components ψ_1, ψ_2, ψ_3, ψ_4. The components are functions of the coordinates just as the ϕ's and g's were, but when the coordinate system and the gauge frame are given, the components of the spinor are not fully determined. You can take a new set of components $\overline{\psi}_1$, $\overline{\psi}_2$, $\overline{\psi}_3$, $\overline{\psi}_4$, which will serve equally well as a set of components of this spinor. The new components are given by means of linear formulas in terms of the old components.

$$\overline{\psi}_1 = T^1_1\psi_1 + T^2_1\psi_2 + T^3_1\psi_3 + T^4_1\psi_4;$$

and three other formulas which look like this one. The coefficients T are arbitrary functions. A linear transformation of this sort is called a spin transformation.

When you have given your coordinates and your gauge, there is still something free, which we will call the spin frame, and we are unable to describe our physical object until the spin frame is fixed. We have to state everything that we say about a spinor so that it will be true no matter what spin transformation is applied to the components. A spin transformation is very analogous to a coordinate transformation, but it takes place completely independently of the coordinate transformation.

This is the simplest example of a spinor. There are spinors with 16 components or in general with 4^k components and you will have linear formulas which give you the other possible sets of components in the same coordinate system.

I have not yet mentioned one of the important facts about spinors which give them their significance. Their components are not ordinary numbers. They are complex numbers of the form

$$a + \sqrt{-1}\, b$$

where a and b are real numbers. In this respect they are like other physical objects which appear in quantum theory. There have been cases in physics before where the complex numbers were used as a convenient device but here they come in an essential way.

The additional degrees of complication which appear in the definition of a spinor correspond to the nature of the physical problem which it is designed to meet. Ordinary vectors and tensors would be well enough adapted to tell where an electron is, in what direction it is going, and what its angular momentum is. But the quantum theory states the problem differently. It does not ask directly what these quantities are but rather, what are the probabilities that these quantities shall take on preassigned values. To meet this requirement, it is not the components of the spinors themselves which are interpreted in terms of physical measurements, but certain combinations of these components with their complex conjugates. These combinations of components of spinors are components of ordinary tensors and are interpreted as probabilities that the electron will be in a certain place moving in a certain way.

Let us now repeat the description of a spinor in a few words. A spinor is a physical object which has components which are complex functions of the coordinates. The number of components is a power of four. A set of components is fixed only after (1) the coordinate system, (2) the gauge-frame and (3) the spin frame, are fixed. Whenever (1), (2) or (3) are changed, the components are replaced by linear combinations of themselves according to definite rules.

Suppose that you have spinors with 16 components with two indices, X_{AB}, and suppose that these spinors satisfy the condition that

$$X_{AB} = -X_{BA}, \qquad (3)$$

so that they are antisymmetric. Then the mathematicians will recognize that connected with them there is a quadratic expression

$$X_{12}X_{34} + X_{13}X_{42} + X_{14}X_{23} = 0. \qquad (4)$$

Those spinors which satisfy this relation have peculiar properties, and it is this quadratic relation which puts the spinors into connection with the fundamental tensor of the relativity theory, because the g's that we have in relativity are also the coefficients of a quadratic expression.

If you are going to describe some particular physical phenomena such as those described by the relativistic theory of the spinning electron, you must pick out one or more particular spinors which embody the physical phenomena in question. It turns out in this special case that you can pick spinors which set up a suitable relationship between the quadratic equation (4) above and the fundamental quadratic form which appears in the relativity theory. The general theory of spinors is the theory of all possible physical quantities of a certain sort. The theory of the electron is the theory of certain particular spinors which describe this electron.

OBITUARY

FRANK LINCOLN STEVENS

WITH the death, on August 16, of Professor F. L. Stevens botanical science has lost one of its most devoted and productive workers; and many younger botanists mourn the loss of his kindly advice and encouragement.

He was born at Syracuse, New York, on April 1, 1871, the only son of H. B. and Helen C. Stevens.

He was graduated from Hobart College with the bachelor of law degree in 1891. From Rutgers he received the B.S. degree in 1893 and M.S. in 1897. During the period from 1893 to 1897 he was instructor in science in Racine and in high schools in the state of Ohio. For two years, 1898 to 1900, he served as sanitary analyst for the Chicago Drainage Canal Commission. At the same time he studied in the graduate school of Chicago University, receiving the Ph.D. degree in 1900. He was then granted a traveling fellowship and spent a year studying at various European laboratories—with Strasburger at Bonn, with Klebs at Halle, and for some time occupied the Smithsonian Institution Table at Naples. Upon his return he was appointed instructor in biology at North Carolina State College.

His ability as a teacher was at once so evident that he was appointed professor of botany and vegetable pathology the following year. In this position he taught general botany, plant physiology, plant pathology and bacteriology. His lectures in all these subjects were scholarly and presented in a manner to catch and hold the interest of students without resorting to anecdotes or other subterfuges so common in college classrooms. Several years after he left the North Carolina State College Dr. D. H. Hill, its former president, remarked that Dr. Stevens was undoubtedly the best teacher with whom he had ever come in contact.

Even with this unusually heavy load of teaching he found time to do considerable research personally and to direct research in plant pathology and in soil bacteriology for the experiment station, developing original methods and making notable contributions in both fields.

It was during this period that I first came under the influence of Dr. Stevens's great enthusiasm for research. I immediately planned my course of study so as to spend all the time possible in his laboratories, and have enjoyed his helpful advice throughout the subsequent years.

In 1912 he was elected dean of the College of Agriculture, University of Porto Rico, where he served two years, returning to the States in 1914 as professor of plant pathology at the University of Illinois, where he remained until the time of his death, exactly 20 years.

While in Porto Rico he became interested in tropical fungi, especially in the Meliolineae, and some of his most notable contributions have resulted from studies in this group of fungi. He made several collecting trips to various tropical countries in furtherance of these studies and devoted much time to collection and study of fungi while serving as visiting professor at the University of the Philippines during 1930–31.

However, this specialized field was not sufficient to monopolize his interest and phenomenal energy. During the 20 years at Urbana he has continued research in mycology and general plant pathology. Among other notable contributions made during this period may be mentioned the classical works on the Helminthosporium footrot of wheat and on the effect of ultra-violet light upon fungi.

He published numerous professional papers in the fields of soil bacteriology, mycology, and plant pathology; and was author or joint author of several textbooks for elementary schools, including "Agriculture for Beginners," the Hill "Readers" and "Practical Arithmetic"; and was author of "Diseases of Economic Plants," "Plant Disease Fungi," and "Fungi Which Cause Plant Diseases." The last three are probably the most generally useful books on plant pathology yet presented in the English language.

Dr. Stevens was active in the organization of the American Phytopathological Society and was made president of the society in its second year, 1910. He was also a member of the Sigma Xi and Phi Beta Kappa honor societies and of several professional societies.

In 1925 he received the honorary Sc.D. degree from San Marcos University, Peru, and in 1931 the honorary LL.D. degree from the University of Glasgow.

Among his associates Dr. Stevens was often pointed out as an example of that rare combination of excellent teacher and unusual ability in research. His keen sense of right and his firm but calm and kindly spirit endeared him to all who worked with him.

B. B. HIGGINS

GEORGIA EXPERIMENT STATION

RECENT DEATHS

DR. ELMER ELLSWORTH BROWN, from 1911 until his retirement as chancellor emeritus in 1933 chancellor of New York University, previously U. S. Commissioner of Education and professor of education in the University of California, died on November 3 at the age of seventy-three years.

DR. JAMES CORNELIUS WILSON, professor emeritus of clinical medicine at Jefferson Medical College, Philadelphia, died on October 28. Dr. Wilson was eighty-eight years old.

DR. PHILIPP FISCHELIS, professor of histology, embryology and general pathology at the Temple University School of Dentistry, died on October 30. He was seventy-six years old.

COLONEL BAILEY KELLY ASHFORD, of the United States Medical Corps, known for his work on hookworm carried out under the auspices of the Puerto