The biology of Zika virus

Learn about the basic biology, origins, life cycle, and symptoms of Zika virus.

Introduction

You may have heard about Zika virus in the news. Because of Zika's recent spread in the Americas many people want to understand more about this virus.

In this article, we'll take a look at Zika from a biological standpoint. First, we'll examine the structure, life cycle and transmission mode of Zika virus, seeing how it infects cells. Then, we'll look at the effects of Zika on humans, as well as the prospects for controlling and managing the virus.

What is Zika virus?

Zika belongs to a group of viruses called the flavi-viruses, which includes dengue, West Nile, and yellow fever . Flavi-viruses are tiny structures made up of protein, RNA (a molecule related to DNA), and a lipid membrane. Each viral particle consists of a single stranded RNA genome tucked inside a protein shell called a capsid, surrounded by an external sphere of membrane known as the envelope . You can see Zika virus particles in the microscope image below right where they appear as small, dark spheres. One particle is marked with an arrow.

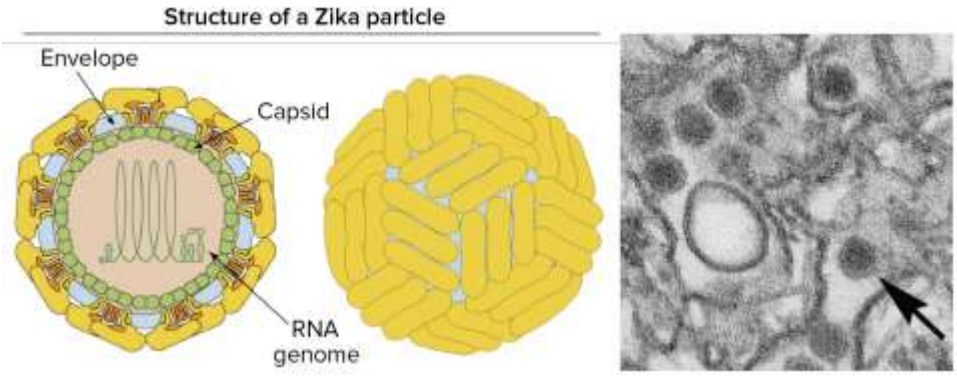


Image credit: left, modified from "Zika virus: Virion," by ViralZone, Swiss Institute of Bioinformatics (CC BY-NC 4.0); right, "Zika virus," by C. Goldsmith, CDC Public Health Image Library (public domain).

A defining characteristic of viruses is that they cannot reproduce on their own. Instead, they must infect host cells and “reprogram” them to become virus producing factories. Zika virus is no exception. It cannot replicate by itself, but can infect and replicate inside of the cells of several species, including humans, monkeys, and mosquitoes. Although we don't know which cell types Zika targets in the human body, studies with cultured cells (cells grown in a dish) show that Zika can infect a variety of immune cells found in human skin .

Where did Zika come from?

Zika is not a new virus. It was first isolated from a monkey in the Zika forest of Uganda in 1947, and the first human case was reported in 1954. A few additional cases were reported in Africa in the following years, and, starting at the end of the 1960s in equatorial Asia as well. No serious health complications or outbreaks were documented during this period, and blood tests for antibodies against Zika suggested that people in the affected areas were widely exposed to the virus. For these reasons, Zika was classified as a benign, sporadically occurring virus.

In 2007, the first documented outbreak of Zika took place, on Yap Island in Micronesia. In this outbreak, it was estimated that over 70% of the island's population

above the age of 3 was infected with the virus. Although no serious complications or hospitalizations were reported, an outbreak on this scale was unprecedented, as the total number of reported Zika cases to that point had been less than 15. A lack of previous exposure to Zika may have made the population of Yap Island more susceptible to outbreak than populations in the virus's normal range.
In 2013 and 2014, another Zika outbreak occurred, in French Polynesia and the surrounding islands. During this outbreak, health authorities noticed an increased frequency of neurological disorders, including Guillain Barré syndrome (which causes temporary paralysis), as well as nervous system and brain abnormalities in infants .

The first locally acquired cases of Zika in the Americas were reported in Brazil in May of 2015. Since then, the presence of Zika has been reported in many countries throughout South and Central America. The strains of Zika virus currently found in the Americas are closely related to those from the French Polynesia outbreak, suggesting that the virus may have reached Brazil from French Polynesia .

How is Zika transmitted?

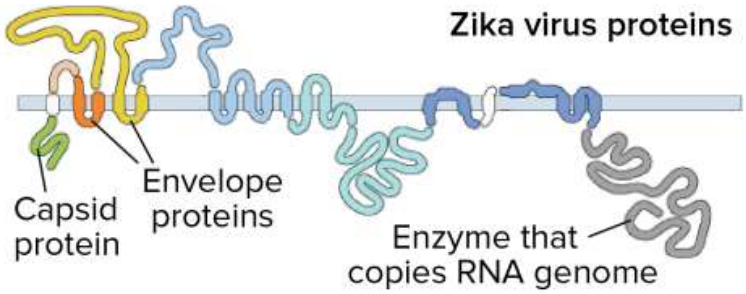
The primary mode of Zika transmission is through mosquitoes in the genus Aedes. In this regard, Zika is similar to related flavi-viruses such as dengue, yellow fever, and West Nile virus. When a mosquito eats a blood meal from a person infected with Zika, the virus can infect the cells of the mosquito. After the mosquito’s infection has developed (usually after a period of about a week and a half), its saliva will contain viral particles. When it bites another human to obtain a blood meal, the viral particles can be transmitted to the human, who may contract Zika.

Image credit: "Aedes albopictus," by James Gathany, in CDC Public Health Information Library (public domain).

Although this transmission pathway is by far the most common for Zika virus, other modes of transmission are also possible. For instance, a pregnant woman who contracts Zika may transmit the virus to her growing foetus, or to the baby during birth. There have also been a few documented cases of Zika transmission through sexual contact or through blood transfusions from a Zika-infected donor.

How does Zika infect cells?

Once Zika virus particles are in the human body, they must enter individual cells in order to replicate and make more viruses. Cell entry is possible because a Zika virus particle carries specific proteins on its outer envelope that interact with receptor proteins on human cells. When the viral proteins bind to cell receptors, they “trick” the cells into taking up the viral particle.



Inside the cell, the RNA genome of the virus is released into the cytoplasm, or fluid-filled main compartment, of the cell. There, the RNA molecule is “read” (translated) by enzymes in the cell to make a long protein, which is chopped up into a number of smaller proteins (see image at left). Some of these proteins are the structural components needed to make new viral particles, such as capsid and envelope proteins. Other viral proteins copy and process the RNA genome.

Viral proteins and copies of the RNA genome assemble at the surface of the endoplasmic reticulum (ER), a membrane compartment that’s part of the cell’s export system. New viral particles bud off into the interior of the ER, taking a small patch of ER membrane along with them. This "stolen" membrane will form the viral envelope. The particles then travel through another structure, the Golgi apparatus, where they undergo more processing before release at the cell surface. Released viral particles can infect other cells, continuing the infection cycle.

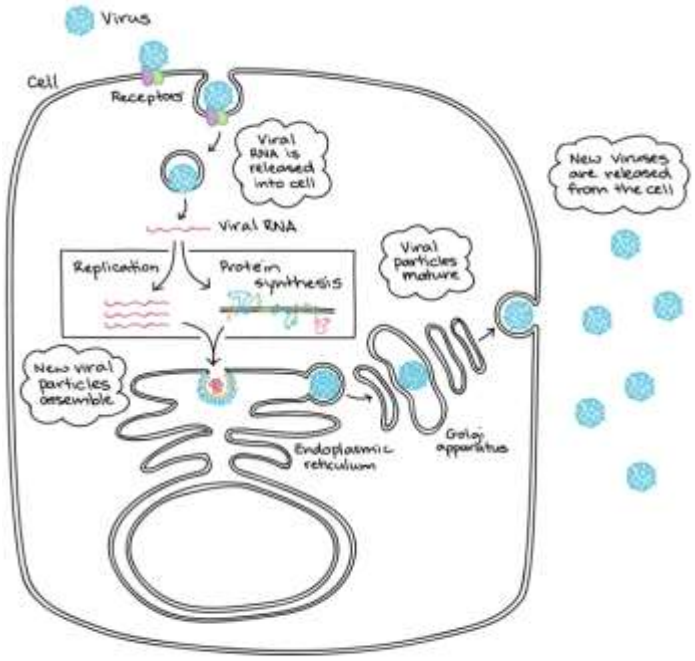


Diagram based on "The flavivirus life cycle." by Ted Pierson [15].

What are the symptoms and effects of Zika?

In most cases, the symptoms of Zika infection are very mild. According to the CDC, only 1 in 5 people infected with Zika will get sick at all, and typical symptoms may include rash, fever, conjunctivitis (irritation of the eyes), and joint pain . These symptoms generally resolve and most people do not experience any lasting effects from Zika.

Pregnant women and their unborn fetuses are at higher risk for harmful effects from Zika. Specifically there is a link between Zika infection during pregnancy and a condition called microcephaly (small head) in newborns. Microcephaly may involve neurological problems or developmental delays, but these effects vary greatly from person to person. Health authorities are encouraging women who are (or might become) pregnant to take steps to avoid Zika exposure.

In a very small fraction of cases, Zika may be linked with neurological problems, such as Guillain-Barré syndrome. Guillain-Barré syndrome is an autoimmune condition that causes paralysis, which is usually temporary (lasting for weeks or a few months in most cases). An increased frequency of Guillain-Barré syndrome has been reported in areas with active Zika infections, but researchers are still investigating whether there is a causal connection.

What can be done about Zika?

In the short term, health authorities have recommended that people protect themselves from Zika by avoiding exposure to mosquitos in areas where the virus is active. For people in high-risk groups, such as pregnant women, this might mean postponing travel to areas known to harbor Zika virus. For others who live in areas where Zika is active, avoiding exposure might mean remaining indoors, using mosquito repellents and mosquito nets and removing sources of standing water (which provide a breeding ground for mosquitoes).

In the longer term, a vaccine against Zika could provide more durable protection. Encouragingly, a vaccine against dengue, a flavivirus related to Zika was recently approved for use in Brazil. This vaccine was built off an inactive version of yellow fever another related flavivirus, and it’s possible that a similar strategy could be used for a Zika vaccine. Recently, promising initial results in mice were reported for one Zika vaccine candidate. However many more tests will be needed to establish whether this and other potential vaccines are safe and effective in humans.