tive than 30 years ago; that we recognize stasis, constraints, multiple levels of selection, differential clade diversification, and historical contingency as valid principles worthy of research; and that Gould has played a leading role in bringing about these changes, in part by arguments retold in this, his *apologia pro vita sua*. He can exasperate but also charm, for as Homer said so memorably, τοῦ καὶ ἀπὸ γλώσσης μέλιτος γλυκίων ῥέεν αὐδή [and from his tongue flowed words sweeter than honey].

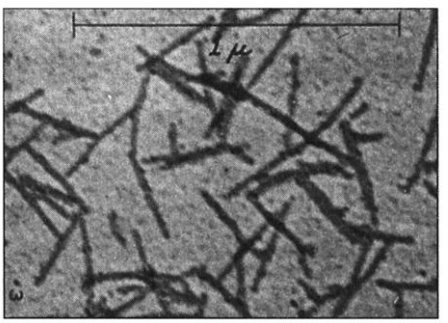
BOOKS: HISTORY OF SCIENCE

TMV in the Lab and Life Sciences

Soraya de Chadarevian

In 1935, in the pages of this journal, Wendell M. Stanley from the Division of Plant Pathology at the Rockefeller Institute in Princeton announced that he had isolated the virus responsible for mosaic disease in tobacco (TMV) as needle-shaped crystals of pure protein. The paper created a scientific sensation. Stanley's feat demonstrated that viruses, the invisible agents responsible for some of the most damaging diseases in plants, animals, and humans, could be treated like a chemical substance. The evidence that TMV was a protein, but one which could reproduce itself, led to heated debates about the role of viruses in the origin of life. On a more general level, it confirmed expectations that proteins represented the material basis of heredity. Subsequent corrections of Stanley's claim not withstanding—the virus was recognized as a nucleoprotein rather than pure protein—the 1935 paper quickly received canonical status in virus research, and Stanley received many awards, including the 1946 Nobel Prize in chemistry.

This event, Angela Creager eloquently tells us in *The Life of a Virus*, marked only the beginning of an immensely successful laboratory career of TMV. The virus, inscribed in a changing set of experimental systems, became a model not just for the study of other viruses but for a wide range of questions of 20th-century life sciences as well. A series of firsts kept it at the forefront of research. After its identification as a protein, TMV became the first virus prepared by sedimentation in an ultracentrifuge. These pioneering investigations, performed in a collaboration between Stanley and Ralph Wyckoff, not only changed the representation of TMV but also triggered the development of ultracentrifuges from analytical to preparative instruments and thus to a much wider range of applications. A few years later, German researchers collaborating with Siemens to develop the first commercial electron microscope published an electron micrograph of TMV, making it the first virus to be so visualized. The electron microscope was used in much subsequent work under Gerhad Schramm at Tübingen as well as in Stanley's new Virus Laboratory at Berkeley (the main focus of Creager's study). Their efforts were aimed at defining the size and shape of the virus. TMV became the first virus for which a subunit structure was postulated. Chemical data together with evidence from x-ray crystallography (based especially on the work of Rosalind Franklin) provided support for this hypothesis and established that TMV was built of protein subunits that form a hollow cylinder around a helical strand of RNA. The isolation of its parts was followed by attempts to reconstitute the virus in vitro. The 1955 announcement by Heinz Fraenkel-Conrat and Robley Williams, members of Stanley's lab, that an infective TMV had been assembled from its purified parts stirred media interest much like the coverage following Stanley's original crystallization of the virus.



Early electron micrograph. Wendell Stanley and Thomas Anderson used electron microscopy to confirm the size and shape of TMV.

The Life of a Virus Tobacco Mosaic Virus as an Experimental Model, 1930–1965
by Angela N. H. Creager
University of Chicago Press, Chicago, 2002. 412 pp. $75, £47.50. ISBN 0-226-12025-2. Paper, $27.50, £16. ISBN 0-226-12026-0.

Closely connected to its model roles in research concerning the nature and structure of viruses and in the development of representation technologies, TMV played a pivotal role in investigations central to the emerging field of molecular biology. Although virus researchers were slow in attributing an infective function to the viral RNA, during 1952–53 James Watson studied TMV at Cambridge in the hope of elucidating the structure and function of RNA. With the ready availability of mutants and the early sequencing of its protein subunits, TMV joined bacteriophage as a prime model organism for studies on the genetic code (though in the end the code was instead deciphered in a cell-free translation system with synthetic RNA polymers).

Creager, a historian of science at Princeton University, firmly places TMV among the few laboratory organisms that have served as model systems for 20th-century bioscience. She offers thoughtful reflections on how such systems guide research and what can be gained by focusing on the laboratory practices that sustain them. By emphasizing TMV's role as an exemplar rather than as a standardized prototype (as has been done for other model organisms), Creager aims to underline the changing nature of TMV and the many ways in which TMV research could be adapted to new contexts.

Perhaps because TMV served primarily as a (changeable) "point of reference," it does not seem to have inspired the creation of a community (with centralized services, a newsletter, and specialized meetings) like those that grew up around the fruit fly and the mouse. Yet the widespread reference to TMV allows Creager to draw connections between apparently separated endeavors and to offer new perspectives on some much-studied historical events. One point in particular seems of wide-ranging importance. The most enduring legacy of World War II for the life sciences, Creager argues, was not the influx of physicists but the rise of public expectations for and lay activists' funding of biomedical research. The TMV story demonstrates that medical concerns and funding also underpinned much of the early research in molecular biology. The impact of funding for cancer research (including the search for cancer viruses) by government and the cancer societies springs to mind. But Creager bases her argument especially on the case of the National Foundation of Infantile Paralysis, whose financial support for biomedical research rose sharply in the 1940s and 1950s. In the "war against polio" declared by this volunteer-based organization and the sustained effort to develop a vaccine against the feared disease, TMV served both as a substitute and as an exemplar guiding much research on the polio virus itself. The polio virus was crystallized in Stanley's laboratory in 1955, an achievement overshadowed by Jonas Salk's development of a polio vaccine in the same year.

Thoroughly researched and well presented, *The Life of a Virus* turns the career of TMV into a rich portrait of the changing practices and images of mid-20th-century life sciences.

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