precisely. What the principle asserts is that this knowledge is no use in predicting what is going to happen later, for it gives no knowledge of how the electron will be diffracted on emerging from the second hole.

This must revolutionize our ideas about one of the most fundamental principles which have always been accepted in science, the principle of causality. We are accustomed to take it for granted that a *full* knowledge of the present would enable us confidently to predict the future. When we are defeated in our attempts at prophecy, we attribute it to ignorance, with the tacit assumption that with more knowledge of the present we could have done better. It never occurred to any one that the present is definitely unknowable; but we have just seen that the mere effort to know it can not help introducing new errors in the determination. It has been suggested that the new outlook will remove the well-known philosophical conflict between the doctrines of free will and determinism, and it has been welcomed by many for that reason. I would personally offer a most strenuous opposition to any such idea. The question is a philosophic one outside the region of thought of physics and I can not see that physical theory provides any new loophole. We can not say exactly what will happen to a single electron, but we can confidently estimate the probabilities. If an experiment is carried out with a thousand electrons, what was a probability for one becomes nearly a certainty; that is to say, we shall expect to have to repeat our experiment a great many times before we get a result departing far from the average. Physical theory confidently predicts that the millions of millions of electrons concerned in matter-in-bulk will behave even more regularly, and that to find a case of noticeable departure from the average we should have to wait for a period of time quite fantastically longer than the estimated age of the universe. How then does the uncertainty principle help to free us from the bonds of determinism?

SERIAL LITERATURE USED BY AMERICAN GEOLOGISTS

By Professor P. L. K. GROSS and Professor A. O. WOODFORD
POMONA COLLEGE

IN 1927, Gross and Gross[1] applied the method of statistical investigation in its simplest form to the problem of evaluation of the periodical literature of a science. They tabulated the references, to other periodicals, in a volume of the *Journal of the American Chemical Society,* and drew certain conclusions concerning the needs of college chemistry libraries. They expressed the hope that workers in other fields might make similar surveys. The interest among librarians and chemists was sufficient to show that the results were worth the labor expended. More recently, other studies have appeared, dealing with mathematics[2] and electrical engineering.[3]

A primary difficulty was encountered in sciences other than chemistry. The *Journal of the American Chemical Society* seems to be unique among scientific periodicals, in that a single volume contains more than 5,000 pages, about 700 articles, and about 5,000 citations to serial literature. It is also sufficiently well balanced in regard to the various branches of chemistry to assure a representative sample of the needs of the American chemist. In other sciences several source journals must be selected.[4]

The present investigation deals with the serial literature of geology, including mineralogy. Six American journals for 1929 were chosen, and the references tabulated. In Table I are listed these *source journals,* together with the total number of pages of the actual articles studied, the total number of citations in each journal, the number of references to books and to personal communications, and the net total, which represents the citations to serial literature. It is these last mentioned references which will be considered in further detail. The totals are probably slightly high, due to unintentional counting in single articles of repetitions of the same citation.

The net total of 3,574 references from six journals of geology (Table I) corresponds to a total of 2,165 from nine journals of mathematics, as reported by Allen,[5] and about 5,000 such references from a single volume of the *Journal of the American Chemical Society.* The contrast between chemistry and the other sciences is evident.

The count of references to books and to personal communications was made because it shows the relative importance of the various sources of information.

If one considers several source journals to be of equal importance, it is evident that there are at least three distinct methods of evaluation: first, an equal

[1] P. L. K. Gross and E. M. Gross, "College Libraries and Chemical Education," SCIENCE, 66: 385, 1927.

[2] Edward S. Allen, "Periodicals for Mathematicians," SCIENCE, 70: 592, 1929.

[3] J. K. McNeely and C. D. Crosno, "Periodicals for Electrical Engineers," SCIENCE, 72: 81, 1930.

[4] An investigation of the serial literature of physics, in progress here, suggests that the *Physical Review* is now so large and varied that it may prove adequate as a single source journal for the science.

[5] *Loc. cit.*

TABLE I

Name of source journal	Number of pages	Total number of references	References to books	Personal communications	Net total
*Am. J. Sci.**	860	898	91	33	774
Am. Mineral.	401	505	53	6	446
Bull. Am. Ass. Petroleum Geol.	959	588	36	33	519
Bull. Geol. Soc. Am.	528	916	158	11	747
Econ. Geol.	787	683	87	15	581
J. Geol.	746	594	57	30	507
Totals	4,281	4,184	482	128	3,574

* Insofar as possible the abbreviations used in this paper follow *Chemical Abstracts*, and may be found in its list of periodicals abstracted, published October 20, 1926, as Part 2, Vol. 20, No. 20. For the journals mentioned here which are not to be found in this list, the writers have chosen abbreviations the meaning of which, it is hoped, will be obvious. The usage of the *U. S. Geological Survey Bulletin* No. 746 (1922) is not followed because of the frequent use of initials, *e.g.*, *J. G.* for *Journal of Geology*. Incidentally the writers desire to protest against the common use in references of mere initials, such as *A.A.A.G.*, *A.A.A.S.*, and *A.A.P.G.* Still less satisfactory are partial or complete translations of foreign titles, such as *Proc. kön. Akad. Wettenschappen Amsterdam* or *Proc. Inter. Geol. Congress.* One common abbreviation, *Min. Mag.*, is ambiguous.

time period may be considered; second, an equal net total of references may be used; third, an equal number of pages of each source journal may be studied. After careful consideration of these three methods, the first was chosen, and complete volumes for 1929 were used with one major and two minor exceptions. These exceptions follow: (1) But eight numbers (May to December, both inclusive) of the *Bulletin of the American Association of Petroleum Geologists* were used. This was, in part, due to the fact that a single volume of this journal contains many more pages than any other source journal considered. (2) The first 1930 issue of the *Journal of Geology* was used instead of the Chamberlin memorial number of 1929, which was more nearly biographical than geological in character. (3) A few articles in the *American Journal of Science* were not included because they dealt with mathematics or pure chemistry. After the main study was completed an investigation was made (by means of weighting) of the other two methods and but few changes, all of little importance, were found. This was to be expected, as inspection of Table I will show that there are few large deviations from equal numbers of references or equal numbers of pages in the source journals as they were used.

The choice of source journals was limited to American publications in order to show the serial literature actually used by American geologists. Excepting paleontology, the various geological sciences are more or less adequately represented. Some paleontological papers are present in the source journals used, but the synonymies of taxonomic descriptions are not included. The *Journal of Paleontology* was not used as a source because its 1929 citations do not begin to cover the varied library requirements of American paleontologists.

Table II*a* shows the results of the tabulation of the citations to the twenty-two journals most frequently mentioned. The distribution of references is

TABLE II*a*

Name of journal cited	Net total citations	1925–1929	1920–1924	1915–1919	1910–1914	1905–1909	1900–1904	1832–1899	No. of libraries*
Am. J. Sci.	240	59	40	39	36	18	12	36	97
U. S. Geol. Surv. Bull.	234	26	60	40	42	38	13	15	.....
J. Geol.	207	62	41	29	25	23	20	7	.....
Bull. Geol. Soc. Am.	187	65	51	18	15	10	16	12	77
U. S. Geol. Surv. Prof. Papers	144	31	28	30	21	23	11	.....	.....
Econ. Geol.	143	64	40	21	11	7	.....	.....	.....
Bull. Am. Ass. Petroleum Geol.	142	119	20	3	.....	.....	.....	.....	44
Z. Krist.	76	17	23	6	5	4	7	14	27
Am. Mineral.	65	49	15	1	.....	.....	.....	.....	49
U. S. Geol. Surv. Water Supply Papers	51	10	4	4	10	18	4	1	.....
Science	47	17	1	3	8	15	1	2	115
Can. Geol. Surv. Mem.	46	13	8	14	10	1	.....	.....	.....
Neues Jahrb. Mineral. Geol.	46	16	5	5	5	4	4	7	39
U. S. Geol. Surv. Geol. Atlas	45	4	4	1	3	17	7	9	.....
Trans. Am. Inst. Min. Met. Eng.	41	13	6	7	4	1	3	7	56
Compt. rend.	40	3	6	11	4	3	2	11	80
Quart. J. Geol. Soc.	39	11	1	0	3	1	0	23	59
U. S. Geol. Surv. Monographs	37	0	0	2	8	1	6	20	.....
Eng. Min. J.	34	22	5	0	4	1	1	1	76
J. Wash. Acad. Sci.	33	16	6	9	2	.....	.....	.....	58
U. S. Geol. Surv. Ann. Repts.	29	.....	.....	.....	.....	.....	11	18	.....
Geol. Mag.	28	5	3	2	3	5	7	3	56

* The data in this column were obtained from the "Union List of Serials" (1,588 pages, H. W. Wilson and Company, New York, 1927), and give the number of libraries which reported current accession of the serial indicated. The "Union List" does not include government publications, and does not give exact data for some common journals. Two hundred and twenty-five general and special libraries contributed information.

by five-year periods. It appears that the leading serials hold their own whether long or short periods are considered. The large percentages of the references to the *Bulletin of the American Association of Petroleum Geologists* and to the *American Mineralogist* which fall in the last five-year period are indicative of the growing importance of these recently established journals.

The totals for the next thirty-one ranking journals are given in Table II*b*. The writers do not mean to give the impression that the dividing point between Tables II*a* and II*b* has significance. They feel, however, that the distribution into short time periods is without meaning when but few citations occur. Toward the end of Table II*b* will be found journals with so few references that their inclusion on a strict statistical basis would not be justified.

TABLE II*b*

Name of journal cited	Number of citations	Number of libraries*
N. Y. State Mus. Bull.	27	66
Z. Gletscherkunde	26	20
Geol. Fören. Förh. (Stockholm)	25	18
Univ. Calif. Pub. Bull. Dept. Geol. Sci.	25	52
Univ. Tex. Bull.	24	.....
Carnegie Inst. Pub.	23	.....
J. Am. Chem. Soc.	23	102
Centr. Mineral. Geol.	21	29
Am. Geol.	20	.....
Smithsonian Inst., Miscellaneous Collections	20	.....
Petermanns Mitt.	19	39
Z. deut. Geol. Ges.	19	29
Can. Geol. Surv. Summary Rept.	18	.....
Geogr. Rev.	18	.....
Z. prakt. Geol.	18	34
Bull. comm. géol. Finlande	17	.....
Mineral. Mag.	17	32
Ontario Bur. Mines Bull.	17	.....
Pan-American Geol.	17	38
Skrifter Norske Videnskaps-Akad. Oslo	17	22
Bull. Mus. Comp. Zool., Harvard	16	34
Geogr. J.	16	.....
Bull. soc. franc. minéral.	15	24
Geografiska Ann. (Stockholm)	15	12
Okla. Geol. Surv. Bull.	15	.....
J. Chem. Soc.	14	80
Oil and Gas J.	14	29
Proc. Nat. Acad. Sci.	14	.....
Trans. Roy. Soc. Can.	14	74
Z. anorg. Chem.	13	63
Z. Ges. Erdkunde (Berlin)	13	24

* See note to Table II*a*.

Many well-known general and geological serials are missing from Tables II*a* and II*b*. Since low standings might be peculiar to the 1929 files, citations to certain of these publications were sought in the 1927 and 1928 volumes of the source journals, with the results shown in Table III.

TABLE III

Name of journal	Citations in 1929	Citations in 1928	Citations in 1927	Number of libraries*
Bull. soc. géol. France	9	5	5	33
Bull. Seism. Soc. Am.	4	7	2	49
Bull. Geol. Inst. Univ. Upsala	5	7	7	34
Compt. rend. Congr. géol. intern.	9	1	8	.....
Geol. Zentr. (abstract journal)	8	1	1	40
Geol. Rundschau	5	1	5	21
Jahrb. preuss. geol. Landesanst.	8	1	2	9
Jahrb. geol. Bundesanst., Wien	2	1	3	20
Proc. Roy. Soc. London, (A)	6	6	5	70
Sitzb. preuss. Akad. Wiss., phys.-math. Kl.	9	5	3	33
Sitzb. Akad. Wiss., Wien	8	0	11	25
Trans. Roy. Soc. Edinburgh	5	11	7	47
Tschermaks mineral. petrog. Mitt.	11	7	5	23
Z. Vulkanologie	6	0	2	24

* See note, Table II*a*.

In no case is there a rise to the horizon of Table II*b*.

While the data for Table III were being obtained, it was noticed that most of the serials of Table II*b* were often mentioned in 1927 and 1928. The exceptions noted were the *Zeitschrift für Gletscherkunde* and the *Geografiska Annaler*. The high positions of these two journals in 1929 were due to a large number of glacial papers published in our source journals during that year.

The last column of Table III indicates that the serials of this table are nearly as common in American libraries as are the series listed in Tables II*a* and II*b*. In fact, half the journals in Table III have a wider distribution among the libraries considered than does the *Zeitschrift für Kristallographie,* the first foreign serial of Table II*a*. In this connection, it may be suggested that the importance of a given file for geologists is not directly proportional to the number of libraries possessing it. On the contrary, it may be argued that the inverse is more nearly true for journals to which there are approximately equal numbers of citations. For instance, by this test the *Geologiska Föreningens i Stockholm Förhandlingar* are more important than the *University of California Publications Bulletin of the Department of Geological Sciences,* as the position of the former was attained

in spite of relative inaccessibility to American workers (see Table II*b*).

Table IV summarizes the data concerning the frequency of references to the various serials. The 480 publications to which citations occurred were found to be distributed among thirty countries (counting British dominions and colonies) and fifteen different languages.

TABLE IV

	No. of serials	No. of references	Per cent. of references
Serials included in Table II*a*	22	1,954	54.7
Serials included in Table II*b*	31	570	15.9
Serials cited 7 to 12 times	36	303	8.5
Serials cited 4 to 6 times	52	246	6.9
Serials cited 3 times	48	144	4.0
Serials cited 2 times	66	132	3.7
Serials cited 1 time	225	225	6.3
Totals	480	3,574	100.0

In choosing source journals the writers limited themselves to national American periodicals. As one test of the selections Table V shows the effect of excluding from the citations to the source journals all self-references, that is, references to papers published in the same journal.

TABLE V

Name of source journal	Table II*a*, totals	Self-references	Other references
Am. J. Sci.	240	94	146
J. Geol.	207	70	137
Bull. Geol. Soc. Am.	187	59	128
Econ. Geol.	143	115	28
Bull. Am. Ass. Petroleum Geol.	142	118	24
Am. Mineral.	65	44	21

It will be seen from the last column of Table V that there is no change in the relative rank of the source journals. There does appear, however, a striking difference between the first three journals and the second three. Although other explanations are possible, it is believed that this is due to the unique positions of the latter in specialized fields. Such an explanation strengthens the case for including the last three serials as source journals.

Government publications have an important place in geological literature. This is evident from the data of Tables II*a* and II*b*. Fifteen per cent. of the total of 3,574 references are to the various series of the United States Geological Survey. It should prove interesting, therefore, to compare the relative importance to American geologists of their own and other governmental publications. These data are summarized in Table VI and show at once three things: first, United States and Canadian governmental reports are of prime importance; second, the small number of Canadian "Other references" suggests that the journals of the United States serve both this country and Canada; third, foreign governmental publications are but rarely used by American geologists.

TABLE VI

Country	References to governmental publications			Other references
	National	Provincial and state*	Total	
United States	607	299	906	1,504**
Canada	97	19	116	23
Gt. Britain and poss. (except Canada)	6	11	17	244
Germany and Aus.	2	17	19	448
France	1	1	2	71

* Including state universities.
** Of these, 984 are to the six source journals.

Many of the domestic references are to areal surveys, and the corresponding publications of other governments are vastly less essential to the North American worker. However, the rarity of references to foreign surveys suggested an analysis of the total number of foreign references, to determine in what portions of the field of geology American workers look abroad. To this end, the citations in individual source journals were tabulated. The differences between the sources were so striking that the writers decided to include the data for 1928 and part of 1930 (for this tabulation only), as checks upon 1929. These results are shown in Table VII.

It appears that journals which include mineralogical papers contain more foreign references than do the more strictly geological periodicals. Further analysis is difficult, and differences seem to be largely idiosyncrasies of individual authors. An example of this variability is found in the 1929 *Journal of Geology,* where all of the references to foreign books or periodicals occur in 17 of the 50 papers. However, glacial geologists seem rather consistently to use foreign data, as shown by the frequent European references in four of the seven glacial papers in this volume of the *Journal of Geology,* and also by the obviously elevating effect of a glacial symposium upon the foreign percentage for 1929 of the *Bulletin of the Geological Society of America* (Table VII).

TABLE VII

Name of source journal	Per cent. of references to serials published outside the United States and Canada			
	1928	1929	1930*	1928–1930
Am. J. Sci.	31.1	30.5	29.3	30.2
Am. Mineral.	36.0	55.6	35.8	42.7
Bull. Am. Ass. Petroleum Geol.	18.1	10.6	10.5	12.2
Bull. Geol. Soc. Am.	17.1	40.0	19.3	28.4
Econ. Geol	23.9	17.4	18.4	20.0
J. Geol.	14.8	10.9	9.9	12.0

* All 1930 issues of the source journals available here on November 24, 1930, were considered, *i.e.*, *Am. J. Sci.*, January to November; *Am. Mineral.*, Nos. 1–11; *Bull. Am. Ass. Petroleum Geol.*, Nos. 1–11; *Bull. Geol. Soc. Am.*, Nos. 1–2; *Econ. Geol.*, Nos. 1–7 and Suppl. to No. 3; *J. Geol.*, Nos. 1–7.

Finally, Table VIII presents the 1,015 foreign references (Canada again considered as domestic, as justified above) classified according to language. Danish, Norwegian and Swedish are grouped together as Scandinavian. The great relative importance of German is apparent. French suffers, perhaps, from the scarcity of paleontological references in the sources considered, but probably gains in number of titles because of the brevity of the contributions (forty in number) to the principal French periodical, *Comptes rendus*.

TABLE VIII

Language	Foreign references	
	Number	Per cent.
German	486	47.9
English	262	25.8
Scandinavian	87	8.6
French	84	8.3
All others	96	9.4
Totals	1,015	100.0

OBITUARY

MEMORIALS

THE significance of the work of John Bartram was commemorated by representatives of leading botanic and horticultural associations in this country and in England at the celebration of the two hundredth anniversary of the founding of Bartram's Garden, the first botanic garden in the American colonies. The observance was held at the Academy of Natural Sciences in Philadelphia on June 5 and 6, also at the Bartram Garden, overlooking the Schuylkill River, by the John Bartram Association, the American Philosophical Society, the Pennsylvania Horticultural Society and the Academy of Natural Sciences. Among the speakers were Dr. Rodney Howard True, professor of botany at the University of Pennsylvania, and Dr. John Hendley Barnhart, bibliographer of the New York Botanic Garden. An address by Dr. Witmer Stone, vice-president of the Academy of Natural Sciences of Philadelphia, was read in his absence.

The British Medical Journal reports that a fund is being raised to establish a permanent memorial to Dr. Hughlings Jackson. Among those who are taking action in the matter are many old friends and pupils who revered and loved Jackson, and who recognize to what an extent the preeminent position of British neurology in the medical world is due to his work and influence. He was among the great leaders of modern neurology, and it is much to be desired that the inspiration that he gave to so many in his lifetime should be kept fresh, and still serve as a stimulus to a younger generation who knew him not. It is hoped to raise an amount sufficient to provide a permanent endowment for the Hughlings Jackson Lecture, given every third year before the section of neurology of the Royal Society of Medicine. Several generous promises of support to such a fund have already been received, but the signatories of this letter feel that an opportunity to subscribe should be given to many who can only be reached through the publicity of the press, and who would certainly wish to show their appreciation of the position which Hughlings Jackson holds in the history of modern medicine. Dr. Wilfred Harris, of 56, Wimpole Street, London, W.1, has consented to act as treasurer of the fund, and subscriptions should be sent to him, marked "Hughlings Jackson Memorial Fund."

RECENT DEATHS

DR. FRANKLIN HENRY GIDDINGS, professor emeritus of sociology at Columbia University, died on June 11. He was seventy-six years old.

DR. JOSEPH H. HATHAWAY, assistant professor of anatomy at the University of Michigan, died on June 12, at the age of fifty-two years.

MISS EMILY HOWSON, professor of astronomy at Agnes Scott College, Decatur, Illinois, died on June 6th.