they would fall easy victims to enemies much weaker and slower than themselves.

On the other hand, we learn from Dufour that the species found in Algeria are exempt from the attacks of the Mason wasps, which, as is well known, in that and in all countries fearlessly attack and destroy numbers of the largest spiders, and could, without difficulty, catch the fleetest Solpuga in the world. The reason for this freedom from persecution is not quite clear, unless it is to be explained by the fact that the Solpuga is too formidable a foe for the wasp to tackle. That this may well be the case is rendered intelligible by the reflection that the large lycosiform and mygaloid spiders fall easy victims because, owing to feebleness of vision and lack of activity, they are not quick enough to elude the final swoop of the wasp. The Solpugas, on the other hand, as compared with the spiders, are exceedingly agile and keen-sighted. Moreover, when on the defence, they have a habit, as described by Dr. Walter, of turning up the abdomen, so as to protect that vulnerable part, and extending the legs forwards and upwards in such a way as to present to the foe a pair of gaping jaws surmounted by five pairs of strong limbs armed with long bristles, stout spines and sharp claws. Small wonder if under the circumstances the wasps think discretion the better part of valour.

The last peculiarity to be mentioned is the presence on the inner surface of the jaws of some strong horny ridges, which by mutual friction emit a harsh grating noise. In some genera these ridges are scarcely at all developed: in others they are very pronounced. That the sound is produced in the way described under the stimulus of sudden fear or irritation was long ago pointed out by Hutton, and even before him by Pallas; and, touching its function, one can only suppose that, like analogous organs found in the rattlesnake and in some of the largest spiders and scorpions, it acts as an advertisement of the whereabouts of the Solpuga, and as a warning to enemies to keep a respectful distance.

R. I. POCOCK.

THE LABOULBENIACEÆ: A NEW FIELD OF STUDY AMONG FUNGI.[1]

THE knowledge of most botanists of the group of Fungi here under treatment is probably confined to the brief description given of them by De Bary, under the head of "Doubtful Ascomycetes," where Peyritsch's figures of *Stigmatomyces Baeri* are reproduced.

Since 1884, when De Bary's "Fungi" appeared, the investigation of the group has, however, proceeded apace; and whereas at that time hardly more than a dozen species had been distinguished, Dr. Thaxter considers that no fewer than 150 species belonging to 30 genera are now known. Almost all of these additions are due to Dr. Thaxter's investigations, and have already been announced, from time to time, in a series of papers emanating from the Cryptogamic Laboratory of Harvard University.

The first to observe one of these Fungi was probably the entomologist Laboulbène, in whose honour *Laboulbenia rougetii* was named by Montagne and C. Robin. The earliest description came from Robin in the "Histoire Naturelle des Végétaux Parasites" in 1853. H. Karsten (1869) and Peyritsch (1871-75) followed with a more detailed treatment of the morphological characters of the group, and still later Berlese, Giard, Istvanffi, and Thaxter, have in turn added to our knowledge of the family.

The Laboulbeniaceæ are, without exception, entomogenous, and occur upon species of beetles and flies almost exclusively. They are attached to the chitin of the insect by only a minute foot, by means of which, however, they absorb all the nutriment they require for their development. Upon examination with a hand-lens, they have the appearance of hairs or bristles of a dark colour, standing out vertically from the substratum. As they seldom exceed half a millimetre in length, it is not surprising that they easily escape the notice of entomologist and mycologist alike.

Their morphological characters present features of unusual interest, inasmuch as they seem to exhibit a marked sexuality, and that of a peculiar type. The male cells are non-motile spermatia, arising for the most part endogenously, but in certain genera abstricted exogenously, as in the case of the Florideæ. These spermatia become attached to trichogynes, whose cell-wall appears to have the same gelatinous consistence as have those of the Florideæ. In some genera, these trichogynes become branched and multicellular; in a few cases they bend over to come into contact with spermatia *in situ*, and then straighten again, carrying off a detached spermatium. Bearing the trichogyne is a "trichophore," itself resting on a "carpogenous" cell. From this latter there are ultimately budded off four or eight asci, each containing, when mature, four or eight usually septate ascospores, the whole being enclosed in a fusiform fructification, recalling the perithecium of a Pyrenomycete. It seems impossible to resist the impression that the asci arise as the result of an act of fertilisation, though the details of the process have not been observed. That the Laboulbeniaceæ are to be included among Ascomycetes can no longer be doubtful, and their morphology, when considered in connection with the observations of De Bary, Janczewski, Stahl, and more recently Harper, lend support to the view that sexuality persists in this class of Fungi. It is difficult to imagine how otherwise Brefeld can account for the structure of Laboulbeniaceæ, when his researches have extended thus far.

The similarity in the method of fertilisation with that existing in Florideæ is very marked. For the occurrence of a receptive trichogyne and detached non-motile spermatia among Fungi, Stahl's observations had already prepared us, though it has been denied that the structures called by these names in Collemaceæ, have the sexual significance they have been shown to have in Florideæ. The analogy of the similar organs in Laboulbeniaceæ with those of Florideæ would seem to be beyond doubt. A further startling analogy with Florideæ is found in the occurrence of a single conspicuous pit in the walls separating successive cells of the hyphæ; and, as in Florideæ, these have already been utilised in tracing the genetic connection of the cells of the thallus. Although Thaxter, on account of these similarities, does not regard the derivation of Laboulbeniaceæ from Florideæ, as unworthy of consideration, it is improbable that they indicate anything more than similarities of adaptation, which often occur in widely separated groups.

Of the 250 different species of insects on which these Fungi have been found parasitic, 241 are Coleoptera, and of these the majority are aquatic or riparian in habit. Of the 7 dipterous host-species one is the common house-fly, which is frequently infested with *Stigmatomyces Baeri* in the neighbourhood of Vienna. The single termite affected came from Africa, and the single acarid from Paraguay. Though most of the Laboulbeniaceæ yet described are exclusively North American, 19 European species are known, and some accompany their hosts into two or three continents. It is probable that the family will be found to be numerous in species, and widely distributed in range. No British locality for a single species is given in Dr. Thaxter's work, and no British writer seems to have yet made any contribution to the literature of the group. In Dr. Cooke's "Vegetable Wasps and Plant Worms," published in 1892, the species then described by Thaxter and others are enumerated, but no discovery of any of these in Britain seems to have been known to the author. It is highly improbable, however, that none of the parasites occur on any of the more than 3000 British species of Coleoptera.

Though these plants do not at present appear likely to become of any economic importance, yet it is clear that they are of exceptional morphological and physiological interest; and Prof. Thaxter has earned our gratitude for the persistence with which he has pursued their study, and for the ability and skill with which he has described and portrayed them. The work forms a worthy successor to the author's monograph on "The Entomophthoreæ of the United States."

R. W. P.

[1] "Contributions towards a Monograph of the Laboulbeniaceæ." By Roland Thaxter. (*Memoirs* of the American Academy of Arts and Sciences, vol. xii. No. 3, December 1896. Pp. 242, pls. 26.)

THE BOLOMETER.[1]

IN the number of the *American Journal of Science* for March 1881, there appeared an article descriptive of the actinic balance (since called the Bolometer), an instrument which has gained acceptance among physicists as a useful aid in the study of radiant heat. It was, it may be remembered, originally devised by the writer to discriminate the heat in any small portion of the grating spectrum, but it has since found wider applications.

[1] Reprinted from the *American Journal of Science*, April. (Communicated by the Author.)

As at first constructed, the strips, representing arms of the Wheatstone bridge, were made of iron from 0·001 to 0·0001 of an inch in thickness. The instrument was, even under these initial conditions, very many times as sensitive as the best thermopile the writer then possessed, but there does not appear to be any definite statement as to the exact sensitiveness in its early form.

In the article referred to, however, the instrument is represented as giving a deflection of about 40 scale divisions (millimetres) from the lunar heat, concentrated by a thirteen-inch lens, and it was sufficiently accurate to give a probable error of rather less than one per cent. for a single observation on a constant source of heat, so that the accuracy of the bolometer (quite a distinct consideration from its sensitiveness) was even then as great as that of the best photometric process. The galvanometer in use at that time was one of the early Thomson pattern made by Elliott.

The first bolometers were made by the writer's own hands. Subsequently the strips were usually cut out from sheets of thin platinum, and in one or two instances made from flatted wire, the strip of the linear bolometer at that time (about 1883) being usually about 10 millimetres long; anywhere from 0·001 to 0·01 of a millimetre thick, and, according to its special purpose, being made from 1 millimetre to 0·1 millimetre wide.

About 1886 the mounting of the instrument had been improved by the writer, so that the strip appeared like the vertical "wire" of a reticule in the focus of a positive eyepiece. It was also movable in some cases by a micrometer screw, and was, in fact, a micrometer thread controlled in the usual way, but endowed with the special power of feeling the radiations from any object on which it was directed.

In the earliest spectrum work the bolometer developed another important quality, its "precision." This quality is quite independent of the accuracy with which it repeats measures of radiation or any constant source of heat, and concerns the precision of setting, as a micrometer thread. It could, even twelve years ago, be pointed, not only like the thermopile, within a fraction of a degree of the place of the source of radiation, as for instance on a bright line in the spectrum, but within a fraction of a minute of arc.

The instrument of course depends for its general efficiency on the galvanometer with which it is connected. That used in 1886[1] had several improvements due to the suggestions of Sir William Thomson and Prof. Rowland, and was perhaps, at that time, the most effective instrument of its kind in use for such a purpose, the mirror and needles having been specially constructed at the Allegheny Observatory. The mirrors were platinised by the kindness of Prof. Wright, and were at that time nearly a centimetre in diameter. The needles were hollow magnets made by Mr. Very of the Allegheny Observatory. For the damping mechanism of the older galvanometer, I had substituted a dragon-fly (*Libellula*) wing, in which nature offers a model of lightness and rigidity quite inimitable by art. At that time, when making a single vibration in 20 seconds, a deflection of one millimetre division of the scale at one metre distance was given by a current of 0·000,000,0005 amperes, the instrument as described being capable of recording a change of temperature in the bolometer strips of less than 0·00001 of a degree Centigrade. So much less than this could be observed by special precaution, that it might be said that this one one-hundred-thousandth of a degree was not only indicable but measurable by the apparatus, which was employed as described, in the determinations of the relations of n to λ for the rock-salt prism, and by which the infra-red spectrum was at that time followed by actual measurement, to a wave-length of rather over five one-thousandths of a millimetre.

Since then the bolometer has been used in various researches, of which some occasional account has been given in the *American Journal of Science*. (See numbers for November 1888, and August 1890.) During recent years it has been specially employed in making a bolographic map of the lower spectrum, the publication of which has been greatly delayed by conditions incidental to the relations of the Smithsonian Observatory with the Government, but which it is hoped will not be deferred much longer.

Without here entering into an account of the work done by it, I have thought that it might be of interest to give very briefly a statement of the present condition and form of the instrument itself, considered under three aspects.

[1] *American Journal of Science*, third series, vol. xxxii. p. 90, 1886.

(1) Its precision, or the degree of exactitude with which it can be set on a special point, as, for instance, on a line of the invisible spectrum, recognised by its heat radiation alone.

(2) Its accuracy, or its capacity for repeating the same measure of radiation under like conditions.

(3) Its sensitiveness, or capacity for detecting minute radiations.

The instrument which I will take as the subject of comparison with the earlier one as described in this *Journal* (August 1886), is now in use in a chamber automatically kept at a temperature constant within one-tenth of a degree Centigrade.

The strips, the essential part of the instrument, are in the present case made by Mr. C. G. Abbot, and are of platinum, the central one being rather less than 0·1 of a millimetre wide. (The case is now made of metal instead of ebonite, and is surrounded by a current of water).

It is quite possible to make bolometer strips much narrower, but this is less necessary with the employment of the long-focus, image-forming mirror, so that in the present case the strip is at such a distance that it subtends an angle of 3·4 seconds. Its angular aperture is in practice adapted to that of the slit, which, with the use of the long collimator employed by the writer, gives a capacity of pointing (pointing, that is, *in the dark*), with a probable error of little over a second of arc. Quite recently, owing to the use of a novel collimating system of two cylindrical mirrors proposed by Mr. Abbot, the slit, though at a moderate distance, can have an opening sufficient to avoid prejudicial diffraction effects, while subtending an angle of considerably less than one second of arc.

In the galvanometer, the use of the fine quartz threads and specially small mirrors, originally due to Mr. Boys, has lately been carried to what seems near the practicable extreme, the quite invisible thread being made some 30 centimetres long, the mirror 2 millimetres in diameter, and weighing but 2 milligrams, and its six needles, of proportionate weight and dimensions.

This system is now made to serve with a much shorter swing than that formerly employed. If we reduce it to a time of single vibration of 20 seconds, only for the purpose of comparing it with the values already given in the earlier form, we obtain the results submitted below.

Before giving them, however, it is to be mentioned that the apparatus at Washington is most unfavourably situated, owing to its being subject to tremor from the traffic of neighbouring streets and to other causes, which it has been the object of years of struggle to conquer. This has been so far done that the values presently to be given (which, it will be remembered, are only attainable in a chamber of constant temperature, with special precaution against disturbance from external tremor), can be counted on as real values, always obtainable under proper conditions, and, in fact, rather within than without the average working capacity of the instrument.

I here consider the bolometer as at present employed.

(1) With regard to its precision, or exactness of pointing. The old thermopile could be set on a portion of the spectrum only with an error of a considerable fraction of a degree. The linear bolometer as employed in 1886 could be set with a probable error of a fraction of a minute of arc. The bolometer as employed to-day, and moved through the spectrum by clockwork, can be automatically set with a probable error of a single observation of little over a second of arc, can be set, that is, in the dark with a precision little inferior to the capacity of the eye in setting a micrometer thread in the light.

(2) As to its accuracy. I have had occasion recently to take a series of measures of successive throws of the galvanometer, using as a source of heat an Argand petroleum flame in a common student's lamp. I had no photometer at hand, but taking the usual statements of the text-books as to the accuracy of vision, it might be expected that such measures with the eye would give a probable error of about one per cent. (This is where sources of light of similar quality are compared.) The probable error of a single galvanometer reading was between 0·03 and 0·04 of one per cent., and this included the fluctuation of the intensity of the source of radiation, and the error of estimating tenths by the reader on the scale, both quantities of nearly the same order as the error in question. It seems safe to say, then, that *no* error attributable to inaccuracy of the bolometer could be detected by the means employed.

(3) As to sensitiveness. In the early work, for a time of single swing of 20 seconds, a deflection of one millimetre with

the scale at a metre's distance was obtainable with a current of 0·000,000,0005 of an ampere. At present, under such circumstances, a similar deflection would be obtained with 0·000,000,000,0012 ampere, that is to say, the apparatus is about 400 times as sensitive as it was when first described.

At present the bolometric apparatus, under the conditions already cited, will indicate a change of temperature in its strips of, at any rate, much less than one-ten-millionth of one degree Centigrade. S. P. LANGLEY.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MRS. PHEBE HEARST has offered to erect for the University of California a new building for the School of Mines.

DRAUGHTSMEN and engineering students familiar with the principles of the science of steam, are given opportunity of advancing their knowledge by a special class in steam-engine trials which will commence at the South-Western Polytechnic, Chelsea, on May 17, and terminate on June 28. The class will be conducted by Mr. W. W. F. Pullen and Mr. H. A. Clark.

THE trustees of Cornell University have just established a Medical Department and a State College of Forestry. The medical department will be situated in New York City, and its faculty will be made up principally of those surgeons and physicians who have heretofore been connected with the medical department of New York University; including all but three of the instructors of that department. The endowment of the new medical school is by a donor whose name is not disclosed. The College of Forestry established by Cornell University will be situated at Ithaca, and called the State College of Forestry, having been authorised and endowed by the State with a grant of 10,000 dollars by the legislature which adjourned a few days ago. Prof. Bernard E. Fernow, director of the United States Division of Forestry, has been made director of this department.

ONE of the most important educational problems at the present time refers to the coordination of the work of the University and Technical Colleges with that of other educational institutions in the neighbourhood. It is unfortunate that in several cities the educational institutions are competing with one another instead of working together as an organic whole, in which each part has a definite function to perform. Efforts are, however, being made in the large provincial centres to prevent the undesirable overlapping which at present exists, in order to make the various educational institutions complement each other's work without competition. Summaries of what has been done in this regard at Birmingham, Manchester, Plymouth, and Sheffield appear in the current number of the *Record of Technical and Secondary Education.* In Birmingham, though no formal machinery exists for the coordination of educational work, the various institutions have adapted their organisation to the circumstances of their environment, supplying any need that was felt, and avoiding duplication of function. An educational ladder has, in fact, been constructed, up which a boy may climb from the Board School to the highest University honours without exciting the jealousy of other schools than those which he attended. This event actually occurred last year, when Mr. W. H. Austin, who began his education at a Birmingham Board School, came out Senior Wrangler at Cambridge. In Manchester the provisions for coordination take the form of an agreement between the Technical Instruction Committee of the City Council and the School Board, and between the authorities of Owens College and the Manchester and Salford Technical Schools. As between Owens College and the Technical Schools it is arranged that the latter shall aim at demonstrating how the general principles of science and art may be applied to the advancement of trade and industry, whilst the college will eschew these obviously bread-and-butter subjects, and address itself to the higher walks of pure science. In Plymouth, also, a scheme has been arranged which correlates and connects the whole of the science and art teaching of the town, from the infant school upwards. In Sheffield a scheme which secures the effective coordination and economical management of the Board Schools, the Technical School, and the School of Art, has been at work since last September, and appears to give entire satisfaction to all concerned; and Bradford has just taken steps to grade its various educational forces. Through all the schemes one main principle runs—that, namely, of making the common schools, Primary and Secondary, the kindergarten and nursery of science and art, and of making the Technical Schools true to their name as the places where is taught the application of science and art to the purposes of industry and commerce, while to the University Colleges are allocated the higher scientific studies. These examples should encourage other county boroughs to consider and adopt educational schemes which will prevent waste of effort and do away with conflicting interests.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, April 22.—Mr. Shelford Bidwell, F.R.S., President, in the chair.—A paper by Prof. T. C. Porter, on a method of viewing Newton's rings, was read by Prof. S. P. Thompson. If a parallel beam of light from a rectangular slit falls at oblique incidence upon a plane plate of glass, the first two reflections occur at the upper and lower surfaces of the glass, respectively, and give two corresponding images that may be formed on a screen. If now a second glass plate is added below the first, and parallel to it, at a short distance, four images of the slit appear on the screen. But when the lower plate is brought into contact with the upper one, the reflection from the lower surface of the upper plate follows the same path as that from the upper surface of the lower plate, so that only three images are now to be distinguished. For the two glass plates the author substitutes a "Newton's rings" apparatus, and by the above device for eliminating a set of reflections he is able to restrict the illumination to the light that comes from the two interior surfaces. As thus observed, the colours of the rings are very brilliant. When the plates are very clean, the darkest area of the "black" spot has a sharply-defined edge, similar to that of the black film of a soap-bubble. By using monochromatic light, the various sets of rings may be photographed; they appear as several systems of concentric circles, the systems intersecting one another. This method of illumination by a slit, enables Newton's rings to be viewed free from all light except that due to reflections at the bounding surfaces of the air-space between the plates. It reveals to the eye the subordinate interference-systems that coexist with the primary rings, and it demonstrates which of these reflections must be taken into account in the theory of the phenomenon. Moreover, it supplies a means for analysing these systems, and it indicates that the interference of monochromatic light is never complete under these circumstances. Prof. Herschel said it was rather difficult to follow the arguments of the author without witnessing the phenomena. Much complication was introduced by the successive reflections; it was not clear what became of them. There was no doubt as to the advantage of a narrow slit for the illumination. He thought some of the secondary reflections might be got rid of by using plates that were slightly prismatic. Prof. Thompson had, in his own laboratory, verified the advantages of the author's method of illumination. The result was a very sharply-defined first system of rings. Curves of subordinate interference were easily to be observed by this arrangement. Prof. Boys noticed in the photograph of the ring-systems that the independent systems of bands were distorted at the points of intersection. The intersecting curves formed a sort of honeycomb, or hexagonal system, instead of a system of curvilinear quadrilaterals. This distortion reminded him of similar effects observed in the photographs of "ripples." Mr. Edser said he had often noticed similar distortions, but he had always been able satisfactorily to explain them as being the result of imperfect focussing. The author had referred to the fact that a thin film when viewed by reflected light appears black. A phase-change of half a wave-length takes place either on reflection at a rarer, or at a denser medium; but there is no information from which to decide between these two alternatives. The truth of the assumption that the phase-change occurs at the denser medium seems to depend, so far as experimental evidence is concerned, upon the observation that in Lloyd's bands the central one is black. To produce the Lloyd's bands only one mirror is used; the bands produced by Fresnel required three mirrors. Wernicke performed an interesting series of experiments in which white-light reflected for various angles of incidence from a thin sheet of glass was examined spectroscopically. The spectrum was crossed by numerous black bands, and from the position of these bands in the spectrum the thickness of the glass was calculated. The calculated thickness when the angle of incidence was great, differed from that obtained with small angles of incidence; the conclusion was that when light is internally reflected, even at an angle of incidence less than the angle of