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THE IMPORTANCE OF VIROLOGY AS A SCIENCE AND ITS CURRENT PRESSING ISSUES

Toshtemirova M. A.
Fergana State University, Acting Associate Professor of Zoology and General Biology, PhD (p.f.f.d.)
Email: Muazzamtoshtemirova29@gmail.com
+998905300701

Abstract
The science of virology is one of the sciences with the most pressing problems today. This article includes the importance of the science of virology, the achievements and successes in the field of virology, including the origin of the science of virology and the development of this science.

Keywords: Virus, primary vaccines, DNA, RNA, capsid.

Introduction

Currently, the demand for virology, as well as microbiology, biotechnology, immunology, and many other sciences, is steadily increasing. Therefore, a thorough study of these sciences and finding solutions to their challenges is one of the primary goals set before contemporary scientists. Virology plays a crucial role in both the theoretical and practical aspects of infectious disease research. The continuous improvement of virological research methods, along with the extensive use of advancements in molecular biology, genetics, and biochemistry, has significantly contributed to the rapid development of virology. As a result of the widespread teaching and research in this field, virology has achieved numerous breakthroughs.

Viruses represent the fundamental unit of life and serve as ideal models for molecular biologists and geneticists. The 20th century witnessed groundbreaking biological discoveries related to viruses, including the elucidation of protein and nucleic acid synthesis mechanisms and the decoding of the genetic code. In recent decades, a decline in bacterial infection epidemics has been observed, while the incidence of viral infectious diseases has significantly increased. Viral infections account for approximately 80% of all infectious diseases, with influenza, adenoviral infections, viral hepatitis, and other virus-induced diseases posing significant threats to public health and the economy.

There exist numerous highly dangerous viruses in nature, and Western virologists are actively developing effective preventive measures against them. The authors of this study have attempted to present contemporary microbiological knowledge in a coherent and logical manner to enhance comprehension. Additionally, key concepts and other essential information have been specifically highlighted to facilitate understanding. It is important to acknowledge that existing microbiology textbooks are often insufficient in quantity and require supplementation with up-to-date scientific information.

Literature Review and Research Methodology

The experiments conducted by D. I. Ivanovsky formed the foundation of his 1888 dissertation titled *"On Two Tobacco Diseases"*. This research was later described in a book of the same name, published in 1892, which marked the official discovery of viruses. Viruses are microscopic particles representing the simplest forms of life, consisting of nucleic acid molecules (either DNA or RNA) enclosed in a protein shell (capsid), capable of infecting living organisms. Viruses are classified as parasites since they cannot replicate outside a host cell. Outside a cell, viral particles behave like chemical substances rather than living entities.

The topic of viruses has been extensively covered in various scientific works, including *Microbiology, Immunology, Virology* by E. M. Muhamedov and E. X. Eshboyev, *Microbiology* by N. A. Bakulina and E. L. Kraeva, *Microbiology* by A. A. Voroboyev and A. C. Bo'kov, as well as *Fundamentals of Microbiology, Virology, and Immunology* by N. V. Prozorkina and P. A. Rubashkina. Additionally, numerous lecture materials and dissertations have provided valuable insights into virology

Results and Discussion

Virology, like microbiology and immunology, is a well-developed medical-biological science. Viruses are diverse in nature and serve as etiological agents of infectious diseases. Virology is a branch of biology that studies viruses. The history of virology dates back to 1892 when the Russian scientist D. I. Ivanovsky discovered microbes responsible for mosaic disease in tobacco plants. In 1893, German bacteriologists F. Loeffler and P. Frosch identified the foot-and-mouth disease virus in cattle, while in 1901, American researcher W. Reed and his colleagues discovered that the causative agent of yellow fever could pass through a standard bacteriological filter. The term "virus" was first introduced by the Dutch scientist M. Beijerinck (1898) and the German geneticist E. Baur (1904). In 1911, American researcher F. T. Rous identified a virus that causes malignant tumors in chickens. The discovery of bacteriophages, the cultivation of vaccinia virus in tissue culture, the development of silver-staining techniques for visualizing viral particles, and the isolation of tobacco mosaic virus in crystalline form—all of these contributed significantly to the advancement of virology. By the mid-20th century, the structure of viruses began to be studied using electron microscopy and X-ray diffraction analysis.

Virology is categorized based on its research objectives into agricultural, veterinary, and medical virology. The development of virology is closely linked to molecular genetics. Key discoveries include the identification of viral DNA (1952), viral RNA (1956), spontaneous assembly of viral RNA and proteins (1955), viral interference mechanisms (1957), and DNA synthesis processes. One of the pioneers of virology was the English physician E. Jenner, who developed the first vaccine against smallpox in 1796.

The historical development of virology progressed through several key phases. In the 1930s and 1940s, laboratory animals such as mice, rats, and rabbits were used to cultivate and identify viruses, including influenza viruses. By the late 1940s, the use of chicken embryos for virus research became widespread. It was discovered that viruses could be cultivated in artificial nutrient media and cell cultures. This led to the development of vaccines, including inactivated and live poliovirus vaccines by Salk, Sabin, Chumakov, and Smorodintsev. In the 1960s, fundamental

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molecular biology methods were developed, enabling the study of viral structures, infection mechanisms, and entry pathways. The 1970s introduced submolecular concepts of virology, emphasizing the structural organization of nucleic acids and proteins. Viruses were classified based on their genetic material as DNA or RNA viruses.

The origin of viruses remains a subject of debate. Some researchers suggest that viruses evolved from bacteria or unicellular organisms through a process of regressive evolution. Others hypothesize that viruses predate cellular life and represent ancient biological entities. A third theory proposes that viruses originated from genetic elements within host cells and later became autonomous, explaining the diversity of viral genomes (DNA or RNA).

Viruses are extremely small infectious agents that lack their own metabolic systems and rely entirely on the host cell's resources for replication. They do not possess cellular structures and do not reproduce by cell division. Instead, they hijack host cells to generate multiple copies of themselves, which then assemble inside the infected cell. Modern classifications recognize viruses as non-cellular entities, highlighting the need to study their ecological interactions with the environment. Viruses play a significant role in biological evolution by contributing to genetic variation. They can integrate into the host genome and act as mutagenic factors. Additionally, viruses facilitate horizontal gene transfer between unrelated organisms, influencing evolutionary processes.

The nature of viruses is well-characterized in biology. Nobel laureate David Baltimore proposed a classification system that remains widely used today. This classification is based on the mechanism of mRNA synthesis, as all viruses must generate mRNA from their genomes for protein production and nucleic acid replication. According to Baltimore’s classification, viruses are grouped as follows:

- Double-stranded DNA viruses without an RNA intermediate: This group includes mimiviruses and herpesviruses.
- Ingle-stranded DNA with a positive polarity (Parvoviruses).
- Double-stranded RNA (Rotaviruses).
- Single-stranded RNA with a positive polarity. Representatives include flaviviruses and picornaviruses.
- Single-stranded RNA with either positive or negative polarity. Examples include filoviruses and orthomyxoviruses.
- Single-stranded positive RNA, with DNA synthesis using an RNA template (HIV).
- Double-stranded DNA, with DNA synthesis occurring through an RNA intermediate (Hepatitis B).

There are several hypotheses regarding the origin of viruses. Science suggests that viruses may have originated from fragments of RNA and DNA expelled from larger organisms.

The **regression hypothesis** posits that viruses were once small parasitic cellular organisms that replicated inside larger cells but, over evolutionary time, lost genes necessary for independent survival, leading to their current parasitic nature.

The **coevolution hypothesis** suggests that viruses emerged simultaneously with living cells as complex assemblies of nucleic acids and proteins developed.

Questions about viral structure, replication, and transmission are studied in a specialized field of

microbiology known as **virology**. Each viral particle contains genetic material (either RNA or DNA) and a protein shell (capsid) that serves a protective function.
Viruses exhibit various shapes, ranging from simple helical forms to icosahedral structures. Their standard size is approximately **1/100th the size of an average bacterium**.

Viral Life Cycle
The viral life cycle consists of several sequential stages.
1. **Attachment** – The virus binds to specific host cell receptors via its surface proteins.
2. **Entry and Genome Delivery** – The viral genetic material enters the host cell, sometimes along with viral proteins.
3. **Uncoating** – The viral capsid disassembles, releasing the nucleic acid into the host cell.
4. **Replication and Assembly** – The virus hijacks the host's cellular machinery to replicate its genome and produce viral proteins.
5. **Maturation and Release** – Newly assembled virus particles exit the host cell. Some viruses lyse the host cell, while others persist inside it without immediately destroying it.
6. This complex cycle enables viruses to propagate and adapt to different environments and host organisms.

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