to the atomic weights for help. It is not too much to say that the atomic weights are the basis of quantitative chemistry.

More than two thousand years ago Plato said: "If from any art that which concerns weighing, measuring, and arithmetic is taken away, little remains of that art." To-day we may paraphrase this saying as follows: "If from chemistry are taken away the atomic weights (or other numerical data representing the same definite proportions), little will remain of that science." As a science becomes more scientific it becomes more quantitative, and greater accuracy in the determination of its fundamental mathematical basis is required.

There is not time this afternoon to go into the details of many determinations of nearly thirty atomic weights carried out during as many years at Harvard. The effort was made to build upon the basis provided by the careful work of Berzelius, Marignac, and Stas, with the help of the new discoveries in physical chemistry concerning solubility, hydrolysis, adsorption, and solid solution. Metals were compared, as to their combining proportion, especially with chlorine, bromine, and iodine; moreover, many other careful comparisons likewise were made, as, for example: oxygen with silver through lithium chloride and lithium perchlorate; silver into nitrogen and sulphur through silver nitrate and sulphate; oxygen with carbon and sulphur sodium carbonate and sulphate, and many others. These, taken together, tend to put our whole table of atomic weights upon a stabler basis. The elements of which the atomic weights have been determined under my own immediate supervision are the following: copper, barium, strontium, calcium, magnesium, zinc, nickel, cobalt, iron, uranium, cæsium, sodium, potassium, chlorine, nitrogen, silver, sulphur, carbon, lithium, and radio-lead. To these should be added, as part of the Harvard contribution, those studied by my most energetic pupil in this line of work, Prof. G. P. Baxter, long since an independent investigator on his own account: arsenic, bromine, cadmium, chromium, iodine, lead, meteoric iron and nickel, manganese, neodymium, praseodymium, and phosphorus. The most interesting outcome of my work is perhaps the discovery that lead from radioactive minerals possesses an atomic weight distinctly less than that of ordinary lead—206.1 instead of 207.2—although it gives the same spectrum.

If I were to sum up in a few words the lessons of these protracted investigations, I should be inclined to say that the secret of success in the study of atomic weights lies in carefully choosing the particular substances and processes employed, and in checking every operation by parallel experiments so that every unknown chemical and physical error will gradually be ferreted out of its hiding-place. The most important causes of inaccuracy are: the solubility of precipitates and of the material of containing vessels; the occlusion of foreign substance by solids, and especially the presence of retained moisture in almost everything. Each of these disturbing circumstances varies with each individual case. Far more depends upon the intelligent choice of the conditions of experiment than upon the mechanical execution of the operations, although that, too, is important. I have often quoted the innocent remark which has occasionally been made to me: "What wonderfully fine scales you must have to weigh atoms!" and have endeavored to point out that the purely chemical work, which precedes the introduction of the substance into the balance-case, is much more important than the mere operation of weighing.

Laboratory work alone can furnish us with accurate values of the atomic weights. No speculative method involving higher mathematics has as yet been able to solve definitively the cosmic puzzle of their relative magnitudes. In this direction, as in many others, chemistry is still largely an inductive science. When we have discovered the realities, we shall be in a position to attempt to explain them. In the meantime more accurate views, discovered little by little through patient investigation, will be of use to the thousands of men throughout the world who daily employ these fundamental data of chemistry.

Matter possesses not only the fundamental properties of weight and mass, measured (from the chemical point of view) by the combining proportions of the elements, but also an equally fundamental attribute which causes it to occupy space. Thus, side by side with the study of weight and mass, the study of volume deserves close attention. This latter property is more changeable and more puzzling in its varied manifestations than the constant attributes of weight and mass. Almost every solid expands, occupying more space as it is heated, expands yet more in the act of melting, and finally swells up into an altogether disproportionate volume when it is converted into vapor. In each of these states of matter the application of pressure produces a lessening of the volume—very small, but still perceptible in the case of solids, usually greater in the case of liquids, and still very much greater in the case of gases. The behavior of gases is very similar in each case: here the molecules must be far apart. On the other hand, solids and liquids behave in a manner entirely different from gases and entirely different from one another. The molecules must be very near one another, and the specific nature of each must come greatly into play. Even for any single substance the space-filling relations of the solid and liquid form are highly complex, and when comparison is made between different substances the complexity is vastly increased: yet none of these varying manifestations of the property of occupying space can be accidental. Each must have its inner significance, and the relation of each to the other cannot but be fundamentally connected with the ultimate nature of the substance concerned. Some of the relations are opened to us by the science of thermodynamics; but many of the data must be found, like the atomic weights, by experiment alone.

These considerations led me, nearly twenty years ago, to begin the study not only of the space occupied by the elements, especially in their liquid and solid states of aggregation, but also of many other related fundamental properties of the elements and their compounds, including the effect of increasing temperature and increasing pressure. Some of the data needed in this study had already been provided by the preceding work of others, but particularly in the case of compressibility, of which I wish especially to speak, very few data had been gathered even as recently as fifteen years ago. Only three or four elements had been carefully studied, and these by methods of doubtful efficacy. Hence the first step was to devise a simple and accurate method capable of determining the exceedingly small compressibilities of the solid elements. This method was devised in 1903, and with its help the compressibilities of nearly forty elements have been determined with sufficient accuracy to trace with some precision their relations to one another and to the bulk occupied by these same elements. Bridgeman has since carried the determination of a few of these to much higher pressures, with confirming results.

The outcome is highly interesting. If the elements are arranged in the order of their atomic weight, we find that the compressibilities show a very well-marked alternating periodic increase and decrease as the atomic weight progresses. This fluctuation parallels in remarkable fashion the periodicity of the atomic volumes noticed long ago by Lothar Meyer. It appears that when an element has a large atomic volume (that is to say, when the bulk occupied by its atomic weight in grammes is large) the compressibility also is large, and *vice versa*; and the changes are of the same order in two cases. That these two properties are fundamentally connected no one can doubt after studying the parallel curves showing their similar progression with increasing atomic weight. Neither can one doubt that in the tracing of this parallelism a real step has been made in the study of the nature of the element.

Other properties, more or less related, also have been shown to have analogous rhythms, but lack of time prevents any attempt to explain them.

One may well ask: Can any conceivable interpretation be found for such parallel rhythms, analogous to Dalton's interpretation of the combining weights of the elements? In other words, can we refer effects concerned with the space occupied by gross matter the atoms themselves, somewhat as the combining proportions of the elements are referred to the weights of the atoms? It seems to me that this can be done.

If one assumes that the practical bulk of the atoms in solids and liquids is compressible, most of these results fit naturally into their expected places. Those atoms which are much distended (that is to say, have large atomic volume) would be expected to be the most compressible. We should expect also to find that increasing chemical affinity, by pulling the atoms more and more together, would likewise cause compression and therefore diminish volume; and cohesive affinity would have the same effect. There is much evidence to show that this interpretation is a reasonable one, but time forbids again that the details should be entered into here. The hypothesis is pragmatic; it considers, not the hypothetical space which may or may not be occupied by an imaginary center or core in the atom, but rather the space which the atom actually requires in solids and liquids. That this space is definite and significant is proved beyond cavil by such curves as those to which I have referred, as well as many other facts concerning solids and liquids. One may well hope that the combined following of this trail may lead one to heights from which a broader view of the materials

*From an address before the Franklin Institute on the occasion of the presentation to him of the Franklin Medal. Republished from the *Journal of the Franklin Institute.*

constructing the universe may be obtained. But even if the hypothesis should some time be found wanting, it has served already a purpose helpful to progress, for it has stimulated many researches leading to the acquisition of new facts. These will stand in the future, whatever may be the fate of the theory.

Do these investigations concerning ultimate properties of things and these hypotheses concerning the correlation of the properties seem to be remote from the pressing problems of humanity? Not so. We must remember that applied science follows in the footsteps of theoretical science. The laws of chemistry cannot be adequately applied until they have been discovered. Only by researches delving into the hidden secrets of Nature by some such processes as these can new discoveries in the realm of pure science be made; and no one can tell how great may be the gain to the philosophy of Nature, as well as to the daily lives of men, ultimately resulting from new knowledge thus gained. The triumphs of chemistry in the future will be used not only for furthering manufacture and agriculture, thereby rendering life more comfortable and prosperous; but also, above all, for advancing hygiene and medicine to a point where the physician will be able really to understand the complex anomalies which confront him every day. Let us hope, too, that with this practical progress may be united the growth of a broader and saner philosophy of Nature, founded upon a truer knowledge of the materials composing the universe and of the energy which animates it. To such ends, full of blessing to humanity, let us dedicate the science in the future.

Genesis and Absorption of X-Rays*

By Sir J. J. Thomson

Roentgen rays are produced when cathode rays strike against matter, and their nature differed when the velocity of the cathode rays and the nature of the matter were changed. X-rays were only a particular kind of light, and the study of their genesis and absorption had a particular interest also in this connection. A regards the emission of light, two cases might broadly be distinguished. The first is that of solid bodies becoming luminous like a lamp filament, whose light changes with the temperature; it first gives out a red glow, then yellow, and finally white light, and the length of the light waves emitted diminish continuously and without any jump—provided there is no chemical action—as the temperature rises. The second case, of gases or vapors, is altogether different; sodium vapor gives no light until the temperature reaches a certain value; then the *D* lines flash up, and when the temperature is further raised the *D* lines become more intense, but the wave-length of the radiation does not diminish until finally another spectrum makes its appearance. To which class do X-rays belong? Again as to absorption of light, two classes may be distinguished—a general absorption or weakening of the light, and a special absorption of specific kinds of light. The question of absorption looks very simple in textbooks. When sodium vapor absorbs the sodium light which falls on it from a hotter sodium flame, and which it itself emits, that is not merely a case of absorption; absorption involves some transformation of energy, not an uninterrupted train of regular waves. To exemplify his meaning, the lecturer showed a rod, several feet long, horizontally supported, which was axially moved to and fro; a number of pendulums of different lengths were suspended from the rod. When the movement was slow, the pendulums more or less moved with the rod; as the rod was speeded up, some of the pendulums became wildly jerky in their movements; at still higher speeds they oscillated quietly again. Further, in the pendulum *A B C* (Fig. 1) a heavy ball *B* and a light ball *C* were attached to the same string, *A B* being longer than *B C*; this pendulum oscillated as a whole. Then the string *AB* was shortened, A_1B_1 being now shorter than B_1C_1; the two balls then oscillated in opposite directions.

Such experiments have an important bearing on the consideration of thet ransmission of light at different periods; there may be a range in which light was not transmitted. When the electric and magnetic forces act in certain directions, at right angles to one another, the direction of the propagation of the light, at right angles to both these directions, is fixed. But when these forces act on a system which itself could produce an electric force, then a field of the opposite direction may be set up, the light would be sent back, and the substance would be impermeable or opaque to that light. Thus one understands that absorption depends upon frequency; yet it might appear independent of frequency for certain ranges. Exhibiting various absorption curves, e. g., that of sodium light, the speaker pointed out that the curve was flat in the infra-red and red, rose to a peak in the yellow, and then fell off rapidly; that meant that the absorption was the same for infra-red and red light, but increased enormously as the wave-length diminished in the yellow, and fell off rapidly beyond the yellow. When the curves for several substances emitting light of different periods were combined, the resulting curves showed peaks joined by more or less flat portions, in which change of frequency did not affect the absorption, while near the peaks any change made a great difference. Showing Kaye's curve for the absorption of Roentgen rays, the speaker remarked that X-rays exhibited these peculiarities of selective absorption in a striking way. The absorption in copper, e. g., decreased in general as the rays became harder (of smaller wave-length); but when the rays became as penetrating as the characteristic rays of the absorbing medium (the *K* and *L* radiation of copper), the absorption increased rapidly.

The particular region of Roentgen radiation that he was interested in was that lying between visible light and the medical rays (so to speak), the little-explored region to which he had referred last year.[1] The difficulty about that region was that the waves were too short to be examined by the aid of gratings (useful for the study of visible light) and too long for making use of the spacings of the planes in which atoms were grouped in crystals (as in the X-ray study of crystal structure). He had thus either to determine the speeds of slow cathode rays, which striking a target would send out those long-wave Roentgen rays, or to determine the absorption of these latter rays. He had first used the former method with the aid of Coolidge tubes, Mr. Coolidge having kindly sent him a series of tungsten spirals. These spirals were heated by the current of a strong battery, and then gave out electrons to which the desired velocity was imparted by the potential of the Coolidge tube. For this excitation by current ranging from a few volts up to 5,000 volts, he had first used storage cells, which were troublesome, however, and had then made use of one of the high-tension dynamos of Messrs. Evershed and Vignoles, which gave a constant voltage within 3 or 4 per cent. In the experiments the rays from a target passed down the neck of a glass vessel (silvered inside) to a second target, which emitted a radiation

Fig. 1.

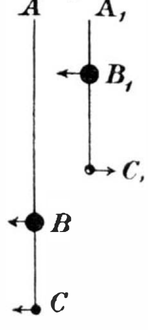
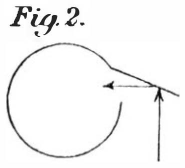


Fig. 2.



toward the silvered surface; that silver was charged up to a certain potential, however, to stop the rays. Now if the radiating body had been an ordinary solid (a filament) the voltage to be applied to the silver would have had to be increased continuously as the wave-length of the arriving rays diminished. But experimenting with rays from 12 volts up to about 1,200 volts, he had found that they were all stopped by 8 or 10 volts, so that these rays were hardly Roentgen rays, and, in fact, they would scarcely be beyond the visible range in the ultra-violet.

To demonstrate that such a constancy of light emission was possible also under other circumstances, the speaker bombarded the shell of some common mussel in a bulb with rays of about 10,000 volts; the shell gave out light, ordinary light, which hardly changed in appearance when a little hydrogen was admitted into the bulb; this was done by heating a closed small palladium tube attached to the bulb by the Bunsen flame, the hydrogen of which passed through the hot palladium. The greater part of the light energy was not in the high-frequency rays in this case, but in the visible and ultra-violet spectrum.

Turning to the study of the absorption, the speaker said that rays so nearly ultra-violet were very easily absorbed, and the exceedingly thin windows and films of celluloid had proved very useful in these experiments. The character of the results had surprised him. Instead of observing a great increase of the penetrating power of the rays with increasing hardness of the rays, gold, e. g., had given two ranges of constant absorption, separated by a sudden drop of absorption; starting with 200 volts, the absorption was rather high, but constant up to a certain value, then dropped, and remained constant again for higher voltage. Under the same conditions aluminium gave a curve which dropped near 200 volts to a small, constant value, while for ordinary—i. e., much faster—X-rays, aluminium showed a regular diminution in the absorption with increasing frequency. In other experiments absorbers of aluminium or of carbon were used with rays from targets of quartz, copper, silver, carbon, lead, aluminium, at voltages ranging from 1,500 to 4,500; the absorption remained in most cases almost constant throughout. With the aluminium absorber it was, further, the same practically for the various substances, the coefficient being about 2, while with the carbon absorber there was a small decrease of the absorption—from 2.8 to 1.7 in the case of copper, e. g. There were certain fluctuations, however. That aluminium absorbed less and less of the rays at really high frequency was shown by an experiment with a Coolidge tube, whose volts were raised from 30,000 to 100,000, and possibly to 200,000, which, of course, required special apparatus. Two screens, a very thin foil of tin and a piece of aluminium 2 millimeters in thickness, held between the tube and the phosphorescent screen, finally became equally transparent, when the volts were raised sufficiently. In order to meet the objection that the influence of the secondary radiation from the windows had perhaps been predominant in his experiments with soft rays, the speaker had changed the experimental conditions in various ways, and he then ascertained that the fluctuations above alluded to gave rise, with gold, silver, copper, aluminium and celluloid, to a decided drop in the absorption between 3,000 and 3,500 volts.

Another way of examining these peculiarities. In front of the window of a bulb containing some gas was hinged a plate of copper. The Roentgen-ray apparatus was so placed that the rays could not enter the bulb, but the cathode rays which they excited in the copper could enter (Fig. 2). The bulb was connected with a Zeleny electroscope. When soft rays struck the plate, no radiation entered, and the electroscope remained at rest; but when the rays were speeded up, to something like 100,000 volts in the experiment, the electroscope became restless. This electroscope, it will be remembered, consists of a vertical strip, in front of which a gold foil is suspended edgeways; the foil keeps on making small oscillations as long as the discharge continues, the rate of oscillations depending upon the intensity current.

The stress of time had not allowed him to make measurements of the wave-lengths corresponding to the characteristic frequencies and absorptions. But the questions he had put in his introduction could be answered in a general way. The Roentgen radiation corresponded to the case of the discontinuous line spectrum of a vapor. Until the cathode rays had a certain velocity there was no X-ray emission; then rays of a certain wave-length appeared, and continued to be emitted as the volts were raised, until a second radiation appeared together with the first; with very swift rays then a third radiation came in, and so on. Only a small fraction of the energy went into the continuous spectrum. The cathode rays drove out electrons from the atoms, first the electrons near the surface; at higher speeds the rays penetrated more deeply, and the inner electrons were knocked out. The resulting spectrum was due to the return of the electrons to the atoms, and was in the main a line spectrum, superimposed, however, on a continuous spectrum of small energy. The lines could be determined not only in the ordinary region of the Roentgen rays, but also in the gap between the ultra-violet and the X-rays proper. Radiations stopped by the thinnest film of celluloid, less than 1/100,000 millimeter in thickness, or able to penetrate through stout glass walls, were all of the same nature finally.

*From a report in *Engineering* of a lecture before the Royal Institution.

[1] See *Engineering*, vol. xcix, p. 384, April 2nd, 1915.

Pioneer British Electric Freight Railway

Although England has had a considerable mileage of electrified roads engaged in passenger traffic, it is but recently that any attempt has been made to operate freight trains by electric power. The electrification of a branch of the North-Eastern Railway, where the traffic is almost entirely the transportation of coal, is therefore quite in the nature of an experiment. This line, which extends from Shildon to Newport, and carries the mineral traffic from the Durham coal fields to the Middlesbrough district, is but eighteen miles long, but the mileage of track electrified, including sidings, is about fifty miles. Overhead wires are used, carrying a direct current of 1,500 volts which is supplied from substations at either end of the line, where rotary converters are located that take current from the alternating current lines of the North-East Coast group of power companies, that cover this entire district. The locomotives used weigh seventy-four tons, each of which is equipped with four motors of 275 horse-power, capable of exerting 28,000 pounds. These locomotives are capable of hauling a 1400 ton train at a normal speed of 25 miles an hour on the level, and of starting such a train on a gradient of 1 in 300, the maximum gradient being 1 in 103.

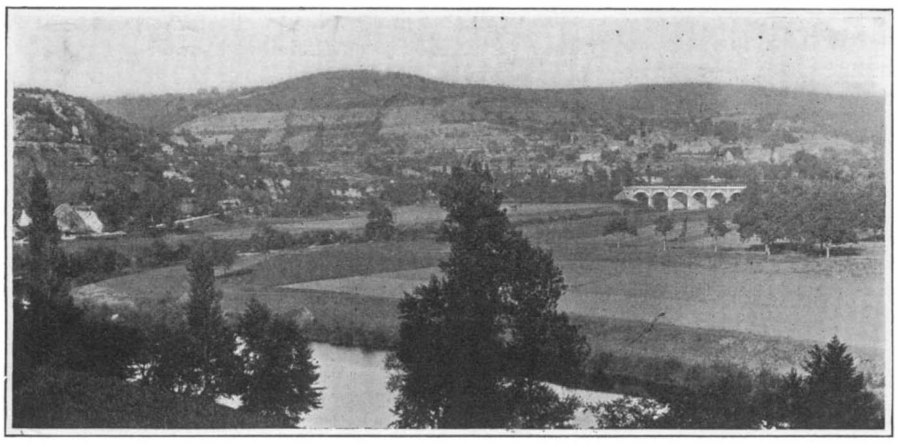


Photo by O. Hauser

View over the Vézère valley, in Dordogne.

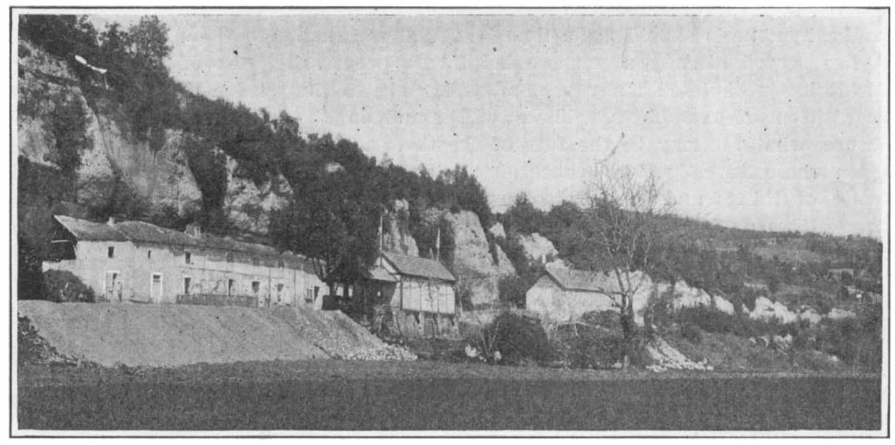


Photo by O. Hauser

The 'Laugerie haute'; largest 'abri sous roche' in the world.

The Dordogne

The Primitive European's Cradle

By Dr. Joseph de Sury

THERE is nothing of more interest in all human studies than the investigation of our own history, the gradual development from a raw animal to the highest and most intelligent being on earth. Indeed, this branch of natural historical science should be the eldest of them all and rested the last. Religious and philosophically spoiled preoccupations of different kinds had the effect that the studies of the prehistory and of the anthropology were till the beginning of the last century neglected and even prohibited. There were no better conditions for the sciences treating the history of the globe for geology and paleontology; but just these are the real arguments for the conclusions of the prehistoric archeology.

The year 1833 was very important for archeological researches. At widely different places (Mayor in Veyrier, near Geneva, Switzerland; Schmerling in Belgium, and Boucher de Perthes and Mortillet in France) remarkably worked flint stones were found and soon recognized by the great scientists as simple instruments of primitive unknown races. Certainly the new discovery was attacked by many good scientists, and the biblical tradition seemed to contradict the possibility of origin of these artifacts 10,000 years before Christ; but finally the strata, made certain by geological knowledge, in which the artifacts were detected, left no doubt about the correctness of the new science. There were various proofs that these flint instruments were prepared by a special method, and were not simply the result of chance. In observing a number of flint scrapers that are made from flakes which are retouched on one side only, one finds that the direction from which the retouching took place is almost always oriented in the same manner with respect to the sides of the flake. If one calls the under or bulb side of the flake the front and the upper side the back, one sees that the blows or the pressure which produced the marginal working was executed almost always from the front toward the back, that the tiny scars left by the chipping begin at the margin and extend over the back. The chipping is, therefore, only visible from the back; only in 4 to 5 per cent of all cases does one find the opposite orientation of the chipping, and these are mostly selected pieces with regular edge and straight forms. It is rather rare indeed to find the back of the flake more regular than the front. When in such a case the chipping is done from the back toward the front, this fact only strengthens the theory that the chipping is intentional and not accidental, i. e., made by the hand of an intelligent being.

Step by step the young science of archeology secured and consolidated its place among the other branches of natural historical knowledge; one discerned different prehistorical periods; the paleolithic, corresponding to the middle and upper horizons of the quaternary and characterized by only chipped flint stones; the neolithic, confined to post-quaternary time and characterized by polished stones (lake dwellings); the Bronze Age, the Iron Age (divided into Hallstatt and La Tène period). We cannot here treat the latter periods, and will only speak of the oldest and most interesting, the Paleolithical era. Though many distinguished scientists have worked in prehistoric archeology, there still exist quite different theories on several points of view, and only at the end of the last century were the principal controversies cleared, and this scientific branch quite equals consideration with the other sciences. The most important conclusions were brought about by the wonderful discoveries of many culture layers in Dordogne in France, especially in the valley of the Vézère. These layers were found first by the Englishman Christy and the Frenchman Lartet in 1859 under overhanging rocks (*abris sous roches*) mostly in eastern or southern direction. Most important is the large group of caverns in the Vézère Valley. Some of these subterranean caverns penetrate the hills to great depths and show en-

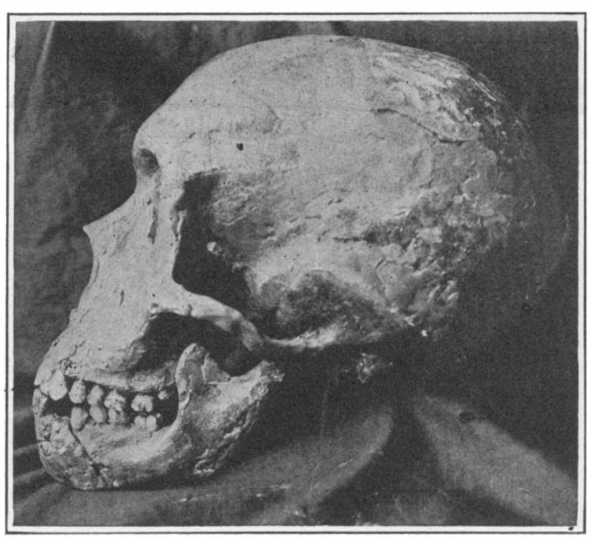
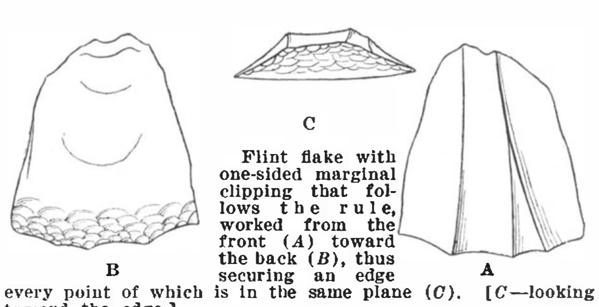


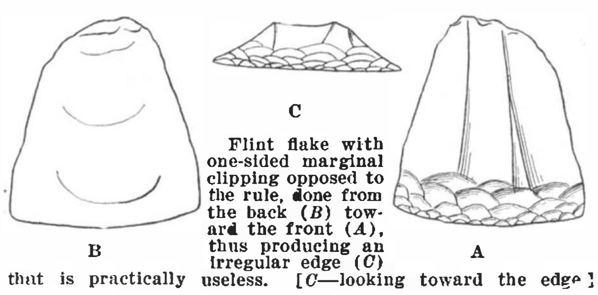
Photo by O. Hauser

Skull of Homo Mousteriensis Hauseri.



Flint flake with one-sided marginal clipping that follows the rule, worked from the front (*A*) toward the back (*B*), thus securing an edge every point of which is in the same plane (*C*). [*C*—looking toward the edge.]

Fig. 1.



Flint flake with one-sided marginal clipping opposed to the rule, done from the back (*B*) toward the front (*A*), thus producing an irregular edge (*C*) that is practically useless. [*C*—looking toward the edge.]

Fig. 2.

gravings on the walls of prehistoric animals. The calcareous formation of the hills was cleft by the Vézère and its tributaries, so we find overhanging rocks on its way which often shelter horizontal galleries and niches. The various and successive discoveries of paleolithic instruments encouraged the Swiss archeologist O. Hauser to go and see for himself these classic stations of the paleolithic period. When the results of his trial excavations gave very good results, he decided to attack this unique region, and for about sixteen years he has made scientific excavations in the valley of the Vézère on a large scale.

One of the most important Acheuléen discoveries by Mr. O. Hauser was the excavation of a human skeleton of the Acheuléen period in one of these classic stations, in Le Moustier itself. During the summer of 1908 he removed the human remains in the lower cave at Le Moustier in presence of a party of German anthropologists, including Prof. Klaatsch of Breslau, who came directly from the German Anthropological Congress held at Frankfurt in August This skeleton of the type of Neanderthal was called "Homo Moustierensis Hauseri." On October 21st, 1907, Dr. Otto Schoetensack had discovered in a sandpit near the village of Mauer, ten kilometers east of Heidelberg, the "Homo Heidelbergensis," i. e., the lower jaw of it only. The first "man fossil" was found in 1856, in Neanderthal-on-Rhine, and the evident differences of its bones and skull gave the first ideas of a primitive race, and the eldest in Europe. But the discovery of Hauser's "Homo Moustierensis" was especially interesting and valuable because there was a complete series of teeth. George Grant MacCurdy, the well known American archeologist, says in a study about it: 'The Homo Moustierensis' shows a rather stocky type, robust and of low stature. The arms and legs were relatively short, especially the forearm and from the knee down, as is the case among the Eskimo. Ape-like characters are noticeable in the curvature of the radius and the femur, the latter being also rounder in section than is the case with 'Homo sapiens.' In the retreating forehead, prominent brow ridges, and prognathism it is approached to some extent by the modern Australian. The industry associated with this skeleton from Le Moustier is that typical of the Mousterian epoch.

While this skeleton belonged to a young individual of about 16 to 18 years, the brothers Bouyssonie discovered in the same summer, 1908, in the village of Chapelle-au-Saints, in the department of Corrèze, in a short distance from the entrance of the cavern, a human skull of an old individual with stone implements and the remains of the reindeer, bison, horse, goat, rhinoceros, fox and of birds. The skull was nearly intact; directly over it were the foot bones, still connected, of a bison—clear proof that the piece had been placed there with the flesh on. Also this skeleton is of the Mousterian type. Thanks to his persistent, painstaking and systematic explorations, Mr. Hauser was rewarded in the following year, 1909, by a rich harvest. At Combe-Capelle, near Montferrand-Périgord, he found an adult skeleton of Aurignacian age. In the following table is given a summary view covering the different paleolithic periods in consequence in Hauser's excavations:

Because the stone implements found with Hauser's second skeleton, about the head, arms, knees and feet, are Aurignacian, it was named "Homo Aurignacensis Hauseri." It is of a higher order than the "Homo Mousteriensis," the difference being greater than might be inferred from its stratigraphic position, and Prof. Klaatsch believes this Aurignacian race did not evolve

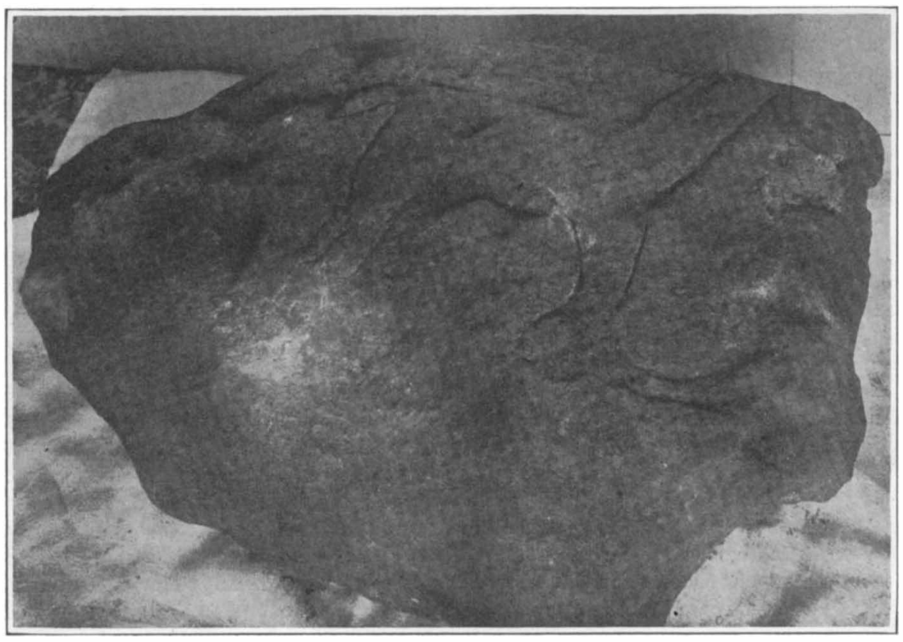
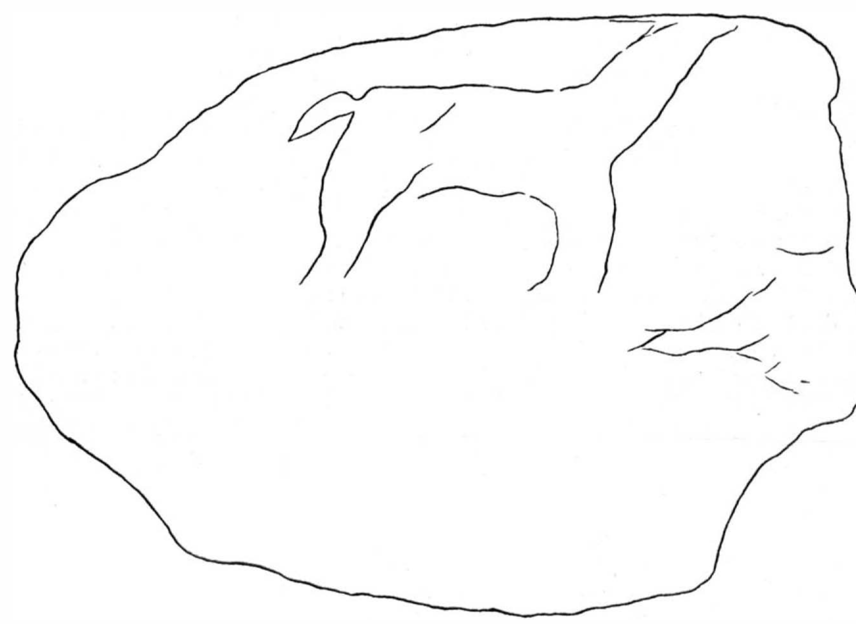


Photo by O. Hauser

The world's oldest drawing. From the Aurignacian period; about 60,000 years old.



Key to accompanying sculptured drawing, showing a reindeer. The head is missing.

directly from the Neanderthal or Moustierian race, but immigrated from the East. On the other hand, he believes it later developed into the Cro-Magnon (paleolithic station near les Eyzies, Dordogne) and Chancelade types (a station near Périgueux, the capital of the

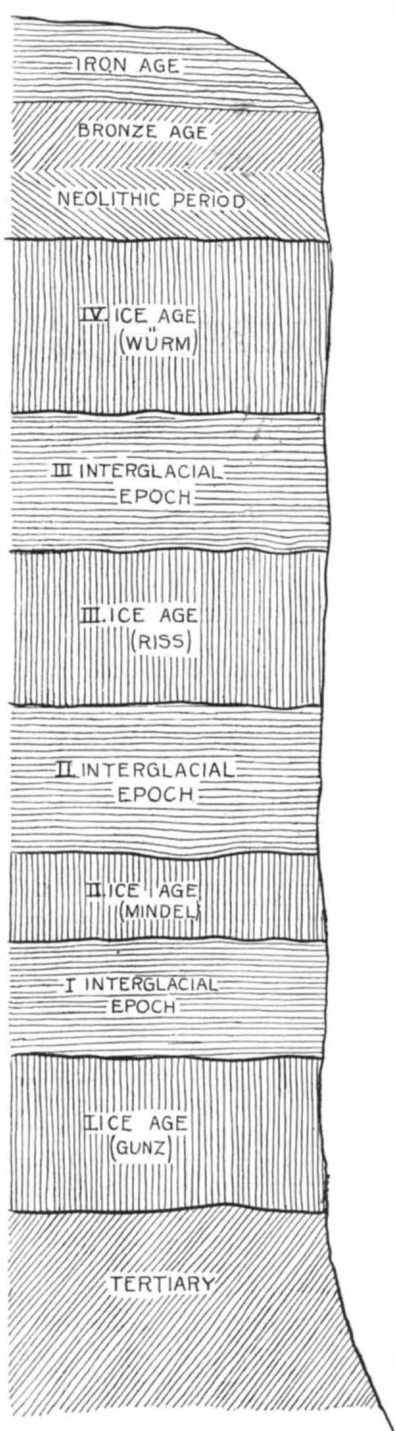
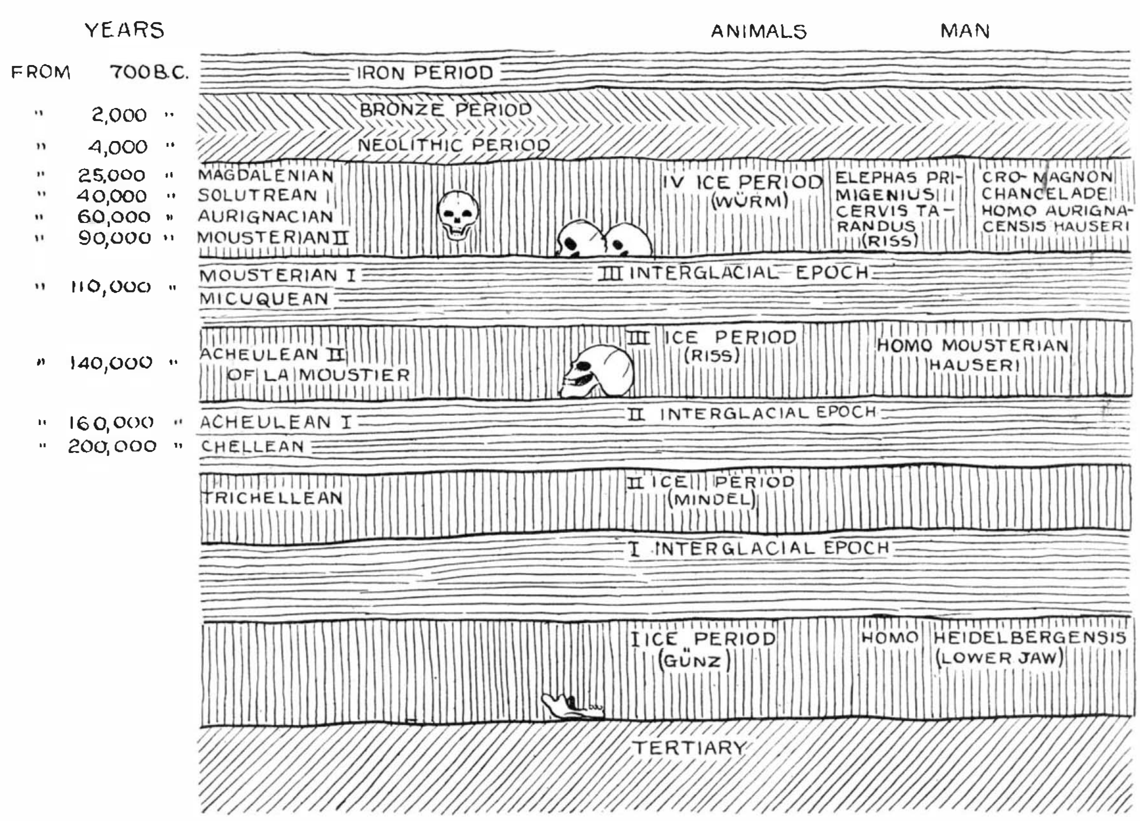


Chart of the Glacial epochs.

Dordogne). In 1910 Hauser found many important fragments of two more skeletons, also of Aurignacian age, in the station La Rochette, 6 kilometers from Le Moustier.

Therefore we know of five different races in this diluvium already, and most probably by persistent excavations we will disclose some more members of the eldest European family. One of these Hauser hopes to detect in the particularly interesting station of La Micoque, characterizing a transitive hot epoch between Acheuléen II. and Moustierien I. This station hitherto considered as an "open air station" in Hauser's excavations is found to be an "abri sous roche," an overhanging rock-shelter, but broken down in the length of time.

The instruments in use by the primitive men of the quaternary are very different in shape, and we see a sort of technical development. This difference of types is in connection with the age of each epoch; therefore a special chronology was established, based on particularly characteristic worked flint-flakes originating from special localities. So a sort of raw-coined fist-wedges found in Chelles (Department Seine et Marne) gave the name to Chelleen Epoch, while a finer variation of such wedges and the first scrapers of a special form discovered in St. Acheul on the Somme characterize the next period. An "abri sous roche" near the village Le Moustier in the Vézère Valley furnishes characteristics of another epoch, the Moustierien, the first flint-points. Other instruments again were found in Aurignac (Haute Garonne). Besides painfully worked flint-scrapers, and flakes with half-round notches on the borders, we find bones worked as awls, peniards and needles. Not far from Lyons, in Solutré, near Macon, one discovered wonderfully worked flint-points for arrows and lances, characterizing a special period; and by discoveries in the cavern of La Madeleine, on the Vézè River, we learn about a last great epoch, the Magdalénien." During this time the most wonderful paintings inside the caverns were done. We show an engraving of a more ancient period, a reindeer, sculpted in the Aurignacian Epoch, the oldest drawing yet found, i. e., about 60,000 years old. Sculpture are known from the Solutréan Time, especially animals connected with the nutrition of the primitive man, such as bears, wild horses, mammoths and reindeers, which exist both inside the caverns. We show an engraving of one of the smaller stones. In 1914 Hauser succeeded in proving the existence of a beginning of writing by signs from the same time as these pictures were drawn. The last very important discovery was the oldest sacrifice-place ever known. In a large "oval" of about 12 yards many great cut blocks are placed. In the center of this ring a lot of paleolithic skulls of men and animals are deposited, as well as most wonderful ornamented and perforated bones, crystal-pearls, a large fireplace and wide cups cut out of stones. Besides this there are many wonderful flint-artifacts and perforated horns with engravings (Batons de Commandement). On all sides of the large blocks are most excellent sculptures, a real sacrifice complete. . . . Then the war came and the work was interrupted.



By O. Hauser

Chart indicating paleolithic periods.

Certainly the Vézère Valley and the Dordogne still contain an enormous quantity of rests of the oldest European dwelling places; there and in the Pyrenees primitive men lived for hundreds of thousands of years, while the most considerable part of the Continent was covered by gigantic glaciers and uninhabitable It is therefore not a simple phantastic phrase to say, the European cradle was located in Dordogne.

The Naval Battle of the Skagerrak*

How the Engagement Is Viewed in Germany

By Capt. Z. S. Hollweg, of the German Naval Department

One hundred and twenty-two years ago, on June 1st, 1794, after a preliminary engagement of several days' duration, the British Lord Howe, with twenty-five ships of the line, decidedly defeated, four hundred miles off Ouessant, the French fleet of approximately the same strength, under Villaret. The English ships were superior to the French in the quality of their crews. Panic ruled in France. In the general butchery of the French Revolution the navy had lost its best officers; the superior generalship of the English admiral drove the untried seamanship of the French commander into battle against the latter's will, and by a reckless onslaught forced him to remain on the defensive to leeward of the British fleet. The loser left seven battleships in the hands of the victor, and others were sunk. Fatigue and the physical incapacities of the British admiral, almost seventy years old and exhausted by the mental strain of five days of continuous effort, hindered the chase and robbed the English of the evident profit to be derived from an unremitting pursuit of the vanquished foe. The best part of the beaten and demoralized French fleet reached a safe harbor, some in the tow of less severely damaged vessels.

Lord Howe attained his tactical victory, but was unable to reach his strategic goal; a strong French commercial fleet from America, which Villaret had been ordered, upon pain of death, to bring to a French port, ran safely into Brest under cover of his defeat.

In the history of English sea-power, the remembrance of this battle lives under the stirring name of "The Glorious First of June." More by reason of this appealing name than on account of its strategic and tactical significance the battle is almost as well known in England as Aboukir or Trafalgar.

On the 1st of June, 1916, the rosy tint of this day in English annals was somewhat dimmed. In the future, the recollection of the glorious day of 1794 will be mixed with the bitter taste of the 1st of June, 1916. Germany, too, now has her "Glorious First of June," when the German victory will be recorded in history under another name.

In spite of the reassurances, partly of official origin, which have appeared in it, in spite of a Churchill and a Reuter, the English press has not succeeded in converting the gloriously won victory of the German fleet into a defeat, into the "greatest success of the British sea-power since Trafalgar." Fortunately for the neutrals there are better sources of truth for open-minded writers than Reuter despatches or Churchill boasts. To the honor of the English press be it said that a considerable part of it is beginning gradually to abandon this falsification, and to speak in all earnestness of the Skagerrak sea fight as a "costly catastrophe for the English sea-power." Herr Hervé, who is a well-disposed critic of his Entente friends, has frankly espoused this interpretation. It is not to be denied that later, when an objective regard of all things is again possible even in France, a faint malignant joy will even here appear over this misfortune to the pretentious sea-power of her often brutal ally. In France the anniversary of the "Glorious First of June" is not in good standing. The remembrance of the loss of so many brave French seamen in this battle will remain alive in France through a certain famous picture in the Louvre. It represents an incident of the battle, the duel between the "Vengeur du Peuple" and the "Brunswick," an incident of true French bravery, to which Barrère devoted at the time an inspiring speech of commemoration.

Tactics and Strategy.

A part of the English press has been at great pains for some time to represent the course of the Skagerrak fight about in these terms: The German fleet has had some secret strategic purpose. The British, on account of the unfortunate lack of light, were, from the first appearance of the Germans, not sufficiently well-informed to be able to attack in full force. The "overbold" cruisers of the English fleet therefore met the greatly superior full force of the Germans. In combat with these vessels, which were also supported by submarines, mine fields, gas bombs, airships, and other "unfair" means, they suffered considerable loss. Then, when the genial British admiral at the proper moment brought up his main fleet, the German fleet unfortunately avoided the defeat and destruction prepared for it by flight to a safe harbor. Result: No attainment of the German strategic purpose, the complete tactical defeat of the German fleet by the superior English gunnery, no loss of prestige for England. The victorious English fleet rules the North Sea now as before.

The day will come when England herself will be ashamed of these fabrications. A correct historical study will be mercilessly freed from such self-delusions.

The official German report sets forth correctly the place, time of day, and course of the fight, and makes it clear what was planned and what was accomplished. No secret strategic purpose actuated the German fleet. It was anxious to fight and sought the enemy for that purpose where he had last been announced. For this very purpose the German fleet had previously gone to sea repeatedly. It is not its fault if the English fleet was not on the spot at an earlier date. Unlike the opponents of the English in the affair of 1794, its movements were restricted by no worries over the safety of a convoy, or any such matters. It always went to sea to fight. That the Germans desired to fight under the most favorable practical conditions possible, was their good right, especially in the role of the considerably weaker party numerically. It was, and is, good tactics to be stronger at the point of contact than the enemy. Lord Nelson taught the world many years ago at Aboukir and Trafalgar that this applies to sea-power. Were it otherwise, the weaker party would never have a chance of victory. The outcome of the battle indicates that the German intention of fighting under advantageous tactical conditions was realized, thanks to skillful management by the German staff. Wind, weather, position of the sun, and location of the scene of action are all weighty factors in such a tactical calculation. The attacker, in this case the German fleet, had, as always, the advantage of determining the time and place of the battle, and of therefore being able to regulate to its own advantage many of the factors mentioned. That is always the advantage of the offensive over the defensive. To take the offensive is to command the enemy. He who does this has trust in his material and personnel. He reckons in advance upon victory and its fruits. To English dullness it seems imcomprehensible that the German fleet, outnumbered almost two to one, did not come to anchor somewhere and wait patiently until the entire English force had gathered about unmolested in order then to be able to put through, without risk, the oft threatened programme of complete annihilation. This was not our intention. The German sea chief would not willingly help the English to such cheap renown..

The German fleet, so says the Naval Act of 1900, is conceived and built as a "risk-fleet." Contemplation of the risk of battle, it was hoped, would keep us in peace. When war became unavoidable, however, the risk of battle should be so great for the enemy that the position of even the strongest sea-power would be threatened thereby. The correctness of this underlying principle of our naval programme is now substantiated by the victory of the German fleet.

In war the deserving often make their own good fortune. The capable man is also lucky, for his plans work out as he intended. The German fleet made its own success on May 31st. The happy sequel demonstrated the correctness of the plans and purposes.

The English assert that the battle was fought only between parts of the opposing fleets. This the official report has unequivocally contradicted. The entire English fleet was in action against the German. It was the constantly repeated attacks of our torpedo boat flotillas upon the head of the English battleship line, led by Admiral Jellico himself, that caused the English leader to break off the fight. An explanation for this can be sought and found only in the fact that the English battleship squadrons had suffered such heavy losses from our guns and torpedoes that a continuation of the maneuvers begun by him seemed dangerous to the English admiral. In any event, from this moment he withdrew from the zone of fire of our ships. Smoke and fog which gathered upon the field of battle unfortunately prevented this movement from being clearly discerned. From this point on, the German Commander-in-Chief executed all movements of our forces already begun without interference and as correctly as though on parade, and got the night march under way.

The absurd claim that submarines, Zeppelins, mine fields and poisonous gases were the sources of the German victory attained in honorable battle has been sufficiently refuted from German official sources. The English claim is very transparent. If neutrals must be informed that the sea-ruling and strongly preponderant English fleet has suffered such extraordinary and unlooked-for losses, the German victory must, at any cost, be denied to have had its origin in the natural way through "sheer hard fighting" of the warships with those queens of weapons, guns and torpedoes; some German deviltry must be exhibited as the source of the misfortune. English pride will not and cannot be satisfied that any other fleet has surpassed its own in gunnery. Popular opinion and the press in England have acted now as in the Anglo-American war of 1812-1814, when, against all expectations, several American frigates vanquished in single combat and destroyed vainglorious English opponents of equal size. Every trick of distortion was then employed in the effort to show that this outcome was due, not to the excellence of the American generalship and gunnery, but entirely to the superior armament of the American vessels.

Finally, the "flight" of the German fleet to its base. Which had the greater numbers—of battleships especially, but also cruisers and torpedo boats—the English fleet or the German? Whose squadron had the greater average speed? Both fleets, as stated above, were in close battle contact almost until the fall of darkness. The German fleet was more than 150 miles from its nearest base, in the open sea. It is almost a straight line from the scene of the battle to Heligoland. Doubt as to the course of the German fleet could hardly exist. It was a short June night with barely five hours of darkness. Is there a single Englishman of intelligence who really hopes to make the world believe that an energetic, eager-to-fight, unhampered English admiral could not have kept in touch with the German fleet during the night by means of his light vessels, if the desire to wipe them out still lived in him, and the strength for this operation was at hand? Was physical and mental strength denied the comparatively young Admiral Jellico, as once before on June 1st, 1794, it was denied the aged Lord Howe? Shall the ill success of the commander of the English fleet be taken as a confession of inadequate seamanship and deficient tactical skill on the part of his scout ships? In the hard drills of the long years of peace has not the English fleet, with its many swift cruisers, learned how to keep track through one short night of a hostile fleet numbering in the neighborhood of thirty capital ships? We do not believe it; we rate English ability too high for that. Sir Jellico has actually thanked Sir Beatty for his work of scouting. He must have been satisfied with it. Will the English commander have us believe that, on the basis of the information brought him by his observers, it was impossible for him, on the morning of June 1st, to take a position which would have enabled him to offer decisive battle to the German fleet? The course of the latter was without doubt known to Admiral Jellico through the work of his scouts, either of those upon which the German fleet had had occasion to direct a precautionary fire, or else of those which successfully engaged the "Pommern" and the "Frauenlob."

Like burning torches in the descending darkness, the wrecked English cruisers and destroyers marked out for him the path of the German fleet. Why did he not hurl at that fleet, whose destruction was his ordained task and his eagerly pursued purpose, the squadron of twelve vessels arriving fresh and intact from the south, thus holding the hostile forces until he himself could reach the new scene of battle? That he did not do this, that he did not even make an effort to do it, proves that he felt himself too weak for further battle. The victorious German fleet and the English admiral both steered for a home port, and the German ships found time on the way to rescue many brave English seamen of the sunken ships and to bring them in as prisoners.

The German commander and the whole German

Editor's Note.—This article, commenting on the great naval engagement, is of special interest when read in connection with the article on the "German Official Story of the Skagerrak Sea Fight," which appeared in the issue of the Scientific American of the 19th, and which is the first genuinely official German account of the battle that has appeared in this country.

*From *Der Woche*.

fleet actually waited on the morning of June 1st, on their way toward the inner German waters, in the hope of finding the reinforced English fleet ready for further fighting. But they did not appear; when the sun of June 1st arose the sea was empty of the foe and remained so. For the German admiral to stay at sea with the purpose of seeking out the enemy there was no occasion. His end had been attained, his work finished. The desire to replenish his provisions and fuel, to give his brave crews their well-earned rest, and to disembark his wounded in order to be quickly ready for a new encounter, easily explains his decision.

WHAT THE NAVY THINKS.

Long before the present murderous war broke out, and in spite of all effort at refutation from authoritative German sources, Englishmen have spread the fairy tale that at every banquet German naval officers drank "to the day;" that is, to the day on which the German power should be called upon to measure itself in conflict with English skill. It is not necessary to point out here that this whole invention had an inciting tendency of the worst sort. The German naval officer has always had the highest regard for the English comrades with whom, in foreign countries, he has often and gladly associated upon most friendly terms. We all know that we have learned much from the English navy, we know the glorious histories and traditions of English sea-power. We know that on the true "glorious 1st of June" namesakes of the "Invincible," "Defence," and "Marlborough," which now on this June 1st our guns have laid low, fought in the victorious English line. We knew English history so very well that we were perhaps a bit inclined to over-value its lesson. With the history of the origin of the present-day British sea-power, built up upon the ruins of every commercial competitor—first Spain, then Holland and France—we were familiar. The envy and hate with which our maritime syndicates were met in England spurred us on to complete at the earliest possible moment the undertakings which were necessary to justify our confidence and put the defense of Kaiser and country in our hands, if it should come to pass that the appeal to arms must be made. We prepared ourselves in advance to do our duty should the Fatherland call. No more, no less. Bloodthirsty hatred or envy of England's fleet we have never cherished. That, in case of necessity, the navy would be eager to do its duty, every single man has solemnly and silently vowed. Drinking and toasting in this connection would have seemed to us the height of bad taste. When the war at length broke out, we were eager to show the worth of our fathers and to return our thanks for all the love and inspiration with which the German people in the past few decades had advanced the growth of its darling child, the fleet.

But now, when the hour of decision has at length struck, when excellent leadership and a favorable fortune have given the fleet opportunity to show that we also know how to fight, to conquer and to die, when material and men have met unfaltering the ultimate test, when England's strongest fleet, severely damaged, must abstain from further action, when all Germany is decorated for a day in honor of the fleet, at this time there shines from the faces of all to whom its participation was granted a gleam of joyful, victorious, sober pride. And a little reflected glory falls also upon the remaining members of the navy, to whom it was not allotted to fight and to conquer. We are not foolish enough to believe that the English sea-power is destroyed, for we know the English tenacity, the oft-tested English skill upon the sea; and we feel that we have not struggled for the last time with the Mistress of the Seas for recognition of our equality. But our confidence in the ability of our leaders, in our ships and in our weapons, is greatly increased. Anyone who knows the state of mind of our people, especially if he has seen the old Reservists in action (on this all reports agree), anyone who has heard the shouting "hurrah" and the thunder of cannon and the rain of hostile fire, anyone who has learned to know the untiring endurance of all our units, must know what to expect from these men in the future. It is not ships that fight, but men! We all await calmly the hour when the preponderant enemy again gives us opportunity to show that the ability and spirit of German sailors will not take second place to the traditional British seamanship and bravery.

Upon the medal which grateful England struck to commemorate the victory of the "Glorious First of June" appears the inscription "*Non sorte sed virtute.*"

The German fleet insists that for the victory of May 31st and June 1st, it also has to thank, not chance, but the bravery and ability of every individual.

Before the battle fleet was afforded its long-anticipated opportunity to prove in this war its power and the necessity for its existence, mild doubts were felt by many of the German people as to whether it was good policy to build the sea-power of the Empire upon strong squadrons of large fighting ships. Many, in their moments of quiet reflection, have wondered whether the millions which this naval establishment has cost would bear fruit and pay interest in this war. There were even technical experts who felt called upon to ventilate their ideas about "cheap" submarines. The cannon thunder of our battleships has now, in the last days of the spring of 1916, resolved all doubts. The winter of our discontent has disappeared before the sun of the "Glorious First of June." Germany's fleet will now live, and Germany's sea-power will make greater headway, for all time. The fleet is proud and may well be proud to have been able to contribute to this assurance. Many years ago, a distinguished official once said to me in discussing the value of the "risk" programme: "If it ever comes to a conflict and if every German ship takes an English vessel with it to the bottom of the sea, of this I am certain; the German people will have the will, and find the strength, to build themselves a new fleet." But the issue has been different from this, and better. The number of sunken hostile ships far surpasses our losses. To-day we feel, we know, that the German people henceforth never can and never will forego whatever naval equipment may seem proper to their sea interests. The gaps left by the war will be filled. The precise appearance of the German fleet of the future we will leave to those who, after searching test, are called upon to interpret the lessons of this war; but that this fleet of the future will contain squadrons of strong battleships is made certain by the victory of May 31st.

His Majesty, the Kaiser, in his address at Wilhelmshaven, after the battle, spoke right from the hearts of the officers and other members of our navy, when he extended his thanks and the thanks of the German people to the great armorer of the fleet, Admiral von Tirpitz, and to the distinguished instructor and exemplar of the officers, Admiral von Köster. The fleet always suspected what it owes to these two leaders, but after this day of battle it knows; without their labors, without their sweeping contributions, the great work of fleet-construction and fleet-formation would have remained incomplete. But in this, its hour of glory, the fleet also has thanks for others. All those who, in year-long tiresome labor, have given their best toward the creation of an efficient navy and a body of glorious traditions are rewarded, by the victorious outcome of this battle, for their silent labors in time of peace so little observed by those outside the inner circle.

In one sentiment, the minds of the entire navy are united, alike those of the victors in the North Sea fight and those who were left at home; in thankful thoughts to those who, in distant foreign lands or upon the shores of the Fatherland, have given their lives for the sake of the flag, and whose names adorn the tablets of honor in our churches. At every anniversary of the "Glorious First of June" the graves of these and of all those who on this day of battle in May, 1916, have died for Kaiser and country will, in grateful remembrance, be decorated with a cross of the bright spring foliage of the German oak.

Sound Propagating and Zones of Silence

On quiet evenings weak sounds are often carried to surprising distances. On the other hand, sailors not infrequently fail to pick up the sound of a fog-horn, which then suddenly bursts upon them, though they had been straining their hearing to catch the signal. Curious observations have been made as regards the distances to which the roar of explosions and of volcanic eruptions have been carried. In the case of a dynamite explosion occurring in 1903, at Förde, near Bochum, in Westphalia, the crash was heard close by and in an irregular area to the East, 100 kilometers and more distant, but hardly in other directions or in the intervening belt. When dynamite exploded on the Jungfrau Railway at Eigerwand in 1908, there were again two irregular areas in which the explosion was heard—one near the spot, the other far out. Here the mountains may have had a decided influence in reflecting the sound waves; but in the Asama eruption of 1914, in Japan, two zones of sound, one east, the other west of the volcano, were separated by a belt of silence nearly 100 kilometers in width. In most of these and similar cases no preparations could be made for observation, and the evidence is of doubtful value.

During the siege of Antwerp, in the beginning of October, 1914, Dr. van Everdingen, director of the Netherlands Meteorological Observatory at Utrecht, was informed that the guns were heard at some places, but not heard at intervening spots, and he asked the meteorological observers at the various stations of the kingdom to pay attention to these phenomena. The result was that in the days October 7th to 9th and later, after the fall of Antwerp, during the battles near Ypres and off the Belgian coast, a great many observations were collected at distances up to 200 and 300 kilometers from the engagements. The reports, which Dr. van Everdingen discussed in the Proceedings of the Amsterdam Academy and also in the *Revue Générale des Sciences* of April 30th, 1916, were not in the best agreement, of course. But it seems to be established that there was, apart from local zones of silence, on various days a zone of relative or complete silence inside the radius of 160 kilometers; this zone of silence had a width of about 50 kilometers; beyond the distance of 160 kilometers the sound became weakly audible again, decreasing in intensity with increasing distance.

Attempts have at various times been made to account for the phenomena on meteorological lines, somewhat after the manner of the mirage problem. As a rule the temperature of the air falls as we ascend from the earth; the velocity of sound therefore decreases upward, and a ray of sound, so to speak, which was nearly horizontal to start with, would curve more and more upward by refraction; this refraction of sound waves is greater than with light waves. On the other hand, there is, in the case of sound, no total reflection which plays so important a part in mirage. When the air becomes first warmer in the lower strata, the velocity of sound increases, and rays of sound are curved downward. The wind especially if across the line of sound propagation, makes little difference. But the wind is of importance in another respect. The wind frequently becomes stronger in the upper strata, and, moreover, changes gradually in direction. The upper atmosphere absorbs much less of the energy of the sound waves than the surface air. The general effect of an increased wind velocity in the upper atmosphere will be that of increased refraction, that is to say, the sound will travel to a greater distance in a curved path than in a straight direction; and if there be a change in the wind direction at a certain height, zones of silence will be created, especially if the air be violently disturbed and locally heated by explosions or the hot gases from volcanoes. Explanations on these lines have been proposed by Mohn, Rayleigh, Fujiwara.

This explanation, though probably correct in most cases, does not well admit of quantitative treatment, and Dr. van Everdingen prefers, in his case, the "physical" explanation of von dem Borne (*Physikalische Zeitschrift,*" 1910, page 483) to the meteorological, because the meteorological conditions over Holland and the Continent on the days in question were unfavorable to the former. According to the physical view the different gases in the atmosphere have each their own velocity of sound. There is hydrogen in the atmosphere; its percentage is very small on the surface (0.01 per cent), but increases with height. Borne even suggests the figure of 98.6 per cent at a height of 100 kilometers. This, of course, is entirely hypothetical; in fact, the suggestion has partly been made to account for phenomena otherwise difficult to explain. As the height increases, the velocity of sound in the hydrogen-air mixture will increase, until finally the curve will turn toward the surface again, which it should strike at a distance of 114 kilometers from its source, according to Borne. Now Everdingen observed this recurrence of sound perception beyond a zone of silence at 160 kilometers. The two figures therefore, do not agree; but the percentage of hydrogen in the surface air is at present assumed to be only 0.00055 per cent (G. Claude's estimate), and accepting that percentage for his deductions, Everdingen finds his figure 160 kilometers confirmed. The weather conditions would influence this consideration very slightly; for weather changes are confined to the 10 or 12 kilometers of the atmosphere next the earth, but do not extend beyond the so-called isothermal layer found at that altitude in our latitude, while the bend of the curve can hardly occur at an altitude of less than 100 kilometers. It may be objected that the acoustic energy of waves coming from that height would be too feeble to affect the ear; but the ear is very sensitive, and as a matter of fact the sounds perceived were weak. The theory might be checked in one way. If the acoustic waves travel first up into the air and then down again, covering perhaps twice the direct distance from the source, they should be heard later than with straight-line propagation. In the case of the Asama eruption there was some evidence to that effect; but the observations were uncertain. The question is not without importance, and experiments might be made during the war. Propagation of the sound waves through the earth, to which Dr. van Everdingen hardly alludes, would have to be considered; in that respect a difference between naval bombardments and land bombardments should be observed.—*Engineering.*

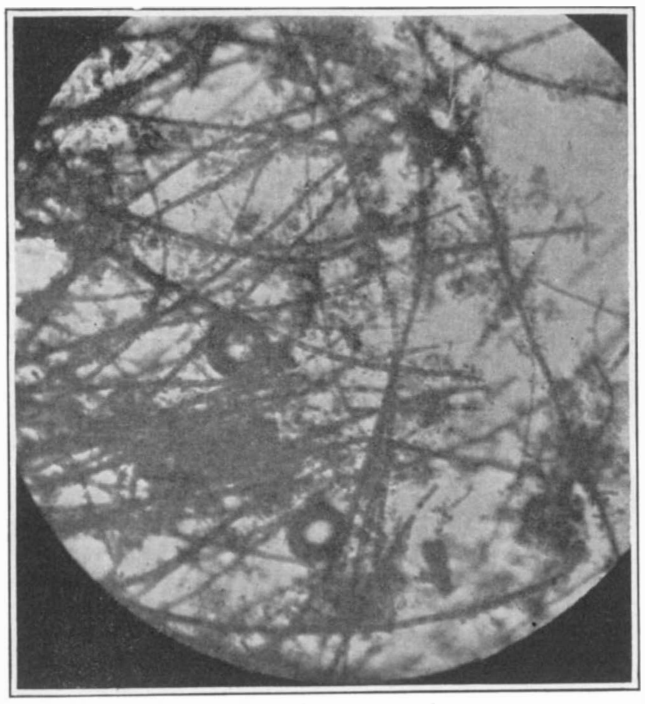


Plate V.—Cladothrix dichotoma; x 500.

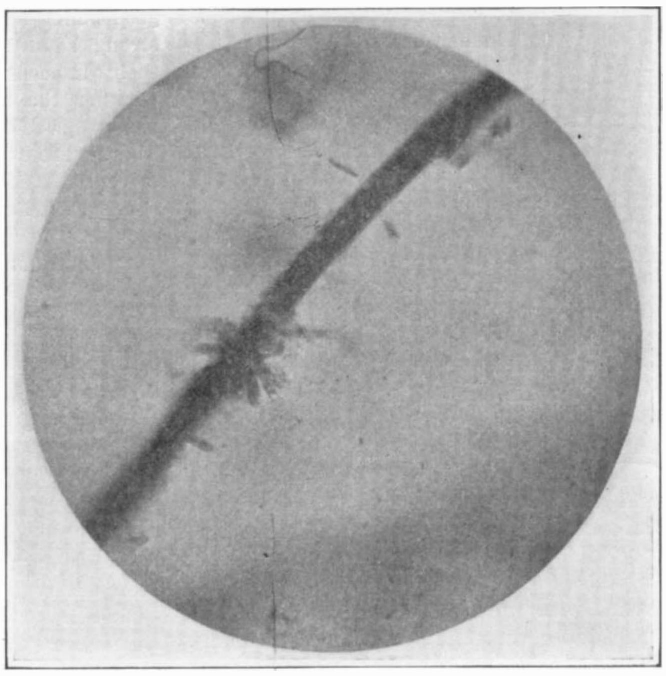


Plate VI.—Cladothrix dichotoma; x 1,100.

The Iron-Bacteria—II*

A Curious Class of Organisms, Their Physiology, and Their Action on Iron Solutions

By David Ellis, Ph.D., D.Sc., F.R.S.E., Royal Technical College, Glasgow

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Cladothrix dichotoma (Cohn).

This organism consists of long thin threads attached at one end to various objects at the bottom and sides of stagnant streams. Like Crenothrix each thread is made up of a number of rods enclosed by a common sheath, but unlike Crenothrix the rods are always in single rows, are of uniform length in each thread, and usually longer and thinner. Also, except in rare cases, the threads are uniform in thickness. Each rod measures from 3 μ to 6 μ in length with a width of approximately 2 μ. A representation is given in Plate V. and Fig. 5. Occasionally the threads appear as if branched. This is due to the fact that some of the rods slip out laterally through the sheath and develop into new threads without severing their connection with the parent plant. This gives the appearance of dichotomous branching, and has given the name to the organism, but in the writer's experience this false dichotomous branching only rarely takes place. When stained with iodine the rods become visible. Each one possesses a distinct cell membrane. The sheath is formed by a contribution from each of the rods. In the younger stages if the rods were removed the sheath would appear as a uniform cylindrical tube divided up into compartments by means of transverse walls (Figs. 6 and Plate VI.). Each compartment contains a single rod. A little farther on in the development the sheath hardens, and while this is taking place the basal rods are dividing and elongating, and by the pressure of their growth forcing themselves upward. The result is that the transverse walls are broken and obliterated, and an opening is effected at the apex (Fig. 7*B*). The sheath therefore becomes a hollow, more or less firm tube, permanently open at the top. In the final stage we see nothing but a hollow sheath from which all the rods have departed. This sinks to the bottom, and takes its place along with the other empty sheaths that have preceded it. If the life of Cladothrix has run its course in ferruginous waters the sheath is impregnated with ferric hydroxide, and in appearance is exactly similar to a dead Leptothrix thread. When the rods slip out of the open sheath they are either carried away as inert bodies or else are endowed with cilia and effect their own locomotion. In the Cladothrix figured by Fischer the cilia are placed in a bunch immediately below one of the ends of the rod, but in the British species, so far as they have been examined, the cilia are placed exactly at the poles. The liberation of single rods is not confined to the apex; some may take a short cut through the sheath, and either slip away or else develop in attachment to the parent thread. Further non-motile or motile *fragments* may be liberated. In the latter case each rod composing the fragment is possessed of one or more polar cilia. In a very exceptional case the writer has observed these detached fragments assuming the form of spiral threads after leaving the parent organism. Each fragment was made up of a few rods enclosed in a common sheath. Motility was effected by means of polar cilia, the fragments also assuming a wavy structure (Fig. 7*C*). Without the use of stains they could not have been distinguished from members of the Spirillaceæ. A still more remarkable occurrence in the same culture was the lateral detachment of single rods, which on liberation assumed a *spiral* form with cilia at both ends, and swam off in the true spirillum manner (Fig. 7*A*). The detachment of spiral fragments from Cladothrix threads was noted by Zopf more than thirty years ago, but subsequent observers have either ignored his announcement or doubted its accuracy. These phenomena were observed in one, and only in one, culture out of an extensive series of observations carried out by the writer, and extending over eighteen months. The theoretical importance of this fact is great, for it shows that one and the same organism can produce both the bacillus and the spirillum forms of bacteria, which at present are regarded as being fundamentally distinct. A closer examination of the rods with the help of staining reagents reveals a delicate, well-defined membrane. In well-nourished cultures each cell has granular contents. Further, the presence of oil and glycogen can be demonstrated. As regards division, that process is essentially the same as in the genus Bacillus. A delicate transverse membrane is thrown across, this is followed by constriction, with eventually the separation of the rod into two cells. Each then grows until the mature form is reached. The distribution of this organism is very wide. As will be seen in the discussion of the physiology of the Iron-bacteria, it is only incidentally a member of the Iron-bacteria, for it is found in many non-ferruginous waters where there is a slight organic decomposition. Further, there can be little doubt that what we call Cladothrix dichotoma is either a group of very closely related species or else is one species capable of much pleomorphism in adjustment to the varied conditions of life.

Clonothrix fusca (Schorler).

The discovery of this organism by Schorler in the waterworks of Dresden added another member to the group of Iron-bacteria. It resembles *Cladothrix dichotoma* in all respects except that the threads taper out at the ends. It is described as varying in thickness from 2 μ at the apex to 5—7 μ at the base. When covered with manganese hydroxide, which substance it attracts as well as iron compounds, the thickness of the organism may reach 24 μ. In view of the fact that it differs from *Cladothrix dichotoma* only in possessing a tapering apex, and considering that the latter name is given rather to an assemblage of closely allied species than to a single specific organism, the suggestion may be made that perhaps it would have been advisable to have inserted Schorler's organism within the folds of the genus Cladothrix. It is shown diagrammatically in Fig. 8.

Siderocapsa treubii (Molisch).

A very peculiar organism was described by Molisch in 1909. This lives as an epiphyte on water plants. Its presence is indicated by the appearance of a rust-colored crust on the surfaces of these plants. In the crust numerous roundish clear spaces appear, each about 1.8 μ to 3.6 μ in diameter. In these spaces numerous round little cells or cocci may be discerned, and it is due to their activity that the crust is formed. Each clear space encloses a colony of cocci, and the crust of iron always begins round these colonies. Another species of the same kind found by this investigator has been named *Siderocapsa major*. This new genus differs very widely from any of the genera hitherto included under the Iron-bacteria; it is to be hoped that we shall be furnished with some details of its life-history, and more particularly with its physiological activities in so far as its relation to iron compounds is concerned.

Artificial cultures of the Iron-bacteria.

Of the seven organisms mentioned above, artificial cultures have not yet been successfully accomplished in so far as *Gallionella ferruginea*, *Clonothrix fusca*, and the genus Siderocapsa are concerned. Impure artificial cultures only have been obtained of *Spirophyllum ferrugineum* and *Crenothrix polyspora*. Pure artificial cultures have been obtained only of *Leptothrix ochracea* and *Cladothrix dichotoma*, the two best known and most widely distributed of the Iron-bacteria. The artificial cultures have brought to light several interesting features. They have in particular demonstrated that the term "Iron-bacteria" in the sense in which the term was originally employed is a misnomer.

The absorption of iron-compounds is not necessary to their growth—except of course that infinitesimal amount that all organisms need—and the best artificial cultures have been obtained from nutrient media which did not contain this substance in any appreciable quantity. This detracts somewhat from the glamor which has surrounded these peculiar organisms, but we are well repaid by the fact that we have approached appreciably nearer to an understanding of their peculiar habits. It is no longer true to say that they derive their energy by the oxidation of ferrous to ferric compounds. What their physiological relations with iron are will be discussed in the next section; it will suffice here to state that the absorption of iron compounds is not necessary for their growth. Another curious fact in connection with these organisms is the great uncertainty which attends all attempts to cultivate them artificially. The virility of the growth of Crenothrix at certain periods has already been mentioned. Garrett mentions most unlikely media on and in which he during such a period

*Science Progress.

secured growth. But at ordinary times the artificial growth of Crenothrix has not been found possible. The same applies to Cladothrix. While Höflich secured growth with the greatest of ease, others have succeeded only after much trouble, and when successful the growth has never been a prolific one. There is no difficulty in the matter of the preparation of the nutrient medium, for it consists merely in the addition to ordinary drinking water of small quantities of such substances as flesh-extract or peptone or ferrous-ammonium citrate. The sole difference between the ingredients of the successful and the partially successful or unsuccessful media has lain only in a difference of the water employed, this naturally varying with the place of abode of the investigator. Whether the determining factor is the presence in certain waters of minute quantities of substances which play the same rôle as the hormones in the animal kingdom, it is impossible as yet to say. Bottomley claims that they exist, but his evidence as yet is unconvincing. Molisch obtained his best artificial cultures of *Leptothrix ochracea* by the addition to water of 0.25 per cent of mangan-peptone, and obtained pure cultures by the use of this medium solidified with 10 per cent gelatine. He describes its activities in a number of liquid and solid media. It is aerobic, liquifies gelatine, grows in light and in darkness, and shows a tendency to form short rods which exhibit a decided motility.

Höflich gives a very complete account of artificial cultures of *Cladothrix dichotoma*. The addition of half a gramme of flesh extract to a liter of water was sufficient to insure an abundant growth. Cladothrix liquefies gelatine very slowly; it is an obligate aerobic organism, and there is a tendency to the formation of short rods. In the case of both organisms the addition of iron-compounds is not essential to growth. If we are to class them under a physiological group both can fitly be included under the peptone-bacteria, as this substance seems to be able to supply them with both the carbonaceous and nitrogenous essentials for the elaboration of protoplasm.

Artificial cultures of *Crenothrix polyspora* have been obtained by Garrett and by Rossler. The accuracy of the latter's results has been challenged owing to the fact that attempts along the same lines by other investigators have invariably produced negative results. Rossler states that he has been successful in cultivating Crenothrix on bricks to which a little ferrous sulphate had been added. It is very probable that Rossler did succeed in making impure cultures of Crenothrix and that the necessary food materials were supplied by organic impurities on the surface and in the substance of the bricks. He states that he obtained pure cultures, but it is difficult to see from his description how this was possible. Still more remarkable artificial cultures were obtained by Garrett, who states that during the period when the growth of Crenothrix became so overwhelming at Cheltenham he was able to obtain artificial cultures. The cocci liberated from Crenothrix threads offered no resistance to growth on a gelatine plate, on coagulated cleared serum at 30 deg. Cent., on potato, etc. There is also here a want of conviction as to the purity of the cultures. No details are given as to the methods adopted to secure pure cultures. While there cannot be any reasonable doubt that artificial growths were obtained by these investigators, one hesitates to accept without further proof that those growths which appeared on serum, potato, etc., were due to Crenothrix, and not to extraneous micro-organisms that had crept in as impurities. In the case of Crenothrix, as in the other two, the results show that the source of energy is not the oxidation of ferrous to ferric compounds, but is rather obtained from the absorption of organic substances.

The writer has obtained slight impure cultivations of *Spirophyllum ferrugineum*, but the results are too scanty and inconclusive to form a basis for discussion.

THE PHYSIOLOGY OF THE IRON-BACTERIA.

The outstanding feature of these organisms is their power of attraction for iron-compounds. In the waters in which they abound, unlike their co-inhabitants, large quantities of ferric hydroxide are found deposited on the sheaths or membranes of these bacteria. Complete agreement as to the explanation of this phenomenon does not at present obtain. Not only the Iron-bacteria, but also a few algae and protozoa possess the same peculiar characteristic. It has been shown above that except in infinitesimal quantities the presence of iron-compounds is not necessary for the successful development of Iron-bacteria. One may therefore dismiss at once Winogradsky's theory that the oxidation of ferrous to ferric compounds was the source from which this energy was obtained. He argued that without the oxidation of ferrous bicarbonate to ferric hydroxide no growth was possible. This oxidation takes place according to the equation:

$$\left.\begin{matrix}2FeCO_3\\H_2CO_3\end{matrix}\right\} + 3H_2O + O = Fe_2(OH)_6 + \begin{matrix}2CO_2\\CO_2 + H_2O\end{matrix}$$

Obviously the whole theory falls to the ground when artificial cultivations can be made from which iron has been rigorously excluded; and further, in Nature there are many iron-waters that harbor Iron-bacteria which do not contain any iron in the form of the bicarbonate. Winogradsky's theory still holds sway in many of the text-books, although he produced no supporting facts.

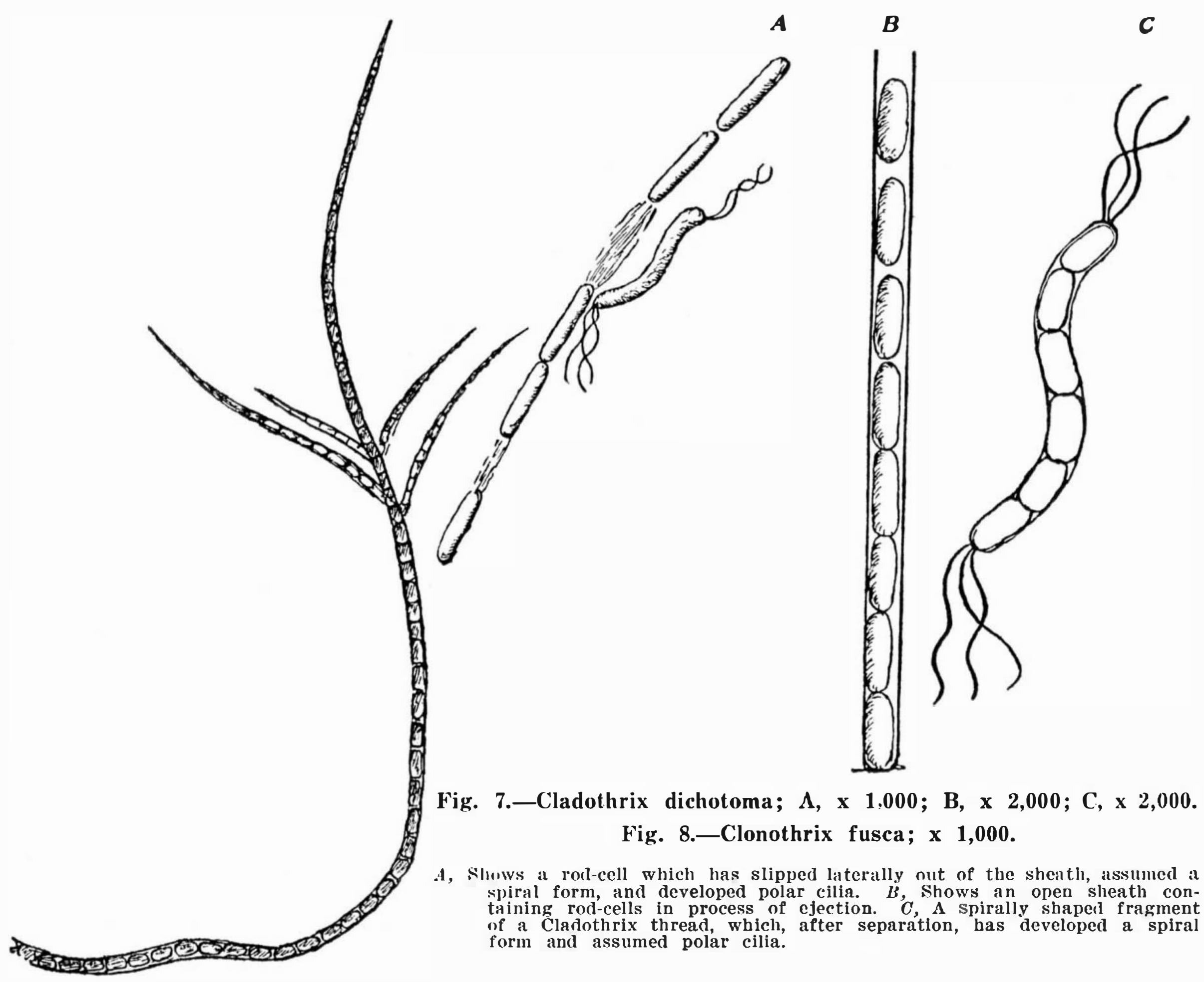

Fig. 7.—Cladothrix dichotoma; A, x 1,000; B, x 2,000; C, x 2,000.
Fig. 8.—Clonothrix fusca; x 1,000.

A, Shows a rod-cell which has slipped laterally out of the sheath, assumed a spiral form, and developed polar cilia. *B*, Shows an open sheath containing rod-cells in process of ejection. *C*, A spirally shaped fragment of a Cladothrix thread, which, after separation, has developed a spiral form and assumed polar cilia.

Another theory is supplied by Molisch. He argues that the accumulation is due to a chemio-tactic irritability for iron-compounds. These substances are attracted by the bacteria, detained by the mucilaginous sheath, and there oxidized into ferric hydroxide. This does away with the necessity for iron-compounds, and is supported by a strong body of facts, as will be seen presently. A third theory is advanced by Campbell Brown, who contends that the activities of the Iron-bacteria are in all cases directed toward the assimilation of organic compounds. When iron is combined in solution with these compounds the removal of the latter brings the iron out of solution, with the result that the precipitated iron collects on and in the membrane or sheath and even invades the cell.

In considering the relative merits of the second and third theories the following facts, which have been proved, must be borne in mind:

1. Iron compounds are not in themselves necessary for growth.
2. Manganese can equally well replace iron.
3. Iron-bacteria obtain their nitrogen from organic compounds as do the vast majority of bacteria.
4. The more organic matter there is in solution in ferruginous waters, the more iron these waters are able to hold in solution.
5. Bacteria in general do possess chemio-tactic attractions and repulsions for a variety of substances.
6. Iron is found not only on or in the membrane or sheath, but actually inside the cell.
7. The growth of Iron-bacteria in ferruginous waters undoubtedly expedites the accumulation of ferric hydroxide in these waters.
8. Other minute organisms, *e.g.* some of the Euglena family, some of the Flagellates, *e.g. Anthophysa vegetans* and some of the Œdogonia group, as well as the Iron-bacteria, possess the same physiological characteristic. When we now apply the theories of Molisch and of Campbell Brown to these proven facts it will be seen that both theories are able to bear the test.

Some of the facts, viz. Nos. 2, 5, and 8, strengthen Molisch's theory considerably; on the other hand, Nos. 3, 4, and 6 give greater force to Campbell Brown's theory. They are, however, not necessarily mutually exclusive, and we shall not be far wrong in granting that each contains a certain measure of truth. If these organisms have a chemio-tactic affinity for iron-compounds, and at the same time remove iron out of solution in their absorption and assimilation of organic compounds, the effect of their growth in expediting the oxidation of ferrous compounds can readily be imagined. The question has lately arisen as to whether the organisms designated as Iron-bacteria are the only members of the group of Bacteria capable of producing these oxidizing changes. Mumford has described an Iron-bacterium which oxidizes a ferrous compound to ferric hydroxide. This work, however, does not adduce incontestable proof that the effects claimed to be produced by the bacterium were due to that organism and not to other agencies such as chemical oxidation. The absence of control cultures is much to be deplored. It further assumes that the oxidation of ferrous compounds is the work of an enzyme, secreted by the organism. As shown above, the facts now at our disposal render this standpoint indefensible. Lately also Harder, of the U. S. Geological Survey, has promised us the proof that a large number of the lower bacteria are capable of oxidizing ferrous compounds. There is every probability that quite a large number of micro-organisms are capable of doing this, for, if we assume the correctness of Campbell Brown's theory, all bacteria capable of abstracting soluble organic matter incidentally combined with iron will by the absorption of this organic matter remove that to which is due the retention of so much iron in the soluble form. It is probable that results will be obtained along these lines.

ARE THE IRON-BACTERIA TO BE REGARDED AS ROCK-BUILDERS?

This question has been dealt with from time to time, but it is only recently that the issue has been placed on a satisfactory basis. Within recent years Molisch has examined sixty-one samples of ferruginous stones from various parts of the world, and in fifty-seven he found no traces of Iron-bacteria. In the remaining four Iron-bacteria were undoubtedly present, but it is difficult to remove the impression that these bacteria were not obtained from a modern sediment on the surface. It is to be hoped that we shall later receive a more detailed treatment of the four stones in question. If the bacteria were found in the body of the stone we should be in possession of a fact of great interest. The writer has recently examined forty-eight of the ferruginous rocks of Great Britain and found four to contain the remains of iron micro-organisms. These four stones were all obtained from the Frodingham ironstone of Lincolnshire, and contained the remains, not of bacteria, but of an iron-mold to which the name *Phycomycites Frodinghamii* was given. This organism was present in the organic remains that are plentifully found in this rock; and while during its lifetime it probably had all the physiological characteristics of the true Iron-bacteria of the present day and thus enriched the ferruginous content of the stone containing it, it cannot in any sense be regarded as an actual rock builder.

Timbers of the Philippines*

Many Woods of Value for a Great Variety of Purposes

The Philippines possess a much greater supply of wood than will ever be used for local demands. The wood consumers of other countries can, therefore, find here a market that will furnish them a large and varied supply for practically all uses to which wood is put; large, because of the immense amount of certain widely useful species which can be obtained by the millions of board feet; varied, because the woods of few countries of equal size, if indeed any at all, can show a wider range of color, grain, hardness, strength, and other qualities demanded by special uses. It is no exaggeration to say that some species of wood can be found in the Philippine forests to suit almost any imaginable purpose the user may have in mind.

Export timbers generally fall roughly into four principal classes: Woods for interior finish and furniture, cabinet woods, woods for special uses, and heavy construction timbers.

1. *Interior finish and furniture woods.*—The prime requisite of a wood for these purposes is that it be at least fairly abundant. Also, it must be not very difficult to work and to finish, of good size, and last, but not least, of pleasing texture and color. All of these requisites are fulfilled by the woods of the dipterocarp (lauan) family. This family (to which belongs nearly three fourths of the standing timber of the islands) occupies the place that the conifers do in the North Temperate Zone, but possesses a wider range of color, hardness, and other qualities. The lauan group of the dipterocarps contains the greatest amount of timber specially fitted for interior finish and furniture. Tanguile, red lauan, and white lauan are obtainable in great quantities, have a fine ribbon grain when quarter-sawn and, in texture and color, the first two resemble true mahogany and its substitutes very closely. White lauan differs from them only in color, being white with a very pale grayish-brown tint. It is pretty in natural finish where a light color is desired and, on the other hand, lends itself very well to staining. Almon, a very pale red lauan, is similar to white lauan as regards stains.

The other woods of the same family, guijo and apitong, are also abundant. This fact and their greater hardness enable them to fill a demand for flooring in place of oak, red beech, maple, and other American woods which are yearly becoming scarcer. Guijo is light ashy brown to reddish brown and apitong is somewhat darker. Finished with wax or varnish, they range from reddish brown to dark chocolate. Both are hard and of rather fine texture. If a very hard wood is desired for flooring, yacal, the hardest and heaviest of the dipterocarps and the most abundant of the hard, heavy, and durable woods in the Philippines, will find a place.

There are several woods of other families which, though not as abundant as the lauans, are still to be obtained in sufficient quantities to supply industries that do not require many millions of feet per year. Such are lumbayao, pagatpat, and nato. Lumbayao is similar to red lauan in appearance but is slightly harder and tougher and has a more conspicuous flake grain when quarter-sawn; nato is of similar color and texture, but of very homogeneous grain; pagatpat also is very even-grained, but of a rich dark-brown color.

There are also frequently used in the Philippines narra, tindalo, acle, molave, supa, calamansanay, ipil, and other hard, durable, and beautifully colored woods; for the export trade, however, these woods, on account of their beauty, comparative scarcity, and higher price, should be rather classified as cabinet woods.

2. *Cabinet woods.*—Of these the Philippines possess such an astonishing variety that it is difficult to give any idea of them in a short pamphlet. Foremost among this class on account of their large size, beautiful color, and grain and durability are the woods of the narra (or locust) family—acle, banuyo, ipil, narra, supa, and tindalo—all of which would delight the eye of every American maker of fancy furniture and cabinetwork. A dining-room set, a piano, a billiard table, or any similar piece of furniture made of one of these would attract attention at once, no matter what comparison it might have to bear with other aristocrats of the lumber world. To attempt an enumeration of different classes of cabinetwork, naming for each one the various Philippine woods available, would necessitate much unnecessary repetition. Perhaps the easiest way to give the cabinet-worker a notion of what he may demand (and obtain!) for his purposes is an enumeration of some of the better-known woods roughly classified by colors: Black—ebony; black streaked or mottled with red brown or gray—camagon, ata ata, bolongeta (the Philippine persimmons); dark brown—dungon, ipil, mancono, pagatpat, pahutan; reddish brown—apitong, batete, betis, catmon, guijo, nato; red—amuguis, bansalaguin, calantas, nato, palo-maria, sibukao, tabigi, tucangealao; grayish—banawi, macaasim, taba; yellow—alintatao, bancal, baticulin, malacadios; pale straw color, creamy or nearly white—kayutana, lanlete, miao, white nato, molave. It must not be thought that the foregoing list is compiled with a view to color alone, any and every wood, good, bad, or indifferent, being dragged in to fill up; on the contrary, those named are all good woods, rarely attacked by boring insects, and not generally subject to discoloration except in the case of such light-colored woods as are easily stained by too slow or otherwise inefficient seasoning. In fact, the list could be doubled by including other woods used, on account of their varied color and grain, for musical instruments, fine cabinetwork, sculpture and carved articles, canes, hilts and sheaths for weapons, inlaid and mosaic work, desk and toilet novelties, picture frames, etc.

3. *Special uses.*—For bowling balls, bearings, stern shaft bearings, mancono has been used successfully. For the first-named purpose, dungon has also been found good. Bansalaguin, alupag, malabayabas, and tiga, all of fine texture, difficult to split, and very heavy, are recommended for experiment. For such articles as dumb-bells, paper weights, etc., requiring weight but not necessarily so fine and tough a texture, not only these, but a considerable number of other very hard and heavy woods are available.

For tool handles and other wooden parts of tools, there are generally required woods that are either hard or tough or both. Chisel and hammer handles and mallets especially need to be hard, tough, and difficult to split: for these agoho, betis, calamansanay, dungon, guijo, malugay, palo-maria, and yacal can be supplied; two of these, guijo and yacal, can be obtained in very large quantities while the others occur in quantities sufficient to make tool handles, if not by millions, at least by thousands. Most of these, as well as many others equally hard or harder but not so tough, would supply turned and shaped handles such as grips and butt plates for braces and drills, plane and saw handles, plane bodies, scratch gages, scraper and drawknife handles, and hollow-tool handles.

For long agricultural tool handles, in which hardness is less essential than toughness and difficulty of splitting, guijo, the hardest grades of lumbayao, malugay, mangachapuy, and yacal would make excellent substitutes for ash. The same species, with the exception of lumbayao, would make good ax handles.

For wagon tongues and other vehicle stocks, hubs, spokes, and felloes, an excellent material is found in guijo; it is not very heavy, but tough, difficult to split, and can be obtained in any size and quantity desired. Malugay, which is a little lighter, but equally tough, is not as abundant as guijo, but can still be supplied in fair quantities.

The cigar-box lumber *par excellence* of the world has for many years been the "Spanish cedar" of tropical America; in calantas is found a perfect substitute, so nearly identical in color, texture, and odor as to be almost indistinguishable. It is the only native wood used in Manila for high-grade cigar boxes. For cheaper boxes several of the lauans and nato are used.

Shuttles and spindles must be hard, rather tough, and resistant to abrasion. For these purposes a considerable supply of the sapwood of the trees of the camagon (persimmon) tribe could be furnished. Calamansanay and malabayabas are also recommended for trial in shuttles.

4. *Heavy construction timbers.*—A number of large trees furnish hard, strong, and very durable construction timbers. It is scarcely probable that the United States market will seek any considerable quantities of such material, except for very special pieces of work; but three species at least are to be mentioned as furnishing a supply of magnificent posts or beams for all kinds of heavy wooden structures, namely, ipil, pagatpat, and yacal. Allied to heavy construction is the use of timber for railway ties, durability and strength being the two qualities required. For this last purpose not only the three species above named are available, but at least twenty others are found, which, although they are not large enough or are not found in sufficient number to yield a great supply of large timbers, still can furnish ties for steam or electric railways. This statement refers, of course, to ties used without any preservative treatment. For treated ties, both the number of kinds and the supply available are much greater; practically all the lauans are very abundant and of great size and are probably susceptible to impregnation. They are about as strong as the medium-grade conifers, being less hard and heavy than Georgia pine, but somewhat stronger than the softest conifers. Besides the lauans, there are two harder woods available in great quantities, namely, guijo and apitong. These two properly treated would make very superior ties.

Following are brief descriptions and notes on some of the most important timbers of the Islands.

DIPTEROCARP FAMILY.

White lauan (Pentacme contorta).—This is perhaps the most abundant and certainly the most widely distributed species of its family in the Archipelago. The wood is whitish with light-gray, yellowish, or very pale-brown tints. It is light, rather soft, with a fairly straight but slightly crossed grain, producing a narrow "ribbon" when quarter-sawn. It is used in the Philippines mostly for the cheapest kind of work, but would serve for furniture and interior finish of a fair grade, especially as it takes stain very readily and, though light and soft, is fairly tough and does not split easily.

Very near it in appearance and mechanical properties, and often sold mixed with it, is—

Kalunti (Shorea sp.).—This is even lighter in color than white lauan and possibly a little softer and lighter in weight. It has not heretofore come into the Manila market in any great quantities nor under its own name; it is found, as far as known, only in Mindanao and some of the adjacent smaller islands.

Mangasinoro (Shorea sp.).—This is very similar to the above two species, but of a more decidedly yellowish tint. It is less abundant than either white lauan or kalunti.

Mayapis (Shorea squamata).—This is a very pale red lauan of straight-grained, smooth, glossy texture. It would make a very pretty veneer where a light red color is desired, but could also very readily be stained. It is less abundant than the following two.

Tiaong (Shorea teysmanniana).—This is intermediate in color and texture between mayapis and red lauan, being of a very uniform, light, glossy red. It is abundant in south-central Luzon, but very little, if any, comes to the Manila market, as no large operators have located in this region up to the present time.

Red Lauan (Shorea negrosensis).—This, as its scientific name indicates, is most abundant in the island of Negros. It is one of the largest trees in the islands, reaching sometimes a diameter of 7 feet or over. Quarter-sawn, the wood has a beautiful ribbon grain which, with its red to dark reddish-brown color, has led to its being exported under the trade name of "Philippine mahogany," though it is not at all related to the mahogany family. Though the Philippine Bureau of Forestry has actively discouraged the use of this name, it had already become rather common in the States, so that any mention in trade journals of "Philippine mahogany" may be assumed in nine cases out of ten to refer to red lauan or tanguile. Red lauan has been used in the last few years in great quantities for interior finish and a good grade of furniture, together with a considerable amount of the next species.

Tanguile (Shorea polysperma).—This is the best of the group so far as concerns grain, figure, and hardness, though it has not the rich red color of red lauan. It varies considerably in different regions as to color and hardness. In Negros, where there is a deep, rich soil and excellent moisture conditions, it has a very rapid growth and is difficult to distinguish from red lauan, especially the red lauan from young or middle-aged trees, which is bright, clear red. In other regions, where it grows more slowly, the wood is denser and heavier and rather of a pinkish brown color. One or two firms who cut tanguile in such regions sell it strictly under its own name, but generally speaking, tanguile and red lauan are mixed and sold indifferently under either name.

Apitong (Dipterocarpus grandiflorus and several other species of the same genus).—The woods of this group are considerably harder and much heavier than those of the lauan group. Apitong ranges from pale grayish red to dark chocolate in color. It is rather close and straight grained, but when strictly quarter-sawn has often a very pretty wavy grain forming diagonal

*Bureau of Printing, Manila.

stripes across the board. Though it is somewhat resinous, the resin does not break out through varnish if the lumber is thoroughly dried before finishing. It is used in the islands to a very considerable extent for flooring and other interior work, as well as for a great variety of medium-grade furniture. Especially the darker grades of apitong (although, for that matter, like the lauans, it can be stained) would make a very handsome and substantial appearance.

Guijo (Shorea guiso).—This wood, though of the same genus as the lauans, is in quality much more like apitong. It is hard, heavy, fine grained, but tougher and much less resinous than the latter. In color it ranges from light ashy red to dull reddish brown. Though the greatest bulk is used in the islands for general construction, ship and boat building, and vehicle parts, it is also much used for flooring, interior finish, and furniture. It is not very difficult to work and, on account of its dense texture, takes a fine finish.

Mangachapuy (Hopea acuminata and several other species of the same genus).—Mangachapuy ranges from soft to rather hard, but all grades are of about the same color, a very pale yellowish white which, on exposure, rapidly turns to dark yellow or even yellowish brown. Sometimes the fresh timber shows bright green streaks which in time turn to dark greenish brown. It is of a very homogeneous and straight-grained texture. It is a favorite in the islands for oars, spars, ship decking and planking, moldings, and similar purposes where a clear, straight-grained wood is required. The golden-brown tint it acquires on exposure makes a very pleasing effect in combination with woods of contrasting color. It is unfortunately one of the least abundant of its family.

It is difficult to draw an exact line of demarkation between the mangachapuys and the woods known to the trade as—

Yacal (Shorea balangeran, and perhaps other species; Hopea plagata, H. mindanensis, Hopea ovalifolia, and other species).—These are, with the exception of narig, the hardest and heaviest woods of the family. Although belonging to a number of different species of two distinct genera, they differ so little in quality that for practical purposes they may be described as one. Yacal is very hard, very heavy, tough, dense, of fairly fine texture, somewhat cross-grained, rather hard to work, and of a dull yellow color changing in time to very dark brown. It is little used for furniture in the islands, the chief objections being probably that it is slow to season, liable to warp if not carefully and thoroughly seasoned, and finally that it is much harder to work than guijo and mangachapuy and has not the brillant color which is one of the chief attractions in a cabinet wood. When well finished, however, it is very handsome and in strength and durability equal to or superior to the best of the oaks and hickories.

Narig (Vatica mangachapoi, and other species of the same genus).—This is the heaviest, densest, and finest grained wood of the family, in color and texture so much like the yacals that it is generally sold with them. It differs notably from yacal in only one respect, namely, that it is almost perfectly straight grained, therefore showing no ribbon at all when quarter-sawn and being consequently considerably easier to finish.

LEGUME OR NARRA FAMILY.

Next in importance to the dipterocarps are the members of the narra, or, as it is known in North America, the locust family. This furnishes a number of brilliantly colored, hard, and durable cabinet woods, which are among the best and most widely known in the islands. Only the best known and most abundant species will be described here. The use of the word "abundant" here is relative only; none of the following are as common as even the least abundant of the dipterocarps.

Acle (Albizzia acle).—Of all Philippine woods, this is almost the only one that in color and mechanical properties closely resembles black walnut; by a curious coincidence, it is also the only one that has a pungent, peppery odor, the shavings and dust (especially when worked with machinery) causing violent sneezing. It is often curly, wavy, and cross-grained, producing a conspicuous, florid figure, especially on the flat or bastard grain. It is practically never attacked by insects. Acle is one of the finest cabinet woods in the islands and would make beautiful veneers, either rotary, flat sawn, or rift sawn.

Banuyo (Wallaceodendron calebicum).—Banuyo is very similar in figure to acle, but it is considerably softer and is of a pale golden brown to dark coffee color, sometimes with a decided reddish tint. It is easy to work and of a smooth, glossy texture. Banuyo bends transversely with ease and therefore is a favorite for curved carriage panels; it is also much used for carved articles, such as ornamented picture frames, as well as for furniture and for interior finish in houses and ship cabins.

Batete (Kingiodendron alternifolium).—This is somewhat harder and darker than banuyo, often with alternating belts of light and dark brown. Compared to other woods of its family, it is but little used, although it is widely distributed and of large size. This is probably due to the fact that it is liable to warp if not piled carefully while seasoning and also to the dark oil that exudes from all sections, staining the surface almost black. This oil, however, does not break through good varnish and under such a finish the wood retains its handsome reddish brown color.

Ipil (Intsia bijuga and I. acuminata).—This wood was little used for furniture by the Filipinos and Spaniards. It is rather difficult to work, very heavy, and changes on exposure from its natural yellow color to a very dark, dull brown. It is, however, an excellent wood, being very durable and extremely stiff and strong, under a good finish assumes and retains a very handsome and rich dark golden brown color. Ipil is one of the woods exported to Europe from the Malayan region and is sometimes known as iron-wood.

Narra (Pterocarpus indicus, P. echinatus, and P. blancoi).—The wood of these three species (which are indistinguishable) is by far the most widely known cabinet wood in the islands. It occurs in practically all the forested islands, is easy to recognize both in the forest and in the lumber yard, is easy to work and insect proof, has a pleasant odor, a beautiful grain, and brilliant coloring, ranging from very pale yellow through all shades of salmon and red to deep blood red. Besides all this, it shrinks but little and warps hardly at all. It is used literally for all kinds of interior finish and furniture. Also, as mentioned above, one-piece round tables are oftener made of it than of any other wood.

The first species of the three named above is identical with the padauk of India.

Supa (Sindora supa).—This is a hard, heavy, fine, and very dense wood; yellow when fresh cut, turning on exposure to a rich, glossy, golden brown. Slash-sawn, it has a large, florid figure, like most of the woods of the family; and quarter-sawn, a broad, wavy, irregular (sometimes diagonal) "ribbon." It is a favorite for flooring on account of its hardness and smooth texture. It makes most beautiful paneling and furniture. A paneled room and dining set of supa was shown in the Philippines exhibit at the Panama-Pacific Exposition.

Tindalo (Pahuda rhomboidea).—Tindalo irresistibly suggests the adjective "gorgeous." Pale orange when fresh cut, it turns rapidly to a deep, glowing orange red which becomes ever richer with age. This, with the very broad, florid figure it shows when slash-sawn, makes it altogether one of the most conspicuous things in any collection of different woods. In addition to its hardness and brilliant coloring, it has the virtue of shrinking very little and of warping hardly at all. If it is less used for furniture and interior finish than is narra, this is probably due only to its being less widely distributed and somewhat scarcer.

No tree family besides the dipterocarps and legumes furnishes anything like the bulk of timber that these do. The following belong to almost as many families as there are species mentioned:

Bancal (Sarcocephalus orientalis).—Not a very important wood, but worthy of mention on account of its unusual color, a bright sulphur yellow, sometimes with greenish or brownish streaks. It is soft, of very homogeneous texture, very easy to work, and durable. It is used for inside finish, carved work, medium-grade furniture, household utensils, etc.

Benguet pine (Pinus insularis) and *Tapulao* (P. merkusii).—These two pines are found only in three strictly limited regions, and the timber has never been brought to the Manila market. The heartwood is very resinous and heavy, resembling closely that of the yellow pines of America. In the Mountain Province, where through a certain region almost no other large trees are found, Benguet pine is used for all purposes.

Ebony (Maba buxifolia).—Ebony is widely distributed in the Philippines, but the trees are scattered and small. The writer has seen no log (and heard of only one) having more than 8 or 9 inches of heartwood. The heartwood is jet black and sharply marked off from the white or grayish sapwood. Ebony is used for fancy cabinetwork, carved jewel boxes, inlaying, canes, sword hilts, scabbards, shuttles, etc. It is, bulk for bulk, the highest-priced wood in the Philippines, selected perfectly clear pieces bringing prices equivalent to about $300 per 1,000 feet board measure.

Camagon (Diospyros discolor, and other species of the same genus, belonging to the same family as ebony and as the American persimmon, Diospyros virginiana).—The sapwood is large and generally pinkish or pale red. The heartwood is generally black with streaks, and mottlings of ashy or brownish red. It is almost as hard and heavy as ebony, and is put to the same uses. It makes very beautiful veneers.

Calantas (Toona calantas, and other species).—This is closely related to, and to all practical intents identical with, the Spanish cedar (Cedrela odorata) of tropical America. It is the only native wood used in Manila for high-grade cigar boxes. It is also valuable for wardrobes, bookcases, clothes chests, etc., as its strong odor keeps out moths and weevils.

Lumbayao (Tarrietia javanica).—This wood is very similar to red lauan in general appearance. It varies from very pale red to dark reddish brown in color and is somewhat harder and heavier and much tougher than red lauan. It is an excellent and beautiful wood for veneers and for interior finish and furniture.

Malugay (Pometia pinnata, and probably other species of the same genus).—This wood has never been brought to the Manila market in great quantities, but it is relatively abundant in some regions and will probably play a greater role in the future than the present. It is the toughest known among the moderately hard and heavy woods and will no doubt make very good material for baseball bats, wagon tongues and other vehicle stock, ax and other handles, etc. It is pinkish to dull red in color and of rather fine texture. It has been used for flooring and interior finish, boats and launches (ribs, planking, and cabin work), and furniture.

Mancono (Xanthostemon verdugonianus).—This is the "ironwood" *par excellence* of the Philippines. It is one of the hardest and heaviest woods of the world, being a trifle heavier than average lignum vitæ and a little harder. For posts and piles it is almost indestructible, even the voracious teredo digging only a little way into the thin sapwood in the course of twenty or thirty years. It has been used with excellent results for stern bushings in steam launches and bowling balls. It can be polished almost like a metal and makes very beautiful dumb-bells, canes, desk novelties, etc.

Molave (Vitex parviflora, and other species).—This is the best known of the hard, heavy, and durable woods of the Philippines. Throughout the islands its name is a synonym for strength and stability. Molave is hard to very hard; heavy, of very fine texture, and ranges from pale straw color to light brown; it is rarely or never attacked by insects unless it has been previously softened by decay. It has only one defect—its lack of toughness, which unfits it for long beams. It is put to almost every conceivable use in construction (with the exception just mentioned) as well as for agricultural, industrial, and household implements and for high-grade furniture.

Molave works easily with all kinds of tools. It would make a fine veneer where a fine-grained, light-colored wood is desired.

Pagatpat (Sonneratia pagatpat).—This is perhaps botanically identical with the prapat (Sonneratia alba) of the Malayan region. At any rate, the wood of the two species is the same. It is pale to dark chocolate brown, under varnish becoming nearly black. It is hard, heavy, and of very even texture and straight grain, and easy to work. It has only one defect, namely, that it contains a considerable amount of common salt, causing small iron nails or screws to rust out rapidly. It is used for all kinds of general construction, shipbuilding, flooring, interior finish, and furniture; also for piles, poles, railway ties, and paving blocks. It would make a beautiful veneer of an even, dark walnut color.

Palo Maria (Calophyllum inophyllum).—This is a very beautiful wood, being of a pale red to reddish brown. It is of very fine texture, with crossed, curly grain, marked with frequently recurring, characteristic, fine zigzag lines formed by cutting though the numerous, wavy, concentric belts of soft tissue which constitute one of the typical features in the cross section. It is a hard wood and difficult to work, but would make a most beautiful veneer.

NOTE.—Additional and detailed information about the above and a great number of other Philippine woods is found in the following publications:

1. Philippine Woods, F. W. Foxworthy, *Philippine Journal of Science*, 2 (1907), Botany, pp. 351-404.

2. Indo-Malayan Woods. same author, *Philippine Journal of Science*, 4 (1909) pp. 409-592.

3. Mechanical Tests of Thirty-four Philippine Woods by Rolland Gardner, Bulletin 4, Bureau of Forestry, 1907. (Abstract reprinted as insert for *Bulletin* 11).

4. The Forests of the Philippines by H. N. Whitford, Bulletin 10, Bureau of Forestry, 1911. (Two volumes, profusely illustrated, $1.25 postpaid.)

5. The Uses of Philippine Woods, Bulletin 11, Bureau of Forestry, 1911. (Pamphlet, 50 pp., with above-mentioned insert, 20 pp., $0.30 postpaid.)

Samples of all of the commercial woods of the Philippines can be obtained by addressing the Director of Forestry, Manila, or at the Bureau exhibit at the Panama-Pacific Exposition. Each sample is ⅜ by 4 by 6 inches, and bears a label with the scientific and common name of the wood. With the exception of 21 species which sell at 20 cents, the price per sample is 10 cents U. S. currency, postage prepaid.

The Importance of the Care of the Teeth

THE dentist is coming into his own, so to speak, for never before has the necessity for having good, clean, sound teeth been so impressed upon the minds of the medical profession and the public at large as it has been recently. Oral sepsis is now held to be responsible, both directly and indirectly, for many conditions of ill health and disease, and it is at last being recognized on all sides that the state of the teeth and mouth is a fair index of the general health.

A remarkable object lesson in this direction has been provided by the war in Europe. The exigencies of a soldier's life and especially the conditions of such a campaign as is going on at the present time render it incumbent that solders should be possessed of teeth that not only will allow them to thoroughly masticate the food that is put before them, but that are kept as free from decay and infection as possible. In fact, a soldier whose teeth are defective has been shown to be, in the majority of instances, unfit to serve in the army. Thus, as one important lesson of the war, has come in Great Britain and France a somewhat tardy recognition that a skilled dental service is one of the paramount needs in maintaining the efficiency of an army. Experience has shown that the dentist is needed not only to repair the defects of the soldier's teeth so that he may be able to eat well and consequently to fight well, but also in cases of jaw injuries, where proper construction together with satisfactory plastic results are impossible without the aid of skilled dental technque. At a meeting of the Eastern Medical Society held at the Breevort House, New York, on February 11, 1916, Dr. W. Seaman Bainbridge in an address dealing with some of the happenings at the front witnessed by himself, showed on the screen some really wonderful examples of jaw reconstruction and plastic surgery performed at the American Hospital in Paris by American surgeons and dentists. Indeed, in this present war, in which head injuries so largely predominate—on the French front at least—it has become apparent that the aid of the dentist is required quite as often as that of the medical man.

The French medical military authorities have accordingly become so greatly impressed with the value, or rather with the necessity, of the dentist in war that a dental service has been made a definitely organized department in the French army. One thousand qualified dentists will be gazetted adjutants, five hundred to serve at the front and five hundred to remain in the depots, there to be associated and work in conjunction with the army surgeons. With each group of stretcher bearers there will be provided a mobile dental staff, the members of which will attend to the men's teeth in their cantonments. Dental clinics, moreover, are to be attached to each hospital center, and a sufficiency of mechanical institutes provided up and down the country to meet all needs for artificial teeth and appliances.

American dentists have always ranked high in European centers, and it is gratifying to note that the American Hospital in Paris at the Lycée Pasteur has been a pioneer in giving proper attention to dental requirements.

A further recent decree in France authorizes the Ministry of Marine to recruit a staff of dental surgeons to be attached to the Naval Medical Service during the war.

The British military authorities, tardy as usual in adopting innovations, have been slow in organizing a dental service for their army and navy, but public opinion day by day in Great Britain is becoming more and more alive to the necessity for the proper dental treatment of the troops. Sooner or later the storm will break and then we may expect to see an efficient service instituted. As the *Lancet* says in a leading article published February 12, 1916, "The modern medical man realizes that the properly trained dental surgeon's opinion it worthy of respect—and that it is impossible without special knowledge to deal rationally with the problems which must arise in connection with dentistry." Everything points then to the view that a dental service is an indispensable adjunct of an army, especially of an army in the field, and without such service it is certain that the efficiency of a fighting force cannot be maintained at its highest point.

It is gratifying to note that the United States officials are alive to the importance of dental care, for an essential detail of the punitive expedition into Mexico was a fully equipped dental outfit under the charge of U. S. Army dental surgeons. The benefits are sure to be soon manifested, for the conditions, climatic and otherwise, our boys are bound to encounter, will tend to aggravate the slightest trouble with the teeth, and add greatly to their suffering and discomfort. Prompt and effective dental treatment will eliminate all this so far as the teeth are concerned, and to the extent that the troops are thus kept more healthy and enduring, the dentists with the expedition may play a more prominent part than will be generally realized in the ultimate capture of Villa.—*American Medicine.*

Photographic Enlargements

THE *Revue genérale des Sciences purés et appliquées* recently made complaint against the unsatisfactory character of photographic enlargements. It is an error, says the writer, to attribute the lack of clearness so frequently found in gelatine enlargements to undue coarseness of grain in the gelatine; for with proper apparatus enlargements of 150 diameters can easily be secured without trace of granulation, while the enlargement most in demand is only of 4 or 5 diameters. True enough, when the emulsion is prepared at a low temperature it is absolutely uniform and transparent, but of low sensitivity; and when the sensitivity is increased by application of more heat, the bromide exhibits a tendency to gather in microscopic grains. But this is merely an accident; there is no fundamental or necessary relation between sensitivity and degree of granulation; and by processes more or less secret various manufacturers produce a rapid emulsion of relatively fine grain. It is not the grain of the emulsion that is at fault; the enlargement will possess all the fineness and precision of the original if first-class materials and good workmanship are employed. That being the case, the first concern of the skillful photographer should be the original itself. Any defects which it may possess must be found again in the enlargement. And most of the trouble of the enlarging may be attributed to unsatisfactory originals.

The prime necessity for a brilliant photograph is a perfectly constructed lens. Spherical abberration and astigmatism thicken the lines, and chromatic aberration plays its part, especially with the use of orthochromatic plates. And when a diaphragm is employed to correct these faults, the image is blurred by diffraction. In the older lenses the influence of diffraction is very negligible, for the far more serious effects of aberration have not been remedied. With a good anastigmat, however, other irregularities are corrected, and we must then consider the matter of diffraction.

It is a source of constant amazement to many photographers that the best anastigmats give the clearest image with the maximum aperture. This is especially the case in making photographs for enlargement. The inconvenience of the large aperture is that it makes proper focusing difficult or impossible. This fault, although not eliminated altogether, is reduced by the use of a diaphragm.

Then, too, it must be remembered that the image is at its best in a single plane only, and that the slightest displacement of the sensitive surface from this plane, forward or backward or by horizontal or vertical tilting, makes for loss of clearness. And again, if the lens is not absolutely perpendicular to the axis of incidence of the light, it is futile to hope for the best results from the finest lens in the world, so that the general principle may be laid down, that in making a photograph for enlargement the maximum aperture should be used, calling, of course, for a minimum exposure. So that to secure satisfactory enlargement, a close approach to mechanical perfection is demanded, of both operator and instrument, in making the original.

Likewise, the processes of development influence the clearness of the photograph. A solution too concentrated will bring out a pronounced grain, whereas a dilute bath used with moderate rocking produces an image of extreme fineness. When circumstances are such as to permit a rather long exposure, it is easy to obtain a remarkably fine negative with the following solution:

Water	1,000 cc.
Paraphenylenediamine	10 gr.
Anhydrous sulphite of soda	60 gr.

Development by this fluid is very slow; a half hour is frequently required in order to attain the desired intensity of tone. Applied to a plate which has not been over-exposed, this solution produces a dim, veiled effect; so that it enjoys a limited field of applicability.

With ordinary developing fluids, the grain at times becomes visible. This can frequently be prevented. Many photographers confuse the grain of the emulsion with that which appears on the plate when the bath is too warm. The latter is easily avoided; if only hot water is available, it should be boiled, a little carbonate of soda added, and the precipitate allowed to form before using. Or the grained appearance will disappear in a 2 or 3 per cent solution of hydrochloric acid. As for the grain, properly so called, of the emulsion, it is not so noticeable as that due to excessive heat. It can be remedied, and the image made extraordinarily clear, by immersing the plate for some minutes in a 6 or 8 per cent solution of chrome alum, which hardens and contracts the gelatine fiber. This produces a sort of settling of the grains of silver, by which the sensitive film is made more homogeneous and compact.

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