the materials stored up in the spore, or even lives parasitically upon the sporophyte, as in *Selaginella,* thus reversing the relation of sporophyte and gametophyte found in the lower archegoniates.

All of these modifications are in the direction of economy of water, in accord with the needs of a more and more pronounced terrestrial habit.

Just as heterospory arose independently in several groups of pteridophytes, so also the seed habit—the final triumph of the terrestrial sporophyte over the primitive aquatic conditions—developed more than once. The female gametophyte, included within the embryo-sac, develops without the presence of free water, and the germinating pollen-spore also absorbs the water it needs from the tissues of the pistil, through which the tube grows very much as a parasitic fungus would do. Except in a very few cases, the male cells of the seed plants have lost the cilia, the last trace of their aquatic origin, and are conveyed passively to the egg-cell by the growth of the pollen-tube.

Once firmly established as terrestrial organisms, and the problem of water supply solved, the further development of the seed plants is too familiar to need any special comment here. The great importance of water in affecting the structure of land plants is seen in the innumerable water-saving devices developed in the so-called 'xerophilous' plants, seen in its most extreme phase in such desert plants as cacti, or in the numerous epiphytes, like many orchids and bromeliads.

In short, it is safe, I think, to assert that of all the extrinsic factors which have affected the structure of the plant body, the relation to the water supply holds the first place. The most momentous event in the development of the vegetable kingdom was the change from the primitive aquatic habit to the life on land which characterizes the predominant plants of the present.

Douglas Houghton Campbell.

SECTION A, MATHEMATICS AND ASTRONOMY.

Vice-President—Professor George Bruce Halsted, Austin.

Secretary—Professor Charles S. Howe, Cleveland.

Member of Council—Professor John M. Van Vleck.

Sectional Committee—Professor G. W. Hough, Vice-President, 1902; Professor E. S. Crawley, Secretary, 1902; Professor G. B. Halsted, Vice-President, 1903; Professor C. S. Howe, Secretary, 1903; Professor Ormond Stone, five years; Professor J. R. Eastman, four years; Dr. John A. Brashear, three years; Professor Wooster W. Beman, two years; Professor Edwin B. Frost, one year.

General Committee—Mr. Otto H. Tittmann.

Papers were read as follows:

Deflections of the Vertical in Porto Rico: Otto H. Tittmann, Superintendent U. S. Coast and Geodetic Survey.

Mr. Tittmann gave an account of some large deflections of the plumb line in Porto Rico. Their existence was first noted by Count Canete del Pinar, of the Spanish Hydrographic Commission, which extended a triangulation around the island, but the war or other causes prevented a verification by that commission. The Coast Survey, however, in the course of its surveys extended a triangulation across the island from San Juan to Ponce and proved their existence beyond question. These deflections are so great that they affect the cartographic representation of the island, and a mean latitude had to be adopted, with the result that the northern coast line, as now shown on the maps, had to be moved by half a mile further south and the southern coast line by the same amount further north than would have been the case if the astronomical latitude had been used.

Saint Loup's Linkage: Professor L. G. WELD, University of Iowa.

The linkage described by M. Saint Loup in the *Comptes Rendus* for 1874 was discussed with reference to its application to the solution of cubic equations. An instrument constructed upon the principle in question was exhibited and operated. The failure of the device to give the numerically greatest root, or the single real root, was pointed out and explained. Attention was also directed to the fact that this root corresponds to a conjugate point of the locus traced by the linkage and can not, therefore, be reached by continuous motion in the plane of reals.

A Device to Prevent Personal Equation in Transit Observations: Professor S. P. LANGLEY, Secretary of the Smithsonian Institution.

Read by title.

The Solar Constant and Related Problems: S. P. LANGLEY, Secretary of the Smithsonian Institution.

Our absolute dependence on the light and warmth received from the sun makes the study of solar radiations of the highest utilitarian value, even apart from their scientific interest. So little is even now certainly known about the actual amount of the solar radiation, and the absorption of it which the solar gaseous envelope and the earth's atmosphere together cause, that it is doubtful if any one can predict just what influence a given change in the total radiation of the sun would produce on earthly warmth and life.

Early work of the author at Allegheny and upon Mt. Whitney relating to these studies was referred to, however, as showing certain limits within which important predictions could be made, and then attention was drawn to the present investigations of the Smithsonian Astrophysical Observatory. The great improvements in instrumental equipment within recent years were pointed out. Charts were exhibited illustrating how the total radiation expressed in terms of each wave-length as it reaches the earth was accurately represented, by means of an observation lasting only a few minutes, where formerly over two years' labor were required to do still less. Other charts showed how these amounts were corrected, step by step, until the rate of the sun's radiation on the outside of the earth's atmosphere (commonly known as the solar constant) is determined.

The absorbing action of water vapor in the air was shown by a chart of results extending from March to November. It was stated that a yearly cycle of these absorption effects is recognized.

Attention was especially called to the probably great utilitarian importance of variations of absorption in the solar envelope, in their effect upon all life, and to the consequent utility as well as scientific interest of the work now being renewed here to determine this with hitherto unknown fullness.

Good Seeing: S. P. LANGLEY, Secretary of the Smithsonian Institution.

Astronomers have at all times been hindered in all delicate observing by the disturbances arising in our own atmosphere, even in clear weather. The ill effect of these disturbances on the telescopic image is known commonly as 'boiling' (as contrasted with 'good seeing'), and it is the great enemy to accurate observation. Within recent years, therefore, there has been a movement to establish observatories in the most favorable localities to avoid this difficulty, regardless of all considerations of convenience. The author who has made a special study of the subject on mountain tops and elsewhere, has been led to think that the major part of the disturbance arises in the air comparatively

near the observer. He has accordingly attempted so to act on this nearer body of air as to prevent what may be assumed to be the main cause of the 'boiling.'

To do this, it has hitherto been sought by astronomers to keep the air in the telescope tube as still as possible. What may be assumed to be novel in the writer's plan is to vigorously churn this air by means of blowers, or in other ways. The still air is known to produce a disturbed image. That the air agitated under this new plan paradoxically produces a still image, has been shown by photographs (exhibited) of the images of artificial double stars whose beams were entirely confined within a horizontal tube in which they traveled to and fro through 140 feet of 'churned' air. These photographs showed that the disturbance within the tube itself appears to be wholly eliminated by the device of vigorously stirring the air column.

In continuation of the experiments, a tube was pointed up toward the sky, and so moved as to roughly follow the sun and thus form an inclined addition to the telescope tube itself. Within this tube the air was similarly churned. Very considerable improvement of the solar image resulted from the whole combination, but owing to the condition of the sun, the weather and the apparatus, the work has not yet reached a stage where it can be shown that improvement was due to the extension toward the sun, distinctly from the agitation in the tube.

The merit of churning the air within the telescope tube itself is believed to be demonstrated by these photographs, which show the results of this artificial 'good seeing.'

The Foundations of Mathematics: Dr. Paul Carus, Editor Open Court Publishing Co., Chicago.

Having briefly sketched the history of metageometry from Euclid to the present day, he declared that the problem was not mathematical but philosophical. At the bottom of the difficulty there lurks the old problem of the *a priori.* Kant wrongly identified the ideal with the subjective, and thus he regarded the *a priori* as a conception which the mind by its intuitive constitution transfers upon the object. The *a priori,* however, is purely formal, and the purely formal is an abstraction from which everything particular, viz., the sensory, is omitted. It can best be characterized as 'anyness'; it is a construction that would suit any condition, hence universality is implied and universality involves necessity.

There are two kinds of *a priori,* the *a priori* of being, which is pure reason, and the *a priori* of doing, a construction that is the result of pure motion. Our metageometricians tried to derive the basic geometrical principles from pure reason but failed. The truth is that other systems of geometry are possible, yet after all, these other systems are not spaces, but other methods of space measurements. There is one space only, although we may conceive of many different manifolds, which are contrivances or ideal constitutions, invented for the purpose of determining space.

The speaker developed space by motion in all directions after the analogy of the spread of light, and characterized the straight line as the path of greatest intensity corresponding to the ray.

Clifford derives the plane by grinding down three bodies until the three surfaces are congruent. The main feature of the plane is that it is congruent *with itself.* It can be flopped, and in either case it divides space into congruent halves. If we halve the plane, which can be done by folding a piece of paper, we have in the crease a representation of the straight

line; and if we double the folded paper upon itself (another method of halving it), we have the right angle. The three planes at right angles are the simplest systems of a combination of these products of halving.

The speaker concluded that Euclidean geometry is a construction *a priori* of both pure being and pure doing, that other geometries are possible, but that no other is so practical as the one which utilizes the straight line, the plane, and the right angle, viz., the boundaries that are congruent with themselves. Further explanation of his views may be expected in articles to be published in the coming year.

Evidences of Structure in the Mass of the Sun: Professor FRANK H. BIGELOW, U. S. Weather Bureau.

This paper discussed the distribution in longitude and latitude of the output of solar energy as shown by the relative frequency of the prominences, spots and faculæ. The observations used were those made in Italy by Secchi, Tacchini and Ricco during the years 1872 to 1900, and as they form a very regular series, the annual variations are comparable and indicate real changes in the transmission of energy from the interior of the sun to the outside. The result is to show that in longitude there is a maximum of spots, faculæ and probably prominences on two opposite sides of the sun, as if there exists in one axial direction an excess of impulse over that at right angles to it. The same distribution on one diameter has been detected already in the terrestrial magnetic field and in the meteorological elements. In latitude it is shown clearly that, on recovering from a quiescent state at minimum output, the new outpouring of energy takes place in middle latitudes, 25° to 50°, and during the increase spreads in two crests, one towards the equator and one towards the poles, the former dying away near the equator and the latter in about latitude 60°. The connection that probably exists between this phenomenon and the Helmholtz-Emden distribution of heat curves in the interior of the sun indicates a very important type of circulation which may prove to be characteristic of the sun. Incidentally, the paper discussed the rotation period in different latitudes, and the application of the periodgram to such a problem.

Spectrographic Proof of the Rotations of the Planets Jupiter, Saturn and Venus: PERCIVAL LOWELL, Director, Lowell Observatory.

Read by title.

The Teaching of Geometry: Professor GEORGE BRUCE HALSTED, Austin, Texas.

Of late, very remarkable discoveries have been made in geometry, affecting its very foundations. These discoveries have a noteworthy application to the teaching of geometry. Some of these discoveries and applications are considered in abstract as follows: (1) The time has come for advance, (2) need for a preliminary course, (3) the preliminary must fit the rational geometry, (4) rigor gives simplicity, (5) Euclid's unannounced assumptions, (6) the betweenness assumptions, (7) superposition, (8) congruence and symmetry, (9) the real beginnings, (10) the definition of straight as shortest, (11) double import of problems, (12) use of figures, (13) graphics, (14) necessity for non-Euclidean geometry, and (15) adaptation to teaching.

Special Periodic Solutions of the Problem of n Bodies: Professor E. O. LOVETT, Princeton University.

This note constructs analytically the particular solutions of Lehmann-Filhés in the problem of n bodies analogous to those of Lagrange in the classic three-body problem.

The method of Poincaré is then used to design other periodic solutions; by an easy reduction the equations become amenable to the treatment proposed by Oppenheim in the corresponding case of three bodies.

The Problems of Three or More Bodies with Prescribed Orbits: Professor E. O. LOVETT, Princeton University.

This paper has points of contact with and generalizes certain theorems due to Bertrand, Darboux, Halphen and Oppenheim. Two problems are studied:

1. The determination of the curves which three bodies may describe under central forces possessing a force function, this function to have a form assigned in advance. The results, other than those which are well known, are transcendental.

2. The determination of forces which maintain the motions of any number of bodies in prescribed orbits independent of initial conditions in a space of any number of dimensions, the forces assumed central. It appears that in general a certain number of the forces may be chosen arbitrarily. In ordinary three-dimensional space this indetermination can not be made to disappear; the solution not becoming determinate until the case of those bodies in the plane is reached.

Note on the Secular Perturbations of the Planets: Professor ASAPH HALL, Professor of Mathematics, U. S. Navy (retired).

It is known that the determination of the secular perturbations of the principal planets of our solar system depends on the solution of an equation of the eighth degree. The roots of this equation depend on the masses of the planets; and if the masses are changed the values of the roots will change also. In this paper an example is given of the changes in the roots, from one set of masses to another, by means of the formulas computed by Stockwell. The results indicate that the formulas of Stockwell can be used with advantage, and that the labor of solving the equation of the eighth degree can be much diminished.

The Bolyai Centenary: Professor G. B. HALSTED, Professor of Mathematics, University of Texas.

On the fifteenth of December, 1902, is the centenary of the discoverer of non-Euclidean geometry, the Hungarian John Bolyai, or, in Magyar, Bolyai Janos. This extraordinarily important and suggestive subject, non-Euclidean geometry, in its inception, evolution, present state and near future development, was treated in this paper.

The Approach of Comet b 1902 to the Planet Mercury: CHARLES J. LING, Manual Training High School, Denver, Colorado.

The questions treated were:

The exact position of comet and planet at time of nearest approach: to obtain accurately distance between the bodies at this time.

The great velocity of comet near perihelion together with the position of orbit takes the comet away from Mercury very rapidly. The effect of Mercury at distance of $2\frac{1}{8}$ millions of miles very slight.

Very questionable, if any, effect will be produced by Mercury which will enable astronomers to tell anything about mass of Mercury.

An Untried Method of Determining the Constant of Refraction: GEORGE A. HILL, U. S. Naval Observatory.

This paper called attention to a method of deriving the constant of refraction from transits of pairs of stars in the prime vertical. Remarks were first made upon our present knowledge of the constant as secured from observations of stars at upper

and lower culmination, either by means of the meridian or the vertical circle. A plan was then suggested by which the constant might be secured by proper groups of stars in pairs, observed in the prime vertical.

A Development of the Conic Sections by Kinematic Methods: JOHN T. QUINN, Warren, Pennsylania.

The paper is an abstract of a more general system of kinematic geometry whereby not only the conic sections, but nearly all the higher plane curves are developed by kinematic methods. The following definition will give some idea of its scope:

Kinematic geometry treats of the properties of the areas and curves regarded as functions of the spacial and angular velocities of lines, which move in accordance with some fixed law.

With reference to the conic sections (as those are the curves in which we are at present interested), the originality of their development consists in the introduction of an auxiliary circle, called the directing circle; and the conditions subject to which the intersecting lines are assumed to revolve. The lines are pivoted in an axis and conceived to revolve and move at such rates that certain angles are constantly equal, then the locus of their intersection is a conic section.

That this mode of development makes manifest more than any other the essential unity of the curves, and their dependence upon the same law of generation, is evidenced by the general definition of a conic in this system, referred to a common property.

A conic section is a curve the ratio of the distances of whose points form a fixed point and a directing circle is equal to unity. For the ellipse and parabola, the fixed point (a focus) is in the diameter of the directing circle, for the hyperbola, in the diameter produced.

The problem of constructing tangents to either of the curves from external points in their plane is solved in an extremely simple manner. The mode of procedure is essentially the same for each of the curves. This problem is facilitated by the directing circle, which becomes the directrix of the parabola when the circle becomes infinite.

The point on either of the curves which is common to the tangent through the external point is located by drawing only two lines.

The normal to a curve always is parallel to one of the generating lines. Consequently, as a problem in construction it presents no difficulty whatever.

To construct asymptotes to the hyperbola we have only to describe a circle, upon the line as a diameter, which is limited by the center and the focus. It intersects the directing circle in two points, which, with the center, determine the direction and position of both lines.

Time Determinations at the Washburn Observatory: Professor GEORGE C. COMSTOCK, Madison, Wisconsin.

This was a discussion of methods employed in the time service of the Washburn Observatory, with especial reference to the advantages to be obtained by a reversal of the instrument upon each star.

Determination of Time by Reversing on Each Star: Professor CHARLES S. HOWE, Case School of Applied Science, Cleveland, Ohio.

Complete determinations of time were made on several nights by the usual method with clamp west and also with clamp east. On the same nights determinations of time were also made by reversing on each star. The clock errors were compared with those found with the almucantar. A table of azimuths, clamp west and clamp east was given, and it

was shown that the instrument changed greatly in azimuth by reversal.

Note on a Geometrical Analysis: Professor James S. Miller, Emory Virginia. Read by title.

Concerning Bolzano's Contributions to Assemblage Theory: Dr. C. J. Keyser, Columbia University, New York City. Read by title.

The Constants of the Equatorial: C. W. Frederick, U. S. Naval Observatory, Washington, D. C.

This paper contained a description of a method for deriving the constants of an equatorial from observations of circumpolar and equatorial stars. The position of the polar axis of the instrument is determined from observations of λ Ursæ Minoris and Polaris near the times of culmination and elongation; also other constants are involved. Collimation and the flexure of the tube are derived from observations of equatorial stars. Very simple formulæ are required in the reduction of these observations.

The effect of the constants in varying the parallel of the micrometer is also considered, and a short process indicated by which micrometer measurements may be corrected for these instrumental disturbances without undue labor.

A Relation between the Mean Speed of Stellar Motion and the Velocity of Wave Propagation in a Universal Gaseous Medium, Bearing upon the Question of the Nature of Ether: Luigi d'Auria, 3810 Locust Street, Philadelphia, Pa.

If the universe were involved in a primordial gaseous medium in equilibrium of temperature, then assuming the density to vary inversely with some power, n, of the distance from the center of this universal gaseous globe, which would be the center of the universe, it is found that $n=2$, or the density varies inversely with the square of distance. If ω and ω_0 denote respectively the density of the medium at any distance z and the mean density of the concentric sphere of radius z, then

$$\omega_0 = 3\omega$$

and

$$\omega = \frac{\bar{u}^2}{6\pi k z^2}$$

in which $\bar{u}$ is the mean square speed of the particles of the medium and K the gravitation constant.

Denoting by σ the density of the medium in the solar system, and by S the distance of this system from the center of the universe, it is found that

$$\sigma = \frac{\bar{u}^2}{6\pi K S^2}.$$

Bodies moving in circular orbits around the center of the universe, at all distances, would all have the same velocity

$$v_0 = 2S\sqrt{\pi k\sigma},$$

and it is found that $\bar{u}^2 = 3/2{v_0}^2$; and if V is the speed of wave propagation in the gaseous medium, it is found also that $V^2 = 5/6{v_0}^2$. As v_0 must be nearly equal to the mean speed of stellar motion, about 19.3 miles per second according to Kapteyn, it is concluded that the ether can not be a gravitational gas, since this gas could not transmit energy with velocity much greater than 17.6 miles per second. Hence, the ether must be imponderable.

Denoting by R and D the mean radius and the mean density of the earth, and by g the acceleration of gravity, it is shown that

$$\sigma = \tfrac{1}{3}\frac{RD}{g}\left(\frac{v_0}{S}\right)^2,$$

and assuming $S = 159$ light years, an estimated distance of Nova Persei, and as-

suming this star to be near the center of the universe, it would follow that

$$\sigma = 3.9 \times 10^{-19} d$$

in which d is the density of ordinary air. That is, the density of the universal gaseous medium in the solar system would be of the same order of magnitude as the ether. On this basis the density of the medium at a distance of 585,000 miles from the center becomes equal to that of ordinary air, and the concentric sphere of the medium within this radius would have a mass about seven times that of Jupiter, a mass entirely too small to be conspicuous in celestial space.

Condition of Atmosphere, Horizon, and Seeing at the Lowe Observatory, Echo Mountain, California: Professor EDGAR L. LARKIN, Director Lowe Observatory. Read by title.

The officers elected for the next meeting are:

Vice-President—Otto H. Tittmann, Superintendent United States Coast and Geodetic Survey.

Secretary—Professor Laenas G. Weld, University of Iowa.

CHARLES S. HOWE,
Secretary.

SCIENTIFIC BOOKS.

Ueber den derzeitigen Stand der Descendenzlehre in der Zoologie. Von DR. H. E. ZIEGLER, Professor an der Universität Jena. Gustav Fischer. 1902. Pp. 54, with 4 text-figures. M. 1.50.

On the occasion of the seventy-third meeting of the German Naturalists and Physicians in Hamburg, September, 1902, the general question of the present status of the doctrine of organic evolution was presented in three lectures—by a botanist (de Vries), a paleontologist (Koken) and the zoologist, Ziegler. The last lecture is now somewhat extended by notes and appendices and published under the title given above.

It is an interesting account of the present standing of the great *Descendenzlehre* in zoology, given in a temperate spirit; a good lecture for the occasion and the place in which it was delivered.

The subject is considered under four sections: (1) The general theory of organic evolution, (2) natural selection, (3) inheritance theories and (4) the application of evolution to the origin of mankind.

Of these, the first section is treated with a firmer hand, as is justified by the state of our knowledge, and the author reviews interestingly, from the zoological side, some of the evidences in support of evolution. He points out that the general proposition has been so strengthened by the researches of the past forty years that all naturalists agree in accepting it as established. We have no other rational theory of the origin of plants and animals, and, notwithstanding the controversies as to the factors that have brought about the diversity of organic life, the fact of evolution as a process of creation is no longer seriously challenged.

But the compelling arguments in support of evolution do not hold in equal force for natural selection or any other particular theory. Here we have conflicting opinions, but they do not seriously affect the main contention. As Huxley, one of the greatest supporters of natural selection, said: 'If the Darwinian hypothesis were swept away, evolution would still stand where it was,' and the same thing can be said in reference to any theory of evolution that has been offered since.

In regard to natural selection, Ziegler comes to the position of so many working zoologists, that as a factor it is not adequate by itself to afford an explanation of variation and development. In many instances its action is clear—as when variations which are of direct use to the animal are fostered by natural selection, but many other cases like the great development of the backward-directed tusks of the mammoth, and horns of other animals, can not be explained by natural selection.

The third section is more lightly treated. The inheritance theories of de Vries, Nägeli, Haacke and Weismann receive passing men-