mously in 1596, contained tables to ten decimal places of the natural trigonometric functions at intervals of ten seconds. This was surpassed in 1613 by the tables in the "Thesaurus Mathematicus," which were based by Pitiscus upon unpublished tables computed by Rheticus, and gave the values of the natural functions to fifteen decimal places.

Soon after the appearance of these extensive tables the public began to realize the great advantages of logarithmic computation. The "Trigonometria Britannica" by Briggs and the "Trigonometria artificialis" by Vlacq appeared in 1633, and served as sources for numerous briefer logarithmic tables of trigonometric functions. For about three hundred years it appeared as if the greater part of the labor put on the natural function tables had been wasted. In recent years calculating machines have to a considerable extent replaced logarithmic tables, and have brought the natural function tables into more prominent use; thus furnishing another instance of unforeseen usefulness of mathematical lore.

In 1897 W. Jordan published a table of the natural trigonometric functions to seven decimal places, basing his work upon the "Opus Palatinum." To-day we have before us this work by E. Gifford based on the tables of Rheticus and aiming to facilitate the use of these tables by computing the values of the natural functions from second to second by interpolation. In view of the recent refinement in observation seven place tables do not always secure sufficient accuracy. Hence the present tables are computed to eight decimals.

One of the most important elements in such tables is accuracy. As the main tables of Rheticus have been improved by successive computers it would appear that serious inaccuracies in such tables as the present could easily be avoided. The author of the present table does not inform us as regards his precautionary measures except that "the sines to 1″ were interpolated by the Thomas calculating machine from Rheticus's figures for 10″, each being copied to 10 places and obvious mistakes corrected so that the differences run in descending series." It is a somewhat curious fact that at the top of the first page of the table we find cosine 1 in place of cosine 90°.

G. A. MILLER
UNIVERSITY OF ILLINOIS

Zur Frage der Entstehung maligner Tumoren. By TH. BOVERI. Jena, Gustav Fischer. 1914. 64 pages.

The eminent position held by Professor Boveri in the field of cytology, if for no other reason, entitles him to a careful hearing in any allied field of research, and the present highly suggestive hypothesis as to the origin of malignant tumors is by no means inappropriate from him since the tumor problems in their last analysis are cell problems. The medical man will probably pay little attention to this theory because it offers no practical solution of the cancer problems. Medical men interested in the theories as to the causation of cancer, and especially those who follow von Hansemann, however, will find in Boveri's hypothesis a most interesting and suggestive *modus operandi* for their favorite theory.

In any hypothesis of cancer origin the difficulty to be overcome is the phenomenon of unrestricted cell division of the malignant cancer cells. This is the crux of the whole matter and it is here that every current hypothesis of cancer origin falls down, but in Boveri's hypothesis this point is met.

The theory rests upon a number of assumptions, some of which are supported by experimental evidence, some are purely conjectural. We may briefly summarize these assumptions as follows: First, the chromosomes are qualitatively different and a certain number and assortment of them are necessary for normal balanced activities of the cell; second, abnormal mitosis in the form of multipolar spindle formation, leads to unequal distribution of the chromosomes in the resulting cells; third, lost chromosomes are never replaced and the abnormal cell, if it divides further, must give rise to similar abnormal cells; fourth, such an abnormal cell with its chromosome complex has a different set of interactions with the surrounding tissues

and with the organism as a whole, than does the normal tissue cell (or, as an alternative assumption, there may be in the nucleus special division-forcing or division-preventing chromosomes); fifth, a malignant cancer cell is one having an abnormal chromosome complex which continually reacts to a division stimulus from the surroundings, or in which the division-preventing chromosomes are absent, or in which possible division-forcing chromosomes are present in multiple number; sixth, the malignant tumor always arises from one single cell; seventh, this primordial cancer cell arises by abnormal division of an otherwise normal tissue cell and may start from any one of a large number of different causes.

Of these assumptions the first, second and third are supported by experimental evidence; the fourth may be accepted as a corollary from the experimental evidence. The remainder, while based upon the experimental evidence, are not supported by direct evidence.

The experimental evidence is based upon the well-known work by Boveri himself on dispermic eggs of the sea-urchin in which, through multipolar spindles, the chromosomes are irregularly distributed in the four resulting cells. Such four-cell stages, submitted to the action of Herbst's decalcified sea water, separate and develop on immersion in normal sea water. The variety of irregular and abnormal larvæ resulting from this treatment indicate the qualitative differences of the chromosomes and the need of a balanced chromosome complex. Further experimental evidence of the qualitative difference of chromosomes is furnished by the modern work in cytology and in experimental breeding, especially in connection with the sex chromosome. Observations and experiment have led to the general acceptance of the theory of the individuality of the chromosomes and of the conclusion that a chromosome, once lost, can not be replaced or regenerated from other chromosomes.

That single chromosomes of tissue cells of vertebrates represent different activities in the cell is the basic assumption in Boveri's cancer theory. In his earlier experimental work he showed that some chromosomes might be absent without causing ill effects on the further activity of the cell, while the loss of others would be shown by pathological effects on future structures and activities. If the same principle holds for tissue cells, an abnormal mitosis might give rise to cells with an unequal distribution of chromosomes, and such cells might have a chromosome complex which would permit the ordinary, controlled activities of the cells of that particular tissue, and the result would be relatively harmless; or, one of such cells might have an abnormal chromosome complex in which the controlling factors of division are either absent or overbalanced and unlimited growth and division would result. Not every abnormal mitosis in normal tissue cells would thus lead to tumor formation but only such as have the abnormal chromosome complex which represents an uncontrolled growth and division energy. His theory thus demands that a given cancer arises from one original cancer-producing cell which transmits its chromosome complex and its abnormal peculiarities to all of its daughter cells and so gives to the cancer, as a whole, its peculiar cellular characteristics. The theory has nothing to do with abnormal mitoses in the cancer cells themselves; such abnormal mitoses tend to break up the peculiar and malignant chromosome complex and to render the progeny of such cells harmless. In a sense therefore, abnormal mitoses in cancer might be indicative of spontaneous healing, although by the theory it is equally possible that a new and more malignant type of cancer might be started.

The cause of a malignant tumor, according to this hypothesis, thus may be anything which induces abnormal mitoses; for example, chronic irritation sets up regenerative processes and continues to act during the mitotic processes involved in this regeneration. One or several mitotic figures might be broken up by such irritation thus giving rise to unequal distribution of chromosomes in the resulting cells, some or one of which might have the chromosome complex necessary for continued

proliferation, abnormal inter-actions, and to cancer formation.

The abnormal activities of cancer cells, together with the products of necrosis present in every cancer, may induce cell division and the formation of cells with the right chromosome complex for cancer origin, in neighboring tissues, and so start up secondary or tertiary growths from the primary, thus giving rise to the phenomenon occasionally met with in transplanted tumors of change in type, carcinoma into sarcoma, for example, as Bashford has found.

The varying frequency of cancer in different organs or tissues depends, according to this theory, upon the frequency of mitotic divisions in the normal tissues; the age incidence of cancer, upon the abnormal divisions which accompany physiologically weakened cells, as in the case of protozoa in "depression" periods.

In his treatment of the theory Boveri gives its application to most of the well-known phenomena met with in cancer growth, and meets some of the arguments which have been brought against it. From the nature of the case the theory is difficult if not impossible to analyze by direct experiment, and for this reason, as well as for its impracticability, it is probable that the hypothesis will not be favorably received by the medical profession.

GARY N. CALKINS

COLUMBIA UNIVERSITY,
DEPARTMENT OF ZOOLOGY

A Text-book of Geology, for use in mining schools, colleges and secondary schools. By JAMES PARK, Professor of Mining in the University of Otago, New Zealand. London, Charles Griffin & Co. 1914. 8vo. Pp. xvi + 598, Figs. 263, Pls. 70.

Professor Park has already become well-known to teachers and students of geology in America by his writings upon mining geology. His cosmopolitan attitude and broad sympathies are attested in the present text-book by a frontispiece from the Grand Canyon of the Colorado, and by acknowledgments, in his preface, to the director of the U. S. Geological Survey for aid kindly extended. A reader on this side of the world would naturally anticipate a text-book specially prepared for Australasia, but one is pleasantly surprised to find that the anticipations are not borne out by the facts. European and American geological sections and remains of life are discussed with the same fulness as Australasian. One can not help wishing that for readers on this side of the world a little more emphasis had been laid on the latter.

Professor Park's text-book is of about the same size and scope as Scott's "Introduction to Geology," or LeConte's "Elements." It will furnish the material, along with laboratory study and suitable field trips, for one year's work in a college or scientific school. It impresses the reviewer as too advanced for secondary schools, despite its title.

There are, of course, several lines along which the subject of geology may be attacked or expounded. Broad, general processes such as erosion and deposition, elevation and subsidence, may be set forth in advance of the handling and learning of minerals and rocks. Or the teacher, as seems best to the writer, may begin with actual rocks and discuss these first; passing later to their large forms and their erosion, disturbance and order in time. A third start is possible if one considers the earth in its astronomical relations and later comes down to the terrestrial details. Professor Park begins with a summary of the science in all its bearings, and in his first chapter outlines the general astronomical relations, history, structure and the play of modifying processes. The chapter closes with seventeen summarizing propositions. Chapter II. in two pages blocks out the subdivisions of the subject and briefly reviews the teachings of several of its founders. Passing then to denudation and the destructive and constructive effects of streams, oceans, and the resulting general rock structures, nine chapters, or about one third the work, are utilized before the rock-forming minerals and the rocks themselves are specifically taken up. One may question if it would not be clearer to a student if the rock-making minerals and the rocks themselves, as formed of them, could