point in mind, and with a negative result. In response to a query from Professor Doolittle as to the precision of the observations Professor Pickering stated from recollection that the error of a single observation might be three or four seconds, but that the hundreds of observations available brought the probable error well within the precision required.

It seems to me there is room for an honest difference of opinion as to the value of the method of least squares in a case like this, where the error of a single observation may be forty-five or more times as great as the quantity to be detected. Surely we must draw a line somewhere.

While I have given this point no extended investigation, I may formulate my own opinion, as a basis for discussion, in the form of a mathematical theorem:

The value of the measure of precision obtained by applying the method of least squares varies inversely as the ratio e/q (where $e =$ error of a single observation and $q =$ quantity to be measured), in such a manner that when $e/q = 1$ the value is zero, and for $e/q > 1$ the value is wholly imaginary.

PAUL R. HEYL

DR. BRUSH'S THEORY OF GRAVITATION

TO THE EDITOR OF SCIENCE: The article by Dr. Brush on "A Kinetic Theory of Gravitation" in SCIENCE of March 10, will become of great interest to physicists when the author does what he partly promises to do in a future paper, viz., explains how a body which is perfectly transparent to a given radiation can shield another body from that radiation, and why, if the other body is also perfectly transparent, it makes any difference whether it is shielded from the radiation or not. It would appear to be immaterial, so far as the effect upon the body is concerned, whether the atoms of a body through which this radiation is streaming in all directions are "buffeted about in every direction by the ether waves in which they are entangled" or whether they remain undisturbed by these waves, so long as they do not absorb any energy from the radiation.

Dr. Brush says that in the former case, "Each atom or molecule may be regarded as a center of activity due to its kinetic energy of translation, with continual absorption and restitution of the ether's energy normally equal in amount." This seems to the present writer equivalent to saying that a perfectly transparent body may be regarded as one in which the atoms are continually absorbing and radiating equal quantities of the same kind of energy. If anything can be gained by making such an assumption, there seems to be no objection to making it, and I, for one, shall look forward with interest to Dr. Brush's explanation of how it will enable such a transparent body to cast a shadow.

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SCIENTIFIC BOOKS

Soil Fertility and Permanent Agriculture. By CYRIL G. HOPKINS, University of Illinois. Pp. xxiii + 653; 14 illustrations, 3 colored maps. Boston, New York and London, Ginn & Co. Price $2.50.

Of this work the author says: "The chief purpose of this volume is to bring together in convenient form the world's most essential facts, gathered from the field and laboratory, and to develop from them some foundation principles of permanent agriculture." The book is a notable contribution to the foundations of practical agriculture, treated in an introduction and four parts, I., Science and Soil; II., Systems of Permanent Agriculture; III., Soil Investigations by Culture Experiments; IV., Various Fertility Factors.

The method of treatment adopted is admirable but not that usually chosen by writers on either soil or agricultural chemistry. The book takes a distinct place in agricultural literature and will be found a mine of information and valuable reference to the subjects it treats. Professor Hopkins holds persistently throughout the volume to the thesis named in the title and does not aim to treat in detail a wide range of topics, but has built his treatment upon a broad, most substantial

foundation of germane data, thoroughly and logically cemented. The 121 tables of foundation data are mostly the results of well conceived, long continued, carefully measured and verified experiments, executed both in Europe and in this country. They are not only put into effectively illuminating form by the author and discussed, for his purpose, with good discrimination, but they will be found most valuable references for many other purposes.

Some will question the wisdom of recalculating the data of some of these tables on the basis of the elements but there can be no doubt that this method serves much better for comparative study, and had earlier investigators adopted the plan no serious criticism would be urged. We feel that the author should have gone a step farther and expressed all results on the basis of weight, and of dry weight, wherever possible. The amounts of plant food elements and of water removed from the soil by a bushel of potatoes, oats and wheat have no proper comparative relation, as they do when expressed on the basis of dry substance.

Within the last few years there has been such a pronounced growth of public appreciation regarding the importance of the maintenance of soil productivity that plant physiologists, pathologists and geologists, with others, are following the lead of bacteriologists in efforts to see if in their fields there may not exist relations which will enable their observations to shed important light on the complex problems involved. This is progress along hopeful lines and such investigators may feel that the volume before us does not give sufficient prominence to these newer lines of research. But as Professor Hopkins has written for the educated farmer, and from the standpoint of every-day field practise, he has wisely chosen not to obscure that which has been proven by prolonged careful research, checked by practical experience, with the presentation of theories suggesting practises not yet tried, which may or may not prove helpful.

Ten chapters are devoted to science and soil, in which fundamental facts and principles are stated, followed by presentations regarding plant food elements and compounds; plant food and the earth's crust as an original source; and soil formations and classifications, two maps being given, one for Illinois and the other for the United States. The composition of soils in general is treated, followed by that of soils of eastern, central, northern, southern and western United States, expressing the results in amounts contained in two million pounds of dry surface soil, or approximately that contained in an acre to the usual depth of plowing. Ten residual soils of Maryland are shown to carry 720 to 1,500 pounds of phosphorus, while the Illinois soils range between 810 and 2,030 pounds per two million pounds of dry soil. These amounts Professor Hopkins considers would be removed by approximate maximum crops in a rotation of wheat, corn, oats and clover in from 37 to 105 years; or if only the grain is sold, in from 68 to 192 years.

It is highly probable that no normal soil can experience the withdrawal of any considerable proportion of its phosphorus without suffering material reduction in producing power, and if so, even if it be true that the phosphorus in the second, third and fourth feet participates equally and continuously in crop production, permanent agriculture with undiminished yields must be impossible except through restoration in some manner. Professor Hopkins considers that usually there is no natural process of restoration sufficient to maintain high yields, and closes the first part, only after considering crop requirements for nitrogen, phosphorus and potassium, together with sources of plant food, thus providing quantitative data for the discussion of systems of permanent agriculture, treated in seven chapters.

In introducing the subject he says:

> For practically all of the normal soils of the United States, and especially for those of the central states, there are only three constituents that must be supplied in order to adopt systems of farming that, if continued, will increase, or at least permanently maintain, the productive power of soil. These are *limestone, phosphorus* and *organic matter*. The limestone must be used to

correct acidity where it now exists or where it may develop. The phosphorus is needed solely for its plant food value. The supply of organic matter must be renewed to provide nitrogen from its decomposition and to make available the potassium and other essential elements contained in the soil in abundance, as well as to liberate phosphorus from the raw mineral phosphate naturally contained in or applied to the soil.

It should be said here that throughout the work Professor Hopkins is concerned only with general farming, not with intensive agriculture where other fertilizers can be used with profit and must be if largest results are secured.

Chapters are given to the discussion of limestone, of phosphorus and of organic matter and nitrogen, as to their function, quantitative needs and maintenance. Then follow chapters on rotation systems for grain farming, live stock farming, the use of phosphorus in different forms and finally theories concerning soil fertility. The subject-matter of these chapters is of the greatest importance; the views presented are in the main fundamentally sound; they are well presented, and must have a very important influence in advancing agriculture in the United States.

Part III. contains an admirable digest of the more important field experiments bearing upon permanent agriculture, conducted at Rothamsted, England; in Pennsylvania, Ohio, Illinois, Minnesota, in the south and in Canada, pointing out their bearing upon the views expressed in the preceding sections.

Professor Hopkins has succeeded in producing a worthy companion volume to Hilgard's great work "Soils."

F. H. KING

MADISON, WIS.,
May 16, 1911

The Ice Age in North America and its Bearing upon the Antiquity of Man. By G. FREDERICK WRIGHT. Fifth edition, revised and enlarged. Pp. 800. 200 illustrations. 8vo, cloth.

The popularity of Wright's "Ice Age" is sufficiently attested by the fact that the fifth edition is now published under date of December 22, 1910, enlarged and embellished with many new and interesting illustrations.

The value of Professor Wright's work consists principally in the illustrations and descriptions he gives of glacial phenomena not only in North America, but in other portions of the world. The main criticism of this work, which has many good features, is that its author is too credulous, and has thus permitted many exploded "chestnuts" like the "Calaveras Skull," the "Lansing Skeleton" and the "Nampa Image" to find in him a defender of their antiquity. This tendency of Professor Wright is unfortunate, since it of itself throws doubt upon his power of critical discrimination in analyzing evidence pro and con in matters of geologic controversy. It is possible that Professor Wright's theological beliefs have unconsciously biased his judgment in matters pertaining to the age of the earth, and to the date of the glacial epoch. In spite of these defects, however, Professor Wright's "Ice Age in North America" will prove a useful work in enlisting popular attention, and study of these most interesting phenomena connected with the Pleistocene glaciation.

I. C. WHITE

SPECIAL ARTICLES

A SCALE FOR MEASURING THE MERIT OF ENGLISH WRITING

ONE inch may be said to be equal to another inch from any one of three lines of evidence. If the two are compared by a hundred experts, (1) the experts will all report the two as indistinguishable; or (2) if some of them do, by microscope, micrometer or the like, find a difference of a trifle plus or minus, the number finding the first inch plus will equal the number finding it minus; or (3) if each man is forced to report a difference, half will find the first inch plus and half minus.

One specimen of English writing may be said to be equal to another from the second or third lines of argument, the only logical difference between equating the two lengths and equating the two specimens of writing being that the variability of expert judges in the