VIRUSES—LIVING OR NON-LIVING?

THE question of the nature of the viruses is producing a rapidly expanding volume of literature. Rawlins and Takahashi[1] have recently given citations to much of the pertinent literature so that their citations will not be repeated here. They contend that the "non-living" nature of viruses still remains to be proved in spite of the many assertions in the literature that the viruses are of the nature of the protein molecules. It is the purpose of this note to call attention to certain other arguments in favor of a living organism.

In the first place the use of the term molecule as derived from ultracentrifugal, diffusion or other physicochemical measurements does not necessarily signify characteristic homogeneity. Such "molecular weights" refer to any particle which behaves from the kinetic standpoint as a unit, each unit acquiring from thermal vibrations an average of $\frac{1}{2}\ kT$ ergs of energy for each of three translational degrees of freedom, neglecting quantum restrictions. Such a definition is vastly different from the chemist's definition of a molecule, *i.e.*, the smallest particle of a substance which can exist as an independent entity.

The "molecular weights" which have been assigned to viruses and the bacteriophage range all the way from 20,000,000 to 300,000,000. Assuming that the specific gravity of the particle of the molecular weight of 300,000,000 approximates the specific gravity of egg albumin and that the particle is spherical, the bacteriophage with the molecular weight of 300,000,000 would have a diameter of approximately 0.05 μ. The particle would thus approach the lower limit of microscopic visibility.

For the purposes of our discussion a naked cell, such as an amoeba, may be considered as consisting of two radically distinct parts, the cytoplasm and a nucleus. Studies in microdissection have demonstrated that the greater part of the cytoplasm can be cut away and, if the nucleus is uninjured, the cytoplasm will be regenerated and the organism will continue to live. We must accordingly attribute two functions to the nucleus of the amoeba, (1) the ability to regenerate amoeba cytoplasm and thus to provide the appropriate environment surrounding the nucleus, and (2) the ability to reproduce its own kind through the process of cell division. In view of the many complex chemical substances characteristic of the cytoplasm, it is perhaps not amiss to believe that the synthetic requirements of the nucleus necessitate a much larger mass of material than would be necessitated if the sole function of the nucleus was reproduction.

[1] T. E. Rawlins and William N. Takahashi, SCIENCE, 87: 255–256, 1938.

We know of various degrees of parasitism. Parasites exist which are relatively non-specific and which can utilize a great variety of hosts as food sources. We are also familiar with special kinds of parasitism where the host range is greatly restricted. Still more specialized forms are the obligate parasites which are restricted to a single host and in many instances to a particular variety within a particular species. It is perhaps legitimate to suggest that the obligate parasite may have lost some of its synthetic functions and has to depend upon a particular host, manufacturing some special chemical necessary for the environment of the parasite's cell nuclei.

If the above picture were projected a little further we might arrive at a living organism, the cell nuclei of which had lost all or nearly all the synthetic functions necessary for the production of cytoplasm and had retained only those nuclear functions necessary for building nuclear material (chromatin) and for cell division (reproduction). This hypothetical organism would be so perfectly adjusted to the host that it would adopt the host's protoplasm as its own cytoplasm and would be wholly dependent upon the host for its nutrition, retaining only the reproductive function which would tend to perpetuate the "naked nuclei." It is conceivable that a naked nucleus deriving its energy from a "borrowed cytoplasm" would lose the phenomenon of respiration which we have hitherto believed characterizes all living organisms and that accordingly when these naked nuclei are isolated in quantity, it will be found that they do not exhibit most of the characteristics which we have considered to be inseparable from "life."

It is well known that the viruses are highly specific, and the recent virus preparations of Stanley and others have demonstrated that "nucleoproteins" (chromatin is composed largely of nucleoproteins) can be isolated from infected tissue. Perhaps these are the hypothetical naked nuclei postulated above.

That this is a possibility is evidenced by the observation of Beams[2] that fertilized eggs of *Ascaris suum* could be centrifuged at approximately 150,000 times gravity for 4½ days and still develop into normal organisms and that the development proceeded at about the same rate as the controls. Furthermore certain of these eggs underwent cleavage while still rotating in a field of 100,000 times gravity. If no microscope had ever been developed which would render visible an *Ascaris* egg, we would have a situation somewhat analogous to that of the virus "proteins" excepting much more extreme. Such particles would be found to be spherical in shape, to sediment at a uniform velocity, and to give the usual protein tests. Because they were not visible in the microscope, we would say

[2] H. W. Beams and R. L. King, SCIENCE, 84: 138, 1936.

that they appeared to be homogeneous particles of a "molecular weight" of 1,000,000,000 or more.

The crystalline-appearing structures isolated by Stanley are another argument advanced in favor of the non-living nature of the viruses. The biologist, however, need only be reminded of the fact that many colonies of unicellular organisms assume special shapes or forms characteristic of the group of individual organisms making up the colony. Furthermore many bacteria tend to arrange themselves in clusters or in long chains, probably at least in part because of the positive and negative polarity which each cell possesses. We know nothing as to the electrical phenomena which would be associated with naked living nuclei, and it is not beyond the realm of possibility that such electrical phenomena would be manifested by specific orientations and specific space groupings of such naked nuclei.

The hypothesis of naked nuclei would account for the "autocatalytic" reproduction of the virus "proteins." It should be pointed out that Woods,[3] in 1899, concluded that the viruses were enzymes and that they were non-living. Unfortunately for Woods the term "autocatalytic" had not yet been coined so that he could not call the virus an autocatalytic enzyme and thus account for its self-propagation. Had he used that terminology, his description would have been essentially that of the present school who insist on the protein nature of viruses. It should be pointed out, however, that all of the classical autocatalytic reactions which have been studied in the chemical laboratory refer to a tearing down process (a chain reaction) whereby energy is released, and the writer does not know of a single instance of a building-up autocatalytic reaction whereby energy is stored. Therefore, if the viruses are autocatalytic proteins, they represent a type of chemical reaction entirely distinct from systems which have been previously studied.

ROSS AIKEN GORTNER
THE UNIVERSITY OF MINNESOTA

POSSIBLE LANDSLIP SCARS ON THE BOUQUET RIVER AT WILLSBORO, N. Y.

THE Bouquet River enters Lake Champlain two miles east of the town of Willsboro, N. Y., after having crossed the belt of lower Paleozoic sediments that lie between the lake and the Adirondack Mountains. In places, the river rests upon bedrock as at the bridge at Bouquet, where it exposes the Potsdam sandstone, and at Willsboro, where ledges of the Beekmantown limestone are visible and serve as the foundation of a dam. Throughout a large part of its course, however, the river is not resting on bedrock, but has cut its channel through unconsolidated Pleistocene sands and is in places flowing on an underlying bed of glacial lake clay.

In the middle of June, 1937, an interesting landslip took place on the east bank of the river about one half mile north of the Essex-Willsboro town line at the point where the river turns westward. For a distance of about five hundred feet, the clay bed of the stream was forced upward, temporarily ponding the flow of water until a new channel was cut in the meadow lands to the west. At this point the east bank rises some sixty feet above the bed of the stream and is made up of Pleistocene sands and clays, while the land to the west is relatively low. At some distance back from the river, on the east bank, a vertical scarp over thirty feet high was produced by the disturbance. Between this zone of slippage and the river, the land was badly broken and dropped vertically in blocks. Trees were uprooted, and one tree six inches in diameter was split up the middle of the trunk for several feet as the ground on one side dropped to a lower level.

Considerable local interest was aroused by this slide, and some of the local newspapers carried articles about the event. Dr. D. H. Newland, New York state geologist, visited the region a few days after the slump and has prepared a paper which will discuss the geology of the landslip.[1]

It is the purpose of this paper to call attention to a topographic feature present along the Bouquet River which might be interpreted in two different ways, either as a river terrace or as the evidence of a former slide.

The writer, who was fortunate enough to be in the region, visited the scene on June 24 and came to the conclusion that the load of Pleistocene sediments on the east bank had caused a displacement along a clay layer at the level of the stream bed and had produced the bulging of the river bottom. Slides of this type have been described from other parts of the Hudson-Champlain valley by Newland,[2] who lists five types of slides and slips which may occur in unconsolidated sediments. His fifth type, "Subsidence of surface from unbalanced pressure upon confined liquid substratum, leading to a reciprocal upward movement at a distance" is the type here represented, and the examples cited by him seem to agree in all major points.

In approaching the area of the recent slide, one crossed a definite well-developed bench about fifteen or twenty feet below the level of the glacial sand plain. The natural interpretation would be that it was a normal river terrace. However, after having seen the results of the slide the question of origin becomes more doubtful, for a bench of this type could well have been produced by a similar slide at some much earlier date.

[3] A. F. Woods, *Centr. Bakt. Parasitenk.*, 2: 745–754, 1899.

[1] D. H. Newland, Personal communication, 1938.

[2] D. H. Newland, *N. Y. State Museum Bull.*, 187, 1916.