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RECORD OF MEETINGS
OF THE
NEW YORK
ACADEMY OF SCIENCES

JANUARY, 1902, TO DECEMBER, 1902

HENRY E. CRAMPTON
Recording Secretary

[ANNALS N. Y. ACAD. SCI., XV, No. 1, pp. 1-108, August 31, 1903.]

RECORD OF MEETINGS
OF THE
NEW YORK ACADEMY OF SCIENCES.

January, 1902, to December, 1902.

HENRY E. CRAMPTON, *Recording Secretary*.

BUSINESS MEETING.

JANUARY 6, 1902.

Academy met at 8:15 P. M., Professor William Hallock presiding. The minutes of the last business meeting were read and approved.

There being no business to come before the Academy, the Academy adjourned at once.

RICHARD E. DODGE,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND
CHEMISTRY.

JANUARY 6, 1902.

Section met at 8:20 P. M., Professor Hallock presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered:

William Hallock, THE MAGNETIC DISTURBANCE OF STEEL
WIRE PLUMB-BOBS.

William Hallock, A THERMOGRAPH FOR SOIL TEMPERATURE.

H. C. Parker, THE VARIATION OF CONTACT RESISTANCE
WITH CHANGE OF ELECTROMOTIVE FORCE.

SUMMARY OF PAPERS.

Professor **Hallock** stated that in the course of the work in the very deep shaft of the Tamarack Mining Co. on Lake Superior it had been found desirable to plumb down certain points from the surface. The plumb-lines used were of No. 24 piano wire and the weights were fifty pounds of iron. At first the lines were 16.33 feet apart at the top and they were later moved to 17.66 feet. The remarkable observation was made that in the first case they were 0.08 feet and in the second case 0.07 feet farther apart at the base than at the top. It was pointed out that a deflection of such an amount could not be explained as due to the gravitational attraction of the walls of the shaft for the nearer plumb-bob. Professor Hallock suggested that the effect was probably due to the magnetization of the wire and the consequent repulsion of the north poles at the bottom. In order to test the possible applicability of this theory a number of experiments were made in the research shaft at Columbia University which gave much corroborative evidence. Two plumb lines, about 85 feet long, were suspended in the shaft. One was of copper wire and the other of iron wire about 0.03 inch in diameter. Lead weights were attached and it was found that the lines were about $\frac{1}{5}$ in. closer together, at the bottom, when the iron line was south of the copper than when it was north. Two lines of iron wire were also used and the distance apart at top

and bottom measured. The deflections obtained were of the same order of magnitude as those produced by the earth's field. The deflections thus obtained give evidence of magnetic forces of sufficient magnitude to explain the deviations observed in the plumb-lines in the Tamarack shaft.

Professor **Hallock** also described a form of recording thermometer which he had lately devised. It consists of a large copper bulb connected by means of capillary copper tubing to a series of cells similar to those used in the construction of aneroid barometers. The bulb, tube and cells were filled with oil and the recording mechanism attached to the aneroid cells.

Mr. **H. C. Parker** gave the results of some experiments he had made on the variation of contact resistance with change of electromotive force. The resistance used in the experiments consisted of oxide of manganese on cobalt glass, the new form of standard high resistance described in a previous paper given before the academy. The electromotive force employed consisted of 10, 50, and 100 dry cells, respectively. It was found in every case that the resistance decreased with increase of electromotive force. This decrease might be only a small per cent. or the resistance might be reduced to a small fraction of the original value. Improving the contacts rendered this change in resistance much less marked. It was suggested that this decrease in resistance when the electromotive force was increased might be due to a kind of coherer action taking place at the contacts. Very high resistances measured by the electrometer method were found practically to obey Ohm's law. It was pointed out that in such cases the contact resistance was probably only a small portion of the entire resistance.

Section adjourned.

F. L. TUFTS,
Secretary.

SECTION OF BIOLOGY.

JANUARY 13, 1902.

Section met at 8.15 P. M., Professor C. L. Bristol presiding.

The minutes of the last meeting of Section were read and approved.

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The following program was then offered:

Franz Boas, THE RELATION BETWEEN THE VARIABILITY OF CELLS AND THAT OF ORGANISMS.

Gary N. Calkins, DEGENERATION IN PARAMECIUM AND SO-CALLED REJUVENESCENCE WITHOUT CONJUGATION.

Henry E. Crampton, NATURAL SELECTION IN SAMIA CECROPIA.

SUMMARY OF PAPERS.

Professor **Boas**, in his paper, which has been printed in full in *Science* for January 3, 1902, established the following conclusions: "(1) The elements of organisms are more variable than the organisms themselves. (2) The elements of organisms vary in correlated groups. (3) The characteristics of the variability of an organism depend upon the correlations of its constituent elements, so that a knowledge of these correlations will enable us to determine the characteristics of the variability of the organism." (4) It was also pointed out that skew distribution of variations does not necessarily indicate selection, or instability of type, but may occur in stable forms.

Dr. **Calkins** presented the history of two individuals, *A* and *B*, of *Paramacium caudatum*, from different localities, which were isolated February 1, 1901. These were fed on twenty-four hour hay-infusion and the number of divisions recorded at periods of from one to three days throughout the year, one individual being isolated each time. Conjugation occurred for the first time, among the extras, in May. This period was followed, in July, by well-marked degeneration of both *A* and *B*, which went so far that nearly all of the stock was lost. The survivors were stimulated to renewed activity by treatment with extract of lean beef. After three months of normal and active divisions, another period of conjugation occurred. This again was followed by degeneration and again the cultures were saved by treatment with beef-extract. At the present date (Jan. 13), *A* is in the 416th generation and *B* in the 375th generation, and no conjugation has taken place in the direct line of the cultures. Thus far the experiments have yielded the following results: (1) *Paramacium* unquestionably passes through more

or less regular cycles of activity and weakness. (2) The period of weakness is preceded by one of greater dividing-activity. (3) The period of weakness ends in death, provided the diet (hay-infusion) remains the same. (4) Beef-extract, without conjugation, restores the weakened functions of growth and division. (5) Exogamous conjugation of *A* and *B*, if followed by the same diet (hay-infusion), does not restore these weakened activities, but is soon followed by death. (6) Exogamous conjugation between wild gametes, and followed by hay-infusion diet, results in normal growth, division, and life. (7) Endogamous conjugation does not differ from exogamous conjugation. The ex-conjugants live and divide normally if fed for a time with beef-extract, but die if fed directly with hay-infusion. (8) One intra-cellular effect of beef-extract upon weakened *Paramacium* is the formation of "excretory granules." Another is the disintegration of the old macronucleus. (9) A few conclusions to be drawn are: (*a*) a change of diet is necessary for the continuance of vital activities; (*b*) the equivalent of parthenogenesis in higher animals may be induced by change in diet; (*c*) conjugation, by itself, does not "rejuvenate"; (*d*) conjugation probably has some other significance than that usually accepted, though what this significance may be is not indicated, thus far, by the experiments.

Professor **Crampton** presented the results of a statistical study upon pupæ of *Samia cecropia*. Twenty-five characters were determined for a lot of 456 pupæ, the measurements were tabulated, and the usual constants of the curves of variation were ascertained, viz., the range, mode, mean, standard deviation, and coefficient of variability. It was found that only 349 of these pupæ produced perfect moths at the time of metamorphosis, the others being imperfect to a greater or less degree, and therefore presumably eliminated as far as reproduction is concerned. When, now, the former class was compared, sex by sex, with the whole group of pupæ, it was found to be a selected class of the less variable individuals, while the more variable ones were eliminated. Selection is therefore "periodic" in the sense of Pearson. The fact of primary interest appears

when this case is contrasted with that of the introduced *P. cynthia*. As reported last spring, selection in the latter species is similarly of the less variable individuals, but is "secular" as well, that is, the perfectly metamorphosing pupæ form a class by themselves, with a type which differs from that of the whole group. It was pointed out that the real basis of selection was probably a correlative one, a physiological "fitness" depending upon the proper coördination or correlation of the various parts of the organism.

HENRY E. CRAMPTON,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

JANUARY 20, 1902.

Section met at 8:15 P. M., Dr. A. A. Julien presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered:

R. P. Whitfield, OBSERVATIONS ON AND EMINENT DESCRIPTION OF *HETEROCERAS SIMPLICOSTATUM* WHITE.

R. P. Whitfield, DESCRIPTION OF A NEW TEREDO-LIKE SHELL FROM THE LARAMIE GROUP.

James Douglas, NOTES ON THE RIO TINTO COPPER DISTRICT.

SUMMARY OF PAPERS.

In the first paper Professor **Whitfield** emended and elaborated the description of the ammonite, *Heteroceras simplicostatum* which he gave originally in the Newton and Jenney Report on the Black Hills;¹ the new observations being based upon material collected in July, 1901, for the American Museum of Natural History by Dr. E. O. Hovey. The present material shows conclusively that the three genera, *Hamites*, *Ancylloceras* and *Heteroceras*, have no independent existence, because single individuals possess the distinguishing characters of all three genera combined. The fact that these genera were not inde-

¹ Report on the Geology and Resources of the Black Hills of Dakota. With atlas. By Henry Newton, E.M., and Walter P. Jenney, E.M., Washington, 1880. Paleontology by R. P. Whitfield.

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pendent was suspected by the author when at work upon the Newton material twenty-five years ago, and the compound character of some ammonites has been stated by Professor Alpheus Hyatt, but these seem to be the first specimens to be described which actually show the combination in a single individual.

Professor **Whitfield's** second paper described a new Teredo-like shell from the Laramie group of eastern Wyoming, collected by Mr. Barnum Brown, of the American Museum. This teredo, to which the author has given the name *Xylophomya laramiensis*, is more than an inch in diameter, thus ranking as the largest species of the family known.

These two papers may be found in full in the current volume (Vol. XVI) of the Bulletin of the American Museum of Natural History.

The third paper of the evening was by Professor **James Douglas**, and gave a description, illustrated by topographic map and numerous lantern slides, of the famous Rio Tinto group of the copper mines of the Huelva district in Spain. These mines have been worked from time immemorial, the earliest knowledge of them dating from the Phœnicians, who occupied the country in the eleventh century, B. C. The Romans also obtained a large amount of copper from these deposits, and it is an interesting fact that the slags which they left are purer, that is, freer from copper, than those which are made there to-day. The ore is a copper-bearing pyrite, carrying some silica. The copper-bearing portions run irregularly through the iron pyrites, and the Rio Tinto Company has removed millions of tons of forty-two per cent. iron ore in getting at its copper ore. The iron ore is not profitable at the present time, although it may become so in the distant future. There are some remains of the workings of the ancients here. At Tharsis in particular the old shafts are very peculiarly constructed, one at least being spiral, to enable the miners to carry the ore on their backs. Shelves are excavated at intervals in the walls of the shaft to enable the men to rest their loads on their weary journey to the surface.

The mines are worked now as open-air diggings in circular terraces. They produce about two million tons of ore per year, and it is estimated that there are one hundred and sixty million tons in sight. Some silver-bearing galena is associated with the copper ore. The old-fashioned method of roasting the ore in heaps was kept up until 1893, but the ore is now leached by means of water. This is a long process, requiring four years for its thorough completion, but the copper is leached out so that less than one fourth of one per cent. is left in the tailings. The great bulk of the world's supply of sulphuric acid is obtained from the Rio Tinto pyrite, which is shipped all over the world for the purpose of manufacturing the acid. Five hundred thousand tons per year are utilized in this way.

The paper was discussed by Dr. Julien and Mr. Howe, and the section passed a hearty vote of thanks to Professor Douglas for his kindness in giving the paper.

EDMUND O. HOVEY,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

JANUARY 27, 1902.

Section met at 8:30 P. M., Professor Farrand presiding. The minutes of the last meeting of Section were read and approved.

After opening the meeting, the chairman called on General James Grant Wilson to preside.

The following program was then offered:

F. S. Dellenbaugh, THE LOCATION OF HISTORIC TOWNS AND "NATIONS" OF NEW MEXICO PRIOR TO 1630.

Harlan I. Smith, A RECENTLY DISCOVERED EARTHWORK IN OGEMAW COUNTY, MICHIGAN.

John R. Swanton, MYTHOLOGY AND ORIGIN OF THE HAIDA INDIANS.

SUMMARY OF PAPERS.

Mr. **F. S. Dellenbaugh** explained his understanding of the location of the historic towns and "nations" of the Rio Grande valley in New Mexico prior to 1630. This differs radically

and entirely from the present accepted arrangement. He maintains that the location of Tiguex, rather than Cibola, is the key to the correct solution of this problem, and from strong evidence derived from Benavides, Espejo, Castañeda and others, he locates Tiguex near San Antonio station. The site at Bernalillo, for this central town, so long advocated by Bandelier and his followers, he declares is impossible. With Tiguex at San Antonio station, the famous "Seven Cities of Cibola," which Bandelier placed on the site of modern Zuñi, are thrown instead into southwestern New Mexico, either on the Gila near Old Camp Vincent, or Old Fort West, or between these and the Florida Mountains, with the balance in favor of a site on the Gila. Cicuyé, instead of being at Pecos, was apparently a Tompiras town, either what has been erroneously called *Gran Quivira* or some village of that locality. The Braba of Coronado would fall in the vicinity of the present Cochiti, instead of at Taos, and Tusayan instead of being at the Moki towns, would fall in its position 20 leagues (50 or 60 miles) northwest of the position of Cibola.

Mr. **Harlan I. Smith** presented a paper on the "Hauptman Earthwork," in Ogemaw County, Michigan. The discovery of this earthwork was first announced by him in *Science*, June 21, 1901 (p. 991). Personal observation in July enabled him to correct its location somewhat. It is on Section 33 or 34, or both, T. 22, N. (instead of 21), R. 1, E. It was found to lie in a lumbered pine area, and, unlike most such earthworks, far from any watercourse. It is covered by dense undergrowth and fallen timber. It is composed of a rounded embankment of earth, about two feet high and twelve feet wide, encircling an area about 197 by 177 feet; outside this is a ditch, two feet deep, six feet wide at the top, but narrowing towards the bottom. Signs of another embankment were seen outside the ditch, and within the enclosed area were several hummocks which may prove to be mounds or similar works. There are three openings in the embankment. The antiquity of the work is indicated by the presence of large pine stumps on the embankment and in the ditch; the largest stump measured thirteen feet four inches in circumference.

An effort is being made to have this ancient work enclosed in a state, county or township park. The land, now worth perhaps less than \$10 an acre, can easily be secured. If neglected, the road to be built on the line between sections 33 and 34 will probably destroy the work.

Dr. **John R. Swanton** reported some results of his investigations into the mythology and origin of the Haida Indians of northern British Columbia. The whole Haida people is divided into two clans, Raven and Eagle, each of which is strictly exogamic with descent in the female line, and has its own crests, its own names, its independent traditional centers of origin. Each is subdivided into a number of families. The Raven clan traces its origin from a single legendary ancestress, who is reputed to have emerged from the waters with the Haida island. Some families of that clan, however, trace their descent from other sources. The Eagle clan has much less traditional unity of origin, and there are certain indications in the tradition that this clan is of foreign origin or at least has received considerable admixture of foreign blood. One important fact that seems to point to the Raven clan as the indigenous element is the great preponderance of Ravens among the supernatural beings of the island.

• R. S. WOODWORTH,
Secretary.

BUSINESS MEETING.

FEBRUARY 3, 1902.

Academy met at 8:20 P. M., President Woodward presiding.

The Secretary reported from the Council as follows:

That the Council had nominated the three following Honorary Members, to be voted upon at the forthcoming Annual Meeting.

James Dewar, M.A., LL.D., F.R.S., Jacksonian Professor of Experimental Philosophy, University of Cambridge, England.

William James, M.D., LL.D., Ph.D., Litt.D., Professor of Philosophy, Harvard University, Cambridge, Mass.

Wilhelm Wundt, Ph.D., M.D., Professor of Philosophy, University of Leipzig, Germany.

That the Council had voted to nominate no corresponding members.

That the Council had voted to nominate the following Fellows to be voted upon at the Annual Meeting :

Maurice A. Bigelow, Herman C. Bumpus, O. B. Hay, E. O. Hovey, W. D. Matthew, S. J. Meltzer.

The Recording Secretary read the list of nominations of Officers prepared by the Council, and announced that it would be mailed to members of the Academy two weeks before the Annual Meeting.

The proposed bill for amending the Charter, which is herewith appended¹ was submitted by the Council, with the recommendation from the Council that it be approved by the Academy, and that if approved the Academy authorize the Charter Revision Committee to take such steps as are necessary to have the bill enacted into law.

It was voted to approve the bill, and to give the Charter Revision Committee the authorization requested.

Adjourned.

RICHARD E. DODGE,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

FEBRUARY 3, 1902.

Section met at 8:40 P. M., Professor Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

Mr. G. B. Pegram, EXPERIMENTAL METHODS OF STUDYING
RADIO-ACTIVITY.

SUMMARY OF PAPERS.

The paper of the evening consisted of a description of the methods which have been employed in studying radio-active substances, and also a brief summary of the more important results which have been obtained.

¹ See Appendix.

The discussion of the paper was confined chiefly to questions regarding these methods and results.

Section adjourned.

F. L. TUFTS,
Secretary.

SECTION OF BIOLOGY.

FEBRUARY 10, 1902.

Section met at 8:15 P. M., Professor Stratford presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

W. B. Scott, THE ORIGIN AND DEVELOPMENT OF SOUTH AMERICAN MAMMALS.

SUMMARY OF PAPERS.

Professor **Scott** began by expressing his great obligation to Dr. F. Ameghino, as also to Dr. Moreno, Director, and to the Curators of the La Plata Museum, for their kindness in giving him the freest use of their collections, and enabling him to examine all the types of the Santa Cruz mammals.

The fauna of every continent is made up of two elements, the indigenous forms which were developed in that continent, and the immigrants from other regions. In South America this distinction is easy to draw, because of the remarkable series of Tertiary deposits which are wonderfully rich in well-preserved fossils. The Santa Cruz beds, which are referable to the lower Miocene, contain an assemblage of mammals altogether different from those of the northern hemisphere. The fauna consists of Primates and Insectivora, very scantily represented, very numerous Rodents (though all referable to the Hystricomorphs), Marsupials, Edentates, and the peculiar South American hoofed animals. The Edentates of this period represent the Gravigrada, Glyptodonts, and Armadillos, but no members of the true sloths or Anteaters have yet been found, a lack of which is probably due to climatic conditions. The Gravigrada, which are very abundant, have forerunners of all the great Pleistocene groups, but are, of course, much less specialized and are rel-

atively small in size. The Glyptodonts, though numerous and well preserved, are not so easily brought into relations with the later genera of the same group.

The paper concluded with a brief examination of the remarkable Ungulates, all of which are peculiar to South America and especial attention was called to Ameghino's discovery, yet unpublished, that in *Nesodon* there are three sets of functional incisors and canines. Incredible as such an observation may be, it seems to be well established.

HENRY E. CRAMPTON,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

FEBRUARY 17, 1902.

Section met at 8:30 P. M., Dr. Alexis A. Julien presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

O. P. Hay, THE SNOUT-FISHES OF KANSAS.

A. A. Julien, THE EFFECT OF VARIOUS KINDS OF HONE-STONES ON THE CUTTING EDGE OF TOOLS.

SUMMARY OF PAPERS.

Dr. **O. P. Hay** presented a brief history of our knowledge of the genus *Protosphyraena* and a statement showing what portions of the skeleton were still unknown. The parts which are best known are the skull, especially the elongated snout, the jaws, the shoulder-girdle and the caudal and the pectoral fins. These parts have seldom been found associated, and there have been established three series of species, one on the teeth, another on the snout and a third on the fins. It is certain that, as new collections are made and studied, some of these new species will be reduced to synonymy. The author pointed out several errors on the part of writers in the interpretation of different elements of the skeleton and illustrated his points by means of specimens.

In his impromptu paper Dr. **A. A. Julien** gave a summary of

the results of some recent investigations he had made on a series of chisels which had been sharpened on several kinds of hones. In the course of his remarks he said that the quality of a hone depended on the size and shape of its component particles, and upon the cement joining the whole together. An exception was noted in the case of the novaculites from Arkansas, in which the honing quality is due to the sharp edges of minute cavities left by the solution of calcite; and in the case of Turkey-stone, in which the honing quality is due to veinlets of quartz intersecting a rock which has been formed by silica replacing a granular limestone. A microscopic study shows that the edge of a tool is not regularly serrated, part of it being smooth and part undulatory. Viewed on edge the sharpest tools are practically straight, while the others are more or less irregularly wavy. Viewed in the cross-section, a fine edge is seen to be a perfect wedge, while the duller tools show a minute shoulder.

EDMUND O. HOVEY,
Secretary.

ANNUAL MEETING.

FEBRUARY 24, 1902.

The Academy met for the Annual Meeting at 8:15, President Woodward in the chair.

Reports of the officers for the past year were called for and presented in the following order:

The Recording Secretary read a report from the Corresponding Secretary to the effect that no correspondence with Honorary or Corresponding Members had been conducted during the year.

The report of the Recording Secretary, filed herewith, was read.

The accompanying report of the Treasurer was read and referred to the Finance Committee for auditing.

The accompanying reports of the Librarian and Editor were read.

The following nominations for Honorary Members, selected by the Council according to the By-Laws, were read, and the

Secretary was empowered to cast an affirmative ballot of the Academy therefor, which was done.

James Dewar, M.A., LL.D., F.R.S., Jacksonian Professor of Experimental Philosophy, University of Cambridge, England, 21 Albemarle St., London, England.

William James, M.D., LL.D., Ph.D., Litt.D., Professor of Philosophy, Harvard University, Cambridge, Mass.

Wilhelm Wundt, Ph.D., M.D., Professor of Psychology, Leipzig, Germany.

The following list of Fellows, nominated by the Council according to the By-Laws, was read, and the Secretary was empowered to cast the affirmative ballot of the Academy therefor, which was done.

Maurice A. Bigelow.

Hermon C. Bumpus.

O. P. Hay.

E. O. Hovey.

W. D. Matthew.

S. J. Meltzer.

The President then appointed Professors Charles Lane Poor and J. K. Rees as tellers; ballots were distributed, votes received and counted, and the following list of officers elected:

President: J. McKeen Cattell.

First Vice-President: Nathaniel L. Britton.

Second Vice-President: Richard E. Dodge.

Corresponding Secretary: Bashford Dean.

Recording Secretary: Henry E. Crampton.

Treasurer: Charles F. Cox.

Librarian: Livingston Farrand.

Councillors: Franz Boas, Hermon C. Bumpus, D. W. Hering, Frederic S. Lee, Charles Lane Poor, L. M. Underwood.

Curators: Harrison G. Dyar, Alexis A. Julien, George F. Kunz, Louis H. Laudy, E. G. Love.

Finance Committee: John H. Caswell, John H. Hinton, C. A. Post.

Three nominations for resident membership were read and referred to the Council according to the By-Laws.

The President and Recording Secretary elect then took the Chair, and President Woodward delivered his Annual Address, entitled "Measurement and Calculation."

At the close of the address a vote of thanks to the retiring President was moved by ex-President Osborn, and carried.

Adjourned.

RICHARD E. DODGE,
Recording Secretary.

REPORT OF THE RECORDING SECRETARY.

During the last academy year the Council and the several sections of the Academy have held their customary meetings, and the academy work has progressed in many ways favorably along the usual lines.

At the meetings there have been 68 papers presented, divided as follows :

Anthropology 7.	Paleontology 6.
Archæology 3.	Photography 1.
Astronomy 4.	Physics 8.
Botany 1.	Physiography 4.
Geology 9.	Physiology 2.
Mechanics 3	Psychology 8.
Miscellaneous 3.	Zoölogy 9.

There are at present 298 Resident Members, 92 Fellows, and the election of six Fellows is pending.

At the May meeting, on recommendation of the Council, Dr. Franz von Leydig, of Würzburg, Germany, was elected an Honorary Member, and in October, the Executive Committee of the Council sent a letter of congratulation to Dr. Rudolf Virchow on the occasion of his eightieth birthday. The Academy has lost during the year one of its leading workers, Dr. Theodore Greeley White, who died in July; a suitable minute concerning Dr. White is printed in the Records for the year. Twelve members of the Academy have been dropped from the rolls for non-payment of dues.

The leading task that the Council has had to consider for the year has been that of modifying the Constitution and By-Laws to suit existing conditions. It was found necessary, in order to bring this about, to have the charter revised, and by vote of the Academy, February 3, a committee of the Council was authorized to have a bill presented to the Assembly and Senate of New York to this end. Word has just come of the passage of the bill by both members of the legislative body. In accordance with the bill a new Constitution must be adopted by the Academy within three months, and a committee is already at work on this problem.

The other serious matter now under discussion by the Council is the question of the method of printing the short papers of the Academy, which will go into effect at the beginning of the current volume of the ANNALS.

Respectfully submitted,

RICHARD E. DODGE,

Recording Secretary.

REPORT OF THE TREASURER.

RECEIPTS.

Balance as per last Annual Report.		\$4,337.20
Mortgage on 113th St. property paid off		9,000.00
Income, Permanent Fund.	\$489.70	
" Audubon Fund.	47.95	
" Publication Fund.	98.45	636.10
Life Membership Fee.		100.00
Initiation Fees.		25.00
Annual Dues, 1898.	10.00	
" 1899.	50.00	
" 1900.	110.00	
" 1901.	2,225.00	
" 1902.	30.00	2,425.00
		<hr/>
		\$16,523.30

DISBURSEMENTS.

Invested in Bond and Mortgage @ 5 %		
on 205 St. Ann's Avenue.....	12,000.00	
Publication of Annals.....	\$1,499.12	
Less Sales.....	247.86	1,251.26
Publication of Memoirs.....	530.97	
Less Sales.....	33.22	497.75
Rent of Rooms.....		325.00
Dues to Scientific Alliance.....		50.12
Expenses of Treasurer.....		31.78
" Librarian.....		191.23
" Recording Secretary.....		211.94
General Expenses.....		51.90
Lectures.....	34.25	\$14,645.23
Balance, Cash on Hand.....		<u>1,878.07</u>

BALANCE SHEET.

FEBRUARY 24, 1902.

	DR.	CR.
Permanent Fund.....		\$10,551.43
Publication Fund.....		1,823.69
Audubon Fund.....		1,897.25
Invested in Bond and Mortgage at		
5 per cent.....	\$12,000.00	
Income Account (Due Permanent		
Funds).....	394.30	
Cash on Hand.....	1,878.07	
	<u>\$14,272.37</u>	<u>\$14,272.37</u>

CHARLES F. COX,
Treasurer.

REPORT OF THE LIBRARIAN.

The work in the Library during the past year has been directed toward clearing up the accumulations in exchanges during the period of financial stress through which the Academy has been passing; and the Librarian is glad to be able to state that through the energy of the present assistant, Mr. W. M. Erb, all material up to date is now sorted, catalogued and filed on the shelves and open to reference to members of the Academy.

The great need of the Library is still, as it has been for a number of years past, an appropriation for the binding of books. Hundreds of volumes of periodicals have now accumulated and while every effort is made to preserve them intact considerable injury and loss is unavoidable. A second need is adequate cataloguing by expert hands. The usefulness of the Library would be much increased if this could be provided. With the limited appropriation at present at the disposal of the Librarian it has seemed wiser to concentrate the energy upon keeping the accessions in order rather than to divert any portion of the funds to the two purposes suggested. The same policy will doubtless be pursued during the coming year.

Respectfully submitted,

LIVINGSTON FARRAND,
Librarian.

REPORT OF THE EDITOR.

Volume XIII of the ANNALS, Parts 2 and 3, comprising four papers, together with the Records of the Meetings of the Academy, from January, 1900, to December, 1900, have been printed and distributed. This completes Volume XIII of the ANNALS, which consists of seven papers, together with the Records forming a volume of 542 pages and 16 plates.

Volume XIV of the ANNALS, Part 1, has also been printed and distributed, and this Part consists of four papers of 84 pages and 5 plates. Volume XIV, Part 2, containing the Records of the Meetings of the Academy for the year January, 1901,

to December, 1901, is now in press, and will be distributed to the members within a very short time.

Volume II, Part 3, of the *Memoirs*, entitled "Palæontological Notes," by Bashford Dean, 4to, pages 87-123; plates 3 to 8, has also been printed and distributed. This *Memoir* was in part paid for out of the Audubon Fund.

When the Editor was appointed, in December, 1900, the funds of the Academy available for publication had been exhausted, and the year was begun with a large deficit. During the year the accounts have been straightened out, the deficit met, and the year will close with practically a clean balance sheet.

Respectfully submitted,

CHARLES LANE POOR,
Editor.

PRESIDENT'S ADDRESS.

MEASUREMENT AND CALCULATION.

In my address of a year ago I sought, in a summary way, and by concrete illustration, to indicate how science originates in and advances with observation and experiment. I would now invite your attention to a similar consideration of the rôle which measurement and calculation play in the higher developments of science.

All sciences are at first qualitative. They pass in their growth from the fact-gathering stage of unrelated qualities to the orderly stage of related qualities and thence upward to the stage of quantitative correlation under theory. Such, at any rate, has been the course of all sciences hitherto developed, and it seems safe to predict that such will be the course of those which may arise in the future. The recognition of this fact is of prime importance. It helps us to understand the great relative diversity in perfection among the sciences; it affords a basis for rational optimism with respect to the continued progress of science; and it ought to make the specialists of the older sciences less contemptuous than they sometimes are in their attitude toward the newer ones which have not yet passed the "rock-naming and bug-hunting stage."

Whenever a quantitative relation between the factors of phenomena is observed, then measurements may be made in response to the question, What is the magnitude of the relation, if constant, or what are the extent and law of variation of the relation if it is not constant? When the law of relation is known, related quantities are subject to calculation, the measured values of some of them sufficing, through computation, to give the values of the others. All calculations, therefore, presuppose a knowledge of the laws of connection of related quantities or quantitative theories of the phenomena considered.

Measurements and calculations are of all grades of definiteness, ranging from the smallest probabilities of the doctrine of chances up to the rigorous certainties of mathematical deduction. Thus the degree of precision attainable in the measured and computed quantities of a science is commonly taken as a gauge of its perfection. But it would be a mistake to infer complete perfection from the precision attainable in one or more branches of science. Astronomy, for example, is a marvelously perfect science in certain of its branches, but nevertheless some of its fundamental constants, notably the gravitation constant and the aberration constant, are known with only a low degree of precision.¹ Whether any quantity may be

¹The gravitation constant is the factor by which the product of two masses divided by the square of their distance asunder must be multiplied in order to express the force exerted by those masses on one another. Thus, if m_1 and m_2 denote two masses, s their distance asunder, F the force of attraction between them, and k the gravitation constant, then

$$F = k \frac{m_1 m_2}{s^2}.$$

It should be remarked that k is not a mere numeral, as many eminent writers on the law of gravitation would seem to imply, but that it is the cube of a distance divided by the product of a mass and the square of a time; or that its dimensions are shown by the exponents in $(L^{+3}M^{-1}T^{-2})$ if L , M , T denote the units of length, mass and time respectively.

It should be remarked also that the above expression of Newton's law of gravitation lacks the precision essential for mathematical calculations. To make the statement definite and general, m_1 and m_2 must be regarded as infinitesimals, so that the resultant attraction between two finite bodies requires, in general, a summation, or integration, for its exact expression. A widespread error exists in the notion that the above equation is exact if the distance s is the distance between the

measured or calculated with precision depends, in general, on the degree of complication of its connections with other quantities, and on the applicability of methods already applied in the determination of other quantities. Frequently, a quantity may be measured directly; but it oftener happens, either by reason of the inapplicability or of the disadvantage of a direct method, that resort is had to an indirect method.

It is a remarkable fact, illustrating the essential unity which pervades the apparent diversity of nature, that all of the numerous quantities with which physical science has to deal may be expressed in terms of a certain very limited number of arbitrarily chosen quantities, or units. The units most commonly used, and those which seem best suited to the present requirements of science, are the units of length, mass and time. All other quantities, however complex, may be expressed readily in terms of these arbitrarily assumed fundamental quantities. It is by no means certain, however, that these units will best satisfy the requirements of science in the future. On the contrary, it seems rather probable that advancing knowledge will find some other system of units preferable, if it does not find several different though interconvertible systems essential. We have, in fact, already attained two such diverse systems in the units of electromagnetic science.

The study of such systems by the aid of the theory of dimensions, which shows algebraically how the assumed units enter into more complex quantities, is very instructive, not only to the mathematical physicist, but to the general student of physical science.¹ To illustrate this idea by some simple examples, it is

centers of gravity of the masses. This is true, indeed, for the class of bodies called *centrobaric*, like homogeneous spheres; but masses in general are not *centrobaric*.

The gravitation constant is in C.G.S. units, about 667×10^{-12} , with some uncertainty in the last significant figure.

The aberration constant, which is (if it is nothing more than a kinematical quantity) the ratio of the velocity of the earth in its orbit to the velocity of light multiplied by the number of seconds in a radian, is about $20.5''$ with some uncertainty in the next significant figure.

¹ Designating the units of energy, length, mass and time by E, L, M, T respectively, the dimensions of some of the most frequently used quantities in mechanics are shown in the following tables. In the first of these length, mass and

well known that all quantities used in rational mechanics are commonly expressed in terms of length, mass and time. But these quantities might be expressed equally well, so far as algebraical statement is concerned, in many other ways. Thus we might take energy as one of the fundamental quantities instead of either length, mass or time; in which case our mechanical

TABLE I.

Quality.	Length Factor.	Mass Factor.	Time Factor.
Velocity	$L + 1$	M^0	$T - 1$
Acceleration	$L + 1$	M^0	$T - 2$
Force	$L + 1$	$M + 1$	$T - 2$
Momentum	$L + 1$	$M + 1$	$T - 1$
Energy	$L + 2$	$M + 1$	$T - 2$
Power	$L + 2$	$M + 1$	$T - 3$

TABLE II.

Quality.	Energy Factor.	Mass Factor.	Time Factor.
Velocity	$E + \frac{1}{2}$	$M - \frac{1}{2}$	T^0
Acceleration	$E + \frac{1}{2}$	$M - \frac{1}{2}$	$T - 1$
Force	$E + \frac{1}{2}$	$M + \frac{1}{2}$	$T - 1$
Momentum	$E + \frac{1}{2}$	$M + \frac{1}{2}$	T^0
Energy	$E + 1$	M^0	T^0
Power	$E + 1$	M^0	$T - 1$

TABLE III.

Quality.	Energy Factor.	Length Factor.	Mass Factor.
Velocity	$E + \frac{1}{2}$	L^0	$M - \frac{1}{2}$
Acceleration	$E + 1$	$L - 1$	$M - 1$
Force	$E + 1$	$L - 1$	M^0
Momentum	$E + \frac{1}{2}$	L^0	$M + \frac{1}{2}$
Energy	$E + 1$	L^0	M^0
Power	$E + \frac{1}{2}$	$L - 1$	$M - \frac{1}{2}$

quantities would be expressed in terms of energy, length and mass; or of energy, length and time; or of energy, mass and time. A consideration of these simple systems shows us, among other things, that rational mechanics might have been developed along time appear explicitly; in the second length does not appear explicitly; and in the last, time does not appear explicitly. A glance at the exponents (dimensions) of the symbols shows clearly how definite the meanings of the terms force, energy, power, etc., may be in comparison with the utter ambiguity attaching to them in common parlance.

lines of thought very different from the lines followed by our predecessors ; and the fact that we do not visualize equally clearly all these systems shows the experience of humanity with physical phenomena has been extremely limited. Most curious and instructive are the system in which length does not appear explicitly and the system in which time does not appear explicitly. May we not see in these systems opportunities respectively for the development of those individuals of our race who seem to possess no realization of distance or no conception of time ?

Confining attention to the simpler and more familiar units of length, mass, and time, and to a few of the more complex quantities expressed thereby, let us first consider briefly the present status of these fundamental units and the possibility of maintaining their invariability. The standards of length and mass which are now universally adopted in science are the meter and the kilogram respectively, carefully intercompared copies, or "prototypes," of which have been distributed by the international bureau of standards to the nations contributing to the cost thereof. The United States possesses two copies of each of these prototypes, and they are, as a matter of fact, our effective working standards, even for the production of standard yards and pounds. It is to be hoped, therefore, that the end of the barbaric system of "weights and measures," we have inherited from an unscientific ancestry, is near at hand, and this not so much in the interest of men of science as in the interests of those less well fitted to struggle with the ingenious intricacies of the British system.

These prototype meters and kilograms are known in terms of the adopted standards, and hence in terms of one another, with a degree of precision which verges close to the limits of the constancy of matter itself. Thus the lengths of the meters are known with an uncertainty expressed by a probable error of only one part in five millions. This degree of refinement corresponds to about one hundredth of an inch in a mile, or to about nineteen miles in the mean distance of the earth from the sun. But this admirable precision is greatly surpassed by that of the kilograms, whose uncertainty falls to one part in five hun-

dred millions. It is well known, of course, that the operation of weighing by means of the balance secures a precision superior to that of every other species of physical measurement; but it is not easy to visualize directly the five-hundred-millionth part of a kilogram. One may get a tolerably definite idea of this magnitude, however, by observing that with the degree of precision in question it would be essential in comparing two kilogram masses to keep the pans of the balance closely at the same level, for a centimeter difference in their altitudes would be appreciable by reason of the variation of the attraction of the earth with distance from its center.¹

For present purposes, therefore, our standards of length and mass leave little, if anything, to be desired. But it is a matter of great importance to the future progress of science that these standards be preserved for an indefinitely long period; and although such a contingency seems remote enough now, one can hardly suppress the query as to what would happen to us if our standards should be lost, or if they should unexpectedly prove unstable with the lapse of time. It is quite certain that our standard of length could be recovered with a high degree of precision if such a calamity should befall us during the next ten thousand, or possibly during the next hundred thousand years. Numerous bars of other metals than the alloy used in the construction of the prototype meters are known in terms of the latter. Many base lines scattered at widely separated points of the earth's surface are also known in terms of the meter with a precision of about one part in a million; and although the

¹ Denoting the mass of a kilogram by m_1 and the mass of the earth by m_2 , the weight of m_1 by w , and the distance from the balance to earth's center by s (since the earth is nearly centrobatic), the Newtonian law gives

$$w = k \frac{m_1 m_2}{s^2},$$

whence the relation of a small change Δw in w to the corresponding change Δs in s is expressed by

$$\frac{\Delta w}{w} = \mp 2 \frac{\Delta s}{s}.$$

Since $\Delta w/w$ is here $1/500,000,000$, and since s is about 630,000,000 centimeters, $\Delta s = \mp 0.63$ centimeter.

foundations of the earth are far from stable, we can hardly expect such lines to become systematically shorter or longer in so brief a terrestrial interval as a million years. Better still, probably, is the check on the invariability of the meter afforded by Professor Michelson's measurement of it in terms of the wave-lengths of particular rays emitted by the metal cadmium.¹ In this, apparently, we have a cosmic standard, although it remains to be proved that the wave-lengths used will remain invariable in the unexplored parts of the universe into which we are journeying along with the solar system at the rate of some kilometers per second.

Our standard of mass is likewise connected directly with various masses which may serve as checks on its stability, and indirectly with the masses of definite volumes of many substances. It is especially well known in terms of the mass of a cubic decimeter of water at a standard temperature. It is less definitely known in terms of the atomic masses of the so-called elements, and it is roughly known in terms of the enormous though slowly varying mass of the earth.² But, on the whole, our standard

¹ See Tome XI, *Travaux et Mémoires du Bureau International des Poids et Mesures*, Paris, 1895. It is remarkable that the ratios of the three wave-lengths used to the meter were measured with a precision requiring seven significant figures, the uncertainty amounting to a few units only in the last figure. Thus the values of the wave-lengths used (designated as red, green and blue respectively) are as follows, in microns, or millionths of a meter:

$$\begin{aligned} &0.643,847,2, \\ &0.508,582,4, \\ &0.479,991,1. \end{aligned}$$

² If we could measure the gravitation constant with a precision extending to five significant figures, the mass of the earth would at once become known to the same degree of precision, provided only that the law of gravitation is exact to the same number of figures. For I have shown that the product of that constant and the mean density of the earth is known with a precision expressed by five significant figures. Thus, calling the gravitation constant k and the mean density of the earth ρ ,

$$k\rho = 36,797 \times 10^{-11} / (\text{second})^2.$$

This relation may be otherwise expressed by the following theorem: Let τ be the periodic time of an infinitesimal satellite which would revolve about the earth close to the equator (assuming no atmospheric resistance). Then the theorem asserts that

$$k\rho\tau^2 = 3\pi$$

where π is the ratio of the circumference to the diameter of a circle. The value of τ is 1 hour, 24 minutes, and 20.9 seconds. See *Astronomical Journal*, Vol. XVIII., No. 16.

of mass must be regarded as less secure than our standard of length, although the prototype kilograms are less likely to change in mass with the lapse of time than the prototype meters are to change in length; for while such a general variation in volume as is known to occur in metals, especially alloys, need not affect the former, it would almost certainly affect the latter.

Our unit of time is also known with a definiteness that meets in most cases the highest demands of science at the present epoch. The period of rotation of the earth, or the sidereal day, is the standard interval of time, though it has been found convenient for many purposes to use the shorter interval of a mean solar second, of which there are 86,164.1 in a sidereal day. That the earth rotates with wonderful regularity is a fact of the highest importance to science. Without that regularity the development of sidereal and planetary astronomy, with all they have entailed, would have been impossible except by the discovery of some other equally trustworthy timekeeper. But the laws of mechanics, which show us plainly why the earth rotates with such remarkable regularity, also show us that its period of rotation is subject to sources of disturbance, some tending to increase and some tending to decrease that period, whose effects, though too minute to be appreciable in such intervals as are known to human history, must certainly become considerable in the course of terrestrial history. Thus, the contraction of the earth due to secular loss of heat tends to shorten the day, while accumulations of meteoric dust and tidal friction tend to lengthen it.¹ There exists also a graver source of disturbance

¹ I have discussed the effects of secular cooling and meteoric dust on the length of the day in a paper published in the *Astronomical Journal*, Vol. XXI., No. 22, July, 1901. From this paper it appears that the change in length of the day from secular cooling cannot be perceptible during any such brief interval as that of human history (twenty centuries, say); but that in the course of complete cooling, or in a million million years, say, the change in length of the day may amount to as much as six per cent. of its original length.

From the same paper it appears that accumulations of meteoric dust will only begin to be perceptible in their effects on the length of the day when the process of secular cooling has been substantially completed. In a subsequent number of the *Astronomical Journal* (Vol. XXII., No. 11), Dr. G. Johnstone Stoney has shown that if the compression produced by a layer of meteoric dust is taken into account the effect will be still less than that just indicated.

in the slow rising and sinking of the crust of the earth in different latitudes so often pointed out by geologists. Such movements are only partly compensating in their effects on the day, and it seems highly probable that they may cause irregularities amounting to a few seconds in a century without entailing any noteworthy fluctuations of the relative positions of the land and sea.¹

It appears, then, that our time unit is the least stable of the three fundamental units and hence the most in need of checks on its stability. Various other standards of time have been proposed, but none of them meets the requisites of permanency and availability. The interests of astronomical science especially demand that efforts be made to find in the solar system some better timekeeper than the earth. Possibly the fifth satellite of Jupiter may serve as a control on the constancy of rotation of the earth.

Turning now to a consideration of the more complex quantities which are expressed in terms of length, mass and time, we enter the boundless fields of physical science in which measurement and calculation have revealed to us all ranges of magnitudes from the vanishingly small to the indefinitely large. It is in these fields that we learn something definite concerning the limitations of our senses; for while measurements alone carry us but a little way along lines of research, calculation discloses not only the unseen, but also, in many cases, phenomena which are quite beyond the reach of any direct sense perception.²

To begin with quantities near the lower limit of determination, think, for a moment, what is going on in the air which for the present is the main medium of communication between us. No one has ever seen the particles of the atmosphere in the sense that we have all seen the particles, or corpuscles, of the blood. But we probably know more about the molecules of gases than

¹ See "Mathematical and Physical Papers of Lord Kelvin," Vol. III, pp. 333-335, Cambridge University Press, London, 1890.

² The reader may be referred to a very instructive paper by Dr. G. Johnstone Stoney, entitled "Survey of that Part of the Range of Nature's Operations which Man is Competent to Study," *Scientific Proceedings of the Royal Dublin Society*, Vol. IX, No. 13; *Philosophical Magazine*, Fifth Series, No. 294, November, 1899; published also in *Report of Smithsonian Institution* for 1899.

we do about blood corpuscles. By actual count it is known that there are four to six millions of the latter in a cubic millimeter; and with equal definiteness calculation shows us that there are about a million million million molecules in a cubic millimeter of the air around us. Notwithstanding this apparently crowded assemblage, the individual molecules move about in the liveliest manner, their average speed being about five hundred meters per second, and this in spite of the fact that the average length of an unimpeded journey is barely visible by the aid of the best microscopes. Each molecule must therefore collide with its neighbors astonishingly often, the encounters occurring, in fact, about five thousand million times per second.¹

More surprising still than the properties of assemblages of molecules, forming gases are the properties of the individual molecules, especially when they are made up of two or more atoms. Such miniature systems, comparable, probably, in complexity with the Martian and Jovian subsystems of the solar system, exhibit degrees of constancy which rival the invariableness of the fixed stars themselves. This is particularly the case with their rates of vibration as disclosed by the spectroscope. These rates afford one of the most delicate tests of the properties of matter, whether it is found on the earth or on the most distant star; and yet the vibrations, which recur with a regularity equal to, if not surpassing, the regularity of the rotation of the earth, are executed at the rate of some hundreds of millions of millions per second.² Herein, perhaps, we may find a cosmic unit of time as well as a cosmic unit of distance, though both appear to be inconveniently small for terrestrial purposes.

But the smaller bodies of the universe do not end with mole-

¹ See, for example, "The Kinetic Theory of Gases," by Dr. Oskar Emil Meyer, translated by Robert E. Baynes, Longmans, Green & Co., New York, 1899.

² The number of vibrations per second corresponding to any given wave-length of light may be easily computed. For the velocity of light is about 300,000 kilometers, or 3×10^{14} microns per second, and this divided by the wave-length in question gives the number of vibrations per second. Thus the average wave-length of the cadmium rays used by Professor Michelson (cited above) is about half a micron. The material sources of these rays must vibrate, therefore, about six hundred million million times per second.

cules and atoms of gases. Recent investigations point to the conclusion that there is another order of bodies of much smaller dimensions and possessing still more wonderful properties. These have been called corpuscles.¹ Their density is only about one thousandth as great as that of the lightest gas, hydrogen; they are freely given off by several of the so-called radioactive substances; and they move about with speeds of the same order as the velocity of light. It appears not improbable that they play a most important rôle in cosmic as well as in terrestrial physics, and the amount of attention being given to them justifies the hope that their study may illuminate many obscure corners in the realm of molecular science.

Passing per saltum from the smallest measurable and calculable quantities to those with which we have an every-day familiarity, I would direct your attention to the great number of articles of commerce which are now weighed, measured and rated with precision and sold at a cost which, a half century ago, would have been thought quite impossible. Standard yards, meters, pounds and kilograms, and pocket time-pieces that will run within a few seconds per day, are available at prices within the reach of all who need them. Screws and screw gauges which will easily measure a hundredth of a millimeter (or four ten-thousandths of an inch) are articles of trade; beautifully true spheres of steel or bronze may be had for a few cents each; helical springs of the finest steel and of remarkable uniformity are sold for a dollar a dozen; while articles like wire, tubing, sheet metal, and an indefinite variety of tools and machinery are made with a degree of perfection and at a cheapness of cost which would have been regarded as quite unattainable by the

¹ See a paper by Professor J. J. Thomson, "On Bodies Smaller Than Atoms," *Popular Science Monthly*, August, 1901.

See also a paper by Professor John Cox on "Comets' Tails, the Corona and the Aurora Borealis," *Popular Science Monthly*, January, 1902.

A fact of great interest in connection with the "corpuscles" considered in these two papers is the repulsion of light impinging on bodies, the amount of which has been actually measured recently by several observers. This repulsion between the sun and the earth is very great, amounting to about a hundred million million dynes; but the gravitational attraction between these bodies is about forty million million times as great as that repulsion.

founders, for example, of the New York Academy of Sciences. The ready availability of, and the constant demand for, all these products to meet the daily needs of the complex civilization of our time affords a sufficient answer to him who would question the efforts spent in attaining those products or the efforts applied in subjecting new objects of study to the rigorous tests of measurement and calculation.

But the principles of measurement and calculation are not limited in their application to external objects, or to the properties of what we are sometimes pleased to call "gross matter." They apply equally aptly in many ways to man himself, and it is clear that with advancing civilization we may confidently expect such application to be greatly extended. While we have not yet attained formulas which will comprehend the vagaries of the individual, we have many formulas which will accurately express the resultant of those vagaries as manifested in racial types. A life insurance company, for example, may not assert at the beginning of a year that any individual of ten thousand men of the same class will die within the year, but it may assert with practical certainty that a definite number of this class will die within the year. Such "facts and figures" are trite enough, of course, but what we commonly fail to see and appreciate is the solid basis on which they rest, and how greatly it would be to our advantage to extend the same sort of reasoning that has built up great systems of fire and life insurance into other departments of human affairs. Most people, I fear we must infer, are like Thomas Carlyle, still scoffers at statistics, and few, even of the educated, have any adequate conception of the order which the principles of probability will bring out of the apparent disorder of statistical data.

Of the larger objects of the universe to which measurement and calculation have been applied with success, the earth easily surpasses all others in interest and importance. So great has been this success that one may assert that we know more of the earth than we do of any other body to which science has given attention. Its size, its shape, the amount and arrangement of its mass, its magnetic properties, its speeds of rotation and trans-

lation, its precession and nutation, and the lately discovered wobbling of its axis of rotation are all known with a definiteness which is truly surprising when one considers its magnitude and the degree of complexity of those properties. That the eight thousand miles in its diameter should be known within a few hundred feet, that the two hundred millions of square miles in its surface should be known within a few hundred square miles, or that the acceleration of gravity at any point on its surface should be known within a few millimeters per second per second, are results little short of marvelous when one reflects that they have all been attained within the brief interval of two hundred and fifty years. It would be quite wrong, however, to consider these achievements of geodesy as marvelous from the point of view of science. They are, rather, just such results as persistent scientific investigation has always produced, and such as we may safely predict will be uniformly produced by persistent scientific investigation in the future. The element of the marvelous comes in only when one takes account of the fact that these grand results were attained by a very small number of men, mostly members of academies, struggling, like our own, to maintain an existence, in whose work the general public took little interest, and whose names, even now, are much less known than the names of the obscure philosophers and the obscure poets of antiquity.

Geodesy is undoubtedly the most advanced of the sciences in which measurement and calculation have attained a high order of certainty. It has made modern commerce possible, and it seems destined to play a still more important rôle than it has hitherto in the advancement of terrestrial affairs. It has also made modern astronomy possible, for the certainty of its data enables us to measure not only the dimensions of the solar system, but also the approximate dimensions of the visible universe.

Not less important to the progress of science and to the general advance in human enlightenment are the achievements of the allied science of geology. It cannot boast, as yet, like geodesy, of a high degree of precision in measurement and calculation, for it deals, in general, with phenomena which have not

yet been reduced to simple laws. But, on the other hand, its subject-matter is more obvious and tangible, and it appeals therefore more forcibly and continuously to the average mind. No science seems comparable with geology in the completeness with which its history and its main processes are contained in the subjects and objects of investigation. Whoso would read the story of the earth's crust will find it written and illustrated in infinite detail in the rocks themselves. No vivid or perfervid imagination of the historian has concealed the facts or misinterpreted their sequence; they are all recorded with a truthfulness that shames the straightest human testimony and with a permanency which permits comparison and verification in endless repetition.

Geology illustrates more clearly, perhaps, than any other science the value of measurement and calculation when the order only of the quantity sought can be attained. The determination of the fact, for example, that nothing short of a million years is a suitable time unit for measuring the age of the earth, was an achievement whose importance can hardly be overestimated; indeed, our race may yet require decades, if not centuries, to appreciate its full significance, for in spite of the great advances in our times it appears probable that not one in a thousand of the good people with whom we live realizes how profoundly definite acceptance of such a fact must modify thought.

A criticism which the devotees of the so-called humanistic learning often apply to such matters of fact, and which is still occasionally accepted by men of science, helps us to see the absolute need of countless recurrences to the evidence so well exhibited in the crust of the earth. "Ah!" says the humanist, "I observe that the physicists and the geologists do not agree on the age of the earth. Some say it is ten million years, others that it cannot be more than two hundred million years, and others that it cannot be less than a thousand million years. I conclude, therefore, that so long as your doctors disagree in this manner, we may continue to accept the age recorded in our sacred books." Thus easy is it to mistake the order of a quantity for the quantity itself.

When we pass from terrestrial limitations to celestial phenomena the field for measurement and calculation is immensely enlarged, though the results attainable are less easy of ready appreciation. The Jovian, the Saturnian and the Martian subsystems, which have been pretty thoroughly explored by the observer and the computer, present to us the type, apparently, not only of the solar system, but of the galaxy of systems within telescopic view. And the surveys of the heavens now in progress indicate likewise that isolated stars are the exception rather than the rule, and that the visible stars are generally attended by one or more satellites, which are probably oftener dark than bright bodies. Visual and photographic measurements have, in fact, united in recent years in the demonstration that the number of material bodies in the universe is enormously greater than we have hitherto imagined. Here again, however, as in the case of the geological phenomena just referred to, we must be content to a great extent for the present with a knowledge of the order of the quantities measured and calculated. But to be able to state what is the order of the distances which separate the fixed stars from one another, the order of the volume of the visible universe, the order of the quantity of mass in that volume, and the order of the time unit requisite for the expression of the historical succession of celestial events, seems little short of a stupendous contribution to knowledge when one reflects on the obstacles, material and intellectual, that have stood in the way of its attainment.

The distances asunder of the stars are so great that the hundred and ninety odd millions of miles in the diameter of the earth's orbit about the sun make an inconveniently small base line for the measurement of the least of those distances and a hopelessly inadequate one for the measurement of the greatest of them. It would appear more fitting, in fact, to express such distances indirectly in the number of years it takes light moving at the rate of 300,000 kilometers per second to traverse them. Assuming with Lord Kelvin that the visible universe is comprised within a sphere whose radius is equal to the distance of a star whose parallax is one thousandth of a second, this dis-

tance would require light about three thousand years to pass over it, while the average distance asunder of the visible stars is considerably less, but still of the same order. Lord Kelvin has shown also in a profound mathematico-physical investigation recently published¹ how we may assign limits to the amount of mass in the visible universe. It appears from this investigation that there are something like a thousand million masses of the magnitude of our sun within that universe. The figures for this amount of mass have little meaning to most of us when expressed in ordinary units. The mass of the earth, for example, with its $6,000 \times 10^{18}$ metric tons,² is a mere trifle, for the sun has about 327,000 times as much mass as the earth. The mass of the sun therefore is the obviously convenient unit in this case; and we have only to imagine our solar system surrounded by a thousand million such suns, each in all probability attended by a group of planets, to get a sufficiently clear idea of the quantity of mass within visual range of our relatively insignificant terrestrial abode. And the time scale for the varied events which take place in the interaction of these millions of suns is not less imposing when expressed in familiar terms. A million years is the smallest unit suitable for estimating the history of a star, although the record of that history is transmitted to us through the interstellar medium by vibrations whose period is so brief as almost to escape detection.

Measurements and calculations have thus made known to us a range of phenomena which is limited only by our sense perceptions, sharpened and supplemented by the refinements of mathematical analysis. In space and mass relations these phenomena exhibit all gradations from the indefinitely small to the indefinitely large; and in time they point backward to no epoch which may be called a beginning and forward to no epoch which may be called an end. Dealing chiefly with those aspects of phenomena which possess permanence and continuity,

¹ "On Ether and Gravitational Matter through Infinite Space," *Philosophical Magazine*, August, 1901. "On the Clustering of Gravitational Matter in any Part of the Universe," *Nature*, Vol. 64, No. 1669.

² The metric ton of 1,000 kilograms, or 2,205 pounds, is about the same as our "long ton" of 2,240 pounds.

or at least a permanence and a continuity compared with which all human affairs appear ephemeral and fleeting, measurement and calculation tend to raise man above the level of his environment. They bid him look forward as well as backward, and they assure him that in a larger study of the universe lies boundless opportunity for his improvement.

But while that sort of knowledge which has been reduced to quantitative expression has done more, probably, than all else to disclose man's place in and his relations to the rest of the universe, it would appear that mankind makes relatively little use of this knowledge and that we are not yet ready, as a race, to replace the indefinite by the definite even wherein such substitution is clearly practicable. It is a curious and a puzzling, though perfectly obvious, fact that mankind as a whole lives less in the thought of the present than in the thought of the past, and that as a race we have far more respect for the myths of antiquity than we have for the certainties of exact science. Our ships, for example, are navigated with great success by aid of the sextant, the chronometer, and the nautical almanac; but what company would dare set Friday as the day for beginning the transatlantic voyage of a passenger steamer? From time immemorial tradition has dominated reason in the masses of men. Each age has lived, not in the full possession of the best thought available to it, but, rather, under the sway of the thought of some preceding age. We are assured even now, by some eminent minds, that the highest sources of light for us are nearly all found in the distant past; and a few go so far as to assert that modern science is merely furbishing up the half-lost learning of ages long gone by.

The work of academies and other scientific organizations is therefore nowhere near completion. Great strides toward intellectual emancipation have been made during recent times, but they have served only to enlarge the field for, and to increase the need of, that sort of knowledge which is permanent and verifiable. Measurement and calculation have furnished an invaluable fund of such knowledge during the two centuries just past, and we have every reason to anticipate that they will

furnish a still more valuable contribution to such knowledge in the centuries to come.

R. S. WOODWARD.

PUBLIC LECTURE.

On February 26, a public lecture was presented under the auspices of the Section of Biology, by Professor **Bashford Dean**, of Columbia University, entitled "Journeys of a Naturalist through Japan and the Philippines."

Professor Dean referred to the zoological relations of the Japanese archipelago with the adjacent continent on the one hand, and with the island series on the other; *i. e.*, first, the Aleutian, second, through the Bonin Islands with the region of New Guinea, and third, through the Liu Chiu Islands with Formosa and the Philippines. The importance of the Line of Blakiston separating the Hokkaido from the southern islands was emphasized.

Special attention was called to the favorable facilities for zoological work which are offered in the region of Misaki, near the mouth of the Bay of Yokyo, and to the work of the Marine Laboratory of the Imperial University in this region. Dr. Dean had an opportunity of examining the centers of animal artificialization, an art in which the Japanese have been so eminently successful. Especially praiseworthy is the method of oyster-culture practiced in the Inland Sea near Hiroshima; hardly less interesting were the establishments in which varieties of gold fish are propagated, and even more striking were those for the cultivation of the breed of Tosa fowls, in favorable specimens of which the tail features attain the great length of fifteen feet. Success in the maintenance of this breed appears to be due to the selection of those fowls in which moulting occurs irregularly, and the effort is made to suppress entirely the moult in that region of the fowl where long feathers are to be produced. In referring to a journey in the Philippines, Professor Dean described many interesting experiences, particularly, those at Maujuyod, where living specimens of *Nautilus* were obtained.

HENRY E. CRAMPTON,

Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

FEBRUARY 28, 1902.

Section met at 8:30 P. M., R. S. Woodworth presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

J. H. Bair, QUANTITATIVE RELATIONS BETWEEN MOTOR AND SENSORY ASSOCIATIONS.

J. B. Miner, INVOLUNTARY MUSCULAR RESPONSES TO RHYTHMIC STIMULI.

Clark Wissler, THE ERGOGRAPH : COMPARATIVE RESULTS WITH SPRINGS AND WEIGHTS.

SUMMARY OF PAPERS.

Mr. **J. H. Bair** reported on some quantitative studies in sensory and motor association. His experiments have been carried out by aid of a typewriter, the subject reacting to different stimuli by striking different keys. Curves were presented showing the rate of formation of association. If, after the stimuli have been presented many times in the same order, the order is then changed, the association is interfered with, and the more so the firmer it has become. If the typewriter keys are interchanged, so that the reaction to each stimulus must be changed, this interferes still more with the association. These results showed, then, that the association of definite sense impressions with definite motor reactions was more persistent than the association of sense impressions with other sense impressions following in serial order, or than the association of movements with other movements following in serial order.

In the discussion of this paper, several other facts were mentioned, showing the importance of motor reactions in the formation of association. Professor Thorndike had observed that good visualizers, who are able to picture mentally a page of printed matter that they have read, yet cannot read off the pictured words ; apparently because the visual images are not associated with motor responses.

Mr. **J. B. Miner** spoke on "Involuntary Muscular Responses to Rhythmic Stimuli." He described some experiments conducted by himself at Columbia and Minnesota universities, in which tracings were obtained for non-voluntary hand and head movements when the subjects listened to a series of uniform sounds. It has been noted by Thaddeus L. Bolton and others in their investigation of rhythm that such a series of sounds appears not uniform, but as if coming in groups of two or more sounds. The muscle responses obtained correspond with this perception of rhythm, one wave coinciding with each rhythmic group. The movements recorded strikingly agree with another phenomenon of rhythm in that a motor wave shows for each stimulus when the sounds came slowly (forty per minute), but when the rapidity of the sounds was increased the wave encompassed two, three and even four sounds. This agrees with the introspective observation that the subjective group includes more units as the sounds come more rapidly. On the basis of the data of muscular responses Mr. Miner believes that an adequate physiological explanation of rhythm may be formulated, while organic rhythms alone would not furnish a completely correlated activity.

Dr. **Clark Wissler** reported some ergograph experiments showing that the contracting muscle presents a power series which is constant, whether the resistance is applied by a spring or by a weight. While this power series is weakened by fatigue, the resistance value of any point in the muscle series is the same for a weight or for a spring. In other words, there appears no difference between the fatigue produced by weights and springs when estimated in terms of the muscle series.

R. S. WOODWORTH,
Secretary.

BUSINESS MEETING.

MARCH 3, 1902.

Academy met at 8:25 P. M., Professor Hallock presiding.

The minutes of the last business meeting were read and approved.

The following candidates for resident membership, approved by the Council, were duly elected :

Frederic Peterson, M.D., 4 West 50th street.

Adolf Meyer, M.D., Pathological Institute.

George I. Finlay, Columbia University.

S. Alfred Mitchell, Ph.D., Columbia University.

Adjourned.

HENRY E. CRAMPTON,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

MARCH 3, 1902.

Section met at 8:30 P. M., Professor Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

C. C. Trowbridge, THE PHYSICAL NATURE OF PERSISTENT
METEOR TRAINS.

S. A. Mitchell, OBSERVATIONS ON THE FLASH SPECTRUM AT
THE SUMATRA ECLIPSE.

SUMMARY OF PAPERS.

Mr. **Trowbridge** gave a list of forty meteor trains which had remained visible to the naked eye for from two minutes to over one hour, all of them seen by reliable observers. Several tables were exhibited, giving the size, shape and color of recently observed meteor trains.

Mr. Trowbridge gave his views as to the most probable composition of meteor trains, and presented several hypotheses which might account for their long-continued luminosity. These are the following: (1) Incandescence of the particles of the train; (2) phosphorescence of the train; (3) electrical discharges; (4) Reflection of the light from the sun, moon, or stars, by the particles of the train; (5) electrons striking the meteoric dust or the air particles in or about the train, causing

a fluorescent glow similar to that in a Crookes tube. The source of the electrons may be either the highly-heated meteor — in which case the long-continued luminosity of the train must be accounted for by a retardation of the fluorescence possibly due to the low temperature — or the electrons may come from the sun — in which case the explanation would be similar to that lately given by Arrhenius for the light of the aurora. The author stated that this last hypothesis has not, to his knowledge, been previously advanced. The balance of evidence seemed to show that the luminosity of the persistent trains must be primarily caused by energy of an electrical nature. The subject is one of practical importance owing to its bearings on meteorology.

The paper by Dr. **Mitchell** gave the results of observations on the flash spectrum, made by him at Sawah Loanto, Sumatra, during the eclipse of May 18, 1901. Through the courtesy of the Astronomical Director of the Naval Observatory, Dr. Mitchell became a member of the expedition sent out by the government to observe this eclipse. The spectroscope employed was a Rowland objective plane grating of 15,000 lines, used in connection with a cœlostæt. The weather experienced at Sawah Loanto was like that at almost every other astronomical station in Sumatra, cloudy during totality. Through the clouds, nevertheless, a spectrum of the flash at the third contact was obtained, which showed 374 bright lines between *F* and *H*. Investigations into the reasons for the differences in intensities in the flash and the Fraunhofer spectrum, showed that the intensities depended upon the heights to which the reversing layers of the different metallic elements around the sun, extend. It was found possible to arrange the elements in three groups according to their atomic weights.

Comparisons were made with Norman Lockyer's list of "enhanced" lines, or those stronger in the spark than in the arc, to confirm, if possible, Lockyer's idea that the "enhanced" lines play an important rôle in the chromosphere spectrum. Fifty-seven per cent. of the "enhanced" lines of titanium were found in the flash, but at the same time all of these lines cor-

respond without exception to strong lines in the sun. On the other hand, so many cases were found where a strong "enhanced" line was not marked in the sun by a strong Fraunhofer line, nor by any line in the flash spectrum, that Lockyer's opinion does not seem to be supported.

F. L. TUFTS,
Secretary.

SECTION OF BIOLOGY.

MARCH 10, 1902.

Section met at 8:20 P. M., Professor Bashford Dean presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Henry F. Osborn, THE FOUR PHyla OF TITANOTHERES.

Bashford Dean, THE EARLY DEVELOPMENT OF SHARKS FROM A COMPARATIVE STANDPOINT.

Maurice A. Bigelow, THE CYTOLOGICAL PHENOMENA OF MATURATION AND FIRST CLEAVAGE IN THE CIRRIPEL EGG.

C. C. Trowbridge, THE EFFECT OF THE WIND ON BIRD MIGRATION.

SUMMARY OF PAPERS.

Professor **Osborn** presented some results recently obtained for the U. S. Geological Survey Monograph. The lower Oligocene Titanotheres prove to belong to four distinct phyla, to which the prior generic names *Titanotherium*, *Symborodon*, *Megacerops* and *Brontotherium* may be applied. The chief distinctions are found to be in the dolichocephalic or brachycephalic form of the skull, in the shape, length, position and mechanical relations of the horns, and in the number and form of the incisor and canine teeth. Each genus obviously had distinctive modes of fighting, locomotion and feeding. *Titanotherium* extends from the base to the summit of the Lower Oligocene. It is distinguished by its long narrow skull, short horns, powerful canines, vestigial incisors. *Megacerops*, on the contrary, is broad-skulled, short-horned, with obtuse canines, and with at least one upper incisor. *Symborodon* is distinguished by the

narrowing of the anterior portion of the premaxillaries, reduction of all the anterior teeth, and by elongate horns placed immediately over the eyes. In *Brontotherium*, the horns are by far the largest and most powerful, and acquire an extreme anterior position, absorbing the free portion of the nasals; all the upper cutting teeth persist; great buccal plates are evolved; and the skull measured along the base line is extremely brachycephalic. The four types were illustrated by models and diagrams.

Professor **Bashford Dean** considered briefly some points in the development of sharks, and attempted to reduce the type of the early development of the recent types to that of their holoblastic ancestor. This form probably occurred within the strict limits of the group Elasmobranchii—for the absence of clasping organs in the palæozoic genera of Acanthodians and Cladoselachids predicates external fertilization, and eggs many in number and of small size. In the line of this comparison, reference was made to the early development of the Japanese “pavement-toothed” shark, *Cestracion japonicus*, in which, as the author showed in a recent number of the “*Annotationes Zoologicae*,” surface furrows are present traversing the yolk, and are best interpretable as reminiscent of holoblastic cleavage. In the peculiar type of early development in *Chimæra*, total cleavage is suppressed until about the time of gastrulation, when cleavage furrows appear in the region of the lower pole and come to divide the egg into a number of distinct blastomeres, only one mass of which, however, become enclosed in the yolk-sac of the embryo. The remaining blastomeres, by a process of continued division, provide nutriment for the embryo, *via* gills and gut. Dr. Dean announced the presence in *Chimæra* of a true archenteric invagination, occurring early and at some distance from the margin of the blastoderm. It is small in size, and has a distinct cellular floor. Its (anterior) dorsal wall was compared to the dorsal lip of the archenteron of sharks, as described by Rückert and others. The ventral wall of the archenteron of modern types of sharks has thus lost its cellular character during the process by which the em-

bryo acquired a more perfect and specialized (caenogenetic) mode of obtaining nourishment from the yolk.

The paper by Dr. **Bigelow** dealt chiefly with protoplasmic movements and associated displacements of the yolk-materials in various cirripede eggs during maturation and first cleavage. The telolecithal distribution of the egg-substances, the formation and disappearance of a yolk-lobe, and precleavage movements associated with differential distribution of the entoblastic materials were described. Finally, a turning of the first cleavage spindle from a transverse to an oblique axis of the ellipsoidal egg was compared with similar more extensive movements in nematode eggs.

Mr. **C. C. Trowbridge** presented the results of systematic observations on the effect of the wind on the migration of hawks and many other birds along the Atlantic coast. The principal points of the paper were illustrated by means of diagrams giving the directions taken by the migrating birds under the influence of different winds. It was shown that a knowledge of meteorology was necessary in considering this subject, because the effective winds depend on storm centers travelling eastward. In one case, in the height of the southward migration, a storm center off the coast of Maine caused northerly winds throughout 800,000 square miles in the eastern portion of the United States and Canada, the velocity of the wind area averaging 20 miles per hour. A former paper on the subject was briefly reviewed, in which the author showed that flights of hawks and other land birds during the migrations were due to the crowding of the birds in a narrow coast-line path by the wind. The recent observations, now, warrant the conclusion that hawks and many other birds regularly depend on a favorable wind as a help in their migratory movements, and as a rule, migrate only when favorable winds occur. A brief account was given also of a retrograde movement of migrating swallows in the spring, evidently due to a return flight of the birds after they had been blown far out of their course by a strong wind from the west.

An election of sectional officers being held, Professor Bash-

ford Dean was elected Chairman, and Professor H. E. Crampton Secretary for the coming academy year.

HENRY E. CRAMPTON,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

MARCH 17, 1902.

Section met at 8:20 P. M., Dr. A. A. Julien presiding.

The minutes of the last meeting of Section were read and approved.

This being the annual meeting of the Section, the first business of the evening was the election of officers for the ensuing year. Professor R. E. Dodge nominated Prof. J. J. Stevenson for chairman and Dr. E. O. Hovey for secretary. On motion of George F. Kunz, W. H. J. Sieberg was directed by unanimous vote of the Section to cast one affirmative ballot for the nominees. He did so and they were declared elected.

The following program was then offered:

George F. Kunz, EXHIBITION OF SPECIMENS.

THE CENTENARY OF JOHN PLAYFAIR'S DEFENSE OF JAMES HUTTON'S THEORY OF THE FORMATION OF RIVER VALLEYS: MEMORIALS BY PROFESSORS STEVENSON, KEMP AND DODGE.

Richard E. Dodge, AN INTERESTING LANDSLIDE IN THE CHACO CAÑON, NEW MEXICO. Illustrated with lantern slides.

Richard E. Dodge, ARROYO FORMATION. Illustrated with lantern slides.

Gilbert van Ingen, THE AUSABLE CHASM, NEW YORK. Illustrated with lantern slides.

George F. Kunz gave an exhibition of specimens illustrating the finding of epidote, grossularite garnet and twinned crystals of quartz of the Japanese type, associated with chalcopyrite, malachite and other ores of copper in a contact vein in limestone in the Green Monster Mining Co.'s mine near Solzer, Prince of Wales' Island, Alaska.

RECORDS

MEMORIALS OF HUTTON AND PLAYFAIR.

Prof. **Stevenson** after speaking of the conditions prevailing in British geology prior to the publication of Hutton's memoir in 1785, gave briefly the characteristic features of Hutton's doctrines, and accounted for the ease with which his work could be misunderstood and misinterpreted. He described the conflict to which the memoir led, and emphasized the bitterness of those who opposed the doctrines on theological grounds. The preparation of Playfair's work was due as much to a desire to defend Hutton as to support his theory. Playfair appealed to those opponents whose knowledge of the theory had been derived chiefly from attacks made upon it. For them he showed that the theory was beautiful, symmetrical and in no sense inconsistent with the Scriptures. In dealing with the other class of opponents, led by Kirwan and DeLuc, he used vigorous language, exposing their ignorance and insincerity, and denouncing the virulence with which they had given a theological turn to the controversy. In defending Hutton's theory, Playfair brought his own great resources to bear, now correcting errors, now elaborating the doctrine, and in some places hardly anticipating some of the great works of later days.

The inviting style gained many readers for Playfair's book, among them Greenough and his associates, who founded the Geological Society of London, that theory might be replaced by observation. Hutton's theory obtained final triumph in 1830, when Lyell published his "Principles." Playfair's work hastened the birth of geology as now understood by a full quarter of a century, and finally divorced our science from cosmogeny.

Professor **Kemp's** memorial was more in the nature of a review of Hutton's personal history. He said in part: James Hutton was born in 1726, and, after his school and university course, entered a lawyer's office to prepare for the bar. He disliked the law, however, and gave up the study after a year. Being greatly interested in chemistry, he took up the study of medicine, attending lectures at Edinburgh and Paris and taking his degree at Leyden in 1749. The career of a physician

did not attract him much, after all his preparation, and in 1752 he went to Norfolk to learn agriculture. There his mind first turned definitely to mineralogy and geology. In 1754 he settled on his ancestral estates in Berwickshire, where he remained fourteen years, with occasional visits to Edinburgh and more distant parts of the kingdom. In 1768 he gave up country life and removed to Edinburgh to devote himself entirely to the study of geology and kindred sciences. His untiring industry enabled him to accomplish a marvelous amount of work in chemistry and finally to elaborate his essays in geology, revolutionizing that science and, with the elucidation given his work by Playfair's "Illustrations of the Huttonian Theory of the Earth," raising it to the high plane which it has occupied ever since. Modern geology dates from the publication in the spring of 1802 of John Playfair's explanation, elaboration and defense of Hutton's theories.

Professor **Dodge**, in his memorial of Playfair, said in brief:

To James Hutton we owe many fundamental truths now recognized in physiography, and to John Playfair we owe the elucidation of these ideas, and their amplification.

The doctrine that rivers are the cause of their valleys, and the proof thereof is perhaps the most important foundational idea that we owe to the combined labor of these two geological worthies. Playfair's clear exposition of the possible origin of river terraces, his acute description of the relation of lakes to rivers, his analysis of the varied forms of shore-lines, and his emphasis of the importance of initial shore-lines, all clearly exploited in his illustrations, deserve to take rank with the much quoted passage on rivers and their valleys, as being accepted geographical truths far in advance of their time.

SUMMARY OF PAPERS.

Richard E. Dodge, AN INTERESTING LANDSLIDE IN THE CHACO CAÑON, NEW MEXICO.

On a high mesa to the southeast of the Chaco Cañon, and about four miles below Putnam, New Mexico, is a series of stone monuments about five feet high and four feet in diameter.

These monuments stand on the edge of the rim rock of an old escarpment nearly 300 feet high. The rim rock of the escarpment is a coarse brown sandstone capped by about two feet of thin-bedded dark-brown sandstone containing shark's teeth. The face of the escarpment has recently slipped along a series of joints running approximately parallel to face of escarpment, and in a general direction of S. 30° E. The recesses between slipped blocks can be sounded to a depth of over fifty feet, and are wider at base than top as a rule.

In the slipping an ancient rock "hogan" 20 feet in diameter has slid 2.5 feet vertically and 8.3 horizontally without displacing the rock walls to any serious extent.

Richard E. Dodge, ARROYO FORMATION.

An arroyo is a steep-sided, narrow gulch cut in a previously filled gravel and adobe valley in the arid West.

The study of process of formation of arroyos, some of which, have been under observation for several years, seems to show that the work has changed from aggradation to degradation because of some influence that has caused the focusing of the running water. Such a concentration of water is made possible by overfeeding of the land, which removes the help of roots in holding soil particles, combined with the habit of cattle to move in processions along trails that make natural channels for water.

The study of the rate of valley filling or erosion is difficult, because of the tendency of arroyos cut in adobe to maintain nearly vertical walls, and because a fallen block of adobe may be sealed over in the next flood, so that it looks in place. This problem is of especial importance, because the adobe deposits in some places contain relics of human occupation to a depth of many feet. The exact or even the approximate antiquity of the deposits cannot be definitely determined, because of the several ways in which the order of events in such a case may be interpreted.

Gilbert van Ingen, THE AUSABLE CHASM.

This paper was a description of the geological and physical features of this celebrated locality, which incorporated the results

of the author's own observations with those which had been arrived at and published by others.

EDMUND O. HOVEY,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

MARCH 24, 1902.

Section met at 8.30 P. M., Livingston Farrand presiding.

The minutes of the last meeting of Section were read and approved.

The name of one candidate for resident membership was read and referred to the Council according to the By-Laws.

The following program was then offered:

Clark Wissler, THE GROWTH OF BOYS.

W. S. Kahnweiler, A TRIP THROUGH FRENCH INDO-CHINA TO THE ANGKOR WAT.

On motion of Professor Boas, the Section reelected Livingston Farrand as Chairman and R. S. Woodworth as Secretary.

Dr. **Clark Wissler** reported on the growth of boys. The annual physical measurements of some three hundred school boys were correlated to discover tendencies and directions of growth. It appeared from the data that growth was rather uniform, as for example, when a boy's legs were growing rapidly, his arms were also growing at a corresponding rate. By correlating the stature with its increment for the following year it was seen that the sign of correlation changes when the pubertal maximum of growth is crossed. This means that boys who are growing rapidly at twelve, for example, continue to grow rapidly until fourteen or fifteen, when they slow down, while those growing slowly before this period now grow rapidly. Thus it appears that the point of pubertal maximum rate of growth, as determined by mass measurements, is really the point dividing the boys who mature early from those who mature late. The relation is yet more in evidence when the annual increments are correlated without regarding the absolute measurements. The results as a whole seem to show that

the rate of growth in any particular year is of no special significance except as an index of the relative maturity of the individuals concerned.

Mr. **W. S. Kahnweiler** reported on a trip that he made last summer through French Indo-China to the Angkor Wat. His paper was illustrated with lantern views of the trip, and of the architecture and sculpture of the ancient temple. The history of the temple was briefly outlined.

R. S. WOODWORTH,
Secretary.

BUSINESS MEETING.

APRIL 7, 1902.

The Academy met at 8.15 P. M., President Cattell presiding. The minutes of the last business meeting were read and approved.

The President stated that the Academy was coöperating with the American Institute of Electrical Engineers, Columbia University, and other scientific societies, in tendering a reception to Lord and Lady Kelvin on the evening of April 21; and that the members of the Academy would receive due notice with regard to tickets, etc.

The Committee on Constitution reported the document filed herewith,¹ which was read by the Recording Secretary. It was stated that a special meeting of the Academy, to take action upon this Constitution, would be called for some evening of the week of April 21st.

The Academy then adjourned.

HENRY E. CRAMPTON,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

APRIL 7, 1902.

Section met at 8:30 P. M., Charles Lane Poor presiding. The minutes of the last meeting of Section were read and approved.

¹See Appendix.

The following program was then offered :

Percival Lowell, MODERN MARS.

SUMMARY OF PAPERS.

Map making began with Beer and Mädler in 1840. Since then many charts have been constructed of the planet. Some of them are so old as to have been more or less forgotten, some are so new as not yet to be known. Collection and comparison of such of these maps as have marked advances in the subject lead to some not uninteresting conclusions. Such are presented in the accompanying series.

The series consists of twelve maps :

1. Beer and Mädler.	1840
2. Kaiser.	1864
3. Dawes by Proctor.	1867
4. Résumé by Flammarion.	1876
5. Schiaparelli.	1877
6. Schiaparelli.	1879
7. Schiaparelli.	1882
8. Schiaparelli.	1884
9. Lowell.	1894
10. Lowell.	1897
11. Lowell.	1899
12. Lowell.	1901

These maps fall naturally into three groups, dividing the history of areography into as many stages.

I. Those from 1840-1877.

II. Those from 1877-1892.

III. Those from 1892-1902.

The maps of the first group are characterized by large patches of light and dark areas. Maps 1-4 show these patches, and by their agreement prove that the patches are permanent in place. For the maps are the work of different observers made at different epochs of time.

The maps of the second group are distinguished by a network of fine, straight lines covering the bright areas of the

disk, the "canals" of Mars. This was the work of Schiaparelli.

The maps of the third group are differentiated by a similar system of "canals" in the dark regions. This is the work since Schiaparelli. It has resulted in a complete change in the belief as to the character of these "seas"; the permanency of the lines showing that the background must be land not water.

Inspection of the series results in three directions:

That the whole series are in fundamental agreement. The basic features appear directly throughout the first period, and as a groundwork upon which subsequently discovered detail is imprinted in the second and third.

The second deduction from these data is that the almost inconceivable regularity in the "canals" was an evolution in perception forced upon Schiaparelli by the objects themselves; not a feature imputed by him to them. His first map in 1877 showed them as arms or inlets of the sea penetrating the continents to great distances, but not characterized by remarkable regularity of form. His second map in 1879, shows them narrower, straighter, and in every way more peculiar. His third map, in 1882, presents them as of geometric precision; as he himself remarks, as if laid down by rule and compass. His fourth map shows that they afterward kept such a character.

Had this precision been of his devising, they should not have gained in it as time went on and as his eye grew versed in decipherment. That they did so, implies that the recognition was forced upon him from without.

The third deduction is that the evolution in detail marks the series, and can be traced steadily on from the beginning to the end. The additions made in each period find themselves superposed upon the work of the period before. Similarly each map of any given period adds to its predecessor and is corroborated and extended by its successor. Thus a chain of evidence is made by them whose strength depends upon this very intertwining of results.

S. A. MITCHELL,
Secretary.

SECTION OF BIOLOGY.

Section met at 8:15 P. M., Professor Bashford Dean presiding.

The minutes of the last meeting were read and approved.

The following program was offered :

J. H. McGregor, THE ANCESTRY OF THE ICHTHYOSAURIA.

A. G. Mayer, COLOR PATTERNS IN LEPIDOPTERA.

C. C. Trowbridge, THE FUNCTION OF INTERLOCKED EMARGINATE PRIMARIES IN SOARING FLIGHT.

SUMMARY OF PAPERS.

Dr. **McGregor** accepted Baur's view that the Ichthyosauria are derived from Permian Rhynchocephalia, but stated that in a study of the Belodontia he had found new evidence as to the nature of the intermediate forms. The latter group is of undoubted Rhynchocephalian origin, and may almost be considered as a subdivision including forms modified for aquatic life. A comparison of Belodonts and Ichthyosaurs shows that both have evolved in the same direction, though modification has proceeded further in the Ichthyosaurs, which were marine in habit. Almost all of the skeletal features of the two orders are reducible to a common type, and, although not directly ancestral, the Belodonts must be considered as standing very near the line of descent of the Ichthyosaurs; the two orders probably had as a common ancestor some aquatic Rhynchocephalian of the upper Permian or lower Trias. The Ichthyosauria are thus brought into relation with the Archosaurian branch of the Reptilia.

Dr. **Mayer** presented the results of his study of the color patterns of 1,173 species of lepidoptera: 453 *Papilio*, 30 Ornithoptera, 643 Hesperidæ, and 47 *Castina*. Counting sexual differences, 1,340 individual insects were examined; 542 *Papilio*, 59 Ornithoptera, 688 Hesperidæ, and 51 *Castina*. The number of rows of spots, bands, or combination markings upon the wings were counted, and as well the number of spots in each individual row, and the number of interspaces over which each

band extended; the results show that each row of spots or bands exhibits a decided tendency to be of uniform color throughout, that rows very rarely break at or near the middle of their extent, and that the end spots of a row are more variable than those spots near the center. "Frequency polygons" were obtained from the above-mentioned data, for the rows of markings, for the number of spots in each row, and for the extent of bands measured in interspaces. Eight such frequency polygons were determined for the spots and bands on the upper and lower surfaces of the wings in the group of *Papilio* Ornithoptera. Of the four representing the conditions in the fore-wing, three exhibit two well-marked maxima, the numbers being arranged in descending series on either side of each. These maxima are three and nine spots, or bands extending over three or nine interspaces. If, now, *Papilio* be divided into the three subgenera *Papilio* s. str., *Cosmodesmus*, and *Pharmacophagus*, and be still further separated into the African, Indo-Australian, Europ-Siberian, and American forms, it is found that the insects of the subgroups still display the tendency to have three or nine spots, or bands extending over three or nine interspaces. This is not a matter of correlation, for only 32 of the 453 species of *Papilio* display *both* three and nine spots upon their forewings. It is somewhat difficult to explain this condition upon the hypothesis of natural selection, owing to the fact that *Papilios* of widely separated regions show the same tendency to produce these two maxima in the same manner. The *Hesperidae* and *Castina* show no such tendency, hence it is not universal for *Lepidoptera*. If it be due to natural selection acting upon *Papilios* and restricting them to this condition, such selection must be universally operative in the case of *Papilio*, but not in the other species. It is easier, therefore, to assume a race tendency in *Papilio* to produce either three or nine spots upon the fore-wing, or bands extending over three or nine interspaces. Other results, quantitatively expressed, were brought out by the author.

Mr. **Trowbridge** gave the result of observations on flying birds for the purpose of showing that the emarginate primaries

of hawks, eagles and certain other birds are interlocked in flight. The speaker referred to his original paper on the subject in which the theory was set forth, which was presented by the late Professor W. P. Trowbridge before the National Academy of Sciences and the New York Academy of Sciences. The paper created some discussion in *Science* at the time, participated in by Dr. Elliot Coues, Professor Newberry, Professor Trowbridge and others. Mr. Trowbridge showed by a number of diagrams and photographs that the primary feathers of a number of birds are emarginate near their ends, and that the webs of the feathers are so shaped that when they are overlapped, a curved and rigid aeroplane is formed at the end of the wing, which, he considered, is of considerable advantage in swift sailing flight. The emarginations of the primaries of hawks and eagles are particularly pronounced, and permit firm interlocking. A table of observations was given, showing that the interlocking of the primaries does take place, the data having been obtained at New Haven during the autumn flights of hawks along the Connecticut coast. It appears that in the case of one species of hawk examined, ten wings out of forty had all five primaries interlocked, and that the number of wings having 60 per cent. of the primaries interlocked was twenty-nine, or 72 per cent. of the total number, forty. It was concluded that emarginate primaries of hawks and other birds are interlocked in flight on the following grounds: (1) It has been found that the webs of such feathers of hawks that had just been killed usually show deep notches where they have rested against one another, which notches could only result from habitual interlocking of the primaries; and (2) in every case of over twenty-five hawks killed while flying and examined immediately after they fall *some* primaries were interlocked (several slightly wounded birds not included). In the case of nineteen perfect specimens on one species, 67.9 per cent. of all emarginate primaries (190) were found to be interlocked. While it is not possible at present to show when the emarginate primaries are interlocked in flight the indications are, however, that this occurs when the wing is partly flexed, as in the case of hawks sailing

rapidly through the woods and flying in a strong wind. The important functions of interlocking appear to be: (1) To make more rigid the outer portion of the wing, that part of the aeroplane formed by the primaries, and (2) to produce a curve of the wing which enables the bird to have a better control of its swift flight through the air than the unlocked condition would permit. The end of the bird's wing when the primaries are interlocked becomes shaped somewhat like the blade of a propeller screw. The interlocking also would keep the primaries extended without muscular exertion on the part of the bird.

Considerable discussion was aroused by Mr. Trowbridge's paper. Dr. **Jonathan Dwight, Jr.**, presented a series of arguments against the theory of the speaker, to the effect, in brief, that in the absence of a proper controlling musculature, any such interlocking as that described could be brought about only by accident; that habitual interlocking would bring about, furthermore, conspicuous wearing of the vane in the areas of contact, a phenomenon not observed in emarginate primaries; and that he concluded from his extensive studies upon feathers and feather structure, that habitual interlocking did not take place. Mr. **Frank Chapman**, with a series of fine lantern slides of birds in actual flight, demonstrated that in some soaring birds, at least, which possess emarginate primaries these feathers are certainly spread and not interlocked. Mr. Chapman agreed with Dr. Dwight that the facts tend to support Allen's theory of the origin of emargination, namely that aerial friction wears down the web; and that no such function is to be attributed to emarginate primaries such as that ascribed by Mr. Trowbridge. Prolonged discussion followed, participated in by Mr. Trowbridge, Dr. Dwight, Mr. Chapman, Professor Dean, Professor Crampton and others.

HENRY E. CRAMPTON,

Secretary.

SPECIAL BUSINESS MEETING.

APRIL 24, 1902.

The Academy was called to order at 8:15 P. M., by President Cattell. Professor Richard E. Dodge was elected Recording Secretary, *pro tem.*

The President stated the object of the meeting, and that a notice had been sent by the Recording Secretary to all resident members and fellows entitled to vote, in accordance with the requirements of Section 5 of the amended charter.

The proposed constitution, filed herewith,¹ was then read by the Recording Secretary, *pro tem.*, and on motion of Professor R. S. Woodward, seconded by Professor Francis E. Lloyd was unanimously adopted.

The academy then adjourned.

RICHARD E. DODGE,
Recording Secretary, pro tem.

SECTION OF GEOLOGY AND MINERALOGY.

APRIL 24, 1902.

Section met at 8:30 P. M., Professor J. J. Stevenson presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered :

Lea McL. Luquer, ON THE DETERMINATION OF THE RELATIVE REFRACTIVE INDICES OF MINERALS IN ROCK SECTIONS BY THE BECKE METHOD.

Austin F. Rogers, THE MINERALS OF THE JOPLIN, MO., LEAD AND ZINC DISTRICT.

SUMMARY OF PAPERS.

Lea McL. Luquer stated that in most schemes for the optical determination of minerals in rock sections, the birefringence and resulting interference colors are made the basis of the scheme of classification. It is also desirable, however, to bring into consideration an approximate knowledge of the indices of refraction, and where the relative differences in the indices of two adjoining minerals is required, the method devised by Becke is found to be very convenient. This method depends upon the principle of the total reflection of light, and with proper adjustment of the microscope, which is to be focused sharply on the

¹ See Appendix.

dividing plane between the two minerals, it is possible, by slightly raising the objective, to observe a "bright line" on the side of the mineral having the higher index of refraction.

The main precautions to be observed are, that the cone of incident light be small, the sections very thin, the cementing material not much lower in refractive index than either of the minerals to be determined, and the plane of contact nearly vertical and clear. When the contact plane is much inclined, the method cannot be applied.

By this method very slight differences in refraction can be distinguished; as for example, between quartz sections cut parallel and at right angles to the optic axis; in which the difference

$$= 0.009, \quad = 1.553, \quad = 1.544.$$

Dr. **Luquer's** paper has been published in the *School of Mines Quarterly* for January, 1902, pp. 127-133.

Austin F. Rogers stated that the minerals of the Joplin District include sulphur, galena, sphalerite, covellite, greenockite, wurtzite, chalcopyrite, pyrite, marcasite, quartz, cuprite, pyrolusite, limonite, calcite, dolomite, smithsonite, cerussite, aurichalcite, hydrozincite, malachite, azurite, calamine, muscovite, chrysocolla, allophane, pyromorphite, barite, anglesite, leadhillite, caledonite, linarite, gypsum, goslarite, chalcantite, melanterite, copiapite and bitumen, all of which have been found by the writer.

Lamellar twinning has been observed in galena, the twinning planes being vicinal tetragonal trisoctahedra. Covellite is found replacing sphalerite. Wurtzite occurs in distinct hemimorphic crystals—the first instance of the kind to be reported. Twin crystals of marcasite are common, among them cyclic fivelings. Quartz crystals are rare and small. Calcite presents an interesting field for crystallographic study, about twenty-four types, with a total of twenty-nine crystal forms, having been noted. Twinning according to all of the four laws for calcite have been observed. Some distinct crystals of aurichalcite confirm D'Archiardi's observations that the mineral is monoclinic

and that the axial angle is not 90° . Calamine occurs in doubly terminated crystals which show their hemimorphic character plainly. Seamon's theory as to the formation of calamine from "tallow-clay" is not in all cases applicable. The rare copper-lead basic sulphates, caledonite and linarite occur at one mine at Galena, Kansas. This mine also furnishes covellite, cuprite and aurichalcite.

The observed paragenesis generally follows this order: dolomite, galena, sphalerite, chalcopyrite, marcasite, pyrite, barite, calcite. The total absence of certain silicates and the rarity and small size of the quartz crystals strongly precludes the theory that the lead and zinc ores have been brought up from great depths by hot water.

Attention was called to the coincidence in the location of the ore deposits of this and neighboring districts and the border areas of the Ozark uplift, as pointed out by Haworth.¹

A fuller discussion of the minerals noted in this paper and their occurrence will be found in the forthcoming Lead and Zinc Report of the University Geological Survey of Kansas.

Section adjourned at 9:40.

EDMUND O. HOVEY,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

APRIL 28, 1902.

Section met at 8:25 P. M., Livingston Farrand presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Robert MacDougall, TWO EXPERIMENTS IN COLOR VISION.

J. E. Lough, MEMORY OF SCHOOL CHILDREN.

J. McKeen Cattell, INTENSITY OF LIGHT AND THE ERROR OF PERCEPTION.

E. L. Thorndike, SEX DIFFERENCES WITH RESPECT TO VARIABILITY.

¹ Bull. Geol. Soc. Amer., 11: 231, 1900.

W. Bogoras, ETHNOLOGICAL OBSERVATIONS IN NORTHEASTERN SIBERIA.

SUMMARY OF PAPERS.

The paper by Professor **Robert MacDougall**, in his absence, was read by title. He found (1) that the subjective intensity and saturation of a given constant objective color increases with the retinal area illuminated by it. This increase is most marked in case of green, least marked in case of red. A similar phenomenon appears in the grays. The apparent difference in brightness between a patch of gray and a light or a dark background is increased by enlarging the patch. (2) A given area of illumination produces a stronger subjective effect when this area is divided and distributed over the retina than when it is compact. This is perhaps because the area of irradiation is increased by distributing the area of illumination.

Professor **J. E. Lough** reported some experiments on the memory of school children. He had tested 682 school girls, ranging in age from 9 to 15. The method employed was the same as that used by Lobsien in a similar investigation of the school children at Kiel. A list of ten words was read to the pupils, who then wrote down as much of the list as they could remember. This was repeated with new classes of words until eight lists had been given. These experiments show: (1) That memory improves but slightly between the ages 9 and 15, being 62 per cent. at 9 and 64 per cent. at 13 and 15. This is in sharp contrast with the results obtained by Lobsien — 38 per cent. at 9, and 75 per cent. at 13. (2) That the amount remembered depends upon the class of words composing the list — names of colors having an average of 87 per cent., names of concrete things 75 per cent., words connected with tactile experiences 70 per cent., emotions 68 per cent., sounds 58 per cent., abstract words 50 per cent., numbers 45 per cent. (3) That the usual retardation at 12 with accelerations at 13 is shown in each class of words, with the exception of emotions, where there is a marked retardation at 13, with acceleration at 14. (4) That in each of the lower grades of school (4A-5B) the

brighter pupils have the better memory, while in each of the higher grades (6A-7B) the duller pupils have the better memory.

In discussing this paper, it was remarked by Professor Thorndike that grammar school girls of 14 to 15 do not fairly represent all girls of that age, since the brighter individuals are apt to leave the grammar school before reaching 14 years.

Professor **Cattell**, in a paper on the "Intensity of Light and the Error of Perception," described experiments in which 211 shades of gray between white and black were sorted out into the order of brightness. The steps were smaller than can be perceived, and there was consequently an error of displacement, measuring the just observable difference. For the more accurate observers the error was six cards or about 0.03 of the range between white and black. Observers differ within the extremes of about 1:2. The just observable difference increases with the magnitude of the stimulus, but not in direct proportion as required by Weber's law. The increase is more nearly in proportion to the square root of the magnitude, which the speaker has found to hold in other cases and has elsewhere attempted to explain.

Professor **E. L. Thorndike** presented results bearing on the question of "Sex Differences with Respect to Variability." A large number of psychological tests of school children has afforded him the opportunity of comparing the variability of boys and girls, as classes, and, on the whole, there is practically no difference between them.

Dr. **W. Bogoras** reported some results of his recent observations, undertaken for the Jesup North Pacific Expedition, in northeastern Siberia, among the Chuckchi, Koryak and Kamchadal peoples. These he found to resemble each other strongly in the structure of their languages and in their folklore. What is especially interesting is the striking similarity, almost identity, between some of their traditions and some of those current among the North American Eskimos and the Indians of British Columbia. It is not, however, the Asiatics living nearest to Bering Strait, but more southerly tribes, that show most evidence of kinship with the Indians. R. S. WOODWORTH,

Secretary.

BUSINESS MEETING.

MAY 5, 1902.

The Academy met at 8.15 P. M., President Cattell presiding.

The minutes of the last regular business meeting, and of the special business meeting of April 24, were read and approved.

The Secretary reported from the Council as follows: That arrangements had been made with the authorities of the American Museum of Natural History whereby the Academy would meet in rooms of the Museum during the coming year; that the Committee on the Constitution was considering necessary modifications of the by-laws, and would report at the meeting in October; and that the Committee on the Budget for 1902 had presented the report, filed herewith, which had been adopted by the Council.

The following candidate for membership, approved by the Council, was duly elected:

Miss Ida H. Ogilvie, New York City.

The Academy then adjourned.

HENRY E. CRAMPTON,
Recording Secretary.

REPORT OF THE COMMITTEE ON THE BUDGET.

TO THE COUNCIL, NEW YORK ACADEMY OF SCIENCES:

Gentlemen—Your Committee, appointed for the purpose of formulating the Budget for the Academy "year," March 1 to December 31, 1902, presents the following estimates. The income for the above period is estimated at \$3,000.00.

Rent, Chemist's Club (March 1 to May 30).....	\$ 125.00
Expenses, Recording Secretary.....	300.00
" Librarian.....	300.00
" Treasurer	45.00
Dues, Scientific Alliance	40.00
General Expenses	100.00

Editor.....	1,000.00
Total.....	<u>\$1,910.00</u>
Surplus.....	<u>\$1,090.00</u>

Respectfully submitted,

J. McKEEN CATTELL,
CHARLES LANE POOR,
HENRY E. CRAMPTON.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

MAY 5, 1902.

Section met at 8:30 P. M., Charles Lane Poor presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered :

R. W. Wood, ANOMALOUS DISPERSION AND ITS BEARING ON ASTROPHYSICAL PROBLEMS.

W. S. Day, AN EXPERIMENT RELATING TO THE APPLICATION OF LAGRANGE'S EQUATIONS OF MOTION TO ELECTRIC CURRENTS.

SUMMARY OF PAPERS.

Dr. **Day's** paper was as follows :

The experiment was analogous to one mentioned by Maxwell in his "Treatise on Electricity and Magnetism," Section 574, Volume II. Maxwell's experiment was made for the purpose of discovering whether or not, in the expression for the kinetic energy of an electric current, there was a term depending on the product of the current and the velocity of the conductor. In a single linear circuit having only one degree of mechanical freedom, the expression for the kinetic energy of the system in the most general case would be of the form :

$$T = \frac{1}{2} I \dot{x}^2 + K \dot{x} \dot{y} + \frac{1}{2} L \dot{y}^2$$

in which $\dot{x}$ is the velocity of the mechanical coördinate, $\dot{y}$ is the current, I is a quantity of the nature of a mass, L is the self-

induction of the circuit, and K is the coefficient of the term consisting of products. Just what mechanical coördinate is to be represented by x is partly a matter of choice. Maxwell chose one whose velocity means a motion of the wire in the direction of its length. There is one other coördinate which seems to be geometrically possible, although it is not one that is naturally suggested by the most satisfactory hypotheses now in vogue as to the nature of an electric current. This other coördinate is one such that its velocity means a rotation of the wire carrying the current around its axis of figure. If x has this meaning, then if the coefficient K is not zero, Lagrange's equations of motion show that if a current is suddenly started or stopped in a wire there would be an impulsive torque acting on the wire. The experiment was performed to look for such an effect, if it existed. A straight piece of aluminium wire 30 cm. long and 0.25 cm. in diameter was suspended by a quartz fiber in such a way that it was free to rotate, and by means of mercury cups, a current could be passed through it at pleasure. No effect of the kind considered was detected. If the value of K expressed in C.G.S. electromagnetic units, and referred to a centimeter of the wire, had been as great as 0.00002, it could have been detected.

S. A. MITCHELL,
Secretary.

SECTION OF BIOLOGY.

MAY 12, 1902.

Section met at 8:15 P. M., Professor Dean presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Edmund B. Wilson, CELL-LINEAGE AND THE STUDY OF HOMOLOGIES.

Gary N. Calkins, ARTIFICIAL PARTHENOGENESIS IN PARAMÆCIUM.

Francis B. Sumner, FURTHER EXPERIMENTAL STUDIES UPON FISH DEVELOPMENT.

SUMMARY OF PAPERS.

Professor **Wilson** pointed out that in the analysis of cell-homologies, as in genetic homologies in general, the essential criterion is that of common ancestral descent. Cell-homologies may be merely incidental or secondary to regional homologies of the egg, and, owing to the plasticity of cleavage-forms, may be more modified than other forms of homology, even becoming obliterated. It was proposed to denote as *equivalent* those cells giving rise to homologous structures, irrespective of their origin; while those cells which are alike in ontogenetic-origin and position may, irrespective of their fate, be termed *homoblastic*. The term homology is applicable in cleavages of like pattern which have been derived from a common ancestral type, and in which the corresponding cells are both homoblastic and equivalent. When the cells, though homoblastic, wholly change their equivalence, or when the cleavage-pattern itself wholly changes, the original homology disappears.

Dr. **Calkins** presented the following results: The experiments in cultivating *Paramacium caudatum* through long periods seem to indicate that, after continued feeding on the same diet, two originally different lines become so similar in chemical composition that conjugation is practically ineffectual. To illustrate, so-called "wild" conjugations were captured, and the ex-conjugants after separation were treated with the regular culture medium; 84 per cent. of these continued living. In the regular culture series (now, May 13, in the 567th and 523d generation, respectively), out of 48 exogamous ex-conjugants, only three continued to live, *i. e.*, about 6 per cent.; while of the 32 endogamous ex-conjugants only two continued to live, again about 6 per cent. The high percentage of fertile wild, and the low percentage of fertile cultivated forms give reason for the assumption that after continued treatment with the same diet, the conjugants get no new chemical compound by exchange of nuclei, and therefore no "rejuvenation" takes place. Experiments with different kinds of reagents are now in progress to ascertain, if possible, what is needed to make such sterile conjugations fertile.

Dr. **Sumner** described his further experiments upon the eggs of *Exocoetus*, *Salvelinus*, *Batrachus*, and two species of *Fundulus*. The methods employed were cautery and impalement with glass needles. The results tended to prove that there is early established in the embryo a definite region of growth, and that the elongation of the body occurs through cell-multiplication in this region. Additions from the germ-ring or other portions of the blastoderm play at most a subordinate rôle. Destruction of this region of growth led to cessation of embryo formation, although the blastoderm continued to spread. On the contrary, destruction at an early period of the entire embryonic sector of the blastoderm was followed by the regeneration of a new "embryonic shield."

HENRY E. CRAMPTON,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

MAY 19, 1902.

Section met at 8:15 P. M., Dr. A. A. Julien presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

George E. Ashby, SOME INCLUSIONS IN MICA AND THEIR RELATION TO THE PERCUSSION FIGURE.

George I. Finlay, GEOLOGICAL OBSERVATIONS ALONG THE NORTHERN BOUNDARY OF MONTANA.

SUMMARY OF PAPERS.

Mr. **Ashby** was able to show by a most interesting series of specimens and lantern slides that definite geometrical relations exist between the percussion figures and the inclusions of magnetite common in mica. The percussion figure often bisects the same angle between the skeleton rays of magnetite.

Mr. **Finlay** dealt with the stratigraphy and petrography of the district along the 49th parallel of latitude west from the great plains. The sedimentary series is of Algonkian argillite,

sandstone and limestone. Intrusive and extrusive flows of diorite and diabase were observed and a few dikes of diabase were noted. The structure of the range at this point is simple, being that of a very gentle syncline, except for the anomalous contact along the eastern face of the Rocky Mountains between the Algonkian sediments above and the Cretaceous sandstones immediately below. This condition is brought about by overthrust faulting along a warped plane dipping very gently to the west.

GEORGE I. FINLAY,
Secretary, pro tem.

BUSINESS MEETING.

OCTOBER 6, 1902.

The Academy met at 8:30 P. M., President Cattell presiding.

The minutes of the last business meeting were read and approved.

The Secretary reported from the Council that, in accordance with the provisions of the new Constitution, a new set of By-laws had been draughted by a special committee, and had been accepted by the Council. By direction of the Council, these By-laws were to be acted upon at the present meeting of the Academy. The Secretary then presented the new By-laws, which, by vote, were adopted. A copy is filed herewith.¹

The following candidate for active membership, approved by the Council, was duly elected:

Alexander S. Farmer, C.E., 140 Rodney Street, Brooklyn.

The Academy then adjourned. HENRY E. CRAMPTON,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY:

OCTOBER 6, 1902.

Section met at 8:45 P. M., Professor Hallock presiding.

The minutes of the last meeting of Section were read and approved.

¹ See Appendix.

The following program was then offered :

Informal Reports of the members upon work during the summer in matters of interest to the section.

SUMMARY OF PAPERS.

George F. Kunz exhibited a section of the tusk of the elephant Tip that was killed several years ago because he had become so cross. The section of the tooth showed a large cavity amounting to a couple of cubic inches — near the end of the conical cavity at the root of the tooth. It was suggested that possibly this cavity represented an ulceration of the tooth, and that the bad humor of the elephant was really due to a bad tooth. After discussion by Professor Cattell and others, it was apparently the opinion of those best qualified to know, that this cavity was not the result of any such ulceration, and that probably the elephant would not suffer from toothache in any case.

William Hallock made an informal report upon barometric and boiling point observations made during the ascent of Mt. Whitney during the month of August. He called attention to the use of the boiling point apparatus as checking the barometer and the necessity of taking into consideration the temperature and humidity of the air, as well as the simple barometric pressure. He also referred to certain interesting lava fields on Whitney Creek to the southwest from Mt. Whitney.

G. B. Pegram gave an interesting account of the work done at the magnetic observatories in this country, and especially at the one at Cheltenham, Md., with which he was connected during the summer vacation.

Dr. **D. S. Martin** referred to the interesting minerals exhibited at the Exposition of the South at Charleston, and showed a sample of the ash from Mt. Pelée which was brought to Charleston on one of the incoming vessels. He will report upon this subject in the section of mineralogy later on.

D. S. MARTIN,
Secretary, pro tem.

SECTION OF BIOLOGY.

OCTOBER 13, 1902.

The section met at 8:15 P. M., Professor Bashford Dean presiding.

The minutes of the last meeting were read and approved.

The Secretary presented a letter from the Recording Secretary of the Academy, calling attention to the fact that sectional officers were to be elected at the November meeting, the officers then chosen to take office at the first meeting in January following. It was also stated that the election of a Chairman by the section constituted his nomination to the Council as a candidate for Vice-President.

The following nominating committee was appointed by the Chair to report at the next meeting: Professors Bristol, Lee, Lloyd, Drs. Mayer and Calkins.

The scientific program consisted of a series of reports by members of the section upon their work during the summer.

Professor **E. B. Wilson** spoke of some of the results of his successful work, carried on at first at the Beaufort, N. C. Fish Commission Station, and later at the South Harpswell Laboratory in Maine. Complete embryological material of *Renilla* had been obtained, after several years' efforts. Important results were also obtained by experiments upon the regeneration of the large claw in *Alpheus*, the conclusions of Przibram being confirmed, and the influence of the nervous system being determined. At South Harpswell experimental work was carried on upon the development of the normal eggs, of isolated blastomeres, and of egg-fragments of the worm *Cerebratulus*, a form extremely favorable for experimentation. In conclusion, the favorable character of the fauna in general in this region was pointed out.

Professor **F. S. Lee** reported the results of investigations upon the effect of alcohol on muscular work in *Gonionema*, which agreed in essentials with his earlier work upon the effect of alcohol on frog muscle. It was pointed out that the effect

might be due to the withdrawal of water from the muscle, or to the action of the small number of ions present.

Dr. **O. P. Hay** described his summer's work upon the fossil fishes of the American Museum of Natural History, particular attention having been given to the Cretaceous forms. Work was also carried on upon the turtles.

Professor **A. W. Grabau** spoke of his collecting expeditions for Silurian and Devonian fossils. He mentioned also an interesting case of non-conformity at Rondout, which he had been able to explain. Explorations of the Palæozoic coral reefs of Wisconsin were also described.

Dr. **G. N. Calkins** referred to the investigations which had been carried on at the Marine Biological Laboratory, under his direction, upon the sporozoa associated with cancerous growth. It was found that the genus *Basiophra* when introduced into the body of a toad would cause the production of a tumor. Dr. Calkins's personal work upon *Paramacium* had been continued, the action of various salts upon this form receiving particular attention.

Dr. **M. A. Bigelow** reported upon his observations upon the power of young birds to distinguish different colors, of interest in connection with the problem of insect coloration. Much of the summer had been utilized in the preparation of a manuscript for a laboratory manual.

Mr. **Naohide Yatsu** described the results of his experiments upon the eggs of the common starfish, which were carried on at Woods Hole. Artificial parthenogenesis was induced by ether, and larvæ were reared up to the eighteenth day.

Mr. **Raymond Osburn** described the location and work of the Vancouver Island Laboratory of the University of Minnesota, where he had spent the summer. His particular interest concerned the invertebrata and birds of the Vancouver region.

Professor **Crampton** referred to the work of the Woods Hole Laboratory, and mentioned briefly his work at the Bayshore Laboratory upon the development of *Bulla* and of his experiments upon moths.

Professor **Dean** reported progress upon several lines of research. A paper dealing with Japanese oyster-culture had been prepared for the government, and experiments upon induced fossilization by means of calcium phosphate had been pursued. The embryology of *Chimera* had received special attention, a conclusion of particular interest being that the breaking up of the extra-embryonic yolk is due to supernumerary sperm-nuclei.

HENRY E. CRAMPTON,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

OCTOBER 20, 1902.

Section met at 8:15 P. M., Prof. J. J. Stevenson presiding. The minutes of the last meeting of Section was read and approved.

The following program was then offered:

William H. Hobbs, GEOLOGY OF THE RIVER CHANNELS ABOUT MANHATTAN ISLAND.

James F. Kemp, COMMENTS ON THE GEOLOGY OF BINGHAM CAÑON, UTAH. Illustrated with lantern slides and specimens.

Wallace G. Levison, EXHIBITION OF SPECIMENS OF GNEISS AND SERPENTINE FROM THE SOUTHERN END OF MANHATTAN ISLAND.

Before the scientific program of the evening was taken up, the Section proceeded to the election of officers for the year 1903, in accordance with the provisions of the new constitution of the Academy.

James F. Kemp was nominated for chairman, and, there being no other nominations, the Section, by unanimous vote, directed the Secretary to cast one affirmative ballot for the nominee, and Professor Kemp was declared elected.

Edmund O. Hovey was nominated for Secretary, and, there being no other nominations, the Section, by unanimous vote, directed Professor R. E. Dodge to cast one affirmative ballot for the nominee, and Dr. Hovey was declared elected.

SUMMARY OF PAPERS.

Wallace Goold Levison exhibited to the Section four specimens of gneiss obtained from the bedrock in certain deep excavations at the southern end of Manhattan Island. One of these was collected July 20, 1902, from a depth of fifty feet below the surface at the corner of Broad and Exchange Streets; the second was collected in the excavations at 40 Exchange Place, forty-five feet below the surface, on July 25; two others were collected at 43-49 Exchange Place, forty-five feet below the surface, on July 25. Mr. Levison also showed several specimens of serpentine from boulders found in excavations for the Stock Exchange building on Broad Street, between forty and sixty feet below the surface, on June 19.

In the absence of the author, the paper by Professor **William H. Hobbs** was read in somewhat condensed form by the Secretary of the Section. The paper was accompanied by a wealth of detailed observations too extensive for reproduction, but a summary of his conclusions is as follows:

In his introduction the author called attention to the unusual opportunities now offered for studying the geology of Manhattan Island through the numerous great engineering works in progress. The waterways surrounding the island are deep cañons, with a depth of nearly two hundred feet in the East River and three hundred feet or more in the North River, now partly filled with drift deposits, the amount depending upon the velocity of the tidal currents.

In 1865 Stevens advanced the theory that the river channels followed lines of faults ("longitudinal and transverse fractures"). Newberry regarded the East River as the lowest reach of the Housatonic River before it discharged its waters into the Hudson, which was then the outlet of the Lorentian series of lakes, and he considered the Harlem River with Spuyten Duyvil Creek a smaller tributary of the Hudson. Dana believed that the relatively easy solution of certain beds of limestone determined the position of the river channels. This view of Dana's has been supported by Kemp and F. J. H. Merrill, while Gratacap rejects the theory advanced by Stevens.

Professor Hobbs finds that no correspondence can be established between the directions of the belts of limestone or dolomite and of the New York water front, except within the stretch from Kingsbridge to Macomb's dam bridge. Along this line too the observed facts point to the occurrence of a narrow strip of limestone dropped down between vertical faults. The sections of the Harlem River which are furnished by the bridges across it show clearly that it is not a simple erosion valley resulting from cutting by the stream. The bed of the stream is marked by sudden changes of level, and the Harlem seems to have chosen its course quite independently of ridges of the harder gneiss. Under the East River limestone has been found at but two localities — under the channel east of Blackwell's Island, and in one of the drill holes underneath the Manhattan pier of the East River bridge No. 3. The limestone east of Blackwell's Island is enclosed between parallel fault walls, and appear to have been dropped down along them. The numerous occurrences, however, of gneiss, and gneiss only along, in and under the East River leave little doubt that the main portion of the bed is composed of this rock.

Regarding the bedrock beneath the North River, comparatively little is known, but the origin of its channel is sufficiently accounted for by its position along the contact of the Newark system with the crystallines. This contact seems surely to be a fault border, on account of its markedly rectilinear extension, the great scarp of basalt, the much inferior position of the newer terranes, and the evidence derived from the borings along the route of the proposed tunnel of the Pennsylvania, New York and Long Island Railroad Company.

The author holds that the directions of the channels of Spuyten Duyvil Creek and Harlem and East Rivers have been determined largely by lines of joining and displacement. Manhattan Island borders directly upon the Newark area, in which the existence of a network of faults has been established by the work of several observers, and the network probably extends beyond the limits of the area. The striking rectilinear outlines of the island, especially of the northern half of it, and its topo-

graphic development are favorable to the view that it represents an orographic block left standing between down-thrown strips of the crust. The rectilinear gorge of the upper Harlem between Washington Heights and Fordham Heights is continued, so far as its western wall is concerned, some two and a half miles south of the river. It is parallel to the direction of the scarp of the Palisades and of the Hudson. Besides the cross fractures indicated by the different parts of the Harlem River which were pointed out by Stevens, several other cross fractures on and about Manhattan Island were pointed out by the same author. Dana also considered that the Manhattanville cross valley was formed by a cross-fracture. A considerable number of faults has been definitely established. Their directions correspond in general to the elements in the courses of the river channels. The exceptions to this rule are the fissures in the East River east and west of Blackwell's Island.

The author went on to cite a number of faults which have been disclosed by numerous borings and tunnels, and in closing called attention to the fact that the buried rock surface in the lower part of the city (south of Twenty-third street), as well as that below the area of the Harlem flats (north of One Hundred and Tenth Street and east of Eighth Avenue) is characterized by the most abrupt changes of level. In his opinion the area of these portions of the island represent orographic blocks depressed by faults, reefs of gneiss and limestone rising along the Harlem area, while reefs of gneiss alone characterize the southern district.

Professor **Hobbs'** paper was discussed briefly by Professors Kemp, Dodge and Stevenson, and it was evident that the author's theory would not be accepted without considerable further investigation.

At the outset of his paper on Bingham Cañon, Professor **Kemp** stated that the article was not a formal one for publication, and that he did not wish to forestall in any degree the forthcoming Bingham folio by Mr. Boutwell of the United States Geological Survey. He then described the geological formations in the vicinity of the large mines. These formations em-

braced the great section of quartzite with smaller exposures of limestone and with intruded masses of eruptive rocks which range from pronounced porphyries to granites. At least three kinds of eruptives can be distinguished. The author described in outline the faults and geological relations of the ores, and stated that the ores especially favored the contact of the eruptive rocks with the quartzites. The evidences of contact metamorphism between the porphyries and the limestones were commented upon. The ores in the great porphyry dike on the claims of Colonel Wall were described, and were stated to be secondary in their origin—that is, they probably were introduced in solution into a mass of crushed eruptive rock. The data for the paper were gathered in connection with the field instruction given to a class of students the past summer. The paper was illustrated by means of lantern slides, maps and specimens.

EDMUND O. HOVEY,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

OCTOBER 27, 1902.

Section met at 8.15 P. M.

At the preliminary business meeting Professor Edward L. Thorndike, of Teachers College, Columbia University, was elected as Chairman of the Section for 1903.

The program of the evening consisted of anthropological reports of summer work. Dr. **Clark Wissler** described his researches among the Sioux Indians in the interests of the American Museum of Natural History, paying particular attention to their decorative art as compared with that of surrounding tribes. Dr. **A. L. Kroeber**, of the University of California, spoke of the field work carried on by that institution under his direction, dwelling particularly upon the distribution of linguistic stocks in California and the correspondence between linguistic and cultured areas.

Dr. **Maurice Fischberg**, of New York, outlined a study in which he is engaged involving the measurements of, and collec-

tion of information regarding the Jews of New York. Immigrants are examined particularly with regard to racial peculiarities and observations on several generations in the same families are made wherever possible. Dr. Fischberg discussed briefly certain preliminary results from his research, promising fuller reports at a later date.

Dr. **Farrand** closed the program with a few remarks on his work during the summer on the Sahaptin stock of Indians for the American Museum of Natural History.

LIVINGSTON FARRAND,
Secretary, pro tem.

BUSINESS MEETING:

NOVEMBER 3, 1902.

The Academy met at 8.20 P. M., Professor Charles L. Poor presiding. The minutes of the last business meeting were read and approved.

There being no business to come before the Academy, it was voted to adjourn.

HENRY E. CRAMPTON,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

NOVEMBER 3, 1902.

Section met at 8:30 P. M., Charles Lane Poor presiding. The minutes of the last meeting of Section were dispensed with.

The following program was then offered:

G. B. Pegram, EXPERIMENTS ON THE ELECTROLYSIS OF
RADIOACTIVE SUBSTANCES.

SUMMARY OF PAPER.

When a solution of a thorium salt is electrolyzed, using platinum electrodes, a temporary radioactivity is imparted to the anode rather than to the kathode, which is remarkable in view

of the fact that in the air near dry thorium compounds a negatively charged body, corresponding to the kathode, becomes radioactive, while a positively charged body, corresponding to the anode, is not made active. The activity of the anode used in the electrolysis of a thorium nitrate solution can become much more intense, for a given extent of surface, than that shown by a thick layer of thorium oxide.

The solution under electrolysis rapidly loses its power of imparting radioactivity, so that after four hours of electrolysis with a current of half an ampere, a solution of 20 g. of thorium nitrate in 100 c.c. water had lost 95 per cent. of its power of imparting activity to the anode. This radioactivity of the anode increases for a while after being taken out of the solution, then its intensity falls off at the rate of half its value in eleven hours, which has been shown by Professor **E. Rutherford** to be the rate of decay in the case of surfaces made active by exposure to the emanation from a dry thorium compound. The radiation is not homogeneous, as is shown by a study of its absorption by successive layers of metal foil.

The activity of the anode seems to increase directly with the concentration of the solution for short periods of electrolysis, but its relation to the current strength and the duration of the electrolysis appears to be less simple.

Solutions containing radium impart activity to both anode and kathode, but this activity decays very rapidly, falling off half its value in about 35 minutes.

S. A. MITCHELL,
Secretary of Section.

SECTION OF BIOLOGY.

NOVEMBER 10, 1902.

The Section met at 8:15, P. M., Professor Bashford Dean presiding.

The minutes of the last meeting were read and approved.

The Nominating Committee appointed at the October meeting presented the following nominations:

For Chairman and candidate for Vice-President, Professor Bashford Dean.

For Secretary, Dr. M. A. Bigelow.

The Secretary was authorized by vote to cast a single affirmative ballot for these nominees. This was done, and the candidates declared duly elected.

The scientific program consisted of a lecture by Professor **R. T. Jackson**, of Harvard University, entitled "Localized Stages in the Development of Plants and Animals."

SUMMARY OF PAPER.

Professor **Jackson** showed that in the study of organisms marked stages in development are found throughout life from the young to adult and old age. Such stages are of the highest importance in phylogenetic studies as affording the key to genetic relations.

In addition to stages in the direct development, in many plants and animals stages exist in localized parts throughout the life of the individual, which are directly comparable to stages found in the young, and to the adults of simpler and more primitive fossil or living types.

Localized stages are typically seen in organisms that grow by progressive addition of similar parts, in which the young or growing part temporarily or permanently presents characters which are closely comparable to characters found in the young and adults of simpler types.

In plants localized stages are seen in the distal and proximal areas of the leaf, in suckers, "witches' brooms," late, sickly or otherwise feeble growths, and, as shown by Cushman (*American Naturalist*, November, 1902) in spring growths and leaves below the flower. The last mentioned are particularly striking as they present a localized senescence, repeating stages in inverse order of sequence from that seen in the seedlings.

In animals localized stages are seen in the newly-added dorsal inter-ambulacral plates of the corona of *Strongylocentrotus* and other sea-urchins. In young plates of the stem of some crinoids, (*Platycrinus*, *Pentacrinus*) and as pointed out by Grabau, in the

distal ends of the arms of *Eucrinus* and *Platycrinus*. The septal suture of *Ammonites* show striking localized stages, in that a progressive complexity of the septum is traceable in passing from the dorsal to the ventral border which series is comparable to the progressive complexity seen in passing from the young to adult, and from primitive to specialized types in the geological series.

HENRY E. CRAMPTON,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

NOVEMBER 17, 1902.

Section met at 8:15 P. M., J. J. Stevenson presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

A. W. Grabau, LIMESTONE REGIONS OF MICHIGAN.

SUMMARY OF PAPER.

The limestones considered are of middle Devonian age, and constitute the bedrock of the northern portion of the lower peninsula of Michigan. They are of great economic importance on account of their purity. They are chiefly used in the manufacture of Portland cement, and for chemical purposes. Throughout them isolated reefs are found, which show all the characters of modern coral reefs. The corals and coralines are in the place they grew, while on all sides of them the fragmental limestone derived from the erosion of the reefs is found. This constitutes most of the bedded limestone of the region. On the flanks of the reef it has a steep dip, while away from it, the dip becomes low. The bedded limestone shows all the character of sandstones, but runs as high as 96 or even 99 per cent of CaCO_3 .

The fossils in the limestones show a mingling of Corniferous and Hamilton types, in the lower beds. A migration from this region to the Ontario and New York region is indicated.

Illustrated with diagrams and specimens.

J. F. KEMP,
Secretary, pro tem.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

NOVEMBER 24, 1902.

Section met at 8:15 P. M., Professor Farrand presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

J. B. Miner, TIME INTERVALS BOUNDED BY VARIED STIMULI.

J. H. Bair, THE GENERAL PRACTICE CURVE.

R. T. MacDougall, ON THE RELATION OF REACTIONS TO CERTAIN SECONDARY STIMULI.

SUMMARY OF PAPERS.

Mr. **J. B. Miner** presented the results of some experiments on the perception of time intervals bounded by varied stimuli. Intervals of one, two, three, four and six seconds bounded by sounds, lights, or one sound and one light, were given the subject, who then endeavored to reproduce the interval by taps on a telegraph key. For intervals bounded by sounds, the reproduced interval changed from plus to minus at a point between intervals of two and three seconds. There is very little difference between intervals bounded by sounds and those bounded by lights; but a considerable difference is given when the interval is bounded by a sound followed by a light or *vice versa*. The same interval bounded by varied stimuli seemed to the subjects to be longer than where bounded by like stimuli. Memory of intervals bounded by varied stimuli required more effort. Mr. Miner believed that this represented the difference in difficulty of muscular adjustment on which the memory of the time interval depended. The increase in variability with the longer intervals followed the law suggested by Cattell and Fullerton, rather than Weber's law.

The paper by Mr. **Bair**, on the general practice curve, was read in his absence by Mr. Miner. This paper was based on experiments made with a pack of 48 cards (six different pictures and eight of each picture). The cards when dealt in the same

order and then immediately after in a different order required a longer time for the second order. If dealt 2, 3, 4, 5 $\dots n$ times in the same order before dealing in some new order, the successive practices in the same order followed the law of the practice curve, which is an asymptotic approach to a physiological limit; and at the same time dealing the cards in any order required also less and less time. This shows that practice in one order gives practice ability in another order antagonistic to it, and the more practice in one order the greater the ability to respond quickly to the new order.

Professor **MacDougal** reported upon a series of experiments showing the influence of variations in visual stimulation upon reactions to auditory signals. Reaction time was shorter in darkness than in light, in weak light than in strong light, and in colored than in neutral light. Reaction time was more constant under neutral than under colored light, and changes in quality of light were followed regularly by increased rapidity of reactions. These changes were apparently due to changes in the attentive condition of the reactor, not to any immediate organic influence of the intensity or quality of the light.

JAMES E. LOUGH,
Secretary.

BUSINESS MEETING.

DECEMBER 1, 1902.

The Academy met at 8:20 P. M., President Cattell presiding. The minutes of the last business meeting were read and approved.

The Secretary reported from the Council as follows: that the Council had voted to nominate the following as candidates for Fellows, to be voted upon at the Annual Meeting: E. F. Buchner, Esther F. Byrnes, R. H. Cunningham, A. W. Chester, William Dutcher, H. C. Dyar, G. I. Finlay, John Eyer-
man, W. J. Gies, A. W. Grabau, J. D. Irving, Gustav Lang-
mann, H. R. Linville, J. E. Lough, R. T. MacDougall, T. C. Martin, Adolf Meyer, S. A. Mitchell, H. C. Parker, F. Peter-

son, J. C. Pfister, J. D. Prince, H. G. Piffard, M. I. Pupin, Ivan Sickels, M. A. Starr, G. T. Stevens, C. A. Strong, F. B. Sumner, W. G. Thompson, C. C. Trowbridge, J. F. Woodhull, E. R. VonNardroff: that the Council had prepared a list of nominations for officers (which was read), which would be mailed to members or the Academy one week before the Annual Meeting.

The Secretary read a letter from the Secretary of the Scientific Alliance, relating to the establishment of The Herrman Fund for scientific research. A copy of the letter is appended.

The Academy then adjourned.

HENRY E. CRAMPTON,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

DECEMBER 1, 1902.

Section met at 8:30 P. M., Charles Lane Poor presiding. The minutes of the last meeting of Section were read and approved.

The following program was then offered:

G. W. Ritchey, RECENT RESULTS IN ASTRONOMICAL PHOTOGRAPHY WITH THE FORTY-INCH REFRACTOR AND WITH THE TWO-FOOT REFLECTOR OF THE YERKES OBSERVATORY.

SUMMARY OF PAPER.

Mr. **Ritchey** exhibited with the lantern some excellent photographs taken by him with the instruments of the Yerkes Observatory. The two-foot mirror of silver on glass was ground some time ago by Mr. Ritchey himself, and the mounting of it was made in the observatory workshop from his designs. Since the reflector was mounted two or three years ago, many exceptionally fine photographs have been taken of star groups, clusters and nebulae, which rival those superb photographs of Keeler. Especially interesting were the photographs of *Nova Persci*, which showed the changes in the nebosity which surrounds this interesting new star.

Another important piece of work taken up by Mr. Ritchey was the application of a color screen to celestial photography, thereby adapting a visual telescope to photographic work. Such a screen was used with the great forty-inch refractor of the Yerkes Observatory, and photographs were exhibited showing the excellence of Mr. Ritchey's work with this giant object glass.

S. A. MITCHELL,
Secretary.

SECTION OF BIOLOGY.

DECEMBER 8, 1902.

The Section met at 8:15 P. M., Professor F. E. Lloyd presiding.

The minutes of the last meeting were read and approved.

The Secretary presented a letter from the Recording Secretary, regarding the establishment by the Scientific Alliance of the Herrman Research Fund, stating also the method of presenting and forwarding applications for grants.

The following program was then offered:

Edmund B. Wilson, ON THE RELATION BETWEEN LOCALIZATION AND CLEAVAGE AS ELUCIDATED BY EXPERIMENTS UPON MEROGENY.

A. W. Grabau, THE PHYLOGENY OF THE FUSIDÆ.

SUMMARY OF PAPERS.

Professor **Wilson** presented the results of his experiments upon the eggs of *Cerebratulus*, which dealt with the problem of germinal localization. It was found that isolated blastomeres of the two-cell stage developed by partial cleavage, but that dwarf larva of a normal structure were finally produced. The upper part of a blastula, however, produced a larva which lacked a perfect archenteron; and a ventral portion of a blastula became a pilidium which was devoid of an apical organ. The development of egg-fragments obtained prior to the initial cleavage, furnished particularly illuminating results. An egg-fragment obtained before maturation, and fertilized later devel-

oped by total cleavage into a perfect larva of dwarf size. It thus appears that localization is progressive, being practically absent before the initial cleavage, appearing in the two-cell stage, and becoming greater in the different regions of the blastula. The relation between cell-division and differentiation was discussed. It is expected that this paper will be published in full at an early date.

Professor **Grabau** showed that the Fusidæ are among the more highly accelerated types of marine gasteropods of the modern fauna. *Fusus* itself dates back to the Eocene, occurring in the Paris and Hampshire basins. The American Eocene species generally referred to *Fusus* are shown by their protoconchs to be more nearly related to *Pleurotoma* although their adult form is like that of the typical *Fusus*. The protoconch of *Fusus* is highly accelerated, showing riblets on the last portion. The typical conch ornamentation appears abruptly. The earliest stage is characterized by round whorls, rounded ribs extending from suture to suture, and simple spirals. These are the characters of the adult of the most primitive Eocene species, and also appear in the young of all later species. The next stage is characterized by the appearance of an angulation on the whorl, and a concentration of the ribs on the angle. In the next stage the ribs are replaced by tubercles, and these later unite to form a keel. This gives the type of the genus *Fusus colus*. In the old members of this species the keel is lost, and the whorls become rounded. Finally in highly accelerated types the adult is marked by the rounded keelless whorl, while many of the intermediate stages are dropped out. Thus *F. longicauda* has dropped the tubercled and keeled stage through a process of acceleration in development. This may be considered as phylogerontism. In every genetic series of the Fusidæ types occur, which in their adult conditions, show characters comparable to one or the other of the stages found in such types as *F. colus*. In the chronogenesis of each series it is found that types whose adults are comparable with the earliest stage of *F. colus* appear first. All Eocene species of *Fusus* for example are of the simplest type. The more complicated

types, whose adults correspond to later stages in the ontogenesis of *F. colus*, appear progressively later and later in time, while at the same time primitive species persist to some extent. A number of distinct lines of divergence or radiation have been found within the genus *Fusus*, each paralleling the *F. colus* series, so that for each member of this latter series a corresponding member can be usually found in each of the other series. Similar series have been worked out among the Eocene Clavilithoids, and a number of other Eocene and later groups. The ontogeny of hundreds of individuals has been worked out with reference to the shell structure, and these data have served as the basis for the determination of the phylogeny of the principal series among the Fusidæ.

HENRY E. CRAMPTON,
Secretary.

ANNUAL MEETING.

DECEMBER 15, 1902.

The Academy met for the annual meeting at 8:15 P. M., President Cattell in the chair.

The reports of the officers for the past year were called for and presented as follows :

The Recording Secretary stated for the Corresponding Secretary, that no correspondence had been carried on.

The report of the Recording Secretary, filed herewith, was read.

The report of the Treasurer, filed herewith, was received too late for presentation.

The accompanying reports of the Librarian and Editor were read.

No nominations for honorary members or corresponding members were presented.

The following list of candidates for Fellows, nominated by the Council according to the By-Laws, was read ; the Secretary was empowered to cast an affirmative ballot of the Academy therefor, which was done :

Edward F. Buchner,	S. A. Mitchell,
Esther F. Byrnes,	Herschel C. Parker,
R. H. Cunningham,	Frederick Peterson,
Albert W. Chester,	J. C. Pfister,
William Dutcher,	H. C. Piffard,
Harrison G. Dyar,	John D. Prince,
John Eyerman,	Michael I. Pupin,
George I. Finlay,	Ivan Sickels,
Wm. J. Gies,	M. Allen Starr,
Amadeus W. Grabau,	George T. Stevens,
John D. Irving,	C. A. Strong,
Gustav Langmann,	F. B. Sumner,
H. R. Linville,	W. Gilman Thompson,
J. E. Lough,	C. C. Trowbridge,
R. T. MacDougall,	E. R. VonNardroff,
T. Cumerford Martin,	John F. Woodhull,
Adolph Meyer,	

The election of officers for the coming year was then held. Tellers were appointed, ballots were distributed, the votes received and counted. The following officers were elected :

President, J. McKeen Cattell.

Vice-Presidents : Section of Geology and Mineralogy : James F. Kemp. Section of Biology : Bashford Dean. Section of Anthropology and Psychology : E. L. Thorndike. Section of Astronomy, Physics and Chemistry, C. L. Poor.

Corresponding Secretary, R. E. Dodge.

Recording Secretary, Henry E. Crampton.

Treasurer, C. F. Cox.

Librarian, Livingston Farrand.

Editor, C. L. Poor.

Councillors : (Three years), Franz Boas, H. C. Bumpus ; (two years), D. W. Hering, N. L. Britton ; (one year), E. B. Wilson, G. F. Kunz.

Finance Committee : John H. Caswell, John H. Hinton, C. A. Post.

Vice-President Kemp then took the chair, and President Cattell presented his annual address, entitled "The Academy of Sciences."

At the close of the address, a vote of thanks was moved by Professor Wilson, seconded by Professor Osborn, and carried. The Academy then adjourned. HENRY E. CRAMPTON,
Recording Secretary.

REPORT OF THE RECORDING SECRETARY.

The present report deals with the work of the Academy from February 24, 1902, to December 31, 1902.

During this period twenty-three meetings of Sections of the Academy were held, at which four public lectures and forty-two stated papers were presented. The subjects were distributed as follows :

Section of Astronomy, Physics and Chemistry —

Astronomy,	2 papers, 2 lectures.	—
Physics,	3 papers.	
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		5 papers, 2 lectures.

Section of Biology —

Palæontology,	2 papers.	
Zöology,	10 papers, 2 lectures.	
	<hr/>	
		12 papers, 2 lectures.

Section of Geology and Mineralogy —

Geology,	5 papers.	
Mineralogy,	4 papers.	
Physiography,	2 papers.	
	<hr/>	
		11 papers.

Section of Anthropology and Psychology —

Anthropology,	3 papers.	
Psychology,	11 papers.	
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		14 papers.

Total,	<hr/> <hr/>	42 papers, 4 lectures.
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At present there are 300 Active Members, and of these 96 are Fellows, while the election of 33 Fellows is pending. During the period under consideration four members (J. Woodbridge Davis, Dr. Benjamin Lord, Rev. E. A. Hoffman, D.D., LL.D.,

and Walter Shriver) have died. Five members have resigned, and one has been dropped; the total loss for the year is therefore ten. Eleven new members have been elected, one of them a life member, and three have been reinstated. There is therefore a net gain of four.

An important change has been made in the method of publication. Hereafter each article will be published as a separate brochure, to be distributed to those members who shall signify a desire to receive the publications. Together with the proceedings of the Academy, all articles will be published in collected form, when sufficient to make a volume of about 600 pages. By this procedure prompt publication is assured.

The past year has witnessed two events of primary importance to the Academy. In the first place, an entire formal reorganization has been effected. At the time of the last Annual Meeting (Feb. 24) a new charter had just been granted to the Academy by Act of Legislature; and by this instrument, which replaced that of 1817, greater freedom for activity and general expansion had been accorded the Academy. Pursuant to its requirements, a Committee of the Council was constituted for the purpose of drawing up a new Constitution and new By-laws; these have been prepared, accepted by the Council, and adopted by the Academy in business session. While the changes which have been made are more in the letter than in spirit, certain advantageous modifications have been introduced in matters of organization, terminology, and procedure. Among these may be mentioned the change of title of Resident Members to Active Members; the abolition of the restriction to the number of Fellows, the representation of the Sections in the Council by making their Chairmen, Vice-Presidents of the Academy, the constitution of the Editor as an officer, and the introduction of stated limitations to the terms of office of the President, Vice-Presidents and Councillors. In the By-laws, changes have been made in the mode of electing Active Members, now nominated directly to the Council, in the establishment of a class of Non-resident Members, and in the chapter relating to sectional organization.

The second event of importance is the change in the place of meeting. After several years of a somewhat roving existence, the Academy has found shelter with the American Museum of Natural History, where it is hoped it may remain for some time. The acknowledgments of the Academy are due to the Director and other officers of the Museum, for the courtesy and interest which have made this step possible.

HENRY E. CRAMPTON,
Recording Secretary.

REPORT OF THE TREASURER.

RECEIPTS.

Balance as per last Annual Report..		\$1,878.07
Annual Dues for 1896.....	\$ 10.00	
“ “ 1897.....	10.00	
“ “ 1898.....	10.00	
“ “ 1899.....	30.00	
“ “ 1900.....	50.00	
“ “ 1901.....	110.00	
“ “ 1902.....	1,965.00	
“ “ 1903.....	30.00	2,215.00
Initiation Fees		35.00
Life Membership Fee.....		100.00
Interest to June 30 on St. Ann's		5
Avenue Mortgage of \$12,000....		292.00
Sales of Publications.....		11.62
		<u>\$4,632.19</u>

DISBURSEMENTS.

Expenses of Recording Secretary...	\$ 200.25	
“ “ “ Librarian ...	166.65	
“ “ “ Treasurer...	28.97	
General Expenses	82.50	
Printing Annals.....	322.61	
Lecture.....	25.00	
Dues to Scientific Alliance.....	50.12	876.10
Balance on Hand.....		<u>\$3,756.00</u>

BALANCE SHEET.

DECEMBER 15, 1902.

DR.

Invested in Bond and Mortgage....	\$12,000.00
Cash on Hand..	3,756.09
	<u>\$15,756.09</u>

CR.

Permanent Fund	\$10,686.43
Publication Fund	1,823.69
Audubon Fund	1,897.25
Income, Permanent Fund	219.37
" Publication Fund	36.56
" Audubon Fund	36.57
General Income Account	1,056.22
	<u>\$15,756.09</u>
	<u>\$15,756.09</u>

CHARLES F. COX,
Treasurer.

REPORT OF THE LIBRARIAN.

The work of the Librarian during the past year has been concentrated upon the proper cataloguing and preservation of exchanges. This task has been chiefly in the hands of the Librarian's assistant, Mr. W. M. Erb, by whose energy the work has been kept practically up to date. As much attention as possible has also been given to the proper arrangement and care of the volumes already in the possession of the library. Efforts are being made to fill out the gaps in serial publications of value with very gratifying results.

The total number of exchanges on the Academy's list at present is 410; of these 313 are foreign and 97 from the United States and Canada.

The total number of volumes, parts of volumes and pamphlets received during the year is 2,400.

The total number on the mailing list of the Academy is 720, of which 292 are members, 410 exchanges and 8 subscribers.

The great need of the library at present is, as for some years past, an appropriation for binding, serious but unavoidable injury and loss constantly resulting from the insufficient protection afforded by the present arrangements.

Respectfully submitted,

LIVINGSTON FARRAND,
Librarian.

REPORT OF THE EDITOR.

During the last year, owing to lack of funds, no scientific papers were published by the Academy. In March, the Academy issued Part 2, Volume 14 of the Annals, containing the Record of the Meetings of the New York Academy of Sciences, January, 1901, to December, 1901, by Richard E. Dodge, Recording Secretary. This was issued as a separate (No. 5, Volume 14, pages 85 to 163) and was mailed to every member of the Academy.

There is now a good balance in the hands of the Treasurer, to the credit of the publication fund, and publication of scientific papers may be resumed.

CHARLES LANE POOR,
Editor.

PRESIDENT'S ADDRESS.

THE ACADEMY OF SCIENCES.

Twenty-three centuries ago, when the first and fairest flowers of civilization were in blossom, Plato and his friends met together in an Athenian garden to talk of the things that appeared to them to be beautiful, good and true. The garden was called "The Academy," and the word has ever since maintained the high traditions of its origin, uniting the ideas of friendly social intercourse and the search for truth. The philosophy of Plato was passed on to his disciples, so that we read of fourth and fifth academies; it was transplanted to Rome, where Cicero named his country house "The Academy," and to Alexandria, where mystical neo-platonism long resisted the dogmatic rationalism of the church.

As part of the Italian renaissance, when civilization was once more young, vigorous and beautiful, as in the Greek period, the word "academy," was revived and used to name a society of scholars. Cosimo dei Medici, the Elder, established at Florence in the fifteenth century a *Platonic Academy*, and academies of letters by the hundred flourished in Italy during the sixteenth century. In 1560 there was established at Naples by the versatile Giambattista della Porta the first academy of sciences — *Accademia Secretorum Naturæ* — to which only those were admitted who had contributed to the advancement of science or medicine. The academy at Naples was suppressed on the accusation that it practised the black arts; but soon afterwards there was established at Rome, with Galileo as one of its members, the *Accademia dei Lincei*, which was later revived and is now one of the great national academies.

The mere word "academy" is of course unimportant; societies of scholars are not always called academies, nor are all academies societies of scholars. The beginnings of associations for the advancement of knowledge are to be found in savage tribes, de-

veloping with the state of civilization, usually in the form of guilds of priests, until we reach the Greek period, whence we date our philosophy and our science. The culture of Greece was carried to Alexandria, where Ptolemy Soter, supposed to be the son of Alexander the Great, established the beginning of the *μυστήριον*, based on the four corner-stones of science and culture, the university, the academy, the library and the museum; and this institution maintained its prestige for centuries. We have here an association of scholars that surpasses anything to be found in Greece or Rome, and one indeed that approaches an ideal more nearly than any existing institution. Supported by the government, we find men of science living together and working together, a system of lectures, a library of 600,000 titles and the like. To these conditions we may attribute the work of Aristarchus, Eratosthenes, Hipparchus, Ptolemy, Archimedes, Euclid, Herophilus and others, who in many ways established the principles of science. Similar if less important centers of learning arose in Bagdad, Damascus and elsewhere; and there was a series of Arabian astronomers, physicians and mathematicians who never permitted the torch of learning to become extinct until it was merged in the dawning light of modern science.

The records of Roman history are chiefly of wars and politics; but its institutions still dominate the world. The names of Pliny, Galen and Lucretius prove that science was cultivated. It is said that there were twenty-eight public libraries in Rome in the fourth century; and the schools of the Roman Empire never became extinct. Rome was the center whence first empire and then the church spread civilization throughout Europe. The removal of the seat of empire to Byzantium, the ever-recurring invasions of the barbarians from the north and the tenets of the Christian church are supposed to have extinguished learning and culture; and the period from the decline of the Roman empire to the revival of learning in Italy is called the dark ages. But perhaps these centuries are only dark in so far as they are obscured from our sight. It may seem absurd for an amateur in history to make an assertion contrary to the com-

mon views ; but the scientific man, saturated with the doctrine of evolution, is loth to accept a spontaneous generation of culture at the period of the late Italian renaissance. Students of medieval history are indeed beginning to date back this period of awakening to the thirteenth or even to the eleventh century ; but there appears to be much evidence for a gradual extension of civilization and culture throughout Europe from the sixth to the eleventh centuries.

It is a long way from the love passages of the *Phædrus* to those of the *Vita Nuova*, from the fawn of Praxiteles to the madonna of Giotto, from the Phrygian mysteries to the order of St. Francis. The Christian church is said to have been inimical to culture and science, but to it we owe the establishment of monasteries, schools and libraries throughout Europe. It is natural that the civilizations of Athens and of Rome should have become merged in the surrounding peoples. We might as well wonder why Shakespeare did not give rise to a line of poets, as to wonder why the Athens of Pericles was not permanent. When Rome came in contact with the peoples of the north, an average resulted which was in the end an extension of civilization. The barbarians who overran Italy and sacked Rome were themselves converted to Christianity, and the traditions of culture were carried beyond the Rhine and the English Channel.

Boetius, whose birth coincided with the fall of the western empire, wrote on science as well as on philosophy. From his death, in 525, education and learning were in the hands of the church. Gregory the Great, pope from 590 to 604, encouraged primary education ; and monasteries, being at once schools, libraries and academies of learned men, were established everywhere under the early popes. Bede, born about 673, wrote on astronomy and medicine. At his school at Jarrow in Northumbria there were 600 monks in attendance besides strangers from a distance. Alcuin, born about the year that Bede died, went from the directorship of the school at York to establish the palace school for Charles the Great, making the court of the emperor more nearly an academy of sciences and letters

than has happened elsewhere in history. Alfred the Great in the following century also cultivated letters at his court, and himself wrote on scientific as well as on literary subjects. He established schools throughout his dominion, including an academy at Oxford.

The traditions attributing the University of Paris to Charles and Oxford University to Alfred are discredited; but the schools they supported and established certainly did not become extinct, but developed into the medieval universities. The curriculum of the monastic and cathedral schools may appear narrow and trivial—the well-known seven arts, the elementary trivium—grammar, rhetoric and dialectic, and the more advanced quadrivium—music, arithmetic, geometry and astronomy; but if we compare it with the curriculum of the American or English college of a few years ago we should cast no stones. Indeed, when we try to picture the state of affairs, the invasions of the Northmen and Saracens, the wars and pillages, we can but admire the spirit that maintained schools and libraries in the monasteries, the academies of sciences and arts of the time. The Roman Church, the Holy Roman Empire, civic life and independence and finally the universities were the offspring of the so-called dark ages.

The medical school of Salerno, whose beginnings are traced to the ninth century, seems to have descended directly from the Greco-Roman period. It was secular in character, extending its privileges to Jews and women. It is of interest to scientific men that the first university should have been a school of medicine, but it must be admitted that it did not contribute considerably to the advancement of science—at Alexandria the living human body was dissected, at Salerno Latin hexameters were written on the urine—nor has its imperfectly known organization the interest for us that attaches to the universities of Bologna and Paris.

The medieval university is certainly one of the most notable institutions known to history. It appears almost incredible that 10,000 students from all parts of Europe should have frequented Bologna, when traveling was as expensive, difficult and dan-

gerous as was the case in the thirteenth century. The guilds or trades unions of the students and teachers represent a kind of organization that is of peculiar interest to those of us who are concerned with the conduct of modern scientific societies. The present period is marked by combinations of labor and of capital, such as have not previously existed, but the guilds of the middle ages had a more complete organization, and the universities of scholars have no modern counterpart. It seems to me that we men of science suffer both in position and in character from the dependence to which we submit, and that we could with advantage learn from the *studium generale* of the middle ages.

The centers at Bologna and Paris developed almost simultaneously. Bologna was primarily a law school and Paris a theological school. The former was more strictly professional, and its students were mostly men of maturity, already holding positions in the church or state. The universities of students, representing different nationalities, obtained control and imposed their authority on the masters and on the city. The school at Paris was less professional in the sense that theology and philosophy were the liberal studies of the age. There was at Paris from the time of Abelard a vast number of teachers gathered together from all quarters; and the formation of a university of masters was followed in the thirteenth century by the complex organization of nations and faculties.

Migrations from Bologna established universities throughout Italy, while the influence of Paris led to the universities of Oxford and Cambridge, of Prague and of the various French cities. Science in the modern sense of the word did not play an important part in the medieval university; but Roger Bacon, born in 1214, was intimately associated with Oxford and Paris, and doubtless found encouragement as well as persecution at these universities. The promise of Bacon was not fulfilled for more than two centuries; but there was a slow growth of science at the universities. Copernicus found masters at Cracow, Bologna and Padua and was himself professor at Rome. Kepler and Galileo filled chairs at universities; they bring us to the period of the organization of academies of sciences.]

Francis Bacon in his *New Atlantis*, published in 1627, pictures Solomon's House as an ideal academy of sciences. I have already referred to the establishment of actual academies of sciences in Italy during the sixteenth century. They were originally clubs of scientific men or men interested in science who met together to discuss and perform experiments. Like the early universities the academies were at first independent of the state; but they subsequently received charters and appropriations of money. In the sixteenth and the first part of the seventeenth century academies of sciences were founded throughout Europe. The period was marked by extraordinary scientific progress which was greatly stimulated by the interchange of ideas made possible by the academies. The state of science was such that each member could understand and take interest in the work of all the others. Intellectual curiosity was widespread, catholic and naïve.

The Royal Society of London and the Academy of Sciences of Paris arose at about the same time and under similar circumstances. At Paris a club counting among its members Descartes, Gassendi and Pascal met at a private house for some thirty years, until an academy of sciences was finally organized by Colbert on the model of the Académie Française established earlier under the auspices of Richelieu. The seven original members included Huyghens, who was called to Paris. They received pensions from the king and grants for instruments. The academy was reconstituted in 1699 with fifteen active members, three each in geometry, astronomy, mechanics, anatomy and chemistry. The academy of sciences became part of the Institute of France in 1795; at which time it was divided into ten sections in each of which were six members and six associates in the provinces, the sections being: (1) mathematics, (2) mechanics, (3) astronomy, (4) experimental physics, (5) chemistry, (6) natural history and mineralogy, (7) botany, (8) anatomy, (9) medicine and surgery, and (10) agriculture. An eleventh section — geography and navigation — was added in 1803 with three members. As constituted since 1833, the Institute of France contains five academies: (1) Française, (2) In-

scriptions et belles-lettres, (3) Sciences, (4) Beaux-arts and (5) Sciences morales et politiques. The academy of sciences contains eighty members and the other academies forty. Each receives a pension. As we all know, the intellectual life of France has been centered largely at Paris and in the academies.

The Royal Society of London resulted from a club that held meetings as early as 1645; it was finally organized in 1660 and chartered in 1662. The membership was larger and less exclusive than in the case of the Paris Academy, and there has not been a division into sections. Under the existing statutes fifteen fellows are elected annually, and the membership numbers about 450. The fellows do not receive pensions as in the continental academies, but pay dues. The society, however, administers a government fund for research (£4,000 annually), and has in many ways coöperated with the government. There has been this year established a British Academy for the Promotion of Historical, Philosophical and Philological Studies.

The Accademia del Cimento, begun in Florence in 1657, and the Collegium Curiosum begun in Altorff, Franconia, in 1672, are types of the scientific clubs of the time. Somewhat later academies were established in various centers—the Berlin Academy in accordance with the plan of Leibnitz in 1700 and the St. Petersburg Academy by Peter the Great in 1724. The members receive salaries from the government; at St. Petersburg these are liberal, so that at one time eminent foreigners, such as Nicholas and Daniel Bernoulli, were attracted to St. Petersburg by membership. Similar academies were established in the capitals and other cities of the continent—at Stockholm, Copenhagen, Munich, Madrid and elsewhere. These imperial and royal academies were patronized by kings and princes and were part of the court life of the time.

The American Philosophical Society, modeled by Franklin on the Royal Society, had its beginnings at Philadelphia in 1743; and the American Academy of Arts and Sciences, modeled by Adams on the Paris Academy, was established at Boston in 1780. Both institutions were originally of national scope and still maintain this character to a certain extent. Academies

more local in character were subsequently established in different cities, the Connecticut Academy of Arts and Sciences, founded at New Haven in 1799, being the oldest of these. Our own academy of sciences was organized in 1817 as the Lyceum of Natural History in the City of New York. The National Academy of Sciences was incorporated by Congress in 1863. It was born into a world that has changed, and we may hope progressed, since the golden age of academies. The differentiation of the sciences, the dispersal of our men of science over a wide area and the general trend of democratic institutions are not favorable to the academy of the type that flourished in the seventeenth and eighteenth centuries.

The nineteenth century witnessed an extraordinary development of scientific activity throughout the world. Each science has had its great leaders who have established new fundamental principles and new lines of investigation, while the workers in the ranks are now a great army. I have had occasion during the past year to compile a biographical catalogue of the living men of science of the United States. On my preliminary list there are eight thousand who have published scientific papers, with a few exceptions, admitted because they are engaged in teaching or other scientific work of some importance. I estimate that the scientific men of the world number about 50,000, not counting those physicians, engineers and others who do not directly contribute to the advancement of science, nor those who are engaged in historical, philological and other studies, not commonly included in the natural and exact sciences.

Under these circumstances scientific organization has been compelled to adjust itself to new conditions. The two great developments have been the establishment of large national associations holding migratory meetings and of special societies for the several sciences. The German Congress of Scientific Men and Physicians was established in 1828 and the British Association for the Advancement of Science in 1831. There are similar associations in other European countries, in Australasia and in South America. Our own association was estab-

lished in 1848, being a continuation of the Association of American Geologists and Naturalists, founded in 1840.

The Linnean Society for zoölogy and botany was founded in London in 1788 and received a royal charter in 1802. The Geological Society of London was established in 1807, and the Royal Astronomical Society in 1820. These societies were offshoots from the Royal Society, and were a necessary result of the differentiation of science and the increase in the number of men of science. At the time, however, they were supposed to weaken the Royal Society, its president, Sir Joseph Banks, saying, "All these new-fangled associations will finally dismantle the Royal Society, and not leave the old lady a rag to cover her."

The scattering of scientific men in this country delayed the establishment of special societies. The American Association was divided into two sections in 1875 and into nine sections in 1882. The American Chemical Society was established in 1876, and we now have national societies for the principal sciences—mathematics, physics, chemistry, astronomy, geology, botany, morphology, ornithology, anatomy, physiology, bacteriology, pathology, psychology and anthropology.

New York city and members of our academy have done their share in establishing and supporting these societies. The Torrey Botanical Club, begun in 1870, was the first of the special societies. The Chemical Society was established in this city and has its headquarters here. The American Mathematical Society began as the New York Mathematical Society and still has its main center in New York, as has also the American Physical Society. The secretaries of the American Physiological Society and of the American Psychological Association are officers of our academy, and the secretary of the American Geological Society was formerly one of our most active members. The societies for civil, mining, mechanical and electrical engineering have their headquarters in New York city.

Apart from scientific societies this city has, during the past fifteen years, witnessed an unusual, perhaps unparalleled, development of its scientific and educational institutions. Columbia University has become one of the dozen great universities of

the world. Its new grounds and buildings, costing \$8,000,000, are but a symbol of its educational position. New York University, with its beautiful new site and buildings, has grown in equal proportion. The City College is erecting new buildings, and high schools have been established. Our libraries have been consolidated, the building for the great public library is in course of erection and numerous branch libraries have been founded. The American Museum of Natural History has more than quadrupled the value of its buildings and collections, and the Metropolitan Museum of Art has equally increased its galleries and endowment. The Botanical Garden, the Zoölogical Park and the Aquarium have arisen as by miracle. Hospitals, asylums and all kinds of public institutions have increased even more rapidly than the wealth of the city. In spite of Tammany Hall, in spite of reform administrations, our public, educational and scientific institutions have developed in a way that has perhaps never been equalled hitherto or elsewhere.

In this marvelous development there are two failures that we must all regret — one, the stationary condition of our Academy of Sciences, the other, the dispersal of our institutions over such

an area as to detract greatly from their usefulness. All the way from the Battery to the Bronx — some twenty miles as the trolley car goes — separated by almost impassable streets and overshadowed by tenements and apartment houses, our institutions may be found or at least looked for. Fifteen years ago the city had a great opportunity, but no leader being at hand it was lost. The situation of some of our scientific institutions is shown on the one chart; what might have been is shown on the other.

The city could have bought the blocks from the American Museum to the North River for about \$10,000,000. These remaining one half park, half the part of Central Park between the American and the Metropolitan Museums might have been used as a site for public buildings without decreasing the

amount of open space, while at the same time greatly increasing its value for all the purposes of a park. The plan shows what might have been done on the west side. The wasteful duplication of libraries and the rest would have been avoided, and there would have been a strengthening through coöperation for which it is not easy to find words. The site of the park and buildings would, of course, have been above the thoroughfares, and all the buildings would have been within five minutes' ride on an underground railway.

The cross arm of Central Park should have extended to the East River, and there should have been a park along the river, facing Blackwell's Island and corresponding to Riverside Park.

Hospitals and eleemosynary institutions could have been built on this arm of the park and facing it, while the various institutions for the defective classes would have been on the islands in the East River. The cross arm of Central Park would always have been near the center of population of the city, and if it had been made a center for its intellectual and higher social life a gain would have resulted which it would scarcely be possible to overestimate. Fifteen years ago this could have been done as far as the west side is concerned with little or no expense to the city; now it would cost \$30,000,000. I should gladly expend one third the yearly income of the city for the purpose; as I am helpless and harmless I suppose there is no danger that I shall be put in the institution on Ward's Island.

The atrophied condition of the New York Academy of Sciences is as lamentable as the dispersal of our scientific institutions, but fortunately it is not so irremediable. The university, the library, the museum and the academy are, as I have already said, the four corner-stones of science and culture. They should be parts of one over-institution, and should, in my opinion, be one of the chief cares and adornments of the state, being no less essential than the police or army and the courts. As the institutions of the city can not now be brought together, we must do the best we can to give the Academy the position it should have. It is immaterial whether the institution be called the New York Academy of Sciences or the Scientific Alliance of New York. We must have an institution that will coördinate the scientific work accomplished in the city. We must have a building for our meetings and other work, and should have as part of it or adjacent to it a club-house. The building should be situated near the Museum of Natural History, this being without doubt the most central position. Let us get money from millionaires if we can, but it seems to me that for the honor of the city the building should be built by the city. I see no reason why it should not be part of the American Museum. The large lecture halls could be used in common, and we should need only two or three rooms of moderate size, one seating about a hundred people, for ordinary society meetings, and others for a commit-

tee room and a room for the archives and secretariats of the different societies. The libraries and any collections there may be could with advantage be merged in those of the museum. Such rooms, if part of a wing of the museum, would cost the city perhaps \$100,000. Then we should collect one or two hundred thousand dollars for a club-house to be placed across the street.

A few words remain to be said in regard to the functions of an academy of sciences under the conditions that obtain at the beginning of the twentieth century. Libraries, laboratories and museums are no longer our charge. We are primarily guilds of scientific men. The organization of science in America toward which I believe we are moving is this: We shall have a national society for each of the sciences; these societies will be affiliated and will form the American Association for the Advancement of Science, which will hold migratory meetings. Winter meetings will be held in large centers where all the societies will come together, and summer meetings will be held at points of educational and other interest when the societies will scatter somewhat. The council of the American Association composed of delegates from all the societies will be our chief deliberative and legislative body. Our national societies will consist of local sections, and these sections will unite to form an academy of sciences. The men who are in one neighborhood and engaged in the same kind of work are the natural unit. They should unite on the one hand with those in other neighborhoods to form a national society; they should join on the other hand with the men of science of the same neighborhood to form an academy of sciences. This plan of organization may appear to be almost too logical for a world that is somewhat careless of logic, but it is in part already realized. It will in my opinion result as a necessary condition from the state of affairs. Our academy has already contributed to it, and it seems to me that we should continue to do consciously what we have hitherto done rather blindly.

We have two main external functions—our meetings and our publications. For both of these the men of science inter-

ested in the same subjects are the natural group. We need not increase the number of our sections; but should allow subsections for each of the sciences, letting those who are immediately concerned meet as they find it most advantageous. These groups should maintain their own autonomy, and we should not require the members to join the academy, least of all so long as our present dues are maintained. The academy should provide convenient places for meeting, arrange for joint meetings of several groups, provide general lectures of interest to more than one group, support a club-house, give receptions and exhibitions and the like.

In regard to publications I am somewhat heterodox. Proceedings and transactions were an important function of the academy of the eighteenth century, but there is no longer any excuse for printing researches on utterly diverse subjects in one volume, because the authors happen to be members of the same academy. We might as well make up volumes according to the cranial index of the contributors. The national society for each science should directly or indirectly have charge of the publications in that science. We need in every science: (1) A series of monographs, each of which should be published as a unit, (2) a "Centralblatt" containing abstracts of the literature with a complete bibliography, and (3) a journal for shorter articles, general discussions, critical reviews, etc. The abstracts and bibliography should be an international undertaking, each country contributing its share. What is now printed in the annals, transactions and proceedings of our academies, should be contributed to the series or journals. In the series of psychological monographs, which I am glad to say exists, should, for example, be printed any monographs that are prepared by our members, and if the academy has funds for publication, it should share the expense. These monographs can be parts of our proceedings and can be given to those members who are interested. Their existence will be known to every specialist throughout the world. They will be purchased by individuals and libraries, and will ultimately become self-supporting. It is to be hoped that the academies of the country will unite in a

plan of this character, and that our academy will initiate the movement.

When we review the whole subject of the history and present status of the academy of sciences we must, I think, come to the conclusion that the function of the modern academy is now modest. Libraries, museums, research laboratories, government departments and universities have developed in a way that leaves no excuse for the academy of sciences to attempt competition with them. The university in its modern form seems to me most suitable for the central institution, and when our universities are controlled and supported by the state and when there is only one university in a region, it seems to me that the university should administer the libraries, museums, research laboratories and the like, and that the academy of sciences will be essentially a part of the university. The national and local societies for each branch of science are the natural groups for meetings and discussion and for publication. Membership in an academy as an honor, the presidency as a distinction, foreign members, medals, prizes and the like, seem to me to belong to the childhood of science. So long as we are still in this state let us rejoice in our innocence, but what is charming in the child is intolerable in the man.

Has the academy of sciences then played its part in the world? Must it, like the mastodon and elephant, give way to organisms better suited to a changed environment? I have already indicated that I believe the academy to have important if modest functions, and have stated what I think them to be. They are essentially those of a guild. We need a center in each community for organization and social intercourse. As capitalists unite in corporations and laborers in trades unions, so men of science should unite in their academies. We should not profess unselfish philanthropy, but we may reasonably claim that whatever is accomplished to improve the condition of men of science, to increase their influence or to forward their work is of benefit to the community and for the welfare of society.

J. McKEEN CATTELL.