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BACTERIOLOGY AND VIROLOGY RESEARCH

Review Article

The Practice of Clinical Virology: Virus Taxonomy

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Received: January 22, 2016; **Published:** February 16, 2016

Abstract

Three standards are applied for the naming of viruses, namely

a. The International Committee on Taxonomy of Viruses (ICTV)
b. The Baltimore classification of viruses
c. The microscopic introduction to virus taxonomy

It should be taken into account that viruses are often morphologically differentiated by shape, namely icosahedral, helical and complex shapes. Viruses can be named after the causative disease; after places where the disease was first reported; by means of the identified host; using scientific and documented evidence of the signs of disease and within the discovery of new and emerging viruses. An example can be illustrated by Rift Valley fever that is a viral zoonotic disease primarily affecting animal health but can also infect humans.

The ICTV was established historically in 1996 and this gave rise to an internationally agreed taxonomy for viruses. The unique name for each virus has now been sustained. Virus identification is recognised at the following levels, namely: order; family; sub-family; genus and species.

The Baltimore classification of viruses distinguishes major groups of viruses by their nucleic acid content that is DNA or RNA. All viruses need to produce positive-sense single-stranded RNA for the production of proteins.

The microscopic introduction to virus taxonomy ensured that viruses could be identified up to the genus classification level.

Selected virus examples include measles virus, rubella (German measles), chickenpox; Yellow fever virus, West Nile virus, Chikungunya virus and Rift Valley Fever virus.

In conclusion, viral classification systems are essential for retaining the specific naming of viruses and form the basis for additional discussion and further description. However, the concept of a virus is not a stable classification as viruses continue to evolve and is determined by technological advances and the contribution of scientific understanding.

Keywords: *Virus taxonomy; Morphology; Cell tropism; Baltimore Classification; Virus nomenclature*

Introduction

There are a number of reasons to understand the actual naming of viruses and three standards have been applied, namely:

a. The International Committee on Taxonomy of Viruses (ICTV)
b. The Baltimore classification of viruses and
c. The microscopic introduction to virus taxonomy [1,2].

Viruses are basically obligate intracellular parasites or entities and virus classification is a process of naming viruses and deliberately placing them into the taxonomic system [3]. Historically, viruses have been classified by phenotypic characteristics such as morphology, nucleic acid types, their modes of replication, the host organism and the types of diseases caused and recognised. Viruses are morphologically differentiated by shape, namely:

a. Icosahedral (examples include herpes simplex virus and poliovirus)
b. Helical (tobacco mosaic virus and rabies virus)and
c. Complex (bacteriophages and smallpox virus) [4].

There are various approaches to naming certain viruses and the following selected examples are included, namely:

a. Named after the disease
b. Named after the places where the actual disease was first reported
c. The identified host;
d. The scientific and documented evidence of the signs of disease and
e. The discovery of new and emerging viruses [5,6].

Viruses are composed of RNA or DNA single-stranded or double-stranded structures and can be further classified by whether they are undergoing reverse transcription (retroviruses), by whether they have a linear or circular genome and then finally according to the tissue that is affected [7].

The International Committee on the Taxonomy of Viruses (Ictv)

The ICTV was established in 1966 and was originally called the International Committee on the Nomenclature of Viruses (ICNV) [8]. This Committee was instructed to develop a universal taxonomic scheme to identify and address the nomenclature and classification of viruses [8]. These gave rise to an internationally agreed taxonomy for viruses, internationally agreed names for viral taxa that included species and sub-viral agents. This was communicated to the international community of virologists and an index of virus names was created [9]. The principles of ICTV was to maintain stability, to prevent any confusion and to sustain the unique identify of each name.

Virus identification is recognised at the following levels, namely:

a. order (*virales*);
b. family (*viridae*);
c. sub-family (*virinae*);
d. genus (*virus*) and
e. species.

An example of this ICTV classification would be the following, namely:

Order: Herpes virales
Family: Herpes viridae
Sub-family: Alphaherpes virinae;
Genus: Simplexvirus and
Species: Human herpesvirus1 and/or herpes simplex virus.

Baltimore Classification of Viruses

This was initially suggested by David Baltimore and viruses were divided into 7 Baltimore classes. This division was based on the genomic type, the mode of replication and the reality model of viral transcription [10,11]. Major groups of viruses are distinguished firstly by their nucleic acid content as either DNA (single-stranded DNA or double-stranded DNA) or RNA (single-stranded RNA or double-stranded RNA) [12]. Baltimore's classification is based on the fact that all viruses need to produce positive-sense single-stranded RNA that produces proteins [12].

Microscopic Introduction to Virus Taxonomy

Microscopic classification of viruses came about from the routine usage of electron microscope and viral particles were viewed morphologically. Viruses could be identified up to the genus level [13,14]. Criteria need to be followed when viewing viruses under the transmission electron microscope and include the viral nucleocapsid that can be naked or enveloped and the size range in viral diameters. The nucleocapsid is composed of nucleic acids and capsomers and the viral envelope contains glycoprotein spikes, transmembrane proteins, lipoproteins and matrix proteins. These criteria could help to distinguish between different families without the use of the ICTV or Baltimore classifications [1]. Naked or non-enveloped virus families may have diverse size ranges and clinical virology examples include hepatitis E virus, Norwalk virus, rotavirus, adenovirus and papillomavirus.

Selected Virus Examples

Measles virus

The name measles virus comes from a Middle English word "Maselen" which means "many tiny spots" that characterises the rash [15]. The resulting infection is highly contagious and is transmitted through droplet spread. The clinical presentation is usually non-specific and can cause a rash, fever, dry cough, a sore throat and conjunctivitis. There is no therapeutic cure and only supportive treatment is considered [16].

German measles or rubella

This was called German measles as a German physician wrote a clear clinical description of its presentation in 1760 [17]. It is responsible for the clinical congenital rubella syndrome but the usual clinical presentation in older children and adults is mild, when compared to measles. It is managed through an effective vaccination programme called the MMR (measles, mumps and rubella) vaccine [18].

Chickenpox

This is one of two diseases caused by human herpes virus 3 (HHV-3) or more popularly the varicella-zoster virus (VZV). VZV is also known to cause another clinical entity called shingles. Chickenpox is a mild symptomatic disease usually affecting young children but can have severe complications in infants, adults and immunocompromised patients [18,19]. The disease is airborne and highly contagious [20]. The virus remains dormant in the dorsal root ganglia of all persons who have had chickenpox and can be reactivated later in life.

Yellow fever virus

Yellow fever virus was discovered in Cuba and it appears the name was derived from the skin pigmentation caused by jaundice [21]. It was hence discovered that yellow fever as a clinical entity was transmitted to humans from the bite of a mosquito [21]. This virus is endemic in Africa and Latin America. The disease presents with fever and jaundice leading to liver, kidney and cardiac disorders [22]. There is no treatment for this disease and supportive care remains critical. Vaccinations are essential for travellers to viral endemic areas and a vaccination booster every 10 years is highly recommended.

West Nile virus

This emerging viral infectious disease was first discovered in Uganda in 1937 and belongs to the Japanese encephalitis viral antigenic complex [23]. It is transmitted to humans through the bites of infected *Culexsp* mosquitoes that also feed on birds. This virus can cause fatal neurological disease in humans as no specific treatment or vaccine is currently available.

Chikungunya virus

The name for this virus is derived from the Makonde (the Makonde Plateau that is a border between the countries Mozambique and Tanzania) and means "that which bends up" and this refers to the posture gained as a result of painful arthritis. The name also means "the illness of the bended walker". The disease originated in Central Africa and re-emergences have been recorded in Asia and Europe [24]. The clinical disease presents with fever, rash, headache, arthralgias and potential bleeding. There is no available vaccine and treatment is supportive [25].

Rift Valley fever

This is a viral zoonotic disease primarily affecting animals but can also infect humans [26]. Although it was first identified in 1931 during an investigation into an epidemic amongst sheep on a farm in the Rift Valley of Kenya, outbreaks were reported in Saudi Arabia, North Africa and sub-Saharan Africa. The majority of human infections arise from direct or indirect contact with blood or organs of infected animals. Clinical symptoms include fever, muscular and joint pains, headache and possible encephalitis [27].

S.No	Virus
1	measles virus
2	German measles
3	Chickenpox
4	Yellow fever virus
5	West Nile virus
6	Chikungunya virus
7	Rift Valley fever virus

Table 1: *Virus Taxonomy - Selected Virus Examples and Viral Diseases.*

S.No	Baltimore Classification of Viruses
1	Genomic type of the virus
2	The mode of replication
3	The different viral transcription models
4	The viral nucleic acid content (DNA or RNA)
5	Single-stranded DNA viruses
6	Double-stranded DNA viruses
7	Single-stranded RNA viruses
8	Double-stranded RNA viruses
9	Positive-sense single-stranded RNA viruses
10	Viral protein production

Table 2: *The Baltimore Classification of Viruses.*

Conclusion

The ICTV and Baltimore classifications for viral taxonomy are essential for the specific naming of viruses and can form the basis for further discussion or description. Viruses and the pathology, epidemiology, modes of transmission, clinical immunology and treatment of infectious diseases can now be studied with a precise understanding of the agent, as illustrated by the examples of the 1918 influenza pandemic and the eradication of the smallpox virus. The first images of a virus revealed their morphological complexity through a variety of shapes and this has lead to their ever-changing concepts. More recently, modes of viral replication, such as nuclear or cytoplasmic strategies and negative or positive DNA/RNA strand coding are being studied and recognised. Viruses are recognised anew through their own properties, relationships and capacities that adequately reflect the science of the time.

The concept of a virus is not a stable classification as viruses continue to evolve and this is determined by technological advances more so than scientific understanding.

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Volume 2 issue 1 February 2016
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