governing diffusion of molecules out of a solid into a stirred liquid, March and Weaver (*4*) demonstrated that such curves occur in simple nonorganic physical systems as well as in biological systems. Danckwerts (*5*) similarly demonstrated, on the basis of classical diffusion theory, that diffusion can be described in terms of a series of exponential functions regardless of the shape of the particle from which the diffusion occurs.

The workers cited previously (*1*) have presumed that the first, rapid portion of the curve is related to diffusion from extracellular spaces, while the later, slower part is related to diffusion from intracellular spaces. No such relationship can be inferred from Fig. 1, for only 10 percent of the sodium was present in the rapidly emitted component. The assumption that this sodium is extracellular requires the untenable conclusion that 90 percent of brain sodium is intracellular. (The hypertonicity of the sucrose solution used was not of basic importance because similar percentages of rapidly diffusible sodium were observed with isotonic Ringer's solution as the immersion medium).

Moreover, the percentage of sodium in the rapid component varies with the surface-to-volume ratio, as shown in Table 1, which presents the data from diffusion curves similar to those of Fig. 1; however, the curves were determined with tissue pieces of different surface-to-volume ratios. The percentage diffusing rapidly was found to be directly proportional to surface area. The calculated ratios between surface area and rapid sodium loss (column three of Table 1) were identical within the limits of experimental error; this is further evidence that the rapid fraction of diffusion is directly related to surface area.

Attention is drawn to two physical factors other than intracellular-extracellular tissue compartmentation that may be of

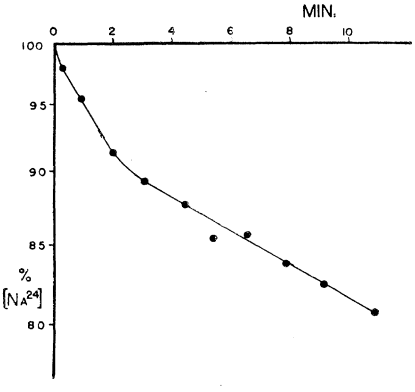

Fig. 1. Semilogarithmic plot of concentration of radiosodium remaining in pieces of hamster brain after various times of diffusion. Medium, 50-percent sucrose in water; average weight of pieces, 230 mg. Each point is the average of 10 to 15 experimental determinations.

Table 1. Effect of surface-to-volume ratio on rapid phase of sodium diffusion in hamster brain.

Approximate surface-to-volume ratio (mm^2/mm^3)	Rapid sodium (%)	Ratio
0.97	8	0.121
1.04	10	0.104
1.83	16	0.114

greater importance in determining the double exponential form of these diffusion curves. First, as mentioned previously, the general physical laws of diffusion out of solid particles give curves similar to those in Fig. 1. Second, microscopically demonstrable shredding and fracturing of the surface of the tissue incident to excision and handling probably increase the effective diffusion area and therefore cause an initially accelerated rate. This suggestion receives additional support from the observation of macroscopic changes in color and fragility of the superficial fraction of a millimeter of tissue. By either mechanism, the slope of the later, slower part of the curve depends upon the rate of diffusion through tissue in the depths of the block. These considerations will be examined in detail in a later publication.

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References and Notes

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2. This work was supported by the Cox Fund for Medical Research and the Lucie Stern Fund for Research in Epilepsy. We thank I. S. Edelman for his interest and helpful comments. This paper is from a thesis submitted by B. Garoutte in partial fulfillment of the requirements for the Ph.D. degree, University of California.
3. Radioactive sodium (Na^{24}) for this study was made available through the kindness of Kenneth G. Scott and Ernest L. Dobson.

4. H. W. March and W. Weaver, *Phys. Rev.* 31, 1072 (1928).
5. P. V. Danckwerts, *Trans. Faraday Soc.* 47, 1014 (1951).

20 April 1955

Reference Samples of Isotopic Abundance

At the request of the U.S. Geological Survey, the National Bureau of Standards has undertaken a program for the preparation and distribution of reference samples of isotopic abundance in forms suitable for mass spectrometric analysis. The National Bureau of Standards will serve as a clearinghouse for data on the isotopic abundance ratios as measured by cooperating laboratories and will distribute the accumulated data with each sample requested.

Laboratories throughout the world are engaged in mass spectrometer research on variations in natural isotopic abundance using a variety of techniques. Different laboratories are equipped to measure mass spectra of gases, of compounds evaporated from a furnace, and of ions emitted by a hot filament. Different compounds of the element are required for these different techniques. Table 1 lists reference samples that are now available for distribution or will soon be available. The gaseous samples are

Table 1. Reference samples of isotopic abundance.

Element	Compound	Source
H	H_2O	Steam condensate from Potomac River Water
	H_2	From H_2O
D	D_2O	Commercial – 99.8 atom percent D
	D_2	From D_2O
He		Atmosphere (commercial)
Ne		Atmosphere (commercial)
A		Atmosphere (commercial)
Kr		Atmosphere (commercial)
Xe		Atmosphere (commercial)
Li	Spodumene	King's Mountain, N.C.
	Li_2CO_3	Commercial
K	K_2CO_3	Commercial
Rb	Rb_2CO_3	Commercial
Sr	$SrCO_3$	Commercial
Mg	$Mg(OH)_2$	Commercial
Cl	NaCl	Marine (commercial)
Br	NaBr	Marine (commercial)
S	Mineral	Wharton County, Tex.
	SO_2*	Mineral and air
O	O_2*	Air
N	N_2*	From air
Pb	Galena	Ivigtut, Greenland
	PbI_2	From galena
	$Pb(CH_3)_4$*	From galena
Ag	$AgNO_3$	Commercial
Cd	CdI_2	Commercial
Hg†	Element	National Physical Laboratory
B	BF_3	Commercial
Si	SiF_4	Commercial
Ca, C, O	Limestone	Solenhofen, Bavaria

* Will be available in the near future.
† A small sample that was carefully measured by several mass spectrometer laboratories.

equivalent to about 3 ml at 1 atm sealed in break-seal containers. Solid samples are about 0.1 g sealed in vacuum in Pyrex tubes. Liquids are in break-seal tubes.

There is an immediate need to accumulate data on these samples, and laboratories wishing to receive samples and measure them should write to the address given here. These laboratories will be kept informed concerning data obtained by others.

The program, which was initiated with the support of the U.S. Atomic Energy Commission, will continue with preparation of other compounds useful as reference samples and with research on compounds best adapted to isotope abundance measurements.

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24 June 1955

Deuteron Bombardment of Oriented Tobacco Mosaic Virus Preparations

Ionizing radiation has been used to study virus size and structure by a series of workers (*1*). The basis of the method of study is the use of energetic local ionizations, distributed in a physically known way, to interfere with virus properties. The method is inferential and relies heavily on the belief that a sensitive region exists and that the volume, area, and thickness of the region can be found by using different kinds of irradiation. This sensitive region is then tentatively identified with some property of the virus.

In the case of tobacco mosaic virus, when the property studied is that of ability to form local lesions on *Nicotiana glutinosa*, the results of radiation studies using deuterons of varying speeds, alpha particles, and fast electrons indicate that the sensitive volume is long and thin, of length 3000 A and diameter 100 A (*2*). This region can be identified with a more sensitive region inside the virus particle proper, but of the entire length of the particle.

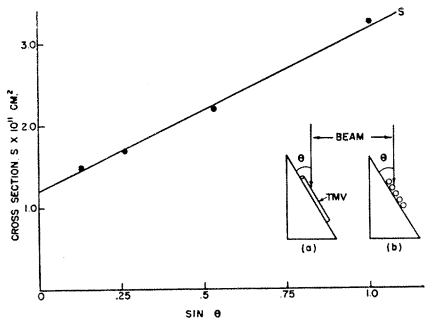

Fig. 1. Plot of the effective sensitive area S against the sine of the angle of exposure of dry tobacco mosaic virus preparations to deuterons. Inset *a*, rods pointed toward the deuteron beam; inset *b*, rods oriented across the beam.

Since it is possible to obtain oriented preparations of tobacco mosaic virus by drying concentrated preparations and gently rocking them back and forth while they are drying, it should be possible to check whether the sensitive region as observed in ionization studies also shows the effect of orientation. If it does not, then any agreement between radiation observations and the actual virus particle is the result of some combination of numerical description with questionable significance; and if it does, it constitutes a valuable confirmation of the validity of the radiation method as a means of studying the size and shape of biological units.

A series of dry tobacco mosaic virus preparations, oriented while drying and checked for orientation by observation of birefringence with polaroids, were bombarded by deuterons of 4-Mev energy (*3*). The preparations were held at angles of 90°, 30°, 15° and 7.5° to the direction of the beam in such a way that the rods were pointed at the deuterons, as shown in Fig. 1, inset *a*. A similar set of preparations served as controls, and the ratio of the amount of activity of each preparation to that of the controls was estimated by counting local lesions by standard techniques. The activity ratio n/n_0 obeys the relationship

$$\ln n/n_0 = -SD$$

in which D is the number of deuterons per square centimeter incident on the preparation, and S is the effective sensitive area. It was found that S varied with the angle of exposure. In Fig. 1 the value of S is plotted against the sine of the angle. It can be seen that a roughly linear relationship holds, so that

$$S = (1.2 + 2.0 \sin \theta) \times 10^{-11} \text{ cm}^2$$

This relationship agrees with the idea of a long and thin sensitive region, which has a maximum cross section when it is lying across the beam direction and a minimum cross section when the deuterons are passing along the long axis.

In order to determine that the observed effect was not caused by beam inhomogeneity, series of preparations oriented across the beam, as shown in Fig. 1, inset *b*, were bombarded at different angles. Here the only effect is to rotate the virus about its long axis without changing its orientation. No effect was observed: a constant value equal to the maximum cross section was found. This, incidentally, shows that no great asymmetry of sensitive material inside the virus can exist.

The afore-mentioned relationship should not be used literally in attempting to determine the size and shape of the sensitive volume of tobacco mosaic virus because it ignores the special properties of ionizing radiation. Thus a densely ionizing particle that misses an end-on virus particle may still produce spurs long enough to cause inactivation from a fair distance. The data are not in disagreement with a sensitive region of length equal to that of the virus particle, 3000 A, and of diameter 100 A. The latter value is less than the accepted width of 160 A.

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References and Notes

1. For reviews see P. Bonet-Maury, "The irradiation of viruses" in *Les ultravirus des maladies humaines* (Maloine, Paris, 1948), and E. C. Pollard, *Advances in Virus Research* 2, 1954.
2. E. Pollard and A. E. Dimond, *Phytopathology*, in press.
3. This work was aided by a grant from the John A. Hartford Foundation.

18 April 1955

Science seems to me to teach in the highest and strongest manner the great truth which is embodied in the Christian conception of entire surrender to the will of God. Sit down before fact as a little child, be prepared to give up every pre-conceived notion, follow humbly wherever and to whatsoever abysses Nature leads, or you shall learn nothing. I have only begun to learn content and peace of mind since I have resolved, at all risks, to do this.—HUXLEY.