for the observation of the proton resonance frequency, the usual nuclear resonance technique. The primary result obtained by them was

$$g_J/g_P = -658.2181 \pm 0.0003$$

In view of the stated uncertainties and the possibility of differences in the internal diamagnetic shielding in different samples of mineral oil, the agreement is good. Because of the limited accuracy for the result $2g_L/g_P$, the value of g_S/g_L is not affected, within the range of its uncertainty, by the discrepancy in the two results.

Conclusion

It is interesting to examine the ratio of g_S/g_L obtained by the sequence of experiments just described in light of the theoretical calculations of the electron moment. The result gives unambiguous evidence that the electron moment is anomalous and that the deviation of the moment from its nominal value is about $\alpha\mu_0/2\pi$. Karplus and Kroll (*20*) have calculated to a higher order the radiative correction to the spin moment of the electron and have found for the spin g value

$$g_s = 2(1 + \alpha/2\pi - 2.973\ \alpha^2/\pi^2) = 2(1.0011454)$$

The result of the experiment is in remarkable agreement with the calculation, especially since the uncertainty in the experiment is much greater than the discrepancy between the experimental and calculated values. The agreement offers conclusive evidence of the validity of the calculation to the order α and very strong support to the validity of the calculations to the order α^2. Thus the new procedures of quantum electrodynamics—which have, perhaps, a questionable a priori validity—are demonstrated to be, in practice, valid for the interpretation of certain observed phenomena and, therefore, useful in the exploration of other aspects of the behavior of matter.

References

1. I. I. Rabi *et al., Phys. Rev.* 55, 526 (1939).
2. G. E. Uhlenbeck and S. Goudsmit, *Naturwissenschaften* 13, 953 (1925); *Nature* 117, 264 (1926).
3. H. A. Thomas, L. Driscoll, J. A. Hipple, *Phys. Rev.* 75, 902, 992 (1949); 78, 787 (1950).
4. P. Kusch, S. Millman, I. I. Rabi, *ibid.* 57, 765 (1940).
5. S. Millman and P. Kusch, *ibid.* 60, 91 (1941).
6. J. E. Nafe and E. B. Nelson, *ibid.* 73, 718 (1948).
7. G. Breit, *ibid.* 72, 984 (1947).
8. P. Kusch and H. M. Foley, *ibid.* 72, 1256 (1947); 73, 412 (1948); 74, 250 (1948).
9. T. C. Hardy and S. Millman, *ibid.* 61, 459 (1942).
10. G. E. Becker and P. Kusch, *ibid.* 73, 584 (1948).
11. A. K. Mann and P. Kusch, *ibid.* 77, 435 (1950).
12. H. Taub and P. Kusch, *ibid.* 75, 1481 (1949).
13. J. Schwinger, *ibid.* 73, 416 (1947).
14. S. H. Koenig, A. G. Prodell, P. Kusch, *ibid.* 88, 191 (1952).
15. J. H. Gardner and E. M. Purcell, *ibid.* 76, 1262 (1949).
16. A. G. Prodell and P. Kusch, *ibid.* 88, 184 (1952).
17. J. B. Wittke and R. H. Dicke, *ibid.* 96, 530 (1954).
18. P. Kusch, *ibid.* 100, 1188 (1955).
19. R. Beringer and M. A. Heald, *ibid.* 95, 1474 (1954).
20. R. Karplus and N. M. Kroll, *ibid.* 77, 536 (1950).

Airborne Radioactivity

Eizo Tajima and Tadayoshi Doke

Artificial radioactivity, in addition to the natural activity in the atmosphere, has been observed after atomic bomb tests. Other investigations in this field might be in progress, but few articles are available. Relatively thorough documents have been published by M. Eisenbud and J. H. Harley on radioactive fallout in the United States (*1, 2*). The present report describes the results of measurements of airborne radioactivity in Japan from 16 March to 4 May 1955 (*3*). We could detect not only the radon and thoron daughter products but also artificial radioactivity, including alpha emitters. The artificial radioactivity appears to have two or more components of different origins. The correlation of the daily variation with meteorological conditions is shown.

The air samplers used in this experiment were of the same type as the "coffee pot" sampler that was presented to the Japanese Science Council by the United States at the Japan–United States Radiobiological Conference that was held in the fall of 1954. A fan draws the air through a No. 41 Whatman filter paper 11 centimeters in diameter. The filter efficiency for normal dust is said to be high but it is not known for fine dust. Although a membrane filter has a higher efficiency for fine dust, it could not be used because the small air flow is not enough to cool the fan motor.

The change in flow rate of the air was checked by an anemometer because clogging of the filter paper might decrease it. The initial rate of the air flow was 27 cubic meters per hour; the rate did not change during the 24 hours of operation. On an average, the flow of the air for 24 hours of operation could be measured as 650 cubic meters with an error of less than ± 10 percent. Little difference was observed among the three samplers that were used.

The efficiency of the filter paper was checked at high humidity. A pair of samplers was made to draw the air through chimneys that were each 3 meters in length and 11.5 centimeters in diameter. One of the chimneys was furnished with a long water-filled boat and a Nichrome winding. After 4 hours' simultaneous operation of both samplers, the natural radioactivity on the filter paper was measured. About 70 milliliters of water was evaporated during the period of operation. The cleaning efficiency of the filter paper in moist air was found to be only 4 percent greater than it was for ordinary air.

The filter papers were ashed in a crucible and the beta radioactivity of the ash was measured by a conventional Geiger-Müller counter with a mica window. The counting efficiency was estimated at 16.6 percent from a 75-disintegration-per-minute substandard of Ra-E. The activity of all samples was measured once a day for about 1 month to get the decay curve. Aluminum absorption curves of some samples of special interest were also run.

For alpha measurements, a scintillation counter with adjustable sample-to-phosphor distance was used. The counting efficiency for alpha particles of 5.3 Mev

The authors are on the faculty of St. Paul's University, Ikebukuro Toshima-ku, Tokyo, Japan.

was 16.7 percent with the afore-mentioned Ra-E substandard, measured at a distance of 8 millimeters from the phosphor. The background was 2 counts per minute and remained constant. The range of alpha particles was measured by changing the distance between the phosphor and the source; it was also measured with an integral pulse discriminator.

Natural Radioactivity

After the air sampler had been operated for a few hours, natural radioactivity was detected. From the decay curve, its apparent half-life was about 40 minutes, which shows that the activity was due to radon daughter products. There were occasional slight changes in the decay curve; these were considered to be caused by a change in the concentration of the daughter products in the atmosphere (*4*).

When the sampling time was extended to more than 3 hours, the intensity of the activity reached saturation. On the basis of the saturation value and the flow rate of the sampler, the radon daughter products in the air were estimated to be of the order 10^{-13} curies per liter, assuming that they were in equilibrium (*5*). The concentration of the radon daughter products was larger at night than it was in the daytime because of temperature inversion (*6*).

After continuous operation of the air sampler for 24 hours, activity with a half-life of 10 to 12 (ThB = 10.6 hours) hours appeared in every case. The ratio of alpha- to beta-disintegration rates was about 0.5, which is compatible with the activity owing to thoron daughter products (*7*).

Artificial Radioactivity

Daily variations in intensity as well as half-life were observed for the residual activity. Figure 1 shows the daily change in intensity. The date is plotted on the abscissa and the activity at 72 hours after sampling is plotted on the ordinate. This was enough time to insure that the natural radioactivity had died out. The measurements covered the period from 16 March to 31 May; many maxima were observed during this time. The error of the measurement was at most 20 percent except in a few cases that had a larger error because of instrument trouble. These cases are represented by hatched marks in Fig. 1. On 31 March, a simultaneous sampling was made at Ichikawa, which is 20 kilometers from Tokyo, and the result was within the experimental error of the sampling at our university. Almost all the samples followed almost the same decay curve of a long half-life (about 25 days); the few exceptions were cases in which appreciable decrease in activity has not yet been observed.

This activity may be attributed to artificial radioactivity and not to naturally existing isotopes in the soil that might be concentrated on the filter paper. There are no natural radioisotopes whose half-life would fit the decay curve and which have the high specific beta activity that was found in the samples. Therefore, the nondecaying activity could be considered as aged fission products, and the decaying activity (25 days) could be considered as fresh fission products or a mixture of the two.

The aluminum absorption curve of the beta activity of 12 April measured 1 week after sampling gave three components whose half-thicknesses were 2, 43, and 112 milligram per square centimeter of aluminum, while the analysis of the sample of 3 April at 5 weeks after sampling gave two components of half-thicknesses 7 and 140 milligrams per square centimeter of aluminum. All the samples seem to belong to one of these two types, as shown in Table 1. The three component samples of the 12 April measure-

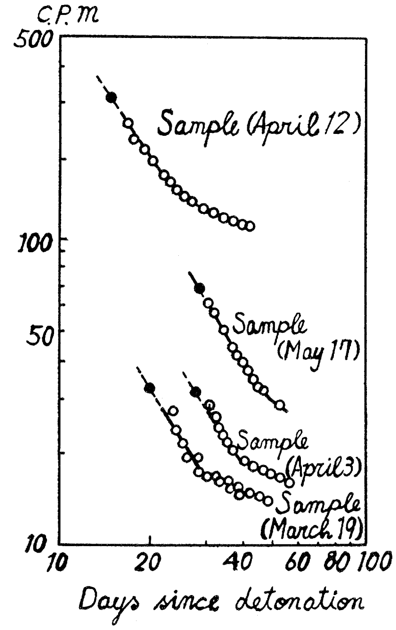

Fig. 2. Log-log plots of the radioactivities.

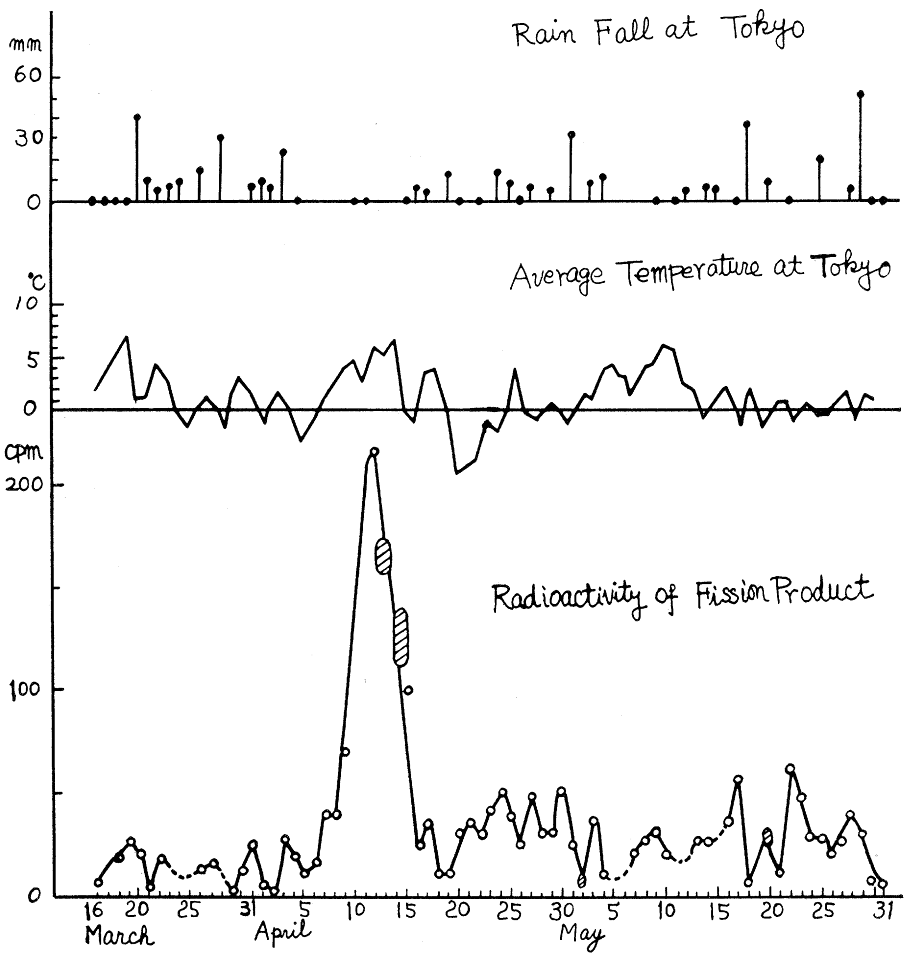

Fig. 1. Daily changes of radioactivity of fission products, average temperature, and rainfall at Tokyo.

ment were of shorter half-life than the two component samples of the 3 April measurement.

Let us assume the intensity of the activity follows the well-known relationship

$$I = At^{-1.3 \sim -1.4},$$

where I is the intensity, A is the constant, and t is the time that has passed since nuclear fission took place (*8*). The date of the detonation can be determined by plotting the points on a log-log graph, taking an appropriate t so that a straight line of slope $^{-1.3} \sim {}^{-1.4}$ may be drawn. However, in every case in the present experiment, the latter points deviated from a straight line as shown in Fig. 2 if the earlier points were aligned. This would imply that the gross activity is composed of two, or more than two, components of different origins. The date determined thus is the earliest possible date of the latest detonation, and the dates of detonations are tabulated in Table 1 with this meaning.

Alpha activity was measured on 2 May 1955 by the scintillation counter and is shown in Table 1. There is very little possibility that the alpha activity should be attributed to radon or thoron daughter products or to natural uranium from the soil that might have been collected on the filter paper. Daughter products are excluded because the measurement was made as long as a month after the sampling, and uranium is excluded by the fact that the uranium concentration in the soil would have to be from 0.01 to 0.1 percent. This was verified by a measurement that showed no alpha activity in 40 milligrams of soil, which was twice as much as the average ash content of our samples.

Table 1. Results of the measurement of airborne radioactivity.

Date of sampling (1955)	Beta activity (count/min)	Alpha activity on 2 May (count/30 min)	Energy of beta rays		Estimated date of detonation (1955)
			Date	Half-thickness (mg/cm²)	
19 March	27	22			1 March
20 March	23				1 March
31 March	23	54	2 April	7, 160	Before 1 January
3 April	28	56	7 May	7, 140	7 March
5 April	10	21			
8 April	40				12 and 29 March
12 April	220	126	19 April	2, 34, 112	29 March
13 April	50	76	8 May	2, 29, 150	29 March
14 April	130	54	8 May	2, 30, ?	
15 April	100		9 May	10, 120	Before 1 January
19 April	10	0			
24 April	50	54	23 May	7, 150	7 March
17 May	55	0	29 June	12, 200	15 April
22 May	60	0	28 June	12, 200	25 April

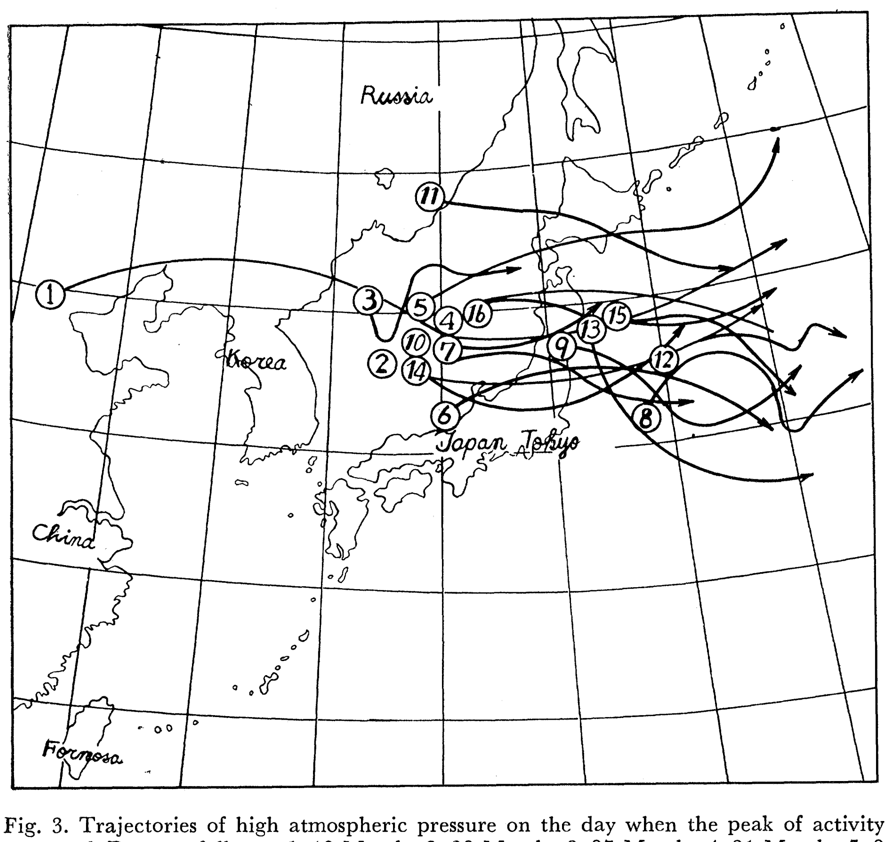

Fig. 3. Trajectories of high atmospheric pressure on the day when the peak of activity appeared. Dates as follows: *1,* 19 March; *2,* 22 March; *3,* 27 March; *4,* 31 March; *5,* 2 April; *6,* 12 April; *7,* 21 April; *8,* 24 April; *9,* 27 April; *10,* 30 April; *11,* 3 May; *12,* 9 May; *13,* 17 May; *14,* 20 May; *15,* 22 May; *16,* 28 May.

Discussion

Although it was difficult to determine the cleaning efficiency of the Whatman No. 41 filter paper for radioactive dust, it seemed reasonable to assume that the efficiency is, on the average, 40 percent for normal dust and 10 percent for the small dust (*5*). Then the concentration of the radioactive dust of the fission products in the air could be calculated as $3 \times 10^{-15} \sim 1.2 \times 10^{-14}$ curies per liter on 12 April; this is comparable to the concentration of natural radioactivity of the atmosphere (*1*).

As mentioned in a previous paragraph, two kinds of aluminum absorption curves and two kinds of decay curves were observed. They have a tendency to correspond—that is, the beta activity that showed three components by absorption tended to decay faster than samples that showed two components. Moreover, when transition of the apparent half-life from the shorter to the longer period took place, a transition in the beta-ray energies could also be observed, although there was some uncertainty in this observation. This is one argument that the activity might have two or more components of different origins.

There were many cases in which the detonations could be considered to have taken place about 10 days before sampling. These detonations might have been the series of tests in Nevada that started on 18 February and ended 15

May 1955. It is possible for the activity to travel from Nevada across the Atlantic Ocean to Tokyo in about 10 days if the dust is carried by the jet stream with a speed of about 55 to 70 kilometers per hour.

The meteorological phenomena that might have a correlation with the daily change of the activity of the fission products are shown in Fig. 1 and Fig. 3. Although the reason is not clear, the average temperature seems to show a good correlation during April, but not in May. Rainfall might be expected to clean up the radioactive dust in the air; however, it shows only a slight correlation, which implies that rainfall does not completely clean up the contaminated air. The location of high pressure areas shows better correlation insofar as our present observation is concerned. Figure 3 shows the trajectories of high atmospheric pressure centers during the period studied. When the activity shows a maximum on the curve in Fig. 1, the trajectories passed through the neighborhood of Japan. On the other hand, when the activity was at a minimum, the trajectories diverged away from Japan without exception. The radioactive dust might have been carried by the jet stream 7 to 10 kilometers above the ground, and the dust might have fallen to the ground along the trajectories of high atmospheric pressure.

References and Notes

1. M. Eisenbud and J. H. Harley, *Science* 117, 141 (1953).
2. ———, *ibid.* 121, 677 (1955).
3. We wish to express our thanks to J. Nemoto and N. Arizumi for many helpful discussions. We also wish to acknowledge the extensive aid of M. Tsukuda and A. Sasaki.
4. E. C. Tsivoglou, H. E. Ayer, D. A. Holaday, *Nucleonics* 11, No. 9, 40 (1953).
5. J. H. Harley, *ibid.* 11, No. 7, 12 (1953).
6. M. H. Wilkening, *ibid.* 10, No. 6, 36 (1952).
7. J. Fresco, E. Jetter, J. H. Harley, *ibid.* 10, No. 3, 60 (1952).
8. F. Yamasaki and H. Kakehi, *Kagaku* 24, 295 (1954); K. Kimura *et al.*, *Bunsekikagaku* 3, 335 (1954).

W. L. Bryan, Scientist, Philosopher, Educator

On 8 July 1892, Clark University was the scene of an important scientific event. On that date the American Psychological Association was founded. Of the 31 original members of this new organization, not all were professional psychologists; among them were several psychiatrists and a number of philosophers. Even those who could technically be called psychologists were not far removed from theological, philosophic, and academic-administration interests.

Yet this organization signalizes for American psychology the establishment and growth of the laboratory tradition. This institutionalizing of experimental study has proved to be a powerful factor in the evolution of psychology toward a high peak of proficiency and performance within the great family of sciences. Since the scientific enterprise is above all a persistent search for the nature of things, it may well be, and often is, carried out under widely different auspices. An organization, therefore, that fostered an accumulation of facts and techniques could not fail to produce a beneficial impact upon science in general.

William Lowe Bryan was an effective participant both in the establishment of the American Psychological Association and in the direct development of scientific psychology. He was a charter member of this association and in 1903 was its president. But this is only a symbol of his psychological interests. His more intimate concern for psychology is to be found in his unique *curriculum vitae*.

When psychology was first being developed as a science in Germany, Dr. Bryan was among the early American students to study there. Later he became a pioneer in the experimental investigation of the development of voluntary motor ability and the learning processes that are involved in attaining skill in telegraphic transmission and reception. In connection with his researches on telegraphic language he worked out some of the earliest learning curves, which still find a large place in textbook literature. Dr. Bryan's investigations became a model for a number of human-learning experiments. Even after retiring, at an advanced age, from his prolonged and successful administrative duties, he resumed work on the psychology of learning a life occupation and published a monograph on this subject as recently as 1941.

In addition to his own studies, Dr. Bryan, throughout his long life, actively supported psychology, as well as other scientific work. As founder of the psychological laboratory at Indiana University, as head of the philosophy and psychology department, and later as president of Indiana University, he constantly demonstrated his eagerness to promote psychological research, both morally and financially.

Dr. Bryan, however, was by no means narrow in his interests. For example, he never relinquished his study of philosophy and published several volumes on Plato in collaboration with his wife, Charlotte Lowe Bryan. He also found time to add the promotion of education on a national scope to his program of university, local community, and state activities. For many years he acted as a trustee of the Carnegie Foundation for the Advancement of Teaching.

As an administrator, Dr. Bryan was a living refutation of the frequently made statement that to become an administrator is to withdraw personally from science and scholarship. What he was unable himself to perform he compensated for by making it possible for his colleagues to achieve. He accomplished this, not only by personal encouragement and monetary aid, but by defending scientists and scholars from the attacks launched by vociferous bigots who presumed to dictate that their form of orthodoxy should be taught in institutions of higher learning.

If the esteem a man commands in his community is any measure of greatness, Dr. Bryan achieved that distinction. By his gentle and frank manner, by his loyalty to his principles, his duties and his vocation, and by his valued public orations, William Lowe Bryan endeared himself deeply to many people. His death at the age of 95 is felt as a personal loss by a host of friends and admirers.

J. R. Kantor

Department of Psychology, Indiana University, Bloomington