Are viruses dead or alive?

If life were a monster movie, would viruses be vampires or zombies? Werewolves or Frankenstein’s monster? Would they be something else entirely? The first step in answering these questions comes down to – are viruses alive or dead? How do we determine whether something is alive? Let’s compare viruses to the 7 criteria researchers have set to determine if something is alive.

1. Living things must maintain homeostasis

Homeostasis is all about balance – can something control its internal temperature, or its internal contents? In earlier drafts of criteria for life, the requirement was that living things must be made of cells. Viruses are not made out of cells. A single virus particle is known as a virion, and is made up of a set of genes bundled within a protective protein shell called a capsid. Certain virus strains will have an extra membrane (lipid bilayer) surrounding it called an envelope. Viruses do not have nuclei, organelles, or cytoplasm like cells do, and so they have no way to monitor or create change in their internal environment. This criterion asks whether an individual virion is capable maintaining a steady-state internal environment on its own. Though some have argued that the capsid and envelope help virions resist change in their environment, the general consensus is that viruses do not pass this first requirement for life. Still, very few things in biology are black and white, so let’s check out how viruses do with the rest of the list before we make our final decision.

1. Living things have different levels of organization

Life is a complicated idea, and live organisms reflect that complexity in their structure. Smaller building blocks come together to make a larger product. Viruses certainly do this. They have genes made from nucleic acids and a capsid made of smaller subunits called capsomeres.

1. Living things reproduce

One of the basic urges in nature is for a species to pass on its genetic information. Viruses definitely multiply. While our immune system could certainly handle a single virion, it’s the hundreds of thousands of virions created in a short period of time that harm our cells. Viruses must use host cells to create more virions. Since viruses don’t have organelles, nuclei, or even ribosomes, they don’t have tools they need to copy their genes, much less create more virions. Since viruses don’t have organelles, nuclei, or even ribosomes, they don’t have the tools they need to copy their genes, much less create whole new virions. Instead, viruses enter living cells and then hijack the host’s cellular equipment to copy viral genetic information, build new capsids, and assemble everything together. We use term replicate, instead of reproduce, to indicate viruses need a host cell to multiply.

1. Living things grow

Living things grow. They use energy and nutrients to become larger in size or more complex. Viruses manipulate host cells into building new viruses which means each virion is created in its fully-formed state, and will neither increase in size nor in complexity throughout its existence. Viruses do not grow.

1. Living things use energy

This criterion is somewhat tricky. Creating new virion units is a major undertaking, from building nucleic acids to putting capsids together – that costs a lot of energy. However, all the energy that goes into this construction comes from, you guessed it, the host. While viruses will definitely benefit from the use of energy they are latching onto the host’s metabolism to get to it (maybe they’re vampires)?

1. Living things respond to stimuli

Whether viruses respond to their environment is one of the trickiest questions to answer. A response to a stimulus is defined by an almost immediate reaction to some change in the environment. While they don’t change behaviors in response to touch or sound or light the way that humans, bacteria, or sea sponges might, there has not been enough research done to definitively say that viruses do not respond to anything.

1. Living things adapt to their environment

Adaptation and evolution happen through unintentional changes (mutations) that are advantageous to an entire species. Viruses definitely adapt to their surroundings. Unlike the previous requirement, which required an immediate response, adaptation is a process that takes place over time. A virus can live in two different phases – the lytic phase (where the virus actively replicates in a host cell) and the lysogenic phase (where the viral DNA incorporate itself into the cell’s DNA and multiples whenever the cell multiples). Sometimes a host does not have enough energy or supplies to support the virus to actively replicate, so it will switch to the lysogenic phase. The virus can eventually reenter the lytic phase when conditions are right. This ability to adapt is what makes human immunodefiniceny virus (HIV) as hard to treat as it is. HIV mutates quickly because it makes frequent mistakes while replicating its genome. Because the virus is constantly changing, it makes it very hard to design drugs and vaccines against it. One drug might prevent a large number of virions from replicating, but just a few will be unaffected. Those surviving virions will continue to infect more cells, making copies of the resistant strains.

Where does this leave us? Are viruses alive or dead? Well, we know they’re not dead. Death is what happens when a living organism stops performing biological functions, and for the moment we’re only interested in the active particles. So were they ever alive? Most biologists say no. Viruses are not made out of cells, they can’t keep themselves in a stable state, they don’t grow, and they can’t make their own energy. Even though they definitely replicate and adapt to their environment, viruses are more like androids than real living organisms. (Think Data from Star Trek, Arnold Schwarzengger in Terminator, the Cylons in Battlestar Galactica or the robots in I, Robot). Just like crazy killer robots, viruses are created fully formed, and rely on host materials to build and power themselves.