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NOTE

Importance of plant virus research – a brief revisit

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Abstract – In this paper, we wish to comment on a recent essay on virus research that was published in The Economist (August 20, 2020). The essay is so well-written and informative that it serves as an excellent example of popularizing science to make it accessible to all segments of an inquiring society. Still, we would like to point out that the paper failed to cover one important area of virus research: the fundamental discoveries achieved by studies of the viruses of higher plants.

Keywords – essay on viruses, The Economist, viruses of higher plants, milestones in virus research, tobacco mosaic virus

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The nucleic acid, which today gets so much attention, was at first overlooked when TMV was described as a globulin, and then dismissed as a contaminant.

Bawden and Pirie (1959)

The goal of this paper is to call the attention of our readers to an excellent essay that the journal The Economist published on August 20, 2020, on viruses (Anonymous, 2020). Similarly to all articles, published in The Economist, this essay is written anonymously.

The title of the paper is "The viral universe. Viruses have big impacts on ecology and evolution as well as human health". The article is a superb example of the popularization of science: it is so well written and so informative that, in our opinion, it deserves to be made available for the general public and taught in schools and universities.

Here we wish to note that an important area was left untouched in the essay: viruses infecting higher plants. We believe they need to be mentioned because viruses were discovered in diseased plants and many later basic findings were achieved through plant virus studies.

Pioneering research that led to the discovery and characterization of viruses was done in the late 1880s in Russia and The Netherlands. In 1887, Dmitri Ivanovsky, a talented student at the University of St. Petersburg in Russia was sent to investigate the rapidly spreading mosaic disease of tobacco plants grown in Ukraine and Bessarabia. After returning from his trip, he studied samples of the diseased plants in his laboratory and, using a sophisticated filtration technique, concluded that they were infected by unknown microorganisms that are much smaller than bacteria or microscopic fungi (Ivanovsky, 1892).

The name virus (from the Latin word for poison) for the new microorganisms was coined in 1898 by Martinus Beijerinck who repeated and corroborated Ivanovsky's experiments (apparently unaware of his research[1]) and developed a new concept of a life form, which is autonomous and subcellular (Bos, 1999). He also supposed that the nature of this life form is liquid (*contagium vivum fluidum*) (Beijerinck, 1898). As an alternative, based on light microscopic observations and diffusion experiments, Ivanovsky suggested that the viruses exist as particles and not in liquid form (Ivanovsky, 1903).

[1] When Ivanovsky (1899) claimed priority for the filtration experiments, Beijerinck (1899b) immediately acknowledged this in a short note.

After Ivanovsky's and Beijerinck's pioneering achievements for more than three decades only a little progress was made in virus research despite numerous attempts to shed light on the nature of these infectious agents**.**

Attempts to isolate and characterize the active principle of tobacco mosaic disease began in 1899 when Beijerinck had shown that the agents can be precipitated from water by adding ethyl alcohol (Beijerinck, 1899a). In 1929, Vinson and Petre added selected salts to the infectious filtrates to produce cleaner precipitates (Vinson and Petre, 1929).

Based on the above results, Stanley developed a method that produced crystallized particles of the virus and concluded that they were proteins with unusually high nitrogen content (Stanley, 1935). Bawden and Pirie further purified the crystals and found that they also contain phosphorus and carbohydrate constituents (characteristics of nucleic acid) (Bawden et al., 1936) (Bawden and Pirie, 1959) thus showing that the virus is a nucleoprotein.

On the grounds of the above ground-breaking studies, tobacco mosaic virus (TMV), as well as other viruses of higher plants, as model systems, have been at the front line of virus research to this day. To mention a few additional ones of the numerous crucial ideas in virology that were created with the help of these systems: the separation and purification of viral nucleic acid and protein building blocks (Bawden et al., 1937)**,** their reassembly from these components (Butler and Klug, 1971**)**, the visualization of a virus in an electron microscope (Bernal and Fankuchen, 1941**)**, the demonstration that the infecting agent of a virus is its nucleic acid component (Gierer and Schramm, 1956)**,** the first sequencing of a viral coat protein (Anderer et al., 1960)**,** the discovery of viroids (they consist of a special nucleic acid without the protein coat that can still infect plants) (Diener, 1971) and satellite viruses (Kassanis, 1962), and the identification of gene silencing as a resistance mechanism against virus infection (Baulcombe, 1996 and 2004).

CONCLUDING REMARKS

Emphasizing once again the exceptional quality of the essay Economist published on viruses, we believe our readers might be interested in the information presented in this Note paper.

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PUBLIC INTEREST STATEMENT

The goal of this paper is to call the attention of our readers to an excellent essay that the journal The Economist published on August 20, 2020, on viruses (Anonymous, 2020)**.** Similarly to all articles, published in The Economist, this essay is written anonymously. The article is a superb example of the popularization of science: it is so well written and so informative that, in our opinion, it deserves to be made available for the general public and taught in schools and universities. In this paper, we wish to note that an important area was left untouched in the essay: viruses infecting higher plants. We believe they need to be mentioned because of their economic importance and their key roles in great scientific findings achieved through plant virus studies.

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