late spheroid will have on its diffusion constant. Substituting our value of 1/36.8 for b/a in Equation 2, and solving for D/D_0 we obtain the ratio of .34. If we assume a spherical particle of weight 17,000,000 and a density of 1.55′, we obtain for the ideal diffusion constant, D_0, the value of 1.33×10^{-7}. The diffusion constant of the virus, then, will have the calculated value of 4.5×10^{-8}.

This value of 4.5×10^{-8} for the diffusion constant of the virus protein is in fair agreement with the value of 3×10^{-8} obtained using a sample of the virus protein in a .1 M phosphate buffer at pH 6.8, which was kindly placed at the disposal of Hans Neurath by Dr. W. M. Stanley.[5] In view of our neglect of the hydration factor in the calculation of the ratio a/b, the close agreement between the observed and calculated diffusion constants does indicate that the protein is relatively hydrophobic.

Inasmuch as the equations used in our calculations were derived on the assumption of rigid and essentially isolated particles, the values we have obtained are at best approximations. It is doubtful that we may regard the particles as isolated, inasmuch as the length of the particles is of the order of the inter-particle distances. In addition, it is not to be presumed that the particles are rigid. And finally, the assumption of a prolate spheroid for the shape of the virus protein particles was for the sake of convenience in calculation.

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THE MOLECULAR WEIGHT AND SHAPE OF TOBACCO MOSAIC VIRUS PROTEIN

SEDIMENTATION studies have been made by Eriksson-Quensel and Svedberg[1] and by Wykoff[2] on the tobacco mosaic virus protein isolated by Stanley.[3] In order to calculate the molecular weight from these studies, it is necessary to know the dissymmetry factor of the protein. This is usually obtained from sedimentation equilibrium measurements, but, because of the extremely high molecular weight of this protein, it was not found possible to obtain satisfactory results by this method. Since the tobacco mosaic virus protein is known to have highly asymmetrical rod-shaped particles in aqueous solution,[4] it seems probable that the molecular weight of 17×10^6, ascribed to the material on the assumption that its dissymmetry factor is 1.3, is too low.

It is possible to obtain an idea of the dissymmetry of rod-shaped particles from studies of the viscosity of solutions or suspensions of these particles. Kuhn[5] has derived the following equation relating viscosity of a suspension or solution of rod-shaped particles to the relative volume and the relative dimensions of the particles of the disperse phase:

$$\frac{\eta}{\eta_0} = 1 + 2.5\,G + \frac{G}{16}\left(\frac{b}{a}\right)^2$$

G is the volume of the dispersed material per cc of solution, $\frac{\eta}{\eta_0}$ is the relative viscosity of the solution, and $\frac{b}{a}$ is the ratio of length to diameter of cylindrical rods of the disperse phase. The specific volume of the protein was taken to be 0.73 cc/gm.[6] Viscosities were determined using a high precision quartz viscometer[7] on very dilute aqueous solutions of tobacco mosaic virus protein isolated by ultracentrifugation repeated 4 and 5 times, without any chemical treatment whatever. The data are given in Table I. The viscosity

TABLE I

RELATIVE VISCOSITIES OF AQUEOUS SOLUTIONS OF TOBACCO MOSAIC VIRUS PROTEIN AT 25° C.

$\frac{\eta}{\eta_0}$	grams protein / 100 cc
1.0059	0.0099
1.0165	0.0296
1.0272	0.0458
1.0278	0.0494
1.0542	0.0920
1.0566	0.0988
1.6009	0.920

is a linear function of concentration up to a concentration of 0.1 per cent., but the linearity does not hold for concentrations as great as 1 per cent. The value of $\frac{b}{a}$ calculated from the limiting slope of the viscosity-concentration curve, using Kuhn's equation and assuming little or no hydration, is 35.0.

Perrin[8] has derived the following expression relating the ratio of minor to major axes of an elongated ellipsoid of revolution to the dissymmetry constant of a particle:

[5] The value of $3. \times 10^{-8}$ is the result of a preliminary study of the virus protein using the refractory method of Lamm (*Z. Phys. Chem.*, A 138: 313, 1928). Detailed studies on diffusion will be presented in a subsequent publication.

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[7] The author wishes to express his gratitude to Drs. D. A. MacInnes and L. G. Longsworth for the use of the quartz viscometer and the facilities of their laboratory.

[8] F. Perrin, *Jour. Phys. et Rad.*, 7: 1, 1936.

$$\frac{f_o}{f} = \frac{\rho^{2/3}}{\sqrt{1-\rho^2}} \log_e \frac{1+\sqrt{1-\rho^2}}{\rho}$$

where $\frac{f_o}{f}$ is the reciprocal of the dissymmetry constant and ρ corresponds to $\frac{a}{b}$ of Kuhn's equation. Substituting the value 1/35 for ρ, we find a value of 0.396 for $\frac{f_o}{f}$ or 2.52 for $\frac{f}{f_o}$. The molecular weight can be calculated by use of the equation[9]

$$\frac{f}{f_o} = \frac{M\frac{(1-Vd)}{S_{20}}}{6\pi\eta N\left(\frac{3\ MV}{4\ \pi N}\right)^{1/3}}$$

M is the molecular weight of the protein, V is the specific volume of the protein in solution, d is the density, S_{20} is the sedimentation constant at 20° C. taken to be 174×10^{-13},[10] η is the viscosity coefficient, and N is Avogadro's constant. A value of about 42.5×10^6, more than 2 times that suggested originally, is found for the molecular weight of the protein by this method. This would correspond to a particle 12.3 mμ in diameter and 430 mμ in length. This value of the molecular weight is reliable only to the extent to which the equation of Kuhn is applicable to the system under investigation and to which the assumption of no hydration is valid. This treatment of the subject emphasizes the necessity of knowledge of the shape and state of hydration of the tobacco mosaic virus protein in order to enable one to interpret accurately the data from the ultracentrifuge.

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THE PRESENCE OF RARE EARTHS IN HICKORY LEAVES

IT has been established in the Bureau of Chemistry and Soils that the leaves of the hickory and sweetleaf may contain as much as 1.5 and 6.5 per cent. of crude Al_2O_3, respectively, in the air-dry leaf. The quantities present in the hickory vary from a few hundredths of 1 per cent. in neutral soils to the above quantities found in acid soils.

The abnormal behavior of the crude alumina precipitate obtained from the hickory leaves from a tree growing in a pegmatite vein of the Moorefield mine, Amelia, Va., led to the separation of a concentrate of the rare earth group of oxides amounting to 0.2 per cent. of the dry weight of the leaves. This figure is probably low, as there may have been some losses in the separations. The colors of the solutions, oxides and oxalates and behavior of the hydroxides indicated a mixture of cerium, lanthanum, praseodymium and neodymium.

A spectroscopic examination was made at the National Bureau of Standards for the individual rare earths, which are extremely difficult to separate when present in small quantities. The presence and relative abundance of the rare earth elements are shown in the following table:

TABLE 1
SPECTROSCOPIC EXAMINATION OF RARE EARTHS FROM HICKORY LEAVES*

Element	Oxides from oxalate, several precipitations	Oxides from fluorides, through hydroxides
Cerium	Very strong	Strong
Lanthanum	Strong	Weak
Praseodymium	Strong	Strong
Neodymium	Strong	Strong
Yttrium	Strong	Strong
Samarium	Moderate	Moderate
Europium	Moderate	Moderate
Gadolinium	Very weak	Weak
Dysprosium	Very weak	Weak
Erbium	Trace	Very weak
Ytterbium	Trace	Very weak

* The strengths of the lines of the respective elements were compared using the following scale: Very strong, Strong, Moderate, Weak, Very weak, and Trace.

Scandium, terbium, holmium, thulium and lutecium were not found. Due to lack of information concerning the spectrum of illinium (61), a test was not made for this element.

The presence of "moderate" lines of europium, one of the rarest of the rare earths, is interesting and may point to a concentration of this element by the hickory leaves.

The rare earths are widely distributed and occur in the earth's crust in quantities smaller, but comparable to the quantities of phosphorus and manganese. They have been found in many soils in concentrations up to .05 per cent. The rare earths, lanthanum in particular, are comparatively strong bases. The fact that the rare earths resemble calcium, in forming insoluble oxalates and fluorides, is an indication that the rare earths may substitute for calcium in the growing plant, where that element is deficient. In some of their properties, however, the rare earths more nearly resemble aluminium, and in this case are absorbed by an aluminum-loving plant.

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10 R. W. G. Wyckoff, *loc. cit.*

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