tions of glacial climate, and, on the other hand, conditions of arid climate.

Limitations to the normal geographic cycle are even more severe than these bare statements intimate. If the United States, for instance, be divided into three north and south belts of subequal size one of the divisional lines coincides with the course of the Mississippi River; and the other with the line of the Rocky Mountain front. The belts are each approximately one thousand miles in width.

In the easternmost of these belts the forces of normal landscape sculpturing are most active. The rivers at the present time are wearing down the mountains and hills towards base-level about as rapidly as is done anywhere else on the face of the globe, and about as fast as it is ever done.

In the central belt, the tract lying between the Great River and the Rocky cordillera, the streams traversing the region are far from doing normal corrasive work or of producing net results. Between the Canadian and Mexican boundaries, a distance of more than 2,000 miles, only five streams leave the Rocky Mountain front, and four of these are quite inconsiderable. They can have relatively little influence in the effort to base-level so vast a region as the Great Plains. Dust and sands from western deserts are constantly exported to this region. In fact, lying on the leeward side of the arid lands the Great Plains country is a chief area of wind-laid depositions. The continental deposits over much of the region are more than 1,000 feet thick, a fact amply attesting the prodigious extent and the unusual rapidity of their formation. This circumstance alone explains the excessively slow rate of continental denudation which the recent government stream-measurements of the Mississippi River give. The normal geographic cycle does not obtain in this region.

In the westernmost belt the general lowering and leveling effects of rivers are inappreciable. Water-work is reduced to its lowest terms. Wind is the mastering erosive agency. The geographic cycle has for its dominant element wind-scour instead of stream-corrasion.

The idea has a still broader bearing. It has world-wide application. According to the late Sir John Murray more than one fifth of the entire land surface of the globe is desert. Another one fifth and more is little affected by normal river corrasion. Still another one fifth of the land surface is, or at least was until very recent geologic times, as truly desert as is the Sahara to-day. Of all the world's land area, therefore, fully two thirds are not subject to normal stream-work; and the normal geographic cycle is without verity.

CHARLES KEYES

UGO SCHIFF

IN SCIENCE, June 30, 1916, page 922, Professor Wm. McPherson, in his obituary notice of Ugo Schiff, says:

> This recalls the fact also that Professor Baeyer's laboratory at Munich did not include any laboratory devoted to physical chemistry until 1913, when a small room was fitted up for this work.

Professor McPherson is mistaken. During a number of years before and after 1887, Krüss gave, in Baeyer's laboratory, courses of lectures and laboratory work in physical chemistry. The complete courses ran through several semesters and the experimental exercises were given in a room specially fitted. They included density determinations of solids, liquids and gases, by various methods, cryoscopic molecular weights, spectroscopic work (emission and absorption), optical rotation, etc. Probably no better courses were given anywhere, at that time, outside Ostwald's laboratory. It may well be that Krüss's premature death caused the courses to be discontinued.

J. BISHOP TINGLE

MCMASTER UNIVERSITY,
TORONTO, CANADA.

SCIENTIFIC BOOKS

The Origin of the Earth. By THOMAS CHROWDER CHAMBERLIN, head of the Department of Geology, The University of Chicago. The University of Chicago Press, 1916. Pp. x + 271. (The University of Chicago Science Series.)

This book, by the distinguished author of the planetesimal hypothesis, is one which has

long been desired by geologists as well as other scientists. The method of treatment conforms to that followed by the University of Chicago Science Series. This requires that the subject shall be presented "in as summary a manner and with as little technical detail as is consistent with sound method. These volumes will be written not only for the specialist, but for the educated layman."

The previous publications on the planetesimal hypothesis and its relations to the origin of the earth are found in articles chiefly by Chamberlin in the *Journal of Geology,* chiefly by Moulton in the *Astro-Physical Journal* and by various collaborators, mostly in publications of the Carnegie Institution; but only the specialist has pursued all of this more or less technical literature to its lairs. In addition, Moulton has given some account of the astronomic aspects of the hypothesis in his text-book of astronomy and Chamberlin and Salisbury in 1906 have given considerable space to the subject in their "Geology," especially the first eighty pages of Volume II. These are works which are not readily accessible to the educated layman. Furthermore, the present volume by going straight to its end and omitting technicalities brings the essential framework of the hypothesis into better relief and perspective than is the case in Chamberlin and Salisbury's "Geology." Published ten years after the latter, it furthermore takes advantage of the research of a later decade. There is added also an essentially new chapter on "The Juvenile Shaping of the Earth."

The form of presentation is very readable and attractive. It follows largely the intellectual trail which led the author, as he says, a specialist in glacial geology, "across the pass that leads from the land of rocks into the realm of cosmogonic bogs and fens. Its mists were already gathering over the path ahead. Strangely enough, the cold trail of the ice invasion had led by this long and devious path into the nebulous field of genesis."

All older views of the origin of the earth had grown up around the idea that the matter which constitutes the planets was a residuum left from the primal gathering in of the solar nebula. This process had been given concrete form in the nebular hypothesis of Laplace. But an examination of the stubborn facts expressed in the structure and motions of the solar system brought out dynamical inconsistencies with the terms of the nebular hypothesis. Modified forms of that hypothesis could not overcome the objections. Therefore Chamberlin was led to build up an hypothesis of earth origin from a totally different beginning. He postulated an ancestral sun already condensed and sought to derive the planetary matter and planetary energies of motion from the expulsive forces set up by the close approach and passage of another star. The result was the development of a great swarm of larger and smaller particles revolving independently but nearly in one plane in elliptic orbits about the sun. This is the basal foundation of the planetesimal hypothesis. In these respects it is in direct opposition to the Laplacian hypothesis and in considerable opposition to the meteoritic modifications from that hypothesis.

The subject is vast and the evidence on many aspects is somewhat vague. A variety of subhypotheses could be raised for comparison with those which are linked together by the author to make a consistent whole. This would lead so far afield, however, that this review will be held rather closely to a presentation of the vital points in each chapter, thus placing stress on a summary of the arguments of the ten chapters rather than on an analysis of their bases upon which they rest.

The first chapter is on the Gaseous Theory of Earth-Genesis in the Light of the Kinetic Theory of Gases. The spheroids of gravitational control of the planets are considered, the minimum radius of the earth's being about 1,000,000 kilometers. The relation of the mass of the planet to its power to retain an atmosphere is the next thesis. Beyond that zone of atmosphere which is dense enough to obey the kinetic law of gases, but within the outer limits of the spheroid of control, must lie an ultra-atmosphere divided into two zones. The lower of these is characterized by fairly free molecules driven upward from below by the impacts

of other molecules and curving back again under the pull of the earth's gravitation into the denser atmosphere. The action is like that of particles of water splashing back in a fountain or like the spray from an effervescing liquid. This attenuated zone in which the molecules describe appreciably curved paths between molecular collisions is named the Krenal atmosphere. Beyond it, but still within the spheroid of control, must lie a zone which has come to be inhabited by molecules moving in elliptic orbits in every direction about the earth and moving with considerable freedom from impact. This Chamberlin names the orbital atmosphere. He shows how the several atmospheres are related, giving and taking molecules, and how the orbital atmosphere of the earth merges into the orbital atmosphere of the sun. Following this constructive argument is a destructive argument, showing how the Laplacian hypothesis fails to meet the requirements of the nature of gases.

This is an illuminating chapter. It shows how, in sweeping up the planetesimal matter, immediate and direct impact with the body of the earth was not necessary. It will be found suggestive also in relation to the later history of the atmosphere. The moon lies far within the zone of the orbital atmosphere and gases given off by the moon during its history would thus be added to the earth rather than diffused into the outer space of the solar orbital atmosphere. As an agent for supplying CO_2 to the earth's atmosphere during times of quiescence of terrestrial igneous activity this may possibly be a factor not to be wholly ignored, though always small.

Chapter II. is on Vestiges of Cosmogonic States and Their Significance. In the structure of the solar system and in the nature of the earth is an autobiography of genesis. These are the material records, but equally if not more important, Chamberlin points out, are the dynamic records. In rotations, revolutions, and other relations are found automatic vestiges of creation; difficult to interpret, perhaps, but rigorously definite if we but understood their evidence. The dynamic vestiges in the sun are found first, in the inclination of its plane of rotation to the mean plane of the planetary orbits; second, in the enormous preponderance of mass in the sun, the enormous preponderance of moment of momentum in the planets.

Chapter III. is entitled The Decisive Testimony of Certain Vestiges of the Solar System. By these vestiges the Laplacian hypothesis is tested and found wanting. The less specific hypotheses, including that of Kant, hardly lend themselves to rigorous testing and therefore can not be regarded as working hypotheses.

The following chapter is given the name of Futile Efforts. It records the results of inquiries by the author along other lines than those of the Laplacian hypothesis. These other lines were found also to lead to unsatisfactory results, but they pointed the way to the general direction in which a successful hypothesis must probably lie. Especially they pointed to spiral nebulæ as dynamically more promising forms.

Chapter V. is entitled The Forbidden Field. The direct rotation of the planets about their axes had been thought to forbid any hypothesis which sought to integrate the planets from particles scattered in a zone and in free orbital motion about the sun. This is shown to be true however, as demonstrated by Moulton, for a system of circular orbits only. For elliptical orbits the distribution of matter in the region of growth may readily be such that the concentration into a nucleus would engender a direct rotation. This field of hypothesis is therefore no longer forbidden.

But how shall be produced such a primal state as that postulated in a slowly revolving central sun with but little moment of momentum surrounded by a small amount of orbital matter revolving nearly in a plane, dispersed over wide limits, and possessing a relatively enormous moment of momentum? This problem is taken up in Chapter VI., entitled Dynamic Encounter by Close Approach. The volume of a star represents a balance between expansional and condensational forces acting on a vast body of gaseous nature. On the approach of two stars their mutual gravitation would produce tidal forces diminishing their

self gravitative power along the line between the centers and give the expansive forces opportunity to rise to explosive violence along that line. This tidal force is actually greatest at the centers and would lead to a very deep-seated disruption. The gas bolts shot out would, owing to viscous resistances, be pulsatory, and separated nuclei would therefore be expelled. These nuclei and the associated dispersed matter would, on the nearer side, be dragged sideways after the passing star. On the reverse side the symmetrical tidal protrusions would be left behind, the sun being dragged more than they. The result would be a spiral nebula, a form which would meet the dynamic demands of the existing solar system.

In comment upon this chapter, it should be noted, however, that the innumerable spiral nebulæ of the heavens, although good illustrations of the initial form of the solar system, do not appear to be stages in a similar evolution. They are of a much greater order of magnitude, they avoid the region where the stars are clustered, are at remote stellar distances, and by their very number show a notable duration of their form. On the other hand, the postulated originally spiral form of the solar nebula would have been evanescent. Within a century from the time of origin all except the outer nuclei would have completed many revolutions about the sun. But the different periodic times of the nuclei would in a few revolutions have caused to disappear the initial spiral form. It would become wound up and further blended together owing to the high ellipticities of the constituent orbits.

Having attained this initial state, Chapter VII. deals with the Evolution of the Solar System into the Planetary System. The building up of the planets is believed to have followed three stages: first, the direct condensation of the nuclear knots of the spirals into liquid or solid cores; second, the less direct collection of the outer, or orbital and satellitesimal matter; third, the still slower gathering up of the planetesimal material scattered over the zone between adjacent planets. This third factor in Chamberlin's view is regarded as very important and he believes this diffused matter contributed much of the earth substance, very slowly and in a dust-like form. This is one of the critical points in the details of the theory, unessential to the larger framework, but upon which turns much of the development of the following argument. In earth-growth the denser planetesimal dust, Chamberlin argues, tended to be somewhat segregated into the primitive ocean basins and served to maintain in them, as the earth was built outward, a greater density than in the elevated zones between. It seems a debatable question to the reviewer if such a large proportion of the added material was necessarily dust-like and capable of being distributed by the primitive atmosphere and ocean. Upon the mean size of the incorporated units various subhypotheses of consequences may be built up. In the absence of knowledge Chamberlin's view may be accepted as the most probable, but the problem illustrates the fertile branching which is possible upon the trunk of the planetesimal hypothesis.

Chapter VIII., entitled The Juvenile Shaping of the Earth, occupies sixty-eight pages, more than twice the average length of the chapters. The earth is conceived as beginning to hold an ocean by the time it contained 30 or 40 per cent. of its present mass. From that time atmosphere and hydrosphere transported, sorted and deposited the planetesimal dust, building up the lighter material into protuberant areas, which became the continental platforms. Great importance is attached under the shaping agencies to periodical changes in the rate of rotation. Accompanying a stage of internal condensation, a corresponding speeding up of the rotation would occur and a relative subsidence of the polar areas. Surface compression in high latitudes, surface tension in the torrid zone, would accompany such an increased oblateness of form. The slow accumulation of planetesimals between stages of condensation would, on the other hand, it is thought, produce a checking of rotational velocity and the converse effects in earth-form and in earth-strains. With growth there was thus a rhythmic oscillation in strain. At times when the polar areas were in tension it is

argued that a cracking would occur, giving three yield zones which tended to be at angles of 120 degrees to each other. These radiated from the poles after the analogy of the hexagonal columnar jointing of basaltic columns due to shrinkage in cooling. These yield zones in vertical meridional planes, it is argued, would, again after the analogy of the basaltic columns, be the elevated zones and determine the larger outlines of the initial continents. There would result six great oceanic basins, counting the Mediterranean as one. These oceanic basins are conceived to be the somewhat circular bases of cones of slightly heavier material built up during earth-growth and having their apices deep in the centrosphere. By periodic settling of these heavier master segments the continental yield tracts between are squeezed up and made more protuberant.

This hypothesis of juvenile shaping is of course, like the other steps in the development of the planetesimal hypothesis, dependent upon the basal postulates. It is not clear that earth-strains due to the causes invoked could initiate such a primary segmentation, in fact calculations on the stresses which the reviewer has made to test this sub-hypothesis pointed to quite a different method of yielding. The distribution of continents and oceans does not accord very closely with it, and the evidence of isostasy does not indicate that the density differences between continents and ocean basins reach below the outer fiftieth of the earth's radius. This hypothesis of juvenile shaping should therefore be accepted with much reserve and does not appear to be as well supported as are the conclusions of the previous chapters.

Chapter IX. is on The Inner Reorganization of the Juvenile Earth. The particles of radioactive matter would tend toward local heating and fusion. Thus they would be progressively concentrated into the outer shell of the earth by the rising of igneous matter. Pulsatory stresses from body tides and from shrinkage are regarded as the chief agents leading fused matter outward and serving to maintain the earth's body in solid form.

Chapter X. is on Higher Organization in the Great Contact Horizons. This is a discussion of the conditions which it is thought favored the rise of life on the surface of the globe. The most favorable environment for this great step in protoplasmic synthesis is regarded as being in the soil layer of the land, the contact horizon of earth, water, air and sunlight. The conditions of planetesimal infall and of the lack of devouring cells would have especially favored the process during the later growth stages of the earth.

Having given this summary of the volume, some statements may be made in regard to it as a whole. It must impress every reader as a notable constructive addition to thought upon this fundamental subject. Chamberlin follows his postulates to their logical conclusion, even though this must involve the building of hypothesis upon hypothesis. He wisely considers this preferable to no attempt in the direction of complete solution. But the limits of the book and the nature of the Science Series to which it conforms preclude him from following that method of multiple working hypotheses which he had elsewhere used and the necessity for which he has urged in an article which every scientist should read.[1] This method is especially desirable where there are alternative postulates which have not been disproved. No one realizes more strongly than Chamberlin, however, the preliminary and tentative nature of many of his conclusions, owing to the nature of his postulates.[2]

Because of the submergence of the method of multiple working hypotheses, however, the lay reader and even those geologists who do not go into the literature behind the volume will be apt to obtain too narrow and rigid a conception of the limits of the planetesimal hypothesis. Each section seems so convincing upon a first reading that it may appear as if future work must be built as added stories or as finishings to the present structure; whereas the lower stories appear in fact so broad and

[1] "Studies for Students. The Method of Multiple Working Hypothesis." *Jour. Geol.*, V., 837–848 (1897).

[2] See especially pp. 171 and 223 for his comments.

well founded that there is room for alternative superstructures beside that which Chamberlin here presents.

The previous paragraph has dealt with alternative possibilities; on page 178, however, an erroneous diagram of stress-differences due to the weight of second harmonic inequalities is taken from G. H. Darwin. The original paper was published in 1882. About a year later Charles Chree pointed out an error in Darwin's procedure which led Darwin to publish a correction in 1885. The correct solution is given in Darwin's Scientific Papers, Vol. II., pp. 459–481, 1908. The erroneous diagram indicates a tidal force eight times greater at the center than at the surface. A corrected diagram would show the tidal stress at the poles, on the equator, and at the center in the ratio of one to three and eight. On the equatorial surface the stress due to either tides or to lack of adjustment between oblateness and rotation period is therefore not one eighth but is in reality three eighths of the amount at the center. The maximum stress-difference at the equator is, however, not in a vertical but is in the horizontal plane. There is doubt if tidal stresses could ever have been an effective agent in kneading liquid matter out of the earth's body, since the forces are relatively small and the *pressure gradient* due to that cause is very much smaller still. On the other hand, if the moon were much nearer the earth in primordial times the tidal stresses may have risen to an important magnitude.

But in closing we must not look at this or that detail, nor at this or that chapter. To gain a proper appreciation of the value of the investigations which are condensed in this volume we must compare the present state of thought upon the general subject with that of twenty years ago, before Chamberlin had begun to publish upon the hypotheses of earth genesis. Measured by that perspective this volume is seen to represent an advance in thought on this subject so great that the names of Chamberlin and Moulton must rank high among those scientists who have dealt constructively with that vast, vague and remote problem—the Origin of the Earth. The subject of earth genesis is now fairly on the road to scientific investigation in place of philosophic speculation. Joseph Barrell

PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES

The seventh number of volume 2 of the *Proceedings of the National Academy of Sciences* contains the following articles:

1. *On the Mobilities of Gas Ions in High Electric Fields:* Leonard B. Loeb, Ryerson Physical Laboratory, University of Chicago.

   The results, though at variance with those of most observers at low pressures for negative ions, are in good agreement with recent results of Wellisch, and likewise lead to the conclusion that the "cluster" theory is no longer tenable.

2. *The Relation of Myelin to the Loss of Water in the Mammalian Nervous System with Advancing Age:* Henry H. Donaldson, Wistar Institute of Anatomy and Biology, Philadelphia.

   There is no evidence that the cell bodies and their unsheathed axons suffer any significant loss of water; the progressive diminution in the water content of the brain and spinal cord is mainly due to the accumulation of myelin, the formation of which is a function of age, the most active production occurring during the first twentieth of the life span.

3. *Differential Mitoses in the Germ-Cell Cycle of Dineutes nigrior:* R. W. Hegner and C. P. Russell, Zoological Laboratory, University of Michigan.

   The most conspicuous difference that we have discovered between the origin of the oocyte in *Dineutes nigrior* and in *Dytiscus* is in the number of differential mitoses; in *Dineutes nigrior* there are only three whereas in *Dytiscus* there are four.

4. *Some Minerals from the Fluorite-Barite Vein near Wagon Wheel Gap, Colorado:* Esper S. Larson and Roger C. Wells, U. S. Geological Survey, Washington, D. C.

   A description of specimens of the unusual mineral gearksutite of a peculiar kaolinite and of a new fluoride-sulphate, creedite.