Cambridge, at the age of 49; and on July 6th, of Mr. James Emerson, to whom we owe a system of heating cars by steam from the engine and other inventions.

Mr. H. Harries read a paper before the Royal Meteorological Society on June 17th, on 'Arctic Hail and Thunderstorms,' in which he showed that the commonly accepted opinion that hail and thunderstorms are almost, if not quite, unknown in the Arctic regions is incorrect. He had examined 100 logs of vessels which had visited the Arctic regions, and found that out of that number no fewer than 73 showed that hail was experienced at sometime or other. Thunderstorms were not so frequent as hail, but they have been observed in seven months out of the twelve; the month of greatest frequency being August. Mr. Harries is of the opinion that the breeding place of thunderstorms in these high latitudes is in the neighborhood of Barent's Sea.

UNIVERSITY AND EDUCATIONAL NEWS.

The foundation plans for a four-story building for Barnard College were submitted to the Department of Buildings by Lamb and Rich, architects. The new building will be of brick, terra cotta and Indiana limestone. It will be erected on the new site, the block bounded by 119th and 120th streets, the Boulevard and Claremont avenue. The cost of construction is estimated at $132,000.

A lectureship in comparative psychology, under a bequest of Dr. William Anderson of the value of £350 per annum, has been established in Aberdeen University. The appointment will be made at the next meeting of the University Court.

Mr. Ernest Gardiner, recently director of the British school at Athens, has been elected to the Yates chair of archæology, University College, London, which has been vacant since the death of Reginald Stuart Poole.

Prof. Sigmund Exner has been chosen Rector of the University of Vienna for the year 1896.

Dr. F. A. Werf, nowdirector of the experimental station in Java, has been appointed professor of botany in the University of Munich in the place of Prof. Rauwenhoff, who has retired.

We learn from the *Academische Rundschau* that the first University Extension courses in Russia have been opened by professors in the University of Odessa. The numbers present at those courses having the largest attendance were as follows: anatomy 350, bacteriology 340, physics 300, zoology 280, chemistry 150, botany 150, mineralogy 130. The courses extend from the first of October to the middle of December, and from the middle of January to the end of April, the fee charged for each course for the term being only three roubles (about $1.50).

On the occasion of the recent coronation of the Czar he gave 300,000 roubles (about $150,000) for the foundation of a students' dining hall in the University of Moscow.

A building devoted to physical chemistry was dedicated at Göttingen on June 4th, the address being made by the director, Prof. Nernst.

At a meeting of the convocation of the University of London, on June 23d, Mr. Rivington was elected a member of the Senate, 963 votes being given him as compared with 846 for Sir Joseph Lister. The vote is regarded as on the whole favorable to the establishment of a teaching University of London, for, though Sir Joseph Lister, who favors the plan, was defeated by a majority of 117 votes, at the election in 1895 the candidate in favor of the plan was defeated by a majority of 498 votes.

DISCUSSION AND CORRESPONDENCE.

REMARKS ON PROF. W. S. FRANKLIN'S REVIEW AND THE NOTE SIGNED 'M.'

To the Editor of Science: In Vol. III., No. 74, of this Journal, Prof. W. S. Franklin publishes a review of my papers on Solar and Terrestrial Magnetism; in Vol. III., No. 76, a note endorsing his position, signed 'M,' is to be found. In its manner and matter Prof. Franklin's article is so unusual that it had not occurred to me to be desirable to answer it till 'M.,' after apologizing for the manner, implies that the matter is deserving attention. But, in

fact, the few points Prof. Franklin specifies are faulty to an unnecessary degree.

1. In determining the 26.68-day period of the solar rotation, Prof. Franklin insists (p. 808, cols. 1 and 2) that I used the 'aspects of the solar corona as photographed during several eclipses' for that purpose. It is true that in my earlier papers an attempt was made in this direction, but it was not employed in my final computation. On p. 712 Astron. and Astro-Physics, No. 118, Oct., 1893, it is said, "the results there published have been entirely superseded by the method which will now be described." There is no possible excuse for having thus confused my work, even spreading out the erroneous conception over an entire page of SCIENCE.

2. Prof. Franklin does not seem to know whether I used the ordinary Gaussian method of least squares in dealing with the residuals, but is inclined to think I did. As a matter of fact, I did not use that method, but avoided it as incapable of reaching the desired results; it having been demonstrated to be so by many previous investigations. My method is described on pp. 713, 714, A. and A. P., No. 118, and bears no resemblance to Gauss's process, uses the variations of the earth's magnetic field and not the visible coronal lines. It involved a large amount of labor in computation, and the details have not yet been published. In this instance as well, a confusion of mind, to such an extent, is inexcusable in a critic.

3. On p. 808 Prof. Franklin says: "At this place we interpose the remark that the position is regarded as proven that the sun and the moon do not continuously influence the terrestrial field by direct action as magnets?" This is an old view, held by students generally, I admit, but it was the very essence of my research to inquire whether it is sound or not. A critic may throw the entire case out of court by such a remark, and then proceed to abuse the author of the investigation, but it is not criticism and it is not science. The old view is based upon a very off-hand computation of magnets (Mascart & Joubert, Elect. & Mag., p. 417, Vol. I.), adduces no study of observations to test it, and in general lets the case go by default. Yet the experimental evidence is abundant that the sun does *in some way* send its energy to the earth, in peculiar periodic variations, aside from the ordinary light field. To go no deeper now, we know that the sun spots and corona, as well as the faculæ and prominences, vary in an eleven-year period; synchronously on the earth there are variations of the magnetic field, the aurora, the pressure, temperature, rainfall, the position of the storm tracks and the velocity of eastward movement; also there are two barometric periods, in the polar and equatorial belts, as yet entirely without explanation. How is this sympathetic condition to be accounted for except by solar action? I have given my explanation of what the nature of the energy is, and the experimental evidence is decidedly on the side of my statements.

My treatment of the magnetic observations has been entirely simple, following the lines of Bulletin No. 2, and the process is too obvious to need any defence. The result is to show that the earth is surrounded by two great systems of magnetic vectors (see *Astron. and Astro-Phys.*, No. 118, and *Amer. Journ. Science*, Vol. L., August, 1895). Both indicate that the earth acts like a conducting spherical shell, with its magnetization at right angles to one field and nearly parallel to the other field, the former therefore parallel to the plane of the ecliptic, and the latter at right angles to the same plane. In the *Meteorol. Zeitschrift*, September, 1895, Dr. W. van Bemmelen, in an interesting paper, finds that the large magnetic disturbances enter the earth along lines nearly orthogonal to the auroral ovals, and gives their relation to the magnetic meridians more in detail than I had done. His work confirms my result published two or three years earlier: 'Die Theorie und Ergebnisse *Bigelow's* scheinen aber ein sehr beachtenswerther Versuch, dieses ganze System zu erklären,' u. s. w., p. 327. The scientific character of my residuals, and my use of them are similar to those commonly employed in determining the diurnal, annual and secular variations of the terrestrial magnetic field, and if Prof. Franklin proposes to throw mine out he must needs accompany them with the entire subject of terrestrial magnetism. I have merely pursued my analysis into deeper conditions,

heretofore neglected by my predecessors. After the reading of the paper referred to before the Congress of Astronomy and Astro-Physics, Chicago, 1893 (No. 118, p. 746): "in the discussion Prof. H. A. Rowland expressed his belief in a magnetic condition of the sun, and remarked that he considered its effect upon terrestrial magnetism a subject well worthy of careful investigation."

Prof. Franklin should properly have attempted to show some defect in the magnetic observations themselves or in my handling of them; also he should show that some other interpretation of them can be given than the one I have offered. A very little mathematics, all well known, has been introduced at certain passages, but nothing of the kind was employed when it could have influenced the nature of the residuals. On the other hand, having obtained the residuals, it was proper to seek the corresponding mathematical solution.

4. Our reviewer now proceeds to remark on the ether fields: "The idea that vortex motion of the ether constitutes magnetic field is, as yet, mere speculative theory intensely interesting, coming from such masters as Lord Kelvin and Clerk Maxwell; supremely foolish as coming from one who, for example, uses the word 'spiral' in speaking of it, or from one who thinks a magnetic field to be a stream of energy." While I admit my intellectual debt to Thompson and Maxwell in my study of these subjects, I must also confess that it seems to me that Heaviside and Hertz are the real masters of modern electricity and magnetism, and that their duplex-law of circuitation is the fundamental principle.

For example, Heaviside summarizes his views (Electromagnetic Theory, p. 35) as follows: "The electric current is the curl of the magnetic force. The magnetic current is the negative curl of the electric force." In a word, any change in the ether stress is accompanied by an electric and a magnetic current; p. 79, "in the case of a simple progressive plane wave disturbance, in which a distribution of electric force and magnetic induction mutually perpendicular in the plane of the wave is propagated unchanged through a medium at constant speed, it is a self-evident result that the energy of the disturbance travels with it;" page 80, "the only dynamical analogue that is satisfactory in this respect is that furnished by Sir W. Thompson's rotational ether, when interpreted in a certain manner;" p. 110, "this is the pressure exerted by solar radiation;" and much more to the same effect. The essence of this view is that whatever may be predicated of the electric system can be transformed to the magnetic system by a simple interchange of words in the notation (Hertz, Waves, p. 225); and in harmony with it an ordinary steady magnetic field surrounding a uniformly magnetized sphere is in reality a dynamic system. Certainly when the magnetization varies for any cause the effect is a propagation of energy throughout the entire system till equilibrium is regained. It is true that the mechanical analogue is lacking in the relations of electricity and magnetism. Fleming (Transformer, p. 11): "The question which yet remains unanswered is, what is that action or operation along certain lines in this medium which causes a line of force to exist? The future of electric and magnetic investigation will perhaps conduct us step by step to the solution of this supremely important problem."

Prof. Franklin continues his comment as follows, p. 809: "Now the magnetic field in light and heat waves is at right angles to the ray and is reversed *in direction* millions and millions of times per second! It is to be noticed that Prof. Bigelow considers the coronal field to be a stream of energy. If such is the case it is of course not a magnetic field, but he surely so considers it and he has also determined its C.G.S." In reply to the first case, the radiant flux of energy from the sun is $W=V.EH$, vector product of electric force and magnetic induction. The rapid reversal, incident upon the passage of a magnetic wave with lag of a quadrant on the electric, makes the field equivalent to a steady field when falling upon a mass whose moment of inertia, like a common magnet, gives a much slower time of swing, and will always be so to any magnets not of atomic and molecular dimensions. The electro-magnetic field at the earth has, therefore, the effect of a uniform field surrounding a conductor, and its lines are disturbed accordingly. In answer to the second case, Heaviside says, Electrical Papers I.,

p. 441: "As the rate of increase of displacement in a non-conducting dielectric is the electric current, so the rate of increase of $\frac{B}{4\pi}$ may be called the magnetic current. Then $G = \frac{\dot{B}}{4\pi} = \frac{\mu \dot{H}}{4\pi}$. Like electric displacement currents, magnetic currents are transient only, *i. e.*, they cannot continue indefinitely in one direction, like an electric conduction current. Also, like electric currents in a dielectric, they are unaccompanied by heat generation. *In ether the electric current and magnetic current are of equal significance.*" Also p. 455: "Imagine the impressed forces to be put on suddenly. We know that a certain definite distribution of magnetic induction is set up, which is steady when the arrangement of matter is fixed. During the transient state there is magnetic current everywhere unless $\mu = 0$ somewhere, which we must believe to be impossible, since μ is very little less than unity for any known substance. Magnetic currents are wholly closed." The author then goes on to treat of energy, work, mechanical forces and the entire correlated system. The sun, if magnetized at all, is not steady; during the changes magnetic currents convey the energy to all space, and if to the earth then some of this energy is consumed in the atmosphere and substance of the earth. Among other things I claim that the time order in the eastward drift formation of the North American Highs and Lows seems to be inverted by such solar action, and that these are in part products of this magnetic field. When the sun is steady it impresses a certain C.G.S. upon the earth's lines of force, which are also given in C. G. S. units. The total force observed at any moment in an observatory is the combined magnetic H. If Prof. Franklin thinks this is absurd I claim the privilege of my own view.

My position is simply this, two different sets of *force radiations* penetrate space surrounding the sun to the distance at least of the earth, because the observations of magnetic instruments yield on computation two definite systems of vectors, one from the electro-magnetic or linear field, and the other from the magnetic or curvilinear field, and their existence finds a suitable explanation on my hypothesis of two radiations. Even if my view is wrong the vector systems yet remain to be accounted for, because the theory in no wise enters into the computation that afforded them. My expressions, flow of energy, lines of force, mean so much as modern science understands of those relations, and nothing more. If the sun is non-homogeneous in its magnetization, and rotates on an axis, if the intensity varies in part or as a whole for any cause, then at the earth there will be corresponding changes in the magnetic elements, and our observations show that this is the case. If the space between the sun and the earth is a *vacuum* as to electric and magnetic forces, my words are meaningless; if it is a *plenum* then, as 'M' admits, the importance of the results is tremendous.

5. Going for a moment aside from Prof. Franklin's article, in reply also to certain objections or difficulties sometimes raised against this magnetic action of the sun, I may remark as follows: (a). *Difficulty:* the sun is so hot that it cannot be a magnet, because a steel magnet loses its force at high temperatures. *Answer:* a steel magnet is not the true analogue to the sun, because it is an induced and not a primitive magnet; a more correct analogue is the *earth itself*, which, though very hot in its interior, yet sustains a permanent magnetic field. Consequently the primitive masses of planetary matter may be magnetic and at high temperatures simultaneously. The sun is a body of the same kind and it should be magnetic. It is important not to confuse energy with heat, which is only a form of energy in molecular relations and does not exclude high temperature magnetization as a potential energy. (b). *Difficulty:* The distance of the sun is so great as to imply an excessive expenditure of energy to reach out to the earth. *Answer:* Laboratory experiments are all conducted within the atmosphere, oxygen and nitrogen, which is a powerful damper of magnetic lines. Artificial observation must therefore be faulty unless reduced to the pure medium ether, which conducts and sustains magnetic energy *without loss by heating.* The solar magnetic force at the surface of the earth as measured gives a normal intensity of mag-

netization in the sun a little more or less than a saturated steel magnet, which does not violate the probable balance of physical forces, A. and A. P., No. 118, p. 717. (c.) *Difficulty:* 'M.' remarks, "A complicated scientific hypothesis receives its confirmation from verified prediction rather than from an analysis of methods and material." *Answer:* This is true of simple or such other processes as are fully understood; many scientific problems have not reached this stage of perfection. On the other hand my 26.68-day period meets the requirement to a remarkable degree, for the ephemeris and solar curve are found to be applicable to available data between the dates 1841 and 1896, without sliding. The same phenomenon of inversion of direct and inverse types occurs throughout this interval, and the law of inversion is distinctly related to the orbital aspects of the sun's and the earth's equators, giving a semi-annual period, that is two direct and two inverse type systems each year. The same period classifies, European magnetic forces, North American pressures and temperatures, and sun spot frequencies, in an unequivocal though loosely constructed manner; it promises the solution of the semi-annual barometric period of the arctic regions, besides the elucidation of other important terrestrial phenomena. I have found the period and curve useful in forecasting the daily maps; with a suitable magnetic outfit this efficiency will probably increase. Will 'M.' indicate any other period in solar or terrestrial physics of similar power!

6. It is perhaps unnecessary to remind your readers that these papers, which Prof. Franklin condemns, were submitted to the Board of Award of the Hodgkins Prize Fund, together with the manuscript, and, although in an unfinished state, they received *honorable mention*, being one of the four American papers reaching that standard of excellence.

At the time of the late China-Japanese War, a distinguished American diplomat had occasion to exhibit a barometer to a very eminent Chinese viceroy, and to explain among other things that it was useful in foretelling the weather and was so employed in his country. The dignitary received the information quietly, but without comment. A few weeks later the same viceroy came to the diplomat in high glee and displayed a fine, new barometer just obtained from Paris. He then declared that he was under certain vows to make a long and expensive journey to the graves of his ancestors, but that fine weather was always indispensable to a propitious result. He stated that he would *start in six months*, and, to the consternation of the diplomat, demanded to know whether the weather would be favorable for the preliminaries and for his journey. After the viceroy reluctantly became aware of the true state of the matter he dashed his barometer upon the ground in vexation.

Prof. Franklin's course in his criticism appears to have been somewhat like that of the eminent official.

The research, therefore, now stands as follows: The program and methods of computation laid down in Bulletin No. 2 have been rigidly adhered to throughout the work. The details have been inspected freely by a score of scientific men, capable of pointing out an erroneous procedure. The published results represent accurately the outcome of the computation, and no elaborate publication can change them. There is no reason for anyone to doubt the value of the scientific work, or to 'suspend judgment' till the final appearance of the work. The conceptions are simple, the results are surprising and important, and will never be brushed aside by imperfect criticism.

In spite of the usual fine phrases 'dielectric polarization' and 'displacement,' electro-static and magneto-static lines of force are a mystery, and no mechanical analogue has matched them fully. Electro-magnetic radiation is fairly well understood. What I have called magnetic radiation is not so well within our comprehension. Nevertheless observation shows that the magnetic polar field exists, and the evidence is very strong that it is in some way the bearer of energy. (1) It may be that the physical condition of the solar seat of magnetization is so very unsteady as to cause the transient magnetic currents to become, by integration, a type of real radiation; (2) it may possibly be that this solar system illustrates the *missing magnetic conduction current*, needed to complete the balance in the duplex electro-magnetic system;

(3) or it may result from the variation of the static magnetic field at the earth, that other energy derived from the electro-magnetic field is more or less readily absorbed in the atmosphere than it would otherwise be. Whatever the mechanism is, there is a synchronous dependence of terrestrial elements upon the solar energy to be accounted for in the solution of the cosmical problem.

FRANK H. BIGELOW.

WASHINGTON, D. C.

SCIENTIFIC LITERATURE.

A GENERAL HAND-BOOK OF BUTTERFLIES.

A Hand-book to the Order Lepidoptera. Part I. *Butterflies.* By W. F. KIRBY. 2 Vols. London, W. H. Allen & Co. 1894, 1896. (Allen's Naturalists' Library, edited by R. Bowdler Sharpe.)

This work is a rewriting of Duncan's two volumes on British and Foreign Butterflies in the old issue of Jardine's Naturalists' Library of sixty years ago, the principal point common to the two being the sixty odd plates, the coloring of which, we regret to say, is far inferior in the present issue. A few new plates are added, and the British species are very fully illustrated, for woodcuts from Newman's work are also introduced.

The plan of the new edition is, however, very much better, for the old British and Foreign volumes are combined in one series and make a systematic presentation of the subject to which the old series did not aspire. The introduction is largely rewritten, the memoirs of Lamarck and Werner (!) omitted, and the body of the work has a continuity which is much more evident than in the old and actually forms a hand-book to our present knowledge. It is, however, too formal to be as useful as it might be, and quite too much space is given to synonomy, which in a work of this sort is quite out of place or should be reduced to its lowest possible terms. The affinities of the different groups are not made evident as they should be in a hand-book, so that it is a guide to a knowledge of names rather than to a knowledge of structure. The early stages are not neglected, but are dealt with in too general terms to make the work of any value as to them; and what might have been a seductive guide to the study of butterflies savors too strongly of the Catalogue.

Mr. Kirby has, in fact, rather missed an excellent chance; notwithstanding which he has produced a useful book for the museum and cabinet, which reflects prevalent views of the classification of butterflies and presents the whole in a systematic and orderly fashion. The first volume contains the Introduction and the Nymphalidæ, the second the remaining families, excepting the Hesperidæ, which did not appear at all in Jardine's series, and which are here relegated to a third volume, with the higher moths yet to appear. The whole series of the Lepidoptera is contemplated to occupy five volumes. The printing is very unequal and in some places execrable, though the type is good.

SAMUEL H. SCUDDER.

The University Geological Survey of Kansas. Conducted under authority of the Board of Regents of the University of Kansas. By ERASMUS HAWORTH and assistants. Vol. I., 1896. pp. xii + 320, text figures 11, plates XXXI. Topeka, Kansas.

During the last few years the State University of Kansas, under the liberal and progressive administration of Chancellor Snow, and through the zeal of its geological professors, has begun a geological survey of the State. The above work is the first volume of this survey, in which is described the stratigraphy of the Coal Measures and Permian of Kansas.

To a large extent this is pioneer work covering the eastern third of the State, and is the first accurate detailed report of the geology of this region that has ever been published. It is stated that a companion volume will describe 'the stratigraphy of the Cretaceous and the Tertiary in a similar manner.'

The men associated with Professsor Haworth as assistants for the present volume are Rev. John Bennett, Prof. E. B. Knerr and Messrs. M. Z. Kirk, George I. Adams and John G. Hall. Of the fifteen chapters composing the work, seven are credited to the assistants, one is by Prof. Haworth and Mr. Bennett, and the remaining by Prof. Haworth.

The first eight chapters are devoted to de-