A if, for some idealized reference particle P, the two events may be regarded as happening at P, the event B happening after A at the particle. Evidently the notion of *after* so defined is more fundamental in character than that based on the classical concept of absolute simultaneity.

Robb's development culminates in the proof of the quantitative formulas basic in the analytic geometry of the space-time.

The alternative type of approach is that associated with the name of the great mathematician, Riemann. Here we proceed inversely from the quantitative to the qualitative, in the following manner. Between any pair of points (events) is assumed a relationship called *interval.* The numerical intervals s between all possible pairs of points may be thought of as given in an (infinite) double entry table. Now it happens that this complete table may be condensed in a single formula, namely,

$$s^2 = (t_2 - t_1)^2 - (x_2 - x_1)^2 - (y_2 - y_1)^2 - (z_2 - z_1)^2$$

where (t_1, x_1, y_1, z_1) and (t_2, x_2, y_2, z_2) are to be thought of as mere labels attached to the points. Geometric facts consist of all those properties ultimately expressible in terms of points and intervals only.

This second Riemannian mode of approach is very much more brief and direct than the Euclidian approach adapted by Robb. In a day when the quantity of mathematical material to be absorbed has become of enormous extent, one can scarcely afford the time necessary to follow the logical sequence of Euclidian ideas set up by Robb when a much deeper understanding is available in this alternative simpler way. Yet the task performed by Robb is well worth doing, inasmuch as the kind of space-time which he treats is so basic in physical theory that it should be treated from different points of view. However, physicists and mathematicians who know the elements of ordinary geometry and possess a slight acquaintance with the physical facts underlying the special theory of relativity will continue to hold firmly to the Riemannian point of view, if only for reasons of intellectual economy.

GEORGE D. BIRKHOFF

THE SCIENCE OF THE EARTH

Down to Earth. By CAREY CRONEIS and WILLIAM C. KRUMBEIN. 501 pp., many ill. University of Chicago Press. $3.75.

THIS is a new-style text-book intended primarily for use in the "New Plan" for instruction at the University of Chicago. It is, however, eminently suitable for any introductory course in geology in any institution. Incidentally, it is also nicely adapted for the general reader who wants to be pleasantly introduced to the science of the earth.

The break with tradition reveals itself most conspicuously in the format of the volume. The large bold type, wide spacing of lines and paragraphs, the liberal use of black-face type and larger type for the initial words of paragraphs, the poetical quotations which embellish most chapters and the simplified diagrams and cartoons, ultra-modern in conception, leave nothing of the stodgy appearance of the classical treatise on a recondite subject. The authors and publisher have recklessly opened themselves wide to the charge that they have succumbed to the lure of the age of jazz and are trying to give to science a popular swing. The charge will doubtless be hurled, but in the reviewer's opinion, it will be entirely muffled by the paeans of rejoicing which their book will also evoke.

The departure from traditional style is also apparent in the text itself—more so in the first than in the second half of the book. There is a studied effort "to enliven the subject without in any sense writing it down." Although the authors have not approached their topic in any spirit of levity, they are witty or facetious on every possible occasion, and occasionally they make use even of slang. The flavor of their writing is well illustrated by many of the chapter headings. "Second-rate Planet" covers the description of the size, shape and density of the earth. "The Tooth of Time" is the title of the chapter on rock weathering. "End of the Line" is the camouflage for an essay on stream deposits. "What Price Continents" intrigues the reader to the consideration of crustal warping which renews the altitude of lands above seas. "Vulcan's Chimneys" refers, of course, to volcanoes. "Universal Cemetery" is the heading of the chapter on fossils and fossilization. "Gargantuan Calendar" introduces the geologic time scale. "Invertebrate Heyday" reveals the record of invertebrate life in early Paleozoic time. "Crossing the Strand" describes the ascent of air-breathing quadrupeds from their piscine progenitors. "Megalomania" is the heading for the chapter on dinosaurs, and "Money and Politics" is a ten-page review of the economic aspects of geology.

Beneath this lightness of touch there is, however, plenty of good solid geology. The customary topics of a college course in "introductory geology" are all here and for the most part are treated in the usual sequence—the materials of the earth, processes which alter the surface of the earth, history of the earth and its inhabitants through geologic time. Not all the problems of geology are solved; indeed, the reader will inevitably gain the correct point of view "that the science of geology is a living, changing, growing one."

The treatment of illustrative material is especially

notable. Hundreds of "thumb-nail sketches," diagrammatic representations of geologic phenomena and humorous drawings adorn the pages of text. These are from the facile and ofttimes facetious pen of Chichi Lasley and help greatly to clarify ideas and maintain interest. Photographic illustrations have been chosen with great care. Almost all are new pictures not previously used in text-books of geology. Many are photographs taken from the air, a point of view which is particularly illuminating in any study of the face of the earth.

The photographs are all assembled on 64 rotogravure plates, four to six pictures per plate, grouped in four fascicles of 16 pages each, distributed at roughly equal intervals throughout the book. This grouping of the pictures was, of course, dictated by the mechanics of press room and bindery, but the authors have done more than bravely bow to the inevitable. "Each group contains the plates that illustrate the chapters immediately preceding or following it. The individual plates illustrate or elaborate on certain concepts presented in the chapters to which they are referred, but they have been designed to tell their own stories. They may be studied, therefore, as a group when the rotogravure sections are reached in the text, or they may be consulted in connection with each chapter. . . . It is hoped that this type of organization will enhance the usefulness of the book by making available for comparative study, in appropriate groups, the photographs on related subjects that commonly are widely scattered throughout a text."

This is a book which will arouse strong sentiments of approval or disapproval. It will either be greatly liked or energetically disliked; no one who appraises it can remain lukewarm. Its success as a teaching tool can only be ascertained by practical experience with it. Certainly, the experiment is well worth trying and in the opinion of the reviewer the chances are excellent that it will prove to be an unusually satisfactory piece of equipment for the modern classroom.

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SPECIAL ARTICLES

PROPAGATION OF RABIES VIRUS IN TISSUE CULTURE AND THE SUCCESSFUL USE OF CULTURE VIRUS AS AN ANTIRABIC VACCINE

RABIES virus is being propagated in tissue culture. The culture virus, when used as a vaccine, protects mice adequately against "street rabies" virus.

The cultivation of rabies virus is carried out in the following manner. Using aseptic technique throughout, 50 cc Erlenmeyer flasks are prepared with 4 cc of Tyrode solution containing 10 per cent. normal monkey serum plus 0.02 cc of a thick suspension of minced mouse embryo brain. This flask culture medium is then inoculated with 1 cc of a 1 to 100 dilution of the brain of a mouse prostrate on the 7th or 8th day following an intracerebral injection of rabies virus. At 3 to 4 day intervals, the contents of the flask is withdrawn to a centrifuge tube, allowed to settle, and 1 cc of the relatively clear supernatant is transferred to a second culture flask. This passage technique is repeated routinely and the virulence of the culture virus is titrated by inoculating the material intracerebrally in tenfold dilutions in Swiss mice.

Skunk strain 3, following 7 mouse passages, has now been carried through 16 serial subcultures, and when inoculated into mice has been uniformly fatal through the 10^{-2} and for the most part, the 10^{-3} dilutions. If the virus were merely surviving, the repeated dilution would have eliminated it at the transfer to the 6th subculture. Its persistence and titre indicate that it is actually multiplying in the tissue medium. Dog strain 1, following 88 mouse passages, has likewise been successfully cultivated.

The culture virus produces typical dumb rabies in mice, following intracerebral, lingual and muscular inoculation, and is neutralized by sera from persons given Semple antirabic vaccine.

The possibilities of using tissue culture virus as an antirabic vaccine are being investigated. Rabies vaccines in current use are composed largely of animal brain or cord tissue containing virus in either a virulent or an inactive form. Nervous tissue is not only a superfluous, but a potentially dangerous vehicle which may produce paralysis following vaccination, hypersensitive reactions or secondary infections of animal origin. Until now, however, no other source of virus has been available and the brain tissue has remained inseparable from the virus.

The disadvantages accompanying the use of animal tissue as a source of virus are largely overcome by the use of culture media. The culture virus protects mice effectively against a direct brain inoculation of rabies "street" virus. A single peritoneal injection of the undiluted culture virus is innocuous and within 10 days makes the animal resistant to 100 intracerebral fatal doses of "street" virus of homologous or heterologous strains. The subcutaneous route of vaccination is not effective. The amount of active virus necessary for immunization is the same for both tissue culture