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.

FRED L. MOHLER
Mass Spectrometry Section, National Bureau of Standards, Washington, D.C.

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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.

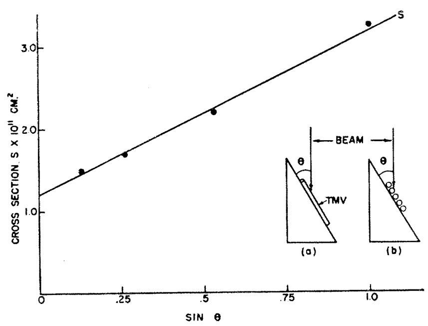

Fig. 1. Plot of the effective sensitive area S against the sine of the angle of exposure of dry tobacco mosaic virus preparations to deuterons. Inset *a,* rods pointed toward the deuteron beam; inset *b,* rods oriented across the beam.

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.

ERNEST POLLARD
G. F. WHITMORE
Biophysics Department, Yale University, New Haven, Connecticut

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.

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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.