tural remains found at the same level. He does however mention some of the numerous accompanying fauna: *Rhinoceros merckii,* stag, horse, ox and cave bear. There was also an abundance of charcoal and flint implements, the latter for the most part apparently retouched points and scrapers.

Two human teeth (one of a child and one of an adult) had already been found in the lower travertine of Taubach. During the summer of 1908, Dr. Pfeiffer found human skull fragments in the same deposit at Ehringsdorf.

Both Obermaier and Schmidt consider the lower travertine of Ehringsdorf (the deposit in which the lower jaw was recently found) and Taubach to be older than Mousterian. Although it contains no typical coups de poings, on account of the character of the fauna as well as the industry, Obermaier would call the deposit of Chellean age. For Schmidt, who has recently published examples of the industry, it is Acheulian.

In any case all are evidently agreed that the deposit belongs to the Riss-Würm interglacial epoch. In that case according to one school it might be Chellean, Acheulian, or early Mousterian; according to the school of Penck, it would have to be later Mousterian, since he places early Mousterian during the Riss glacial epoch and the Chellean-Acheulian during the second or Mindel-Riss interglacial epoch.

Whichever view is correct, on account of its anatomical characters, as well as the position of the deposit and the nature of the associated cultural and faunal remains, the anthropologist may justly claim for the Weimar lower jaw an antiquity surpassed perhaps only by the skull of Piltdown and the Mauer (*Homo heidelbergensis*) lower jaw.

George Grant MacCurdy
Yale University,
New Haven, Conn.

THE CHICAGO MEETING OF THE NATIONAL ACADEMY OF SCIENCES

The National Academy of Sciences will meet December 7, 8 and 9 at the University of Chicago. Social headquarters will be at the Quadrangle Club, 58th Street and University Avenue, where the members will meet for the first time December 7, 1:00 P.M., for luncheon. A feature of the meeting will be the second course of William Ellery Hale lectures on evolution, two lectures by Professor William Wallace Campbell, director of the Lick Observatory, on Stellar Evolution and the Formation of the Earth. These lectures and four sessions with papers by members of the academy and others will be open to the public.

The council will meet at 4:30 P.M., December 7, at the Quadrangle Club.

A preliminary program of the scientific papers is as follows:

I. *Mathematics*

Gilbert Ames Bliss: *A Generalization of a Theorem of Gauss Concerning Geodesic Triangles.*

If a line OA of unit length is parallel to the normal at a point a of a surface S, then A may be regarded as the image of a on the unit sphere with center at O. It is a theorem due to Gauss that the difference between π and the sum of the angles of a geodesic triangle on the surface is numerically equal to the area of the image of the triangle when each point is mapped on the sphere as above described. The paper is concerned with a generalization of this theorem. The magnitudes involved in the statement of the theorem, angles, the equations of the geodesic lines, the area of the image of the triangle, are expressible in terms of invariants associated with the integral of length on the surface S. For a more general integral of the calculus of variations some of the analogous invariants have been found by the author and other writers. In the present paper the remaining invariants are described, and a theorem corresponding to that of Gauss is deduced.

Leonard E. Dickson: *Recent Progress in the Theories of Modular and Formal Invariants.*

Contrast between algebraic and modular invariants. Formal invariants and their construction. Modular plane curves for modulus 2.

G. A. Miller: *The ϕ-subgroup of a Group of finite order.*

In 1885 Frattini introduced the ϕ-subgroup of a finite group G as the characteristic subgroup whose individual operators enter into no set of

independent generators of G. In the present investigation the ϕ-subgroups of various important groups G are studied,—in particular, of groups of order the power of a prime, of direct product groups, of abelian groups, of the Sylow subgroups of the symmetric group on n letters. Two of the principal results are: (1) The ϕ-subgroup of a Sylow subgroup G of the symmetric group on n letters is the commutator subgroup of this Sylow subgroup G. (2) The various sets of independent generators of a group G of order the power of a prime contain the same number of generators, so that this number is an invariant of the group G.

ELIAKIM H. MOORE: *On the Integration by Successive Approximations of the Ordinary Differential Equation of the First Order in General Analysis.*

The classic problem of integration of a simultaneous system of n ordinary differential equations of the first order may be expressed as follows: To determine the n-partite number or point $\xi = (x_1, \cdots, x_n)$ in n-space S_n as a function of the real variable t in such a way as to satisfy the differential equation

$$\frac{d\xi}{dt} = K(t, \xi)$$

with the initial condition:

$$\xi(t_0) = \alpha = (a_1, \cdots, a_n).$$

Here for every t of a certain interval T' of the real number system T and point ξ of a certain region S' of S_n. $K(t, \xi)$ denotes a point of S_n; t_0 lies within T'; α lies within S'; and K satisfies the continuity and Lipschitz conditions. A point ξ may be thought of as a function of i; $\xi(i) = x_i$ $(i = 1, \cdots, n)$. If in this problem we replace systematically the special variable i with the special range $i = 1, \cdots, n$ by a general variable p with the general range P we obtain the corresponding problem in general analysis. Then by imposing suitable conditions on S', K and α we validate for the general equation with initial condition the process of integration by successive approximations. The general treatment covers the classical case and, for example, certain types of infinite simultaneous systems of differential and of integro-differential equations.

F. R. MOULTON: *An Extension of the Process of Successive Approximations for the Solution of Differential Equations.*

With the exception of the Cauchy polygon process, which is not of practical value, the existing methods of solving differential equations have, in general, only a limited domain of applicability. The processes defined in this paper apply to a very general class of differential equations, they are convenient in practise, and they furnish the solution with any prescribed accuracy in an arbitrary part of the domain of its existence. The range on the independent variable for which the solution exists is not known in advance, but the process enables one to determine when he is safely within that range.

H. S. WHITE: *The Synthesis of Triad Systems Δ_t in t Elements, in Particular for $t = 31$.*

This note reviews earlier and recent studies in triad systems, and signalizes one advance step. The field is largely unexplored, and progress requires study of specimens and induction. Twenty-three specimens of Δ_{15}'s showing odd and even structure, many new, are available in Miss Cummings's dissertation (Bryn Mawr, 1914); and one of different structure, headless. Upon these one new theorem is verified, then demonstrated, relating t with $2t + 1$. This makes possible the precise enumeration of Δ_{31}'s of odd and even structure which can be compounded from a headless Δ_{15} and any other. Headless systems (yet unpublished) prove the resulting Δ_{31}'s to number above 14!

E. J. WILCZYNSKI: *Conjugate Systems of Space Curves with Equal Laplace-Darboux Invariants.*

It is well known that four linearly independent solutions of a linear differential equation of the form

$$\frac{\partial^2\theta}{\partial u\,\partial v} + a\frac{\partial\theta}{\partial u} + b\frac{\partial\theta}{\partial v} + c\theta = 0$$

determine a surface upon which the parametric curves form a conjugate system. A great deal of work has been done upon the special case when the Laplace-Darboux invariants of the equation are equal to each other. The geometrical significance of this condition, which up to the present time seems to have escaped notice, is the object of Mr. Wilczynski's communication.

II. *Astronomy*

E. E. BARNARD: *Explanation of Certain Phenomena of the Tail of Comet Morehouse* (III., 1908).

Within certain limitations, there is nothing so wonderfully effective for the study of cometary phenomena as the stereoscope. The author has applied this method for the study and explanation of the remarkable phenomena of the tail of

Morehouse's comet on October 15, 1908. A good series of photographs of the comet was obtained on that date in this country and in Europe, the earliest of these being made at Geneva, Switzerland. The photographs made at the Yerkes Observatory (continuously) on that date with the Bruce telescope extended from $6^h\ 18^m$ to $13^h\ 28^m$ C. S. T., or for a period of $7^h\ 10^m$. A set made in France, another in England, and two sets obtained by the author with the Bruce telescope of the Yerkes Observatory, are available for stereoscopic combination. It is from the study of these combinations that the following simple explanation of the phenomena is derived.

The photographs all show a twisted appearance of the tail about $\frac{1}{2}°$ from the head, apparently joined to the head by a slender straight beam. The broken part of the tail became more disrupted, and changed more rapidly in the later photographs, until it formed a broad mass with a broad tail. A study of the stereoscopic views shows what really happened. At a time earlier than the first photograph the comet had discarded its tail (by ceasing abruptly to emit matter in that direction) which drifted away into space. For some reason, perhaps from a disturbance due to the cessation of emission at that point in the comet's head, the rear end of the receding tail "buckled" and became twisted into a spiral which finally formed an irregular ring—very much like the smoke ring familiar to the users of tobacco. Every part of this condensation ring sent out a continuous stream of matter until it formed, roughly, a long open cylindrical tail to the ring, with one end pointed more or less towards us.

This last phase of the disturbance was the condition of the tail at the time of my last photographs of that night. By the next day the remnant of the discarded tail had drifted farther away and had become so changed as to be of little interest in connection with its form on October 15. The slender beam of light that apparently connected this phenomenon with the head was really a new tail which was forming and which did not touch the masses in the old tail but passed behind them, at a considerable angle as shown by the stereoscope.

W. W. Campbell: *On the Radial Velocities of Nebulæ.*

The radial velocities of 54 planetary and ring nebulæ and nebulæ of irregular form, have been determined at the Lick Observatory and at the D. O. Mills Observatory in the past three years by spectrographic means. The nebulæ are remarkable for their high velocities. Only a fifth of the radial velocities are less than 10 km. per second, there are 9 radial velocities greater than 60 km. per second, and the average for the 54 nebulæ is 42 km. per second. This is 7 times the average radial velocity of the so-called helium stars, which have generally been supposed to be the stars most recently evolved from nebulæ. Omitting 12 extended and ring nebulæ, the average radial velocity of 42 planetary nebulæ is 46 km. per second. Two nebulæ, close together in the sky, have been observed as 202 km. per second recession and 141 km. per second approach, respectively,—a relative radial motion of 343 km. per second.

The prevailing high velocities of planetary nebulæ make difficult the continued acceptance of Sir William Herschel's view that the planetary nebulæ evolve into stars [whose speeds are of average dimensions]. On the contrary, there is some basis for the suggestion that the planetary nebulæ have been formed from the rushing of high-velocity stars through resisting media in space. Rapidly-moving stars are the ones which would have the greatest chance to encounter resisting media, and the collisional or bombardment effects would be the more effective in generating nebular condition the higher the velocities of impact.

Heber D. Curtis: *Preliminary Note on Nebular Proper Motions.*

Knowledge of the distances and linear dimensions of the nebulæ are important in studies as to the nature of the nebulæ themselves, and especially as to their relation to the stellar system. It is desirable, therefore, that every opportunity be utilized to determine the proper motions of the nebulæ.

Professor Keeler's program of nebular photography with the Crossley Reflector of the Lick Observatory was inaugurated in 1898, continued by him into 1900, and in the next few years completed by Professor Perrine. A new series of photographs of the same objects, with the same telescope, was begun last winter and should be completed in the early summer of 1915. About one third of the proposed photographs have been obtained to date, and nearly all of these have been compared, as to the accurate positions of nebular nuclei and other very definite masses of nebular structure, with the photographs of the same objects secured from twelve to sixteen years ago. If any motions of translation or rotation in the

objects re-photographed have occurred in the interval, these changes seem not to be appreciable, or at most, are exceedingly small. The conclusion drawn from this fact is that the nebulæ concerned are very remote, and therefore are enormous in linear dimensions. These provisional conclusions apply to many of the large irregular nebulæ, such as the Orion and Trifid nebulæ, and to many of the more prominent spirals, including the great spiral in Andromeda.

EWDIN B. FROST: *An Interesting Stellar System.*

Observations have been continued on the spectroscopic binary β Cephei, which has the remarkably short period of 4^h34^m. Some features of the system are discussed, and reference is made to the detection at Berlin of variations in the star's brightness by the photo-electric method.

GEORGE E. HALE: *The Direction of Rotation of Solar Storms.*

It is well known that cyclones and tornadoes in the earth's atmosphere rotate in the right-handed (clockwise) direction in the southern hemisphere and in the left-handed direction in the northern hemisphere. What is the case for solar storms?

The existence of a magnetic field in sun-spots, supported by other spectroscopic evidence, proves that sun-spots are electric tornadoes of immense size. The direction of rotation of the spot-vortex is given by a simple spectroscopic observation.

The results were at first confusing, as spots rotating in both directions were found in the same hemisphere. But it soon appeared that sun-spots usually occur in pairs, lying close together on a nearly east and west line, and always having opposite directions of rotation. Tabulating the polarities separately for the eastern (following) and western (preceding) members of bipolar pairs, we find (with very few exceptions) that the directions of rotation for preceding or for following spots are opposite in the northern and southern hemispheres.

Prior to the recent sun-spot minimum the preceding spots of the old cycle rotated left-handedly in the northern and right-handedly in the southern hemisphere, as in the case of terrestrial storms. Since the minimum the direction of rotation has been reversed. But the spots of the old cycle were all in low latitudes, while those of the new cycle are all in high latitudes. Thus there probably exist in each hemisphere a high latitude zone, in which preceding spots rotate right-handedly in the northern and left-handedly in the southern hemisphere, and a low latitude zone, where preceding spots rotate left-handedly in the northern and right-handedly in the southern hemisphere.

J. C. KAPTEYN AND W. S. ADAMS: *On the Relations between the Proper Motions and the Radial Velocities of the Stars of the Spectral Types F, G, K and M.*

(1) The radial velocities furnish a very thorough test of the theory of the star streams. The results found for the F, G, K and M stars are in close agreement with those we should expect from the theory as derived from proper motions. (2) The radial velocities of the stars of the smallest proper motions show the effects of the two star-streams with the same certainty as those of the other stars. The existence of the two star-streams is, therefore, proven at the greatest distances for which we have adequate data. (3) The K stars behave in general like the other stars, but there are a few exceptional cases. These do not appear to be due to the absence of the second stream. (4) For all of the spectral classes the average radial velocities show a regular increase with the proper motion. (5) Such a change of radial velocity is a necessary consequence of a velocity distribution (for the peculiar motions) different from that given by Maxwell's law. (6) A first approximation to the velocity distribution has been derived for the K stars. It explains the change of velocity with proper motion in a satisfactory manner. (7) Some positive indications have been found of a change of radial velocity with absolute magnitude, the brighter stars moving more slowly than the fainter stars.

S. B. NICHOLSON: *Discovery of a Ninth Satellite of Jupiter.*

A satellite of Jupiter was discovered by means of photographs made with the Crossley Reflector of the Lick Observatory on July 21 and 22, 1914. These photographs were secured in order to determine positions of the eighth satellite, and the new object was in the same photographic field. The ninth satellite is considerably fainter than the eighth, being estimated at about the nineteenth magnitude. Additional observations of the new satellite have been secured in August and September. The preliminary orbit, computed under Mr. Leuschner's direction, shows that the orbital motion is retrograde, that the first estimate of the period is approximately three years, and that the other elements of the orbit are similar to those of the eighth satellite.

C. T. Knipp: *Experimental Data on the Stability of Positive and Negative Ions.*

In an investigation by Dr. O. H. Smith and the writer of the properties of the retrograde rays from a Wehnelt or hot lime cathode, it was found necessary in order to make their presence known, to accelerate these rays by passage through a strong electrostatic field. The photographic method of J. J. Thomson[1] was employed.

A number of plates show anomalies as to the direction of deflection, *i. e.*, the appearance of *positive* lines with *negative* acceleration, while the same exposure shows but little or no trace of the negative lines. This is contrary to what is expected under the given conditions.

This anomaly, the appearance of positive lines on the photographic plate when the acceleration is such as to allow only negative ions to get through the accelerator into the electric and magnetic deflecting fields beyond, can be satisfactorily explained if it is assumed that the positive ion is more stable than the negative ion. In other words a negative ion loses an electron more easily than does a positive ion.

The paper in detail follows the path of the negatively accelerated ion as it issues from the accelerator and notes the possible changes that evidently take place (upon the supposition stated above) as it moves on through the deflecting fields to the photographic plate. In this way every part of the line on the photograph (*i. e.*, the straight portion as well as the parabolic portion), is satisfactorily accounted for, and hence the conclusion that the positively charged ion is more stable than the negatively charged ion.

A number of photographs showing these lines accompany the paper.

III. *Physics*

A. A. Michelson: *Behavior of Metals and Other Substances Near the Rupture Point.*

R. A. Millikan: *The Coefficient of Slip in Gases and its Relation to the Nature of the Impact between a Molecule of a Gas and the Surface of a Solid or Liquid.*

In 1911 I brought forward a new method[2] for the very accurate evaluation of the coefficient of slip between a gas and the surface of a liquid or solid. This coefficient was shown to be equal to the quantity Al in the equation for the law of fall of a small sphere through a gas.[2] This quantity Al was in turn shown to be proportional to the slope of the line obtained by plotting $e_1^{\frac{3}{2}}$ against l/pa in the "droplet" method for the determination of e. The values of this slope have now been obtained with different gases and different kinds of droplets. It has hitherto been supposed from the work of Kundt and Warburg that the coefficient in question is in all cases proportional to the mean free path of the gas molecule. This conclusion is now shown to be incorrect; for the above-mentioned slopes are not only found to depend on the nature of the surface against which the gas molecule impinges when this molecule remains the same, but also upon the value of the impinging molecule when the surface is the same. These results show that in general gas molecules are not "diffusely" reflected from liquid and solid surfaces as they have recently been assumed to be by Knudsen and others.[3]

IV. *Chemistry*

C. W. Balke and Geo. W. Sears: *The Atomic Weight of Tantalum.*

In order to determine this constant two ratios were studied, $2TaCl_5 : Ta_2O_5$ and $TaCl_5 : 5Ag$.

In the study of the ratio $2TaCl_5 : Ta_2O_5$, the tantalum chloride was hydrolyzed, using nitric acid, and the resulting tantalum oxide was evaporated to dryness and ignited. In five determinations, however, a constant weight was not obtained even after repeated ignition. A fine white deposit was found in the exit tubes of the reaction flask after each analysis showing that the oxide was being lost. An examination into the cause of this showed that the hydrochloric acid was completely removed by ignition, that the nitric acid was difficultly removed, if at all, and that tantalum oxide was lost either mechanically or by volatilization, all of which indicated that the method was unsatisfactory.

In the study of the ratio $TaCl_5 : 5Ag$, several methods involving the removal of the hydrochloric acid from the tantalum were tried but without success. The only method found satisfactory was to dissolve the tantalum chloride in an approximately 5.5 per cent. hydrofluoric acid solution and to precipitate the resulting hydrochloric acid in the presence of the dissolved tantalum. Platinum vessels were used throughout and the final end point was determined in the nephelometer.

[1] J. J. Thomson, "Rays of Positive Electricity," 1913.

[2] Physical Review, XXXII., p. 382, 1911.

[3] *Annalen de Physik*, Kundsen Papers, 1909–1912.

Three determinations by this method gave 181.30 for the atomic weight. From one to two days were allowed for the equilibrium to become established. A further study of this equilibrium, however, showed that from three to five days were required. A final series of determinations is now in progress.

W. D. HARKINS AND E. C. HUMPHREY: *The Capillary and Electrical Forces at the Interface between Two Liquids.*

A method which gives very accurate determinations of the capillary constant at the interface between two liquids has been devised. The method consists in a measurement of the capillary height under the special conditions which are necessary to secure accuracy. The capillary height method proves inaccurate in all cases where one of the liquids gives an alkaline reaction. For such liquids the drop-weight method may be used. This method has been adopted largely by workers in the field of colloidal chemistry, but without any use of the corrections which have now been determined. Since these corrections frequently amount to as much as 37 per cent. they should not have been neglected.

The latter method has been used to investigate the relation between the change of the surface tension and the change of the electrical potential between two non-miscible liquid phases, in order to see if the relationship is such as would be in accord with one of the theories of muscular motion. This theory is in short that in muscular motion the muscle changes from a neutral to an acid reaction, that this causes a change of electromotive force between two different phases (of the order of one volt), and that this in turn gives rise to such a change of surface tension at the neutral point as was found by von Lerch in Nernst's laboratory. The present work shows that von Lerch's results were in accord with the general theory only because of the inaccuracy of his experimental work.

HERBERT N. MCCOY: *The Solubilities of Radium Compounds as Indicated by the Solubilities of Analogous Compounds of Calcium, Strontium and Barium.*

If it be assumed that radium is the fourth member of the alkali earth group, it is to be expected that the properties of compounds of this element, other than those dependent upon its radioactivity, should be determinable from a knowledge of the properties of corresponding compounds of calcium, strontium and barium. A knowledge of the solubility relations of radium and barium compounds is of great practical importance, since the former must always be separated from large amounts of the latter in the course of the extraction of radium from minerals. A systematic theoretical study of the problem indicated the chemical and physical conditions most favorable for the separation of these elements. The theoretical predictions have been verified by experiment and as a result a new method of separating radium from barium has been found which is many times as efficient as the best hitherto known.

S. W. PARR: *The Development of an Acid Resisting Alloy for a Bomb Calorimeter.*

Coals of the Illinois type when burned in an oxygen bomb generate a mixture of nitric and sulfuric acids, equivalent to approximately 30 c.c. of 1/20 N acid. The correction called for as a result of the heat of formation of these acids approximates 100 calories. If in addition some of the metal of the bomb is dissolved, there is generated an additional increment of heat for which a correction can not readily be applied. Hence the use of platinum or gold as a lining for such bombs.

In April of 1911 the first attempt was made to produce an alloy sufficiently resistant to these acids to permit of its use in the construction of an oxygen bomb. The first successful casting was obtained in December, 1911, but this could not be duplicated until quite recently on account of the difficulty experienced in casting the metal in a dense non-porous form free from flaws.

The alloy is of the nickel chrome type with copper 7 per cent. tungsten and molybdenum from 3 to 5 per cent. The standard of reference for solubility is taken as the amount dissolved by 4 N nitric acid at room temperature per 100 sq. cm. per hour. The average amount dissolved for such unit area and time is 0.09 milligram. The original bomb has had upwards of 1,500 combustions with no indications of corrosion.

A large number of parallel determinations with a platinum-lined bomb show a full equivalent of acid as indicated by the resulting titrations. Test bars show a tensile strength of 50,000 to 60,000 pounds per square inch while a sample of wire gave a tensile strength of 124,000 pounds. Attempts to roll the metal into sheets have not been very successful, only small areas having so far been produced.

JULIUS STIEGLITZ: *Molecular Rearrangements of Triphenylmethyl Derivatives.*

The study of the molecular rearrangements of triphenylmethyl derivatives was planned to shed light on the classical rearrangements of oximes, acyl azides, acyl halogen amides, etc., and to test the author's theory concerning the nature and causes of these rearrangements. The investigation has been developed in four directions: (1) Triphenylmethylhydroxylamines, halogen amines and azides have been shown to give the same products of rearrangement. (2) Derivatives of the unsymmetrical radicles $(C_6H_5)_2(C_6H_4X)C$-, $(C_6H_5)(C_6H_4X)_2C$-, and $(C_6H_5)(C_6H_4X)(C_6H_4Y)C$- yield quantitatively the same ratio of products in the different groups as far as these have been examined. (3) Complete proof of the rearrangement of $(C_6H_5)_3C{\cdot}NCH_3{\cdot}OH$ and of the course of the action has been brought—the first rearangement of the kind ever observed. (4) Rearrangement of the hydrazine $(C_6H_5)_3C{\cdot}NH{\cdot}NH{\cdot}C(C_6H_5)_3$ has been effected—the first instance of a hydrazine rearrangement of this type.

E. W. WASHBURN: *Our Systematic Knowledge of the Properties and Behavior of Solutions of Non-electrolytes.*

A satisfactory theory of solutions must first of all give us an answer to the question: What is the relation connecting the thermodynamic potential (or the fugacity, or the osmotic pressure) of a given molecular species in a solution with the composition of that solution, its pressure and its temperature? When this relation is known for any given class of solutions we are at once in a position to calculate the values of such quantities as freezing points, boiling points, vapor pressures, osmotic pressures, solubilities, equilibrium, constants, etc., for solutions of known composition; or vice versa by directly measuring the above quantities we may compute the molecular composition of our solutions and discover what reactions, if any, have taken place between the various components of the solution.

The purpose of this paper is (1) to outline and describe (*a*) the manner in which, (*b*) the extent to which, and (*c*) the conditions under which the above question is satisfactorily answered by our present systematic knowledge of solutions; (2) to state a number of the laws of solutions as formulated in terms of this theory; and (3) to present some experimental data illustrative of the quantitative agreement between theory and experiment.

V. *Geophysics and Geology*

L. A. BAUER: *Present Status of the General Magnetic Survey of the Globe.*

On April 1, 1914, the Department of Terrestrial Magnetism of the Carnegie Institution of Washington had completed the first decade of its existence. One of the first tasks undertaken was a general magnetic survey of the globe. During the period 1905–1914, 47 land expeditions to 107 different countries and island-groups, in all regions of the earth, were sent out. Magnetic observations have been made by these expeditions at 3,000 points, extending from 80° north to 70° south. The total length of the cruises of the two vessels used in the ocean magnetic work, the *Galilee* (1905–1908) and the *Carnegie* (1909–1914), is 161,000 miles. By the end of 1916, the first general magnetic survey of the globe for the region between about 70° north and 70° south, or for about 90 per cent. of the total area, will have been completed. Satisfactory progress has likewise been made in the atmospheric-electric work. Perhaps the most important result of the observations made on the *Galilee* and the *Carnegie* is a confirmation of the somewhat striking phenomenon that, while the conductivity over the ocean is, on the average, at least as great as over land, the radioactive content is much smaller. The values of the potential gradient obtained at sea were of the same order of magnitude as those on land.

T. C. CHAMBERLIN: *The Fundamental Segmentation of the Earth.*

The paper proceeds on the assumptions (1) that the earth-body is and always has been an elastic solid, (2) that it is and always has been crystalline throughout, (3) that the specific gravity of its constituents varies appreciably throughout its mass, (4) that it grew up by accessions which varied in the velocities with which they were added and in the positions at which the additions took place, and (5) in general, that the mode of growth was that postulated by the planetesimal hypothesis. It is further assumed that the nebular knot which constituted the nucleus of the earth-growth inherited (1) a certain unknown measure of rotation from the sun, (2) that successive changes in the rate of rotation arose later from the accessions, and (3) that still other changes arose from the contraction of the mass as it adjusted itself to the stresses incident to its growth and to the progress of internal reorganization.

The segmentation discussed in the paper is assigned to changing rates of rotation, the most powerful agency of deformation to which the earth is subject. The first order of deformation under rotation, the passage from a sphere to an oblate spheroid, is passed hastily as familiar ground, save that an analysis is offered of the mode by which an earth-body of crystalline texture, affected by a concentric structure, arising from accretion, and a radial structure, arising from vulcanism, would respond to the varying stress-demands imposed by changing rates of rotation. This first order of deformation or segmentation proceeds by halves acting reciprocally, its basis being the simplest of divisors, two. The essence of the paper consists in showing that when such bipartite division is extended to the second order of segmentation it develops mechanical inadaptabilities, but that a second order of segmentation on the basis of the next simplest divisor, three, results in working adaptations. This order of segmentation gives rise to six sectors of similar form arranged symmetrically relative to the axis of rotation and alternately respecting the sectors of the opposite hemisphere. The special adaptability of this segmentation to ease the stresses that arise from changes in the rates of rotation is pointed out, as also certain causal relations that exist between these sectors and their essential parts. The surficial expression of these sectors is identified with the great physiographic features of the earth's surface.

VI. *Botany Bacteriology*

CHARLES E. ALLEN: *Development of the Male Germ Cells of Polytrichum.*

At the conclusion of the antheridial divisions, each cell contains a blepharoplast which behaved like a centrosome in the last division. This blepharoplast begins to elongate. At about the same time a large spherical body, the limosphere, appears, variously situated in the cytoplasm; later it comes to lie near one (the anterior) end of the blepharoplast. The blepharoplast is now in contact with the plasma membrane; two long cilia grow out from its anterior portion. The nucleus elongates in the same direction as, and in contact with, the blepharoplast. The limosphere divides into two bodies; the smaller remains in contact with the anterior end of the blepharoplast; the larger lies close to the posterior part of the nucleus. The nucleus becomes a long, coiled, finally homogeneous body, of about one and one half turns. The cytoplasm contains another body of variable size, often lying in a vacuole, which is recognizable from a time a little later than the appearance of the limosphere until nearly the completion of the metamorphosis of the nucleus. During this history the cell becomes first approximately spherical, then lens-shaped. The cytoplasm, aside from the special bodies mentioned, gradually decreases in amount. The body of the mature antherozoid consists of the nucleus, with a short portion of the blepharoplast, bearing the cilia, at its anterior end. The rest of the blepharoplast has become indistinguishable. Adhering to the posterior end of the nucleus, but not a part of the body of the antherozoid, are the remains of the cytoplasm, including the larger derivative of the limosphere.

CHARLES J. CHAMBERLAIN: *A Phylogenetic Study of Cycads.*

The cycads, as the only surviving family of an ancient phylum reaching back into the Paleozoic, are peculiarly favorable for phylogenetic study, and the work of others upon the Paleozoic and Mesozoic predecessors of the modern family adds to the opportunity for comparison. The nine living genera of the Cycadaceæ are confined to tropical and subtropical regions, chiefly Mexico, Cuba, Australia and South Africa, but during the past ten years all the genera and many of the species have been studied in the field, and material has been collected for a somewhat complete study of life histories. The accounts already published have dealt with cycads in the field and also with cytological details of development and have been descriptive rather than theoretical, the natural tendency to discuss the comparative morphology and phylogeny of the phylum being restrained for the present. Cytological features have proved to be more uniform and distinctive than the characteristic habit of the family.

The investigation, as it stands, adds support to the already strong conviction that the Cycadofilicales, Bennettitales and Cycadales constitute a single phylum; when completed it may throw some light upon variation, development and retrogression.

WM. CROCKER AND J. F. GROVES: *Method of Determining the Life Duration of Seeds.*

In most seeds in a dry condition the viability persists from 1 to 150 years, varying with the species. There have been several explanations offered for the loss of viability. Exhaustion of food by respiration, degeneration of digestive and

respiratory enzymes, and the others have proved out of accord with known facts. The hypothesis that loss of viability is due to a slow coagulation of cell proteins of the embryo has been proposed and is being tested out by the writers. The testing of this hypothesis is carried out by getting the life duration at any two high temperatures and using these values in the formula that expresses the relation between time and temperature for the coagulation of proteins to find the life duration at any desired temperature. As an illustration of the results, a variety of wheat with 12.5 per cent. moisture gives a calculated longevity of 9.8 years at 20° C. and 110 years at 0° C. This and other calculated values at 20° C. tallies rather closely with records of longevity in wheat. Also the calculated values at various high temperatures tallies rather closely with the found life duration at those temperatures. Two points of technique deserve special mention, the method of maintaining the constant high temperature and the method of sterilizing the seeds for germination. If the hypothesis and method prove tenable they will be of great economic significance in making possible a quantitative statement of longevity as influenced by the factors of moisture content and temperature.

Edwin O. Jordan: *Variation in Bacteria.*

An attempt is made to distinguish in specific cases between true mutations and the more or less permanent adaptive modifications evoked in bacteria by definite environmental stimuli, and to determine the relative value of each in the formation of so-called bacterial species and varieties. The effect of acclimatization upon bacteria is considered as part of the problem. Specific instances of the extent of variation in a given direction and of the plasticity of a pure line strain are also brought out.

William Trelease: *Phoradendron.*

Outline of a taxonomic revision of this genus of American mistletoes, with indication of a new basis for its primary subdivison. The paper embodies the results of a study of all of the materials in the principal American and European herbaria in the course of which almost all of the species have been photographed from the types. One fourth of the recognized species belong to a section that is found in the United States, Mexico and Central America, but is absent from the West Indies and South America; and three fourths, to a section that extends through South America and the West Indies and through Central America and southern Mexico, but is entirely absent from the United States.

Though apparently well adapted to dissemination by birds, the species are rarely of wide geographic range and in general are confined to areas limited by barriers which are effective for non-parasitic plants.

VII. *Zoology and Paleontology*

C. M. Child: *A Dynamic Conception of the Organic Individual.*

Organic individuation may be either radiate or axiate. An organic radius or axis in its simplest terms is dynamically a gradient in rate of metabolism or of certain fundamental reactions. In this gradient the region of highest rate of reaction is in greater or less degree dominant over other regions because of its higher rate of reaction and therefore influences the dynamic processes in them and determines the orderly course of development and functional relation. This dominance apparently depends primarily rather upon transmitted dynamic changes than upon transported chemical substances and the integrating action of the nervous system is its final expression. Since a decrement occurs in transmission, dominance becomes ineffective beyond a certain variable distance and the size of the individual is therefore physiologically limited. Reproduction results from the following conditions: first, physiological or physical isolation of a part from the influence of the dominant region; second, a greater or less degree of dedifferentiation or loss of its characteristics as a part in consequence of the isolation; third, the presence or establishment in the isolated mass of an axial gradient or gradients; fourth, a new individuation and developmental history in consequence of the presence of the gradient and a dominant region. The axial gradients are not fundamental properties of protoplasm but result from local differences in the action of factors external to the protoplasm, cell, or cell mass in question. Orderly progressive development and definitely coordinated function are impossible except where such gradients exist or have existed.

Frank R. Lillie: *The Fertilizing Power of Sperm Dilutions.*

On the basis of the usual supposition that a single active spermatozoon may fertilize an egg of its own species, fertilization of eggs in series of sperm suspensions of increasing dilution should run in accord with the following law: To the point in the series in which each egg receives a single spermatozoon all of the eggs should be fertilized;

beyond this point the percentages of eggs fertilized should fall off at first slowly, then rapidly, and then slowly again to a vanishing point.

This condition is not realized, however, in actual experiments *unless* the time interval between preparation of the more dilute sperm suspensions and addition of the eggs is made very short (less than five minutes). Under such optimum conditions the curve of percentages of fertilized eggs begins to fall from 100 per cent. at a dilution of about 1/3000 of 1 per cent. sperm; the curve falls slowly to about 1/24000 per cent., then rapidly to about 1/300,000 per cent., then slowly again to about 1/90,000,000 per cent. where however about 1 per cent. of fertilizations may still take place. The observations show that beyond a dilution of 1/20,000 of 1 per cent. only a single spermatozoon can possibly be concerned in the fertilization of each egg.

If the time interval be lengthened to twenty minutes, fertilizing power of sperm suspensions may be completely lost at 1/1000 per cent., a point in the series of dilutions at which each egg recieves several spermatozoons. Comparing sperm suspensions of increasing dilution it is found that the rate of loss of fertilizing power is inversely proportional to concentration. Thus the time required for complete loss in a series of sperm suspensions between 1/600 per cent. and 1/120,000 per cent. forms a curve ranging from 45 down to 6 minutes. Presumably the time is even shorter at greater dilutions.

Spermatozoa may be perfectly motile after loss of fertilizing power. Their ineffectiveness in these experiments is therefore due to loss of a necessary substance. This is an interesting confirmation of the postulate, for which all experimental proof has hitherto been lacking, that the fertilizing power of spermatozoa is due to a definite substance. The spermatic substance in question represents the "sperm-receptors" of my theory of fertilization.

W. L. TOWER: *Experimental Production of a New Character.*

The antennæ of the Chrysomelidæ are highly invariable organs and are used but little in taxonomic differentiation, even of the genera and families. Of especial interest, therefore is the experimental production, by means of continued environmental pressure of a factorial group that is productive of antennal conditions not known to exist in any living or fossil Chrysomelidæ. In origin it arose progressively, in one direction, exists in three states of stability, each of which is capable of transference to other species through crossing, thus giving a picture of what may be one method of the production of nearly related genera. A final point of significance is that its behavior in crosses is no criterion of its method of origination, as it arose progressively, with all possible intergrades, but was at all points in the series alternative and dominant to the normal.

S. W. WILLISTON: *The American Land Vertebrate Fauna and its Relations.*

The land vertebrate fauna of Lower Permian or Permocarboniferous age in North America comprises, so far as now known, at least sixty definitely distinct genera, distributed about equally among the Amphibia, *Cotylosauria* and so-called *Pheromorpha.* From all other parts of the world, of approximately equivalent age, less than a dozen genera are known, for the most part imperfectly. In North America vertebrates are known only from New Mexico, Texas and Oklahoma, Illinois, and Pennsylvania. The fauna of New Mexico comprises, so far as is yet known, sixteen valid genera, twelve of them unknown elsewhere, the remaining four somewhat doubtfully identified with Texas forms. Not a single genus or family even of the American fauna is definitely known to occur elsewhere.

The American forms, and especially the higher reptiles, within the limits of their more generalized characters, are very diverse. That localities so little remote as Texas and New Mexico, though showing intimate family resemblances, should be so distinct in their genera is evidence that the world's fauna in Lower Permian times was an exceedingly abundant one. Probably at no time in the earth's history has there been a more extensive fauna of reptiles. As it is, there is no formation known in geological history of approximately equal duration that has yielded a greater number of genera of reptiles and amphibians than the American deposits.

The conclusion is legitimate that as early as the close of Carboniferous times the reptilian fauna of the world was a relatively old one. It has been urged that the relationships of this reptilian fauna with that of the Middle and Upper Permian of Africa was a close genetic one. From a recent study of most of the known specimens of European Permian vertebrates I am convinced that their resemblances are yet closer. On the other hand it has been urged that the American Permian fauna is an isolated one, with-

out any real genetic relationships with any known subsequent fauna; that such resemblances as have been shown are merely primitive or archaic, due to heredity from common ancestors. The truth probably lies between the two views.

VIII. *Physiology*

A. J. Carlson: *Some New Observations on the Physiology of the Stomach in Man.*

A. The relation of the stomach to the sensation of hunger. (1) Peripheral, and central control of the hunger mechanism. (2) Chemical control of the hunger mechanism. (3) The change in the hunger mechanism with age.

B. The relation of the stomach to appetite. (1) The qualitative difference between hunger and appetite.

C. The secretion of gastric juice in man. (1) The chemistry of normal human gastric juice. (2) Factors influencing the rate and quantity of the secretion. (3) The action of tonics or bitters on (*a*) the hunger mechanism; (*b*) on the secretion of gastric juice.

Shiro Tashiro: *On the Nature of Nerve Impulse.*

Lack of fatigue, as measured by ordinary methods, and absence of heat production during continued stimulation in the nerve, have driven some physiologists to consider that the nerve impulse passes through the fiber without consuming any material. With new apparatus which measures as little CO_2 as 0.0000001 gm., we have demonstrated that a living nerve gives off a definite amount of CO_2 and that when it is stimulated, this CO_2 production is increased. These new facts may be interpreted in two different ways. Some believe that a living nerve should be metabolically active like any other tissue, but that the chemical change is not identical with the nerve impulse, but is the result of functional activity. Others consider that the progress of chemical change itself constitutes the nerve impulse. This latter view is supported by some recent results, which show that CO_2 production from the resting nerve under different conditions is parallel to the physiological state of the nerve; that the normal nerve impulse passes toward a point of lower CO_2 production; that the rate of nerve impulse is closely connected with the rate of CO_2 production and that factors which influence the rate of nerve impulse equally influence the metabolism of the resting nerve. The nerve impulse is probably a propagated chemical change, the propagation being due to restoring the equilibrium which was disturbed first at the point of stimulus.

THE PHILADELPHIA MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The sixty-sixth meeting of the American Association for the Advancement of Science and of the affiliated scientific societies will be held in Philadelphia beginning on December 28. We hope to publish next week full details of the preliminary program. It may now be noted that while the council of the association and some of its sections and affiliated societies will meet on Monday morning, the first general session will be held in the University gymnasium on Monday evening. The retiring president, Dr. Edmund B. Wilson, of Columbia University, will introduce the president of the meeting Dr. Charles W. Eliot, of Harvard University, and will give the annual address entitled "Some Aspects of Progress in Modern Zoology." After the meeting there will be a reception in the University Museum by Provost and Mrs. Smith.

The meetings of the sections and of most of the affiliated societies will be in the buildings of the laboratories of the University of Pennsylvania. Luncheon will be served daily in the gymnasium and all those in attendance are cordially invited to be present. The Houston Club is the headquarters at the University of Pennsylvania, and the Hotel Adelphia is the hotel headquarters.

An interesting event of the meeting will be the first session of the newly established section of agriculture, which will meet on December 30. The program will be a modest one, as becomes a new section, and will be specialized to cover some of the questions surrounding the business side of agriculture and the life of people living under it, rather than the strictly production phases. The address of the vice-president of the section, Dr. L. H. Bailey, late director of the College of Agriculture at Cornell University, will deal with "The Place of Research and of Publicity in the Forthcoming Country Life Development." The other main feature of the program will be a symposium on the general subject of "The Field of Rural Economics." Special phases of the subject will be presented by speakers invited to discuss