life. On the contrary, all progress in research only throws into greater relief the difficulty of the problem; the better we become acquainted with it, the more the mystery deepens. Nor would it be right to assert that the microscope is the sole instrument of research in this field. Our knowledge of the properties and activities of the living substance and of living things advances daily by leaps and bounds through methods of investigation in which the microscope plays no part. I have referred to the knowledge that has been gained of the life-history of the parasite of yellow fever, in spite of the fact that the microscope has failed completely, so far, to detect the parasite itself. But we may safely claim that the greater and most important part of modern biological knowledge could not have been gained without the instrument which it is the object and purpose of our club to study, to perfect, and to apply; and, further, that to be able to see the objects with our own eyes makes them much more real and true to us than merely to infer their presence and properties from experiments in the dark, so to speak. "Seeing is believing" is an English proverb which has its counterpart in all languages. We may be satisfied in our minds as to the existence and behaviour of the yellow-fever parasite, but nevertheless its discovery by optical means would be greatly welcomed as an important advance in our knowledge.

There is no greater stimulant to the all-important study of living things than the feeling of wonder and delight which the first sight under the microscope of objects otherwise invisible produces in even the most uninstructed mind. Most of us probably can date our first interest in minute living objects from the time when, perhaps in early youth, we were given, or allowed to use, a microscope, with which we could gratify, without satisfying, our curiosity in looking at all kinds of minute objects. In such an occupation the appetite comes with eating, as the French proverb says, and the instrument which was at first a fascinating toy leads us on until, one might almost say, it masters and enslaves us. In this development there is another instance of the parallel between the progress of the individual and the history of the race. To the majority of early microscopists the microscope was but a toy, an instrument which competed with the magic-lantern as an amusement for drawing-room séances, and only a serious minority made use of it as a means of earnest scientific investigation. There are, perhaps, still microscopists whose chief delight is to thrill their friends, especially those of the fair sex, by the sight of hairs on a spider's leg, or the elephantine proportions of a cheese-mite. If so, let us not scoff, as some do, at the amateur; we ought rather to regard him with the same interest that a zoologist looks on an okapi or a lepidosiren, as a living representative of a bygone age. For the modern microscopist is fearfully in earnest, and has but little opportunity for amusement in pursuing a science which taxes, not only his brain, but his eyes to the utmost. There is scarcely any greater physical strain than the long-continued investigation carried on with the highest powers of the microscope, and in my own experience I have known some who lacked the physical endowment for such work, and others who have been obliged to retire disabled from the field. Let us, then, in a pursuit which but too frequently dulls enthusiasm by fatigue and exhaustion, in which our "native hue of resolution" tends to become "sicklied o'er by the pale cast of thought," rather envy those who retain the freshness of their early delight, and strive to cultivate, rather than to stifle, that feeling of wonder and curiosity which should be the starting point of all philosophical and scientific investigation. "Two things," said Kant, "fill my mind with ever-renewed wonder and awe, the more often and the deeper I dwell on them—the starry vault above me and the moral law within me." I venture to think that had Kant lived in our days he would have found a third source of wonder in the contemplation of the simplest living things as revealed by the microscope, in the combination they present of apparent simplicity with infinite complexity, and of extreme minuteness with the most extraordinary powers. To me the observation of a minute organism, such as an amœba, under the microscope, is in its way as marvellous as the sight of the starry firmament. I see a minute, formless creature, without definite parts or organs, which nevertheless exercises all the functions of life and exhibits the germ of every faculty we possess, and thereby proves that its apparent simplicity and formlessness cloak a complexity of organisation far transcending our powers of observation and eluding our means of detection. What, again, can be more wonderful to contemplate than the fact that peculiarities in the complex mental endowment and physical structure of a human being can be transmitted from one generation to the next through the medium of a spermatozoon, the tiniest cell of the human body, in which the microscope reveals only a structure of the simplest kind? These things must rank with the most wonderful and inexplicable of the phenomena that nature presents to us, and we are as yet only on the threshold of investigation. The stellar universe has been observed, its laws and motions studied, for many thousands of years, but our acquaintance with the beginnings of life and its properties as exhibited by the simplest living things is but an affair of yesterday, as it were, and the scientific study of life is as yet in its infancy.

In these days of vast and rapid increase of knowledge in such matters there is danger that we may lose the true perspective, and that our perception of the whole may be blunted and obscured by the immense mass of detail which forces us to attend only to a small part of our science. It is the special function of a club such as ours to keep fresh our enthusiasm and to enlarge our outlook by contact and intercourse with those working in other fields, to spread the infection, if I may use the term, of intelligent curiosity in the minutest natural objects, and thereby to attract and enlist new workers in a field in which the harvest is plentiful but the labourers are few.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The electors to the Allen scholarship give notice that they are prepared to receive applications from candidates. Any graduate of the University is eligible for the scholarship provided that his age on the first day of the Lent term, 1910, does not exceed twenty-eight years. This year the scholarship is open to candidates who propose to undertake research in any branch of study which comes within the department of any of the following special boards:—medicine, mathematics, physics and chemistry, biology and geology. The scholarship is tenable for one year, during which period it will be the duty of the student to devote himself to research in Cambridge or elsewhere. The emolument of the student is 250*l.*, or such smaller sum as the fund, after payment of all expenses, shall be capable of providing. Every candidate must send to the Vice-Chancellor, Pembroke College Lodge, on or before February 15, his name and a definite statement of the course of research which he proposes to undertake, together with such evidence of his qualifications as he thinks proper, and with the names of not more than three referees to whom the electors may apply for information.

THE University of California has received from Mrs. Phœbe Hearst an offer to build, at the cost of about 100,000*l.*, a museum for the housing of its anthropological specimens. During the last ten years Mrs. Hearst had already contributed an equal sum to the establishment and maintenance of the University's department of anthropology, and to the cost of its foreign expeditions.

ACCORDING to the Berlin correspondent of the *Times*, the latest returns from the German universities give the total number of students as 52,407, including 1850 women, as compared with a total of 48,730 last year and 32,800 ten years ago. There are also 3314 men and 1923 women attending courses as guests. Berlin takes the first place among the twenty-one universities with 9242 students, as against 8641 last year, and is followed by Munich with 6537, Leipzig with 4761, Bonn with 3652, Breslau with 2405, and Halle with 2393. Göttingen has 2230, and Heidelberg 1934. In Berlin University this winter there are 632 women students, an increase of 232 as compared with last year.

AN address delivered by Prof. Alexander Smith before the section of education of the American Chemical Society at Detroit, and reproduced in a recent number of *Science* under the title "The Rehabilitation of the American College and the Place of Chemistry in It," is of more than local interest and importance. The author is strongly impressed with the difficulty of teaching his subject effectively to classes of students of widely varying mental capacities, and especially of teaching it in such a way as to be of service to those who do not expect to become professional chemists. He is a profound disbeliever in the method of imparting instruction which relies mainly upon lectures, and urges that the essential feature of all teaching should be "problem-solving" in some form or other. This method, he suggests, is fully developed in the teaching of languages, in which "the grammar furnishes the laws and general principles, together with all the known exceptions," "the dictionary supplies the isolated facts," and "the text provides the subject of study in constant and definite form." In the case of chemistry, he urges a closely interwoven scheme of laboratory work and class-room discussion, supplemented (if lectures are used) by briefly written answers to set questions and home study in varying amounts to suit the necessities of the individual student.

THE annual general meeting of the Association of Headmasters was held in London on January 12 and 13. Mr. Philip Wood, headmaster of Darlington Grammar School, the president for the year, in his presidential address referred to the question of the provision of free places in secondary schools receiving grants from the Board of Education. He said there are many grammar schools in towns with a population of less than 20,000 which educate the sons of the professional people and better-class tradesmen, but depend largely for their existence on being able to attract boarders. The position of such a school at the present time is very precarious. It has had always something of a struggle, and the grants of local education authorities and of the Board of Education are just what it requires to give it new life; but the grants are conditioned, and the conditions, at least of the Board of Education, would seem to contemplate a large day school in a large town rather than the kind of school in question. In a small market town, for instance, it is ridiculous that a school of, perhaps, seventy-five boys should be increased to 100 in order to provide for the education of twenty-five boys from the two or three elementary schools in the town. Boys capable of taking advantage of these opportunities are not to be found; and what is also a matter of common experience, their admission, whether they are capable or incapable, generally means the displacement of an equal number of boys whose parents do not like the new situation. Thus the 25 per cent. rule, which does not greatly embarrass a large day school, will, if rigorously applied, almost ruin many schools which we can ill afford to lose.

THE Department of Agriculture and Technical Instruction for Ireland has issued a pamphlet giving an account, by Mr. George Fletcher, assistant secretary for technical instruction, of the summer courses of instruction for teachers instituted by the Department in 1901. The courses are held in July and August, and extend over a period of about a month. They are held in Dublin and elsewhere. In selecting teachers to attend the courses, regard is had to the qualifications of the teachers and the needs of the school or district from which they come. After each year's course, teachers who pass the examinations are provisionally recognised as qualified to teach the subjects in which they have passed. Courses are held in experimental science, drawing, manual work in wood, and domestic economy. Besides preparing teachers to conduct classes in the Department's "Programme for Day Secondary Schools," the summer courses are year by year coming to serve a further purpose. Side by side with the development of the Department's scheme in day secondary schools there has grown up a system of specialised technical education all over Ireland. The rate of growth has been rapid, and a large and increasing number of Irish teachers are engaged in the schools and classes organised through urban and county councils. While it was necessary in the initial stages of such a system to employ teachers having experience of similar work, from whatever source they might be obtained, special efforts have since been made to train Irishmen when and where possible. Hence it is that year by year an increasing number of summer courses are organised to deal with subjects purely technical in character and having for their object the further education and training of teachers already engaged in Irish technical schools. It would be difficult to over-estimate the value of these courses as an element of educational progress. The typical courses described in the pamphlet by means of syllabuses, descriptions, and illustrations indicate what great pains have been taken by the authorities to make the lectures and practical work meet the needs of the teachers exactly.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society. January 13.—Sir Archibald Geikie, K.C.B., president, in the chair.—Sir Edward **Thorpe** and A. G. **Francis**: The atomic weight of strontium.—L. F. **Richardson**: The approximate arithmetical solution by finite differences of physical problems involving differential equations, with an application to the stresses in a masonry dam. In order to deal with irregular boundaries, analysis is replaced by arithmetic, continuous functions are represented by tables of numbers, differentials by central differences. Then problems fall into two classes. (A) The relation between the equation obtaining throughout the body and the boundary condition is such that the integral can be stepped out from a boundary. This class includes equations of all orders and degrees. It has been treated by arithmetical differences by Runge, W. F. Sheppard, Karl Heun, W. Kutta, and Richard Ganz. Examples of a specially simple method are given. (B) The integral must be determined with reference to the boundary as a whole, as in Dirichlet's problem. The method given has only been worked out for a limited group of linear equations, namely, for those in connection with which a function analogous to potential energy exists, which is a complete minimum when and only when the difference equations are satisfied. Under this condition the difference between the integral ϕ_u and a function ϕ_1 of the independents, having the correct boundary conditions but otherwise arbitrary, can be expanded in the form $\phi_1 - \phi_u = \Sigma A_k P_k$ where the $A_1 s \ldots A n$ are constants and $P_1 \ldots P_n$ are "principal modes of oscillation" defined by $\mathbf{D}' P_k = \lambda_k^2 P_k$ where $\mathbf{D}' \phi_u = 0$ is the difference equation to be integrated and λ^2 is a constant. Now we start with the table of numbers ϕ_1 and calculate $\mathbf{D}' \phi_1$. Then as $\mathbf{D}' \phi_u = 0$ we have $\mathbf{D}' \phi_1 = \mathbf{D}'(\phi_1 - \phi_u) = \Sigma A_k \lambda_k^2 P_k$. Multiplying both sides by some number α_1^{-1} and subtracting from ϕ_1, and altering the boundary numbers so that the boundary condition is still satisfied, we have a new table which may be called ϕ_2; and $\phi_2 - \phi_u = \Sigma A_k (1 - \alpha_1^{-1} \lambda_k^2) P_k$. Repeating the process with $\sigma_2 \ldots \alpha_m$ we get:

$$\phi_{m+1} - \phi_u = \Sigma A_k (1 - \alpha_2^{-1} \lambda_k^2)(1 - \alpha_2^{-1} \lambda_k^2) \ldots (1 - \alpha_m^{-1} \lambda_k^2) P_k.$$

Now a function I exists such that $\mathbf{S} I P_k^2 = 1$, $\mathbf{S} I P_l P_k = 0$ where $\mathbf{S}$ denotes a summation throughout the region. Therefore:

$$\mathbf{S} I (\phi_{m+1} - \phi_u)^2 = \Sigma [A_k (1 - \alpha_1^{-1} \lambda_k^2) \ldots (1 - \alpha_m^{-1} \lambda_k^2)]^2.$$

Now by a sufficient number of suitably chosen *as* the polynomial in λ^2 on the right can be made small throughout the range from λ_1^2 to λ_n^2. Therefore the error of ϕ_{m+1} can be made small; for, since I is one signed it is measured by the L.H.S. The process is arithmetical. The error due to finite central differences is of the form

$$e_2 h^2 + e_4 h^4 + e_6 h^6 + \text{\&c.},$$

where h is the coordinate difference and the *es* are functions of position independent of h. If the integral has been found for two or more sizes of h, more exact values of it can be extrapolated by this formula. These methods have been applied in the paper to calculate the stress-function in a masonry dam.—A. O. **Rankine**: A method of determining the viscosity of gases, especially those available only in small quantities.—Dr. P. **Phillips**: Recombination of ions at different temperatures.—Dr. G. C. **Simpson**: The electricity of rain and snow. This paper relates to measurements of the electricity of rain made in continuation of those described at the beginning of last