HIV (human immunodeficiency virus) is composed of two strands of RNA, 15 types of viral proteins, and a few proteins from the last host cell it infected, all surrounded by a lipid bilayer membrane. Together, these molecules allow the virus to infect cells of the immune system and force them to build new copies of the virus. Each molecule in the virus plays a role in this process, from the first steps of viral attachment to the final process of budding.

Since 1986, research on the structural biology of HIV has revealed the atomic details of these proteins. These structures are all publicly available in the Protein Data Bank (PDB) archive. Using these data, researchers have designed new treatments for HIV infection, including effective drug regimens that halt the growth of the virus. The structures also provide new hope for development of a vaccine.

The Structural Biology of HIV

Viral Enzymes

RT: Reverse transcriptase builds a DNA copy of the viral RNA genome, which is then used to build new viruses. This structure captures the structure for it in the PDB.

IN: Integrate takes the DNA copy of the viral genome and inserts it into the infected cellular genome. In this way, HIV can lie dormant in cells for decades, making it incredibly difficult to fight. Anti-HIV drugs that block integrase have been developed: PDB entry 1es4.

PR: HIV protease is essential for the maturation of HIV particles. The proteins in HIV are built as long polyproteins, which then must be cleaved into the proper functional pieces by HIV protease. Protease inhibitors are widely used as anti-HIV drugs, often in combination with drugs that block reverse transcriptase and integrase. PDB entry 1hpw.

Accessory Proteins

Vpr (viral protein u) helps the virus escape the cell during budding by weakening the interaction of the new envelope proteins with cell receptors. It is not thought to be present in the mature virion. PDB entries 1tp7 and 1vpa.

Vif (viral infectivity factor) attacks one of the cell’s defense proteins, which forces the cell to destroy it. Only a small portion of Vif (green) is shown in this structure, bound to proteins from the infected cell (purple). PDB entry 1slg.

Vpu (viral protein r) guides the viral genome into the nucleus following infection. PDB entry 1esx.

Nef (negative regulatory factor) forces the infected cell to stop making several proteins that are important in cell defense. Nef is important in the progression of HIV infection to Acquired Immune Deficiency Syndrome (AIDS). PDB entries 1a1t and 1qa5.

Rev (regulator of virion) protein binds to a hairpin in the viral RNA and regulates the splicing and transport of viral RNA. The structure shown here includes only the portion of the protein that is bound to the RNA—the whole protein is several times larger. PDB entry 1ef.

Tat (trans-activator of transcription) protein binds to a hairpin in the viral RNA and greatly enhances the amount of protein that is made. PDB entries 1hiv and 1jfw.

Structure References

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