The Zombies of the Scientific Community
Viruses
The Structure of Viruses

- viruses do not satisfy all of the criteria for being considered "alive" because they possess only a portion of the properties of living organisms
  - they cannot reproduce on their own

Viral Components

- **Capsid**
  - Shell surrounds the nucleic acid
  - **Nucleocapsid:** capsid and nucleic acid together
- **Envelope**
  - Not found in all viruses
  - Usually a modified piece of the host cell membrane
- **Naked viruses**
  - Consist only of a nucleocapsid

- **Spikes**
  - Found on both naked and enveloped viruses
  - Project from either the nucleocapsid or envelope
  - Allow viruses to dock with their host cells
- **Virion**
  - Fully formed virus able to establish infection in a host

The Viral Capsid:
The Protective Outer Shell

- Capsomeres
  - Identical protein subunits that spontaneously self assemble to form the capsid
- Helical capsid
  - Rod-shaped capsomeres that form a continuous helix around the nucleic acid
- Icosahedral capsid
  - Three-dimensional, 20-sided figure with 12 evenly spaced corners

The Viral Capsid

Complex capsids:

- Found in bacteriophage, the viruses that infect bacteria
- Have multiple types of proteins
- Take shapes that are not symmetrical

The Viral Envelope

- Composed of the membrane system of the host
  - Cell membrane or nuclear membrane
  - Regular membrane proteins are replaced with viral proteins
  - Spikes: protruding glycoproteins essential for attachment to the host cell

Nucleic Acids: At the Core of a Virus

- Genome: the full complement of DNA and RNA carried by a cell
- Viruses contain either DNA or RNA **but not both**
- The number of viral genes is small compared to that of a cell
- Possess only the genes necessary to invade host cells and redirect their activity

Nucleic Acids

- Positive-sense RNA
  - Single-stranded RNA genomes ready for immediate translation into proteins
- Negative-sense RNA
  - RNA genomes that need to be converted into the proper form to be made into proteins

Other Substances in the Virus Particle

- Enzymes for specific operations within the host cell
  - Polymerases: synthesize DNA and RNA
  - Replicases: copy RNA
  - Reverse transcriptase: synthesizes DNA from RNA
- Substances from the host cell
  - Arenaviruses pack along host ribosomes
  - Retroviruses "borrow" the host's tRNA molecules

Viral Size Range

- Ultramicroscopic size:
- Smaller than the average bacterium
- Electron microscopes are required to detect them
  - Parvoviruses: 0.02 μm in diameter
  - Mimiviruses: 450 nm in length—larger than some small bacteria
  - Cylindrical viruses: 0.8 μm long, but 0.015 μm in diameter

How Bacteriophages Enter Prokaryotic Cells

- **bacteriophages** are viruses that infect bacteria

  - there is a large diversity among these viruses in terms of shapes and amounts of DNA and proteins

  - when the virus kills the infected host in which it is replicating, this is called a **lytic cycle**

  - at other times the virus integrates itself into the host genome but does not replicate
    - this is called the **lysogenic cycle**
    - while residing in the host in this fashion, the virus is called a **prophage**

- during the integrated portion of the lysogenic cycle, the viral genes are often expressed along with the host genes

- the expression of the viral genes may have an important effect on the host cell
    - this process is called **lysogenic conversion**
    - the genetic alteration of a cell's genome by the introduction viral DNA is called **transformation**

How Animal Viruses Enter Cells

- animal viruses typically enter their host cells by membrane fusion
- a diverse array of viruses occur among animals
    - a typical example of an animal virus is **human immunodeficiency virus (HIV)**
    - HIV infection leads to acquired immunodeficiency syndrome (AIDS)
        - there is a long latency period between HIV infection and developing AIDS
- the HIV infects only certain cells within the human bloodstream
    - **macrophages** are attacked by HIV
        - the normal role of macrophages is to pick up cellular debris
    - HIV recognizes specifically the surface marker on macrophages, called **CD4**
        - protein spikes, called **gp120**, fit precisely to CD4 and allow HIV to attach to the macrophage
- certain cells of the immune system also possess CD4 markers
    - these include T lymphocytes, or *T cells* but they are not infected right away
    - once the T cells are infected and killed, AIDS commences
    - researchers speculate that the presence of a second receptor found on macrophages but not on T cells might be responsible for the infection rate differences
        - this co-receptor protein is called **CCR5**
- once inside the macrophage, the HIV virus sheds its coat and exposes its viral RNA
- reverse transcriptase from the virus makes a viral DNA copy of the RNA
    - the copying is not 100% accurate so many mutations can be incorporated into the DNA copy during each reverse transcription
    - the viral DNA version can then be integrated into the host cell DNA
    - new versions of the virus will be produced and released but this does not harm the host cell
- during the long latency period of HIV infection, the HIV cycles through macrophages and multiplies powerfully

- eventually, by chance, HIV alters the gene for gp120 in a way that causes the protein to change its allegiance with its coreceptor

- the new version of gp120 prefers to bind to a different coreceptor, **CXCR4**, which occurs on the surface of T cells with a CD4 marker
  - when HIV takes over the machinery of these cells and makes new viruses, the T cell dies

- the destruction of T cells, which fight other infections in the body, blocks the body's immune response and leads to the onset of AIDS

Disease Viruses

- **emerging viruses** are viruses that originate in one organism and pass to another organism
  - for example, influenza is fundamentally a bird virus and smallpox is thought to have passed from cows to humans
  - air travel and world trade in animals make emerging viruses a greater threat today than in the past

- the influenza virus is one of the most lethal viruses in human history
  - different strains of virus vary with respect to the composition of their protein spikes, which can be made of
    - hemagglutinin (H) or neuraminidase (N)
  - tremendous variability in these proteins makes it difficult to develop specific vaccines against a generation of virus
    - different flu vaccines are needed to protect against different subtypes of virus

- new strains of influenza usually originate in the Far East, where influenza hosts are common
  - the most common hosts are ducks, chickens, and pigs
  - these hosts live in close proximity to each other and to humans

Coronavirus

- Large family of viruses
- Some cause cold-like illnesses
- Some cause illness in animals
- Some (SARS-CoV and MERS-CoV) can be spread from animals to humans

COVID-19

- Positive-sense ssRNA
- Helical nucleocapsid
- First infections linked to live-animal market
  - Now being spread from human to human

Symptoms

- Fever
- Cough
- Shortness of breath
- Symptoms may appear from 2 days to 14 days after exposure