somewhat pretentious work brought out by an English publisher, we feel bound to state that it is full of grave defects. This is due probably to the incompetence of the editor, or the total absence of any such necessary functionary; for the original was written in Italian, and we cannot believe that the author himself corrected or supervised the proofs. In the first place a considerable number of the illustrations seem to be thrown in at random, and are not referred to at all in the text. Such are the portraits at pp. 59, 140, and 151 in vol. i. Ornaments and implements from the Fly River are figured in the first instead of in the second volume. A cut of thirty-four separate articles (at vol. i. p. 416), though all numbered, has no reference to the numbers; while at vol. ii. p. 136, four elaborate spears or ornamental staves are

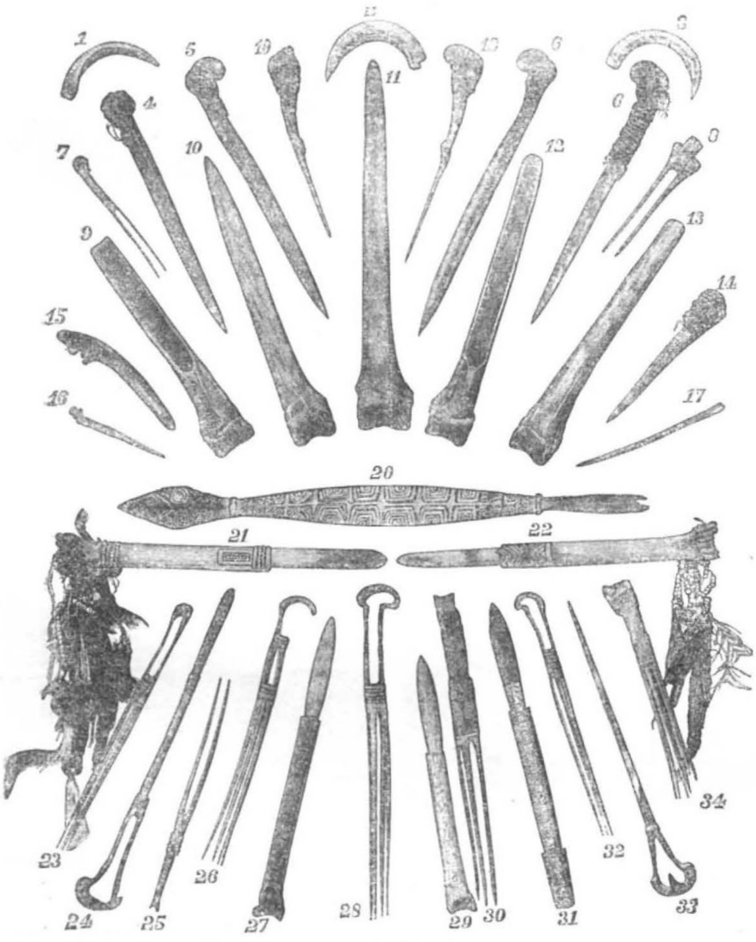

FIG. 7.—Implements and Weapons. From the Fly River (upper set) and Hull Sound (lower set).

described as "Baratus," which are said in the text to be "pieces of armour for war," and to be "worked in very hard stone"!

The misprints and misspellings are excessively numerous. At p. 4 we read of "temples excavated in the deserted roads" in Java. At p. 49 the traveller goes to the "source of the river" instead of to its mouth; and at p. 222 we have "stone nails" instead, probably, of stone clubs. The names of places and of plants and animals are rarely spelt correctly, and are often spelt differently in adjacent pages. The Italian mode of spelling scientific names has not been altered, and they are often almost unintelligible to an English reader, as *Oloturia* for *Holothuria*, *Stafilinus* for *Staphylinus*, and *Cicas* for *Cycas*. Orankaya (a village chief) is sometimes spelt Orankay and sometimes Oranhay. Waigiou is spelt Waigen, and immediately afterwards Waigeu. Battanta is spelt Battauta, and Daudai is spelt Dandai. At the end of the book four vocabularies of native languages are given, but as if to make these of as little use as possible, they consist of four different sets of words, all differently arranged, and none in alphabetical order; so that any comparison with each other or with vocabularies given elsewhere is practically impossible without the preliminary labour of rearranging them. Add to this that there is no index to the book and that the only map given is a poor and imperfect one, and it will be seen that the merits of Signor D'Albertis' work have not been enhanced by the manner in which it is presented to the reader.

The illustrations on the whole are good, the coloured plate of birds of paradise being excellent. But far too many skulls are figured, since these are of no possible interest to the general reader, while, as we have no guarantee for their accuracy, or that they are all figured on exactly the same scale, they will have little value for the man of science.

From the notices scattered through these volumes Signor D'Albertis appears to have made very large collections in natural history, especially of birds, reptiles, and insects. It is to be hoped that complete series of these have been kept together, and that, in conjunction with those collected by Dr. Beccari, they will be made the subject of some important works. The birds are being carefully elaborated by Prof. Salvadori; but the reptiles and the insects would probably throw even more light on the zoological relations and past history of this wonderful island.

ALFRED R. WALLACE

PHYSIOLOGY OF PLANTS

THE two papers[1] which we notice together under the above heading, though relating to different questions in the physiology of plants, have nevertheless something in common. Both of them bear on the relationship between the external and internal conditions of life, between external forces, such as light and gravitation, and the constitution of the organism on which these forces act. And both tend to show the importance of recognising in plants those specific forms of sensitiveness which may be said to determine the results which will follow external changes.

I. The behaviour of leaves in relation to light may be illustrated by the cotyledons of a seedling radish; if it is illuminated from above, the cotyledons are extended horizontally, and are thus at right angles to the direction of incident light. If the seedling is then placed at a window, so that it is lighted obliquely from above, and if the stem (hypocotyl) is prevented from bending, the cotyledons will accommodate themselves to the changed conditions by movements in a vertical plane. The cotyledon which points towards the light will sink, while the other will rise, and thus both will become once more at right angles to the incident light.

Two theories have been proposed to account for this

[1] I. "The Power possessed by Leaves of placing themselves at right angles to the direction of Incident Light." II. "The Theory of the Growth of Cuttings, illustrated by Observations on the Bramble, *Rubus fruticosus*." Read by Francis Darwin before the Linnean Society, December 16, 1880.

property of leaves: the first is that of Frank ("Die natürliche wagerechte Richtung von Pflanzentheilen," 1870), who ascribes to leaves and to some other organs a specific sensitiveness to light called "transversal-heliotropismus" or diaheliotropism ("Power of Movement in Plants," p. 438). Just as an ordinary heliotropic organ has an inherent tendency to become parallel to incident light, so a diaheliotropic organ has an inherent tendency to place itself at right angles to the direction of the light. The two classes of organs differ from each other exactly as some creeping rhizomes differ from ordinary stems; the rhizome tends to extend itself horizontally under ground, while the stem above the surface grows vertically upwards (see Elfving, in Sachs' "Arbeiten," 1879).

A different theory has been proposed by de Vries (Sachs' "Arbeiten," i. 1872), whose views are supported by Sachs ("Arbeiten," ii. 1879) with additions or modifications. According to these views it is not necessary to assume the existence of any special kind of heliotropism, since the phenomena might result from the ordinary forms of heliotropism and geotropism acting in concert. Thus in the case of the seedling radish illuminated from above, if the cotyledons were apheliotropic (negatively heliotropic) and apogeotropic (negatively geotropic) it is possible that they might be kept in equilibrium by these opposing tendencies. The tendency to move away from a vertical light will make the cotyledons curving downwards towards the earth, and the apogeotropism or tendency to move away from the centre of the earth may exactly balance the downward tendency, so that the cotyledons remain horizontal.

Besides the various geotropic and heliotropic tendencies there are other modes of growth which may enter into the combination. In some cases there is a natural preponderance of longitudinal tension or growth along the upper surfaces of the petiole, so that owing to impulses arising within the plant there is a tendency for the leaf to curve downwards, or more accurately in the direction in which the morphologically lower side of the petiole is directed; this tendency is called longitudinal epinasty, or simply epinasty; the opposite tendency is called hyponasty. According to the theories of de Vries and Sachs epinasty may be opposed by heliotropism, or by apogeotropism, while hyponasty will of course be opposed by apheliotropism and geotroprism, and all these opposing forces may combine in producing an equilibrium. The object of the present paper is to test the relative values of the two above described theories: that of Frank, and that of de Vries and Sachs.

The method employed was to fix the plants under observation to a horizontal spindle, which was kept in slow rotation by clockwork. This instrument (called the klinostat) has been employed by Sachs for the study of ordinary heliotropism; light is admitted parallel to the axis of rotation, and the plants are thus subjected to a constant lateral illumination, while they are freed from the disturbing influence of gravitation, for, owing to their being kept in constant slow rotation, there is no reason why they should bend apogeotropically in one direction more than another (see Sachs in his "Arbeiten," Bd. ii. 1879). On the same principle the behaviour of leaves which place themselves at right angles to the incident light has been studied. If a plant with horizontally-extended leaves, which has been illuminated from above, is fixed on a slowly-revolving, horizontal spindle, so that the axis of the plant is parallel both to the axis of rotation and to the direction of incident light, we shall have a means of testing the opposing theories above mentioned.

The plant's leaves will still be illuminated by light striking them at right angles; therefore if Frank's theory is the right one they ought to remain in this position. But if de Vries and Sachs are correct in their views, the leaves ought *not* to be able to remain at right angles to the incident-light, since apogeotropism has disappeared, which was one of the tendencies necessary to keep the leaves in a position of equilibrium.

A considerable number of experiments were made with the celandine, *Ranunculus ficaria*, the results of which are decidedly in favour of Frank's views. The leaves of the celandine are sometimes extremely epinastic, so that they press against the ground, and when a plant is dug up it often happens that, the leaves being released from the resistance of the soil, curve nearly vertically downwards. If such a plant is fixed on the klinostat in the position above described, the leaves will be pointing away from the light, so that if the leaves were apheliotropic, as might be expected according to de Vries' theory, the leaves would remain pointing away from the window. But this is not the case, they move forwards until they are approximately at right angles to the light, and then come to rest. Again, if a celandine is placed in the dark its leaves rise up so as to be highly inclined above the horizon, if the plant is then placed on the klinostat the leaves (which now of course point towards the light) again accommodate themselves by curving backwards until they are at right angles to the light. Thus the leaves cannot be called heliotropic or apheliotropic; we are forced to believe that under the stimulus of light they are able to move in either direction, which may be necessary to bring them into the plane at right angles to the light. The other experiments with *R. ficaria*, the details of which we omit, lead to the same general result.

Besides a few observations on Vicia, Cucurbita, and Plantago, a series of experiments were made on seedling-cherries, and these lead to a somewhat different result. A cherry-plant illuminated from above has its leaves approximately horizontal, and when placed on the klinostat, as above described, the leaves are unable to remain at right angles to the light, but curve backwards so as to become parallel to the stem of the plant. This movement can be shown to be due to epinasty, not to apheliotropism, and is the result of the loss of balance which follows when apogeotropism is removed. It is clear therefore that the horizontal position of the leaves of seedling-cherries growing normally must largely depend on the balance struck between epinasty and apogeotropism, in accordance with the views of de Vries and Sachs. But since these forces obviously cannot produce the power which the cherry possesses, of altering the position of its leaves in accordance with the direction of the light, we must assume that some kind of heliotropism enters into the combination. The view to which the present research lends most probability is that dia-heliotropism (transverse-heliotropism) is the really important influence at work. In the case of the celandine we have seen that the sensitiveness to light is strong enough to determine the position of the leaves—although the natural balance is disturbed by the annihilation of apogeotropism. It seems probable that an essentially similar state of things holds good in the case of the cherry. When the plant is growing normally it trusts to epinasty and apogeotropism to produce an approximate balance, the final result being determined by the stimulus of light. But when the balance is disturbed by placing the plant on the klinostat, the light-stimulus is not strong enough to produce a condition of equilibrium.

This view is the same as that given in "The Power of Movements in Plants," and is in accordance with the principle there given: that the chief movements in plants are due to modifications of the circumnutating motion.

II. When a cutting, for instance a piece of a willow-branch, is placed in circumstances favourable for growth, it produces roots at its lower end, while the buds at its upper end grow out into branches. The experiments of Vöchting ("Organbildung im Pflanzenreich," Bonn, 1878) on the growth of cuttings were made by suspending pieces of stems, branches, &c., in large, darkened jars, the air in which was kept constantly moist by a lining of wet filter paper. The cuttings were suspended both in the normal position—that is with the upper end upwards —and also upside down. Vöchting found as a general result that there is a strong tendency for the roots to appear at the *basal* end,[1] and the branches to be developed at the *apical* end, whether the cutting had been hung apex upwards or downwards in the glass jar.

Vöchting believes that the growth of roots at the base and of branches at the apex of a cutting are determined chiefly by an innate, inherited, growth-tendency. When the knife divides a branch into two cuttings it separates a mass of identically-constituted cells into two sets, one which form part of the apex of the lower cutting, and another set which form part of the base of the upper cutting. And under appropriate circumstances one of these sets of cells might develop into roots, the other into adventitious buds. Vöcht holds that it is the morphological positions of these sets of cells (the fact of one being at the base and the other at the apex of a cutting) which chiefly determines the course of their subsequent development. The idea may be expressed somewhat familiarly by saying that each cutting into which a branch is divided is able to distinguish its base from its apex, and can tell where to produce roots and buds, by means of an internal impulse or morphological force which is independent[2] of the external forces, gravitation and light.

The theory which Sachs has brought forward in his paper on "Stoff und Form der Pflanzenorgane" ("Arbeiten des bot. Inst. Würzburg," 1880, p. 452) is entirely opposed to that of Vöchting. Sachs conceives that Vöchting's morphological force is not an innate hereditary impulse, but a tendency produced by the action of external forces during the growth of the formative cells. Thus Sachs believes that the force of gravity acting on the developing cells of an organ produces in it a "predisposition" or enduring impulse which manifests itself in the results which Vöchting ascribes to a hereditary force. The mode in which Sachs believes gravitation to act is interesting, not only in itself but also as a modification of a theory of Du Hamel's. It is assumed that difference of material is a necessary concomitant of difference of form, and that accordingly the materials from which roots are formed are chemically (used in a qualified sense) different from those which supply the branches. Sachs' theory supposes that the growth of roots or buds at a given place will be determined by the distribution of the root- and branch-forming materials, and that the distribution of these materials is regulated by the force of gravity. The root-material is in a certain sense geotropic and flows downwards, the branch-material having the opposite tendency. But they are not supposed to be *simply* geotropic, the tendency of the root-material to flow towards the base of a branch is continued after the branch has been made into a cutting and hung upside down, so that the root-material flows upwards towards the base of the cutting, because that end was originally downwards, and *vice versâ* with regard to the branch-forming matter.

The observations on the bramble, which form the subject of the present paper, were carried out with the object of deciding how far the natural growth of roots in the bramble agrees with Vöchting's or Sachs' theories on the growth of cuttings.

The long sterile shoots of the bramble are well known to possess the power of rooting at their ends. The terminal bud is thus protected during the winter, and the store of nutriment contained in the club-like thickened end of the branch forms a starting-point for new growth in the spring. It is commonly the long pendant branches growing vertically downwards which reach the ground and form roots. It might therefore be supposed that gravitation determines the growth of roots at the *lower* end of the branch, just as in a cutting made from an erect willow branch the roots grow at what was originally the lower end. But observations made on brambles under certain circumstances show that this is not the case. When brambles grow on a steep bank the majority of the branches grow down hill at once, or else straggle more or less horizontally along the bank and finally turn downwards. But a certain number of branches grow uphill, and some of these take root at the apex. When therefore we find on the same individual plant some branches forming roots at the physically lower, and others at the upper end, we may feel sure that the distribution of root growth in the bramble is not determined by gravitation. We mus believe that there is a morphologically directed impulse which tends to the production of roots at the apex of the branch, whether the direction of its growth has been upwards or downwards. It is true that in the observed cases the extreme end of the branches was bent so that from 1 to 9 inches was inclined at from 2° or 3° to 5° below the horizon, but it can hardly be imagined that this fact influences the growth of roots at the apex; and experiment shows that it is not necessary that even a single inch should be inclined below the horizon. A bramble branch was tied, apex upwards, to a vertical stick, and was surrounded by damp moss and covered with waterproof cloth; under these circumstances a plentiful crop of roots sprang from the terminal part of the branch. This result combined with the observations made with brambles growing on a steep bank seem to show that an internal impulse or morphological force regulates the growth of roots in the bramble.

When a cutting is made from a bramble the only development that takes place is the growth of the axillary buds at the apical end of the cutting. Under certain circumstances these side shoots take on a root-bearing function. They are stunted in growth, being, it may be, 10–12 mm. in length and 3 or 4 mm. or more in breadth; they assume a peculiar club-like form, being thicker at the apex than at the base, and are clothed with rudimentary scale-like leaves, from among which a number of relatively large roots spring forth.

In order to determine whether the production of this root-bearing type of root is determined by gravitation or by a "morphological force," cuttings were made from branches whose direction of growth was above the horizon. Such cuttings were hung apex upwards, and it was found that the most apical buds were capable of developing under these circumstances into the root-bearing type of branch. Similar rooting side-shoots are produced by cuttings made from branches which have grown beneath the horizon, it is therefore clear that gravitation is not the chief[1] determining force in this form of root production.

When the end of a branch is injured, which often occurs when a bramble grows along the ground near a pathway, the most apical bud or buds grow out into branches; these may be ordinary branches which ultimately take root. Under certain circumstances, the stunted club-shaped root-bearing side-shoots may be developed whose whole formation is devoted to the bearing of roots. It is therefore clear that the production of such rooting shoots in cuttings is the same process that occurs in branches injured in a state of nature; a process which enables the branch to perform the function, the normal performance of which had been interfered with. And this fact enables us to see in what way a

[1] The basal end is that end of a cutting nearest to the parent plant; the apical, is the opposite end.

[2] Vöchting states distinctly that gravitation and light do affect the positions in which organs are developed in cuttings, but he considers the internal impulse as the stronger determining cause.

[1] The experiments seem to show that gravitation has *some* influence on the growth of roots in the bramble.

morphological growth-impulse is better fitted for the requirements of the case than any possible dependence on gravitation as a guiding force. When the end of a branch is injured it is clear that if a side-shoot is to be developed to carry on the function of the injured apex, it will have the best chance of success if it starts from the position which the end of the original branch had already gained before it was injured. Therefore the bud which is nearest to the injured apex will be the most suitable one to be developed into a new branch. And thus it is advantageous to the plant that the place where the new development is to take place should be determined morphologically, not by gravitation.

Thus in the bramble the behaviour of cuttings is a repetition (cf. Vöchting, "Organbildung," p. 107) of the normal process of restoration of a deranged function in the plant; how far this is the case with other plants must remain at present undetermined.

NOTES

WE are very glad to hear that Bedford College is taking a leading part in giving to women the opportunity of studying thoroughly physical science. It has this session opened a physical laboratory, under the able direction of Dr. Lodge. A chemical laboratory was added to the College some years ago, and has proved of great service to the students, several of whom have passed the science examination of the University of London.

THE death is announced of M. Lécard, a promising French botanist, as the result of excessive fatigues during his late journey in Soudan. M. Lécard was formerly director of the Public Botanical Gardens at Saïgon, in Cochin-China, and at Richard Toll in the colony of Senegal. During the past year he was intrusted by the French Minister of Public Instruction with the important mission of studying the flora of the Upper Niger, a question now of no slight interest in view of the probable construction of the Trans-Saharan Railway. Various difficulties prevented his reaching the Niger. At Kouridiam, however, the most distant point reached in his journey, where he was forced to pass the rainy season, he made the valuable discovery of five varieties of annual vines, the fruits of which so closely resemble our ordinary grapes that he regarded them as fully able to replace the grape in the production of raisins and wine. M. Lécard hoped also to find in his new discovery the means of satisfactorily combating the phylloxera, and inspired with this desire, sought to make extensive collections of the seeds of the vines to bring back to France. M. Lécard, in a letter recently read by Dumas before the French Academy of Sciences, expressed the fear of having lost his health by the privations incident to this journey—a prevision unfortunately too completely realised.

THE death is reported of Dr. Wilhelm Heintz, Professor of Chemistry at Halle University, at the age of sixty-three years.

THE death has taken place, on the 16th inst., at the age of ninety-one years, of Mdlle. de Montgolfier, daughter of Etienne de Montgolfier, the inventor of the balloon to which his name is attached.

PROF. WILLIAMSON, Graham's successor in the Chair of Chemistry at University College, London, has complied with the request of the committee of the Chemical Section of the Philosophical Society of Glasgow that he should act as adjudicator in the competition for the Graham Medal.

PROF. TYNDALL, Prof. Haeckel, and Dr. Andrew Buchanan have been elected Honorary Members of the Philosophical Society of Glasgow.

AMONG the buildings which are to be erected on the new Observatory grounds in Paris when legally handed over to Admiral Mouchez will be the great dome for the large refracting telescope which is now building. This dome will measure twenty metres in diameter, and its weight will exceed sixty tons.

THE credit of 300,000 francs asked by M. Cochéry for the forthcoming Exhibition of Electricity and Congress of Electricians at Paris has been voted by the Chamber of Deputies unanimously. The Bill has been sent to the Senate, which will probably have passed it by the time this number is published.

ON December 12 took place at the Sorbonne the celebration of the fiftieth anniversary of the foundation of the Polytechnic Association for delivering scientific lectures all over France. This Society was established a few months after the Revolution of July, 1830, by a certain number of pupils of this celebrated school. The principal address was given by M. Gambetta, who praised science in magnificent style. M. Gambetta declared his conviction that Auguste Comte was the profoundest thinker of the whole century.

FREQUENT observations on the retrograde motion of glaciers have been made of late years. One of the most assiduous of observers is Herr W. Grömer, proprietor of the Hotel on the Schafberg. He reports that during September the retrograde motion was exceptionally large, larger indeed than he had ever seen during seventeen years. The Gosau glacier (Dachstein), the Hochalmspitze, and the Uebergossene Alp showed hardly any ice at all on September 12 last, so that with the telescope only *débris* of rocks could be seen. Herr Grömer ascribes this phenomenon to the unusually high temperature which reigned upon the Alps during last winter, as well as to the constant rain during the summer.

WE are glad to receive a third edition of vol. i. of Harcourt and Madan's "Exercises in Practical Chemistry" (the Clarendon Press). Mr. Madan is the sole reviser of this edition, and we quote with approval the following passage from his preface:—"Practical chemistry seems in danger of being made far too much a study of a few reactions of salts, got up for the purpose of detecting them in the course of an analysis. This is of course due to the requirements of examiners, to satisfy which nearly all the very moderate time available for practical instruction in schools must at the present day be spent. Moreover analytical work (in the narrow, technical sense) entails, like Latin verses, less trouble to the teacher and less risk to the pupil than other kinds of practical work; while it undoubtedly affords, when intelligently used, a very excellent training in the application of logical methods. But it may well be doubted whether a more real and valuable advance in a scientific education is not made by the careful preparation and examination of the properties of such a substance as oxygen, or by an exact study of a few examples of oxidation and reduction, than by simply observing, for instance, that chlorides give a white precipitate with silver nitrate which is soluble in ammonia."

MR. C. SCHOESSTER, one of the Commissioners at the Melbourne Exhibition, we learn from the *Colonies and India*, has been visiting the Geelong vineyards, and reports that they are suffering from *Phylloxera* in the worst form, and ought to be totally destroyed.

PROF. DEWAR will give the first of his Christmas Lectures (adapted to a juvenile audience) on Atoms, at the Royal Institution on Tuesday next, December 28, at three o'clock.

A BOTANICAL society for Northern Thuringia has been founded at Sondershausen by Prof. Leimbach. The new Society takes the title of "Irmischia," in memory of the celebrated botanist Irmisch, who died at Sondershausen last year. The immediate object of the Society, which has already a good