THE SIZE OF THE TOBACCO MOSAIC PARTICLE FROM X-RAY DETERMINATIONS*

By JOHN W. GOWEN

DEPARTMENT OF GENETICS, IOWA STATE COLLEGE

Communicated December 7, 1939

The size of the tobacco mosaic particle has been determined by two techniques, filtration through pores of calculated dimensions and rate of fall in a field of known force. These size determinations lead to quite different results, the filtration size being larger than that estimated from the ultra centrifuge. Both methods are subject to technical difficulties and mathematical assumptions which, if not fully met, may lead to erroneous conclusions. But there are, as critical thinkers point out, even greater intrinsic difficulties with these techniques. If the ultimate virus particle is a rather small molecule which is adsorbed to a larger inert complex, both techniques will err on the side of assigning too large a size to the disease-producing particle. A quite different technique is needed to substantiate the estimated size measurement. This technique may be available in x-ray studies of the virus.

X-rays, like light, mark out the size of an object as the blacked-out area in which they are absorbed. In visible light this area is delimited on an optical micrometer. With x-rays the area may be found from the inactivation produced in the absorbing medium. The x-ray size estimate, in contradistinction to estimates based on filtration or ultra-centrifuging, is dependent on the size of the ultimate entity inactivated, not on any inert material to which it may be adsorbed. If the virus particle of tobacco mosaic is minute the rate of inactivation should be very moderate. If larger the inactivation rate should be more rapid. These rates are independent of any materials to which the virus particle might be adsorbed. The difference in rates would be present whether the true virus was free to move or fixed to inert matter.

Ordinary tobacco mosaic and several of its derivatives have been irradiated with x-rays from three metals, chromium, copper and silver. The effective wave-lengths from these tubes were 2.1, 1.5 and 0.7 Angströms.

Figure 1 shows certain of the survival curves obtained by treating tobacco mosaic and its derivatives with x-rays.

The inactivation rates of ordinary mosaic and the derivatives are essentially alike. They are concordant in showing a wave-length effect. The type of effect exhibited is explicable on the hypothesis that one absorption of x-ray energy within that portion of the particle is sufficient to inactivate it. The average size of this vital volume of the mosaic particle determined from these different wave-lengths is 7.5×10^{-18} cm.[3] The data on organic crystals show that the interatomic distances between atoms vary between 1 and 3*A* with 2*A* as a fair average. With an atomic spacing of 2*A* this volume, which in our material has to do with reproduction, is equivalent to about 940,000 atoms. Seemingly highly purified materials, carrying the properties of tobacco mosaic are made up by percentage composition of 51.0 C, 7.1 H, 16.7 N, 0.5 S, 0.5 P and 2.5 carbohydrates.[1] The average atomic weight of this material is 16, or it corresponds rather well with that of most proteins. Multiplying the atomic volume of the portion having to do with reproduction by this value gives 15,000,000 as the molecular weight of this volume.

The estimated minimum molecular weight of the whole molecule by Svedberg[2] from ultra-centrifugal analysis is 17,000,000. The reproductive

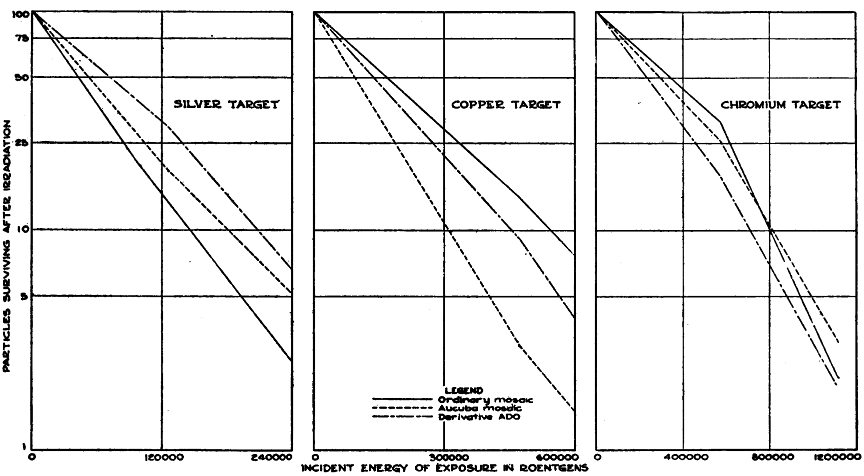

FIGURE 1

Survival curves of 3 tobacco mosaic viruses when exposed to roentgen rays of 3 wave lengths.

volume as determined above is less than this total volume but not very much less, a result which seems reasonable in view of the importance of reproduction in the organized world. The span between 15 and 17 million is left for atomic rearrangements which are not lethal to the organism. This span is known to be partly filled in as the mosaic diseases may mutate to other forms which retain the original reproductive capacity. We should expect this rate of mutation under x-rays to be quite small, an expectation which checks with our experience. Other approaches to the problem indicate that the virus entity is in the nature of a repeat molecule and may have a molecular weight of 40 to 100 million, a conclusion which gives added significance to the relative strengths of the bonds between the different molecular elements.

The data from our x-ray experiments are in agreement in viewing the tobacco mosaic virus as a rather large molecule of 16 to 20 million in molecular weight. The large portion of this molecule is important to its reproduction leaving a smaller portion capable of change without effecting this power to reproduce.

* Journal Paper No. J709 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 573. I am deeply indebted to the Fuller Fund and the International Cancer Research Foundation for coöperating in these researches.

[1] F. C. Bawden, N. W. Pirie, J. D. Bernal and I. Fankuchen, "Liquid Crystalline Substances from Virus Infected Plants," *Nature*, **138**, 1051–1052 (1936).

[2] T. Svedberg and I. Erickson-Quensel, "Sedimentation and Electrophoresis of the Tobacco Mosaic Virus Protein," *Jour. Amer. Chem. Soc.*, **58**, 1863–1867 (1936).

"PERSONALITY" DIFFERENCES AS DESCRIBED BY INVARIANT PROPERTIES OF INDIVIDUALS IN INTERACTION

By Eliot D. Chapple

Department of Anthropology, Harvard University

Communicated December 13, 1939

For many years, workers in social and psychological subjects have been concerned with the problem of "personality." This term is taken to mean a particular organization of behavioral elements, characteristic of the individual, which are supposed to be the product of the action of heredity and environment. Unfortunately, the discussion has been based almost entirely upon subjective impressions, and hence not only are we unable to define the properties of this entity in a precise and quantitative fashion, but also we cannot do more than hazard guesses as to the forces producing it. Attempts to define "personality" have either been in terms of a qualitative isolation of traits regarded as constituents of this entity,[1] or else they have been devoted, again qualitatively, to the task of describing and classifying individuals into "types."[2] From our own experience, we recognize that individuals differ from one another in what we call their "character" and "temperament," and we feel intuitively that this is of importance in determining how they get on with other individuals; but up to the present time, no quantitative definition has been attempted.

In a previous communication,[3] some preliminary results of the measurement of human interaction were presented, and it was there indicated that there are definite uniformities in the interaction of individuals. The facts described, however, were obtained by the use of a very crude measuring device which did not adequately describe the phenomena (durations of actions and inactions with two individuals). The present paper is a