Howard Hughes Medical Institute
2010 Holiday Lectures on Science

Viral Outbreak
The Science of Emerging Disease

Two leading virus researchers explain how they use both simple and sophisticated technologies to detect and fight infectious agents.

Joseph L. DeRisi, Ph.D.
University of California, San Francisco

Eva Harris, Ph.D.
University of California, Berkeley

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www.holidaylectures.org

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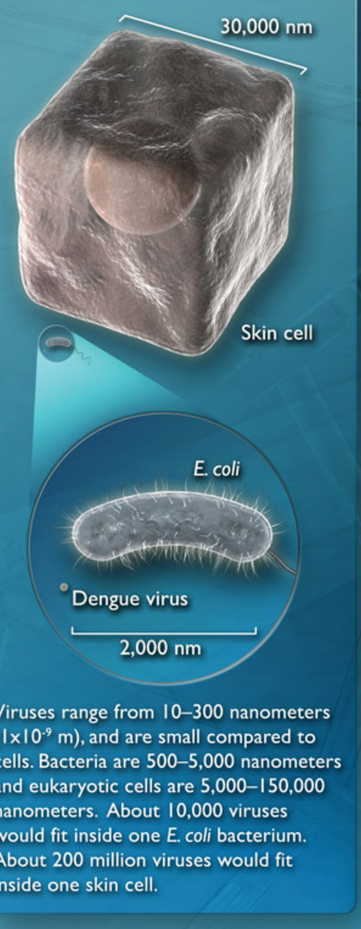
Diversity of Viruses

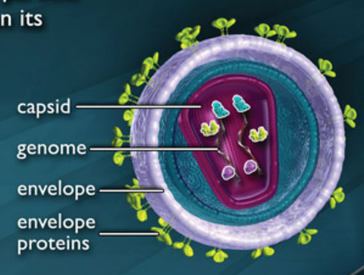
Relative Size



Viruses range from 10–300 nanometers (1×10^{-9} m), and are small compared to cells. Bacteria are 500–5,000 nanometers and eukaryotic cells are 5,000–150,000 nanometers. About 10,000 viruses would fit inside one *E. coli* bacterium. About 200 million viruses would fit inside one skin cell.

What's a virus?

A virus is an infectious particle that cannot reproduce on its own and is dependent on the machinery of a host cell that it has invaded.



It has a small genome typically consisting of a dozen or so genes encoded in either RNA or DNA. The genome is surrounded by a protein shell called the capsid. Some viruses have an outer lipid bilayer envelope, derived from host cell membranes. Some have envelope proteins associated with the envelope.

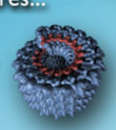
Virus Geometry

Most viral capsids form a symmetrical polyhedral shape. Twenty-sided icosahedrons are the most common, but twelve-sided dodecahedral capsids also exist. When enveloped, these viruses appear more spherical.

Some are bullet-shaped, like the rabies virus.

Others have more complex structures...

like the tobacco mosaic virus...



or various phages.

Virus Classification

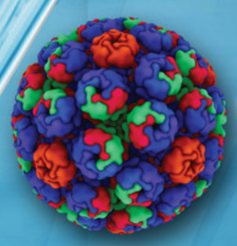
Viruses are genetically and structurally diverse. Each virus is specific about the host species, and even the cell it infects within the host. Plant, animal, and microbial cells are all susceptible to viral infections. It is not known how many different viruses there are, but estimates run in the millions. Because of the uncertain origins of viruses and their highly diverse host interactions, scientists have looked for relatively simple ways to describe and classify viruses. One way to classify a virus is by its type of genome. Some viruses have DNA, others have RNA, and in either case the genome can be single- or double-stranded.

Double-stranded DNA
Single-stranded DNA
Double-stranded RNA
Single-stranded RNA

The Baltimore Classification (below) is a system that groups viruses based on seven types of genome. Even this simple system has exceptions. Some viral genomes are made up of both RNA and DNA, some RNA viral genomes are both positive-* and negative-sense†, and some have both single- and double-stranded DNA.

The Baltimore Classification

I
double-stranded DNA viruses
For example, adenoviruses and herpesviruses

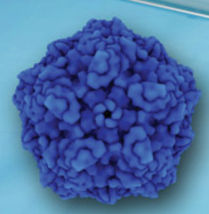


Simian virus 40

Found in many primates, including humans. SV40 infection is associated with tumors in hamsters, but no studies have linked SV40 to tumors in humans.

II
single-stranded DNA viruses
For example, parvoviruses

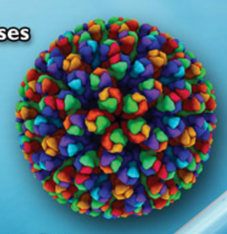
Canine parvovirus



Mainly affects dogs, especially puppies, by attacking lymph nodes and intestinal crypts. This leads to infection of the blood by bacteria that usually live in the intestines.

III
double-stranded RNA viruses
For example, reoviruses

Rotavirus



Causes stomach flu in humans, particularly in infants and young children.

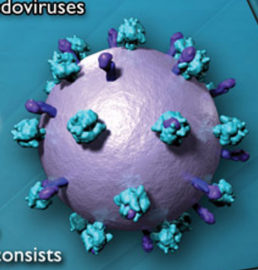
IV
(+)single-stranded RNA viruses
(genome is positive-sense* strand)
For example, picornaviruses

Dengue virus

Causes dengue fever in humans. It is an enveloped virus, but in its mature form, the lipid layer is completely obscured by envelope proteins.

V
(-)single-stranded RNA viruses
(genome is negative-sense† strand)
For example, orthomyxoviruses and rhabdoviruses

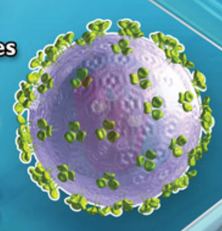
Influenza virus



Infects birds and mammals. Causes flu in humans. It is an enveloped virus. Its genome consists of seven or eight pieces of RNA.

VI
single-stranded RNA-RT‡ viruses
For example, retroviruses

HIV



Infects humans and chimpanzees. Causes AIDS in humans. It is an enveloped virus. During infection, its RNA genome is reverse-transcribed into DNA and inserted into the host genome.

VII
double-stranded DNA-RT‡ viruses
For example, hepadnaviruses

Hepatitis B virus

Capsid shown. Actual virus has an envelope around it. Causes hepatitis B in humans. Its DNA genome is partially single- and partially double-stranded. It replicates by first transcribing its DNA to RNA, then reverse-transcribing to DNA.

Other Classification Systems

International Committee on Taxonomy of Viruses: An ongoing effort to create a taxonomy similar to that for cellular organisms based on evolutionary relationships derived from sequence analysis and other characteristics. This taxonomy is important but also complicated to determine because of rapid viral evolution and transfer of genes between virus and hosts.

LHT system: Based on chemical and physical characteristics such as genome type, symmetry, presence or absence of envelope, diameter, and other factors. Some of the characteristics are not related to phylogeny. This is a little like classifying cars according to their body styles such as sedans, SUVs, or convertibles.

* **Positive-sense RNA**: Can be directly translated into proteins.

† **Negative-sense RNA**: Needs to be converted to positive-sense RNA before translation.

‡ **Reverse transcriptase** (RT): Viruses with RT synthesize DNA from RNA during infection.

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