promptly with the general secretary, Dr. William Bierman, 471 Park Avenue, New York City. The registration fee is $15.00.

THE post-doctorate fellowships in the biological sciences (zoology, botany, anthropology, psychology, agriculture and forestry), available through the National Research Council for the academic year 1937–38, will be awarded by the Board of National Research Fellowships in the Biological Sciences at a meeting which is to be held the latter part of April. Applications should be filed with the office of the board by February 15, 1937. Appointments may be made prior to the conferring of the doctor's degree, to be effective upon the receipt of the degree within six months. Application blanks and statement of conditions will be furnished upon request by the secretary, Board of National Research Fellowships in the Biological Sciences, National Research Council, Washington, D. C.

THE Committee on Scientific Research of the American Medical Association invites applications for grants of money to aid in research on problems bearing more or less directly on clinical medicine. Preference is given to requests for moderate amounts to meet specific needs. For application forms and further information, the committee should be addressed at 535 North Dearborn Street, Chicago, Illinois.

NEW premises for the research laboratories of the British Institution of Automobile Engineers have been acquired on the Great West Road, Brentford, near the Firestone factory. According to the London *Times*, the front of the building is imposing, the two-story block housing the general offices, library and committee room, while at the rear there are sections for physical and chemical testing of materials, a bay for testing complete vehicles and another for the simultaneous testing of as many as eight engines. Beyond a car park there is a further building containing the stores, workshop and another bay where several independent researches can be undertaken. The premises are now being fitted out, and it is hoped that they will be opened in the early spring. Most of the investigations sponsored by the institution have been carried out at the Chiswick laboratories, which consist of a large private house with a workshop at the rear. These premises have served their purpose well, but it became obvious during the past year that a move would have to be made to more modern premises. The rapid development of the institution's research activities is illustrated by the fact that four years ago there was only one item on the program of research, whereas now there are ten. During the same period the number of manufactures and vehicle operators affiliated to the institution has increased from 28 to 180.

DISCUSSION

SIGNIFICANT FIGURES IN STATISTICAL CONSTANTS

PROFESSOR JOSEPH BERKSON'S discussion, under the above heading, in the November 13 number of SCIENCE pertains to a subject with respect to which there has been a great deal of misunderstanding. More than twenty years ago, however, I published a paper (in the *American Mathematical Monthly*, 1913, vol. 20, p. 242) in which I explained in detail the reason for the properties of the solutions of linear equations which Professor Berkson notes. Since my paper is not now readily accessible to many who may be interested in the subject, I will repeat its conclusions, without entering into proofs.

In order to make my statements as concrete as possible, I will relate them to the linear equations

$$a_1x + b_1y + c_1z = n_1,$$
$$a_2x + b_2y + c_2z = n_2,$$
$$a_3x + b_3y + c_3z = n_3,$$

in which a_1, b_1, . . . etc., and n_1, n_2, and n_3 are given numbers, and from which x, y and z are to be determined. In practical problems the coefficients a_1, b_1, . . . etc., and the right members n_1, n_2 and n_3 will be known approximately; that is, to some number of significant figures. For the purpose of illustration here, it will be assumed that they are all given to six significant figures.

There are two questions to be answered: (1) Are x, y and z determined by the equations, and if so, (2) to how many significant figures? The answer to the first question is given in every algebra. It is: The equations have a solution, and only one, for x, y and z if the determinant of the coefficients a_1, b_1, . . . etc., is not zero. (If the determinant is zero, at least one of the quantities x, y, z may be assigned an arbitrary finite value.)

The answer to the second question is that the number of significant figures in the solution for x, y, z can not exceed the number of significant figures in the determinant of the coefficients a_1, b_1, . . . ,but usually equals the number of significant figures in the determinant. To illustrate, suppose the determinant of the coefficients of the given equations has only three determined significant figures. Then, although the coefficients a_1, b_1, . . . and the right members n_1, n_2, n_3 are all given to six significant figures, the values of x, y and z are not determined by the equations beyond three significant figures, and the retaining of a large number of places in the calculations can not improve the results.

Perhaps it is advisable to make a few comments on

the determinant of the coefficients. It is a sum of six products, each of three of the coefficients, of which $a_1b_2c_3$ is one. Since by hypothesis each of the coefficients is given to six significant figures, the product is determined to six significant figures (and possibly one or two more when the product of the leftmost digits of a_1, b_2 and c_3 exceeds 9 or 99). Although each of the six products is determined to six significant figures, their sum may be determined only to a smaller number of significant figures. For example, suppose the six products are .346215, −.178243, −824171, .129572, .238847, .287416. The sum of these six numbers is −.000364, which is the value of the determinant so far as it can be determined. In this case, x, y and z are not determined by the equations beyond three significant figures.

Professor Berkson states that in certain cases he has found it necessary to retain many places in his calculations in order that his solution, as found, may have as many significant figures as his original equations. By whatever steps he may have carried out his calculations, in all such cases the determinant of his equations contained fewer significant figures than the given constants of his original equations. His results beyond the number of significant figures in the determinant of his original equations were wholly illusory, and much of his laborious calculation, which might easily have been ten times as costly as they would have been under an adequate theory, was wasted.

As has been stated, the solution of the foregoing equations, under the conditions assumed, is determinate only to three significant figures. But by such calculations as Professor Berkson has used, values of x, y and z to six places can be obtained. The extra three figures, however, have no real significance, for other solutions differing in the last three places and exactly satisfying the equations to six figures can also be obtained. All this was illustrated by numerical examples in the paper to which reference has been made.

For the sake of completeness it should be stated that the conditions which are being discussed in the case of simple linear equations occur also in the case of simultaneous equations of any degree or character. This more general problem was encountered, discussed and illustrated in a paper on the theory of the determination of orbits which I published in the *Astronomical Journal* in 1914. In that paper it was shown by numerical illustrations that the elements of the orbits of comets are sometimes given to hundreds of seconds of arc, when other values of the elements differing from them by minutes of arc also satisfy the observations exactly.

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HYDROGEN AND CARBON DIOXIDE PHOTOASSIMILATION IN PURPLE BACTERIA

THE uptake of hydrogen together with carbon dioxide under the influence of light by suspensions of purple bacteria (van Niel)[1] was discovered by Roelofsen[2] and further investigated by Gaffron.[3] In spite of the fact that the over-all reaction is slightly exothermic we find that the process is similar to green plant photosynthesis, the quantum yield of which was measured by Warburg and Negelein,[4] in that both processes take about four quanta of light for the reduction of one carbon dioxide molecule.

Measurements of gas pressure changes were made in a mixture of 5 per cent. CO_2 in H_2 over thin suspensions of *Streptococcus varians* in 0.05 M $KHCO_3$ in tap water, irradiated with known intensities of near infra-red light of wave-length 852 with 894 mu from an Osram caesium tube. Separate measurements with the same suspensions gave the fraction of the incident light absorbed by the active photosensitizing pigment, thus allowing the calculation of quantum yields from the measured intensities and pressure changes.

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LENGTH OF LIFE OF A RABBIT

ASSUMING that the length of life of a domestic rabbit might be of interest to biologists, I submit the following case, which I think might establish a record.

The first week in December, 1926, I took a month-old brown and white female rabbit from the Biology Building, University of Wisconsin, to my home. I put the rabbit in a room in the cellar which was dimly lighted by a small window. The rabbit's activity was limited to a floor space ten by twelve feet. The rabbit ate fresh vegetables of all kinds, toast, a handful of shelled peanuts each day and drank water freely. A bale of alfalfa, which was kept in the room to supplement the above feedings, was consumed each year.

Under these conditions the rabbit lived an active life until she died in February, 1936. Death was preceded by a two weeks period of inactivity due to a stiffening of the hind legs. The span of life was ten years and three months.

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[1] C. B. van Niel, *Cold Spring Harbor Symp.*, 3: 138, 1935.

[2] P. A. Roelofsen, Thesis, Utrecht. "On Photosynthesis of the Athiorhodaceae," 1935.

[3] Hans Gaffron, *Biochem. Z.*, 275: 301, 1935.

[4] Otto Warburg and Erwin Negelein, *Z. f. Phys. Chem.*, 106: 191, 1923.