personal subscriptions as never before. And they must do it now or never. We beg this.

Fortunately there is no deficit to wipe out. The year 1937 closed with some $12,000 on hand, just about enough to cover the printing bill of the three indices in arrears. But the staff can not be retained unless publication is to continue. If salaries have to come from this index fund, drastic editing of the remaining indicies must be resorted to. The board does not feel justified in starting Volume 12 till about $40,000 in subscriptions is assured, though the text of number 1 has long been ready for the press.

This number would cover the literature from December, 1937, into 1938. The second would complete the 1937 arrearage. Thereafter coverage would be prompt, and it would expand with expanding resources. Already several societies have taken action to give support. Others will act in March. It will not be long before it is a general habit. We have no fear of the future if we can but get through the present squeeze.

We are most fortunate in our new editor, Dr. J. E. Flynn. He has had long experience, possesses a cool head, promises no miracles and loves *Biological Abstracts* like a child. At great personal sacrifice he and his devoted staff work on margins all too narrow. They deserve well of us. In after time, this little group will hold an honored place in the annals of American biology.

So, too, the University of Pennsylvania, which so generously provides free quarters. And most of all the foundation which so willingly made possible the initiation of this project.

A new board of trustees took office in mid-February. They are: George S. Avery, Jr., Connecticut College; Howard P. Barss, U. S. Department of Agriculture; A. F. Blakeslee, Carnegie Institution; Paul R. Burkholder, Jr., Connecticut College; Anton J. Carlson, University of Chicago; Alden B. Dawson, Harvard University; Hubert B. Goodrich, Wesleyan University; A. P. Hitchens, Army Medical College; George W. Hunter, III, Wesleyan University; D. D. Irish, Dow Chemical Company; M. Llewellyn Raney, University of Chicago. The committee on arrangements gives way to an executive committee, consisting of Messrs. Hunter (*chairman*), Burkholder and Raney.

Mistakes your leaders old and new have made. *Abstracts* has not met expectations. The present plan works injustice and must be amended—later, not now while crossing a treacherous stream. In another year, we can change and then abandon the plan, while with many standing committees from the Union membership we can shape the journal to our needs. But all hands now to the rescue and afterward reform. Quickly, please.

Address Biological Abstracts, University of Pennsylvania, Philadelphia, Pennsylvania.

GEORGE W. HUNTER, III,
Chairman,
PAUL R. BURKHOLDER,
M. LLEWELLYN RANEY,
Executive Committee

THE NATURE OF VIRUSES[1]

DURING the last several years considerable evidence favoring the inanimate nature of viruses has been obtained. Perhaps it may be well to discuss some of the recent evidence that appears to favor the animate nature of viruses.

In an earlier paper[2] it was reported that juice extracted from mosaic tobacco plants contains a high concentration of material capable of producing stream double refraction, sometimes called anisotropy of flow. The concentration of this material parallels that of active virus in most cases; this and other evidence were considered to indicate that the virus is composed of sub-microscopic elongated particles. Stanley[3] refined what is apparently the same material and obtained it in the form of visible, spindle-shaped particles about 20 μ long $\times$ 0.4 μ wide, which were regarded as crystals and which gave the reactions of a protein. Wyckoff and Corey[4] x-rayed this material and from the x-ray pattern concluded that these particles are crystals. Bernal and Fankuchen[5] repeated the x-ray work and interpreted the results to indicate that Stanley's visible particles are not true crystals showing an indefinite repetition of identical units in three-dimensional space, but are composed of elongated molecules in the liquid crystalline state.

A majority of the workers on liquid crystals[6] appear to agree on the following explanation of the liquid crystalline state (this state is also sometimes called the mesomorphic, paracrystalline or anisotropic liquid state): Elongated molecules tend to come together and to orient themselves with the long axes of the molecules parallel, thus forming sub-microscopic elongated groups called swarms. In a suspension of material in this state the liquid does not necessarily show double refraction unless the swarms are oriented by streaming or by an electric or magnetic field. Upon standing, the swarms are supposed to come together, arranged with their long axes more or less parallel and

[1] The assistance of non-technical employees of the federal Works Progress Administration is acknowledged.

[2] W. N. Takahashi and T. E. Rawlins, SCIENCE, 81: 299–300, 1935.

[3] W. M. Stanley, *Phytopath.*, 26: 305–320, 1936.

[4] R. W. G. Wyckoff and R. B. Corey, *Jour. Biol. Chem.*, 116: 51–55, 1936.

[5] J. D. Bernal and I. Fankuchen, *Nature* (Lond.), 139: 1923, 1937.

[6] "Symposium on Liquid Crystals," *Trans. Faraday Soc.*, 29: 881–1084, 1933.

to form the larger, doubly refractive, groups that can be seen by viewing the quiet liquid between crossed nicols. These visible groups are called liquid crystals. Under polarized light they may be indistinguishable from similar groups called tactoids or microtactoids, which are supposed to consist of oriented, elongated, sub-microscopic crystals. Upon stirring, liquid crystals or tactoids may be disorganized and disappear from view but are again formed after standing. Bawden, Pirie, Bernal and Fankuchen[7] and the authors[8] have observed the stream double refraction in the refined tobacco mosaic virus protein, and the former workers have observed what appear to be prolate liquid crystals or tactoids, after the concentrated virus protein has stood for a time. From the above discussion it appears that the virus may exhibit at least some of the properties shown by liquid crystals and tactoids.

By the use of the ultracentrifuge, Ericksson-Quensel and Svedberg[9] and Wyckoff, Biscoe and Stanley[10] calculated the molecular weight of refined tobacco mosaic virus protein to be between 10 million and 17 million. Northrup[11] studied a refined nucleoprotein phage and calculated the molecular weight to be 200 to 300 million. He suggested that the phage and certain viruses may be enzymes. The highest molecular weight reported by Svedberg[12] for known enzymes is 82,800. The question at once arises as to why the virus nucleoproteins, supposed to cause certain infectious diseases, have "molecular weights" so much higher than known enzymes. Are these particle weights really molecular weights or are they the weights of aggregates of molecules? Bawden and Pirie[13] report that the refined virus proteins used in the determination of "molecular weights" are retained by filters having a pore size about eight times as great as that required to pass the same virus before the purification treatment. These results suggest that the virus particles within the living plant may have particle weights somewhat below those determined by centrifugation.

So far as we have been able to determine, none of the known enzymes that have been analyzed have been found to be made up of nucleoproteins. If the virus nucleoproteins are enzymes why are they all of the type of protein found in the nuclei of organisms rather than the types found in known enzymes?

Miescher,[14] Schmidt[15] and Rinne[16] have reported that a large proportion of the material in the heads of certain sperms is a doubly refractive nucleoprotein. Rinne reports that x-ray analysis of these sperms indicates that this material is in the liquid crystalline state. If living sperm cells show double refraction and x-ray patterns of the same type shown by the refined virus, as has been reported above, it is perhaps possible that tobacco mosaic virus may be a sub-microscopic, elongated organism composed largely or entirely of liquid crystalline nucleoprotein, and that such elongated organisms tend to become oriented by streaming or by standing to produce the double refraction that has been observed.

Barnard[17] has attempted to photograph virus particles by the use of ultra-violet light. In the vesicular fluids from animals affected with foot and mouth disease and with vesicular stomatitis he has photographed minute rod-shaped particles that certainly appear to be bacteria. These particles, like refined tobacco mosaic virus nucleoprotein[18] and like the nucleoprotein in chromosomes,[19] have been reported to show high absorption of wave-lengths in the neighborhood of 2570 Å. Certain enzymes and proteins other than nucleoproteins have been reported to show relatively little absorption of light in this region of the ultra-violet spectrum.[18,19] These results suggest the possibility that the bacterium-shaped particles photographed by Barnard may have a composition somewhat similar to that of refined tobacco mosaic nucleoprotein and to the nucleoproteins in chromosomes. More information must be obtained before conclusions can be reached regarding this relationship.

Bawden and Pirie[20] reported that tobacco mosaic is not appreciably hydrolyzed by proteolytic enzymes until the virus is inactivated by heating. This behavior toward enzymes is similar to that shown by organisms.

It is obvious that much of the above speculation is based on meager evidence; it is presented with the hope that it may stimulate further research in this field rather than that it may enable the reader to reach a conclusion regarding the nature of viruses.

T. E. RAWLINS
WILLIAM N. TAKAHASHI
UNIVERSITY OF CALIFORNIA
BERKELEY

[7] F. C. Bawden, N. W. Pirie, J. D. Bernal and I. Fankuchen, *Nature* (Lond.), 138: 1051–1052, 1936.
[8] W. N. Takahashi and T. E. Rawlins, SCIENCE, 85: 103–104, 1937.
[9] I. Eriksson-Quensel and T. Svedberg, *Jour. Amer. Chem. Soc.*, 58: 1863–1867, 1936.
[10] R. W. G. Wyckoff, J. Biscoe and W. M. Stanley, *Jour. Biol. Chem.*, 117: 57–71, 1937.
[11] J. H. Northrup, SCIENCE, 86: 479–483, 1937.
[12] T. Svedberg, *Chem. Rev.*, 20: 82–98, 1937.
[13] F. C. Bawden and N. W. Pirie, *Proc. Roy. Soc. London*, Ser. B., 123: 274–320, 1937.
[14] F. Miescher, *Arch. Exp. Path. Pharm.*, 37: 100, 1896.
[15] W. J. Schmidt, *Zool. Jahrb. Abt. f. Allgem. Zool. u. Phys.*, 45: 177, 1928.
[16] F. Rinne, *Trans. Faraday Soc.*, 29: 1016–1032, 1933.
[17] J. E. Barnard, *Proc. Roy. Soc. London*, Ser. B., 124: 107–113, 1937.
[18] G. J. Lavin and W. M. Stanley, *Jour. Biol. Chem.*, 118: 269–274, 1937.
[19] T. Caspersson, *Zeit. f. Wissenschaft. Mikros.*, 53: 403–419, 1937.
[20] F. C. Bawden and N. W. Pirie, *Proc. Roy. Soc. London*, Ser. B., 274–320, 1937.