The Code of Life:
A look at emerging Artificial Life

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AGCCCGTAAGCTACATCA
TTTACCATACTTACATAAC
TACGTTAGGCAGTACGGTA
CGTTACGTTACGAGTTCAG
CAGGACCTTAAGACGTGAC
GACAGTGTAGCAGTGAGAC
CGAGACACTCTAGACTAGC
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TATCGTAGACAGTACAG
TAGAACCGTGAACGTAGC
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01101010101011011101000101
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History of the Computer Virus

Long before computers became mainstream, self-replicating programs were being theorized. In 1949, computer "pioneer," John Von Nuemann published his paper, "Theory and Organization of Complicated Automata." In it, he proposed that it would be possible for computer programs to replicate themselves, or 'reproduce.' In the coming years, Bell Labs helped realize Von Nuemann's theory by creating a game called 'Core Wars,' in which two programmers would release "organisms" that fought for control of the computer. The hypothesis of self-replicating programs was driven forward in the 1970s by two science fiction writers, Brunner and Ryan. In their novels, *Shockwave Rider* and *Adolescence of P-1*, Brunner and Ryan (respectively) depict worlds in which programs can transfer from one computer to another without detection. Before given a formal name or description, the first virus was released into the "wild," or public domain, on Apple computers at Texas A&M University in 1981.

In 1983, Cohen coined the term "virus" in his Ph.D Thesis – a mathematical definition for the first computer virus. However, viruses were still seen as theoretical to the majority until 1986, when two brothers, Basit and Amjad, released the first PC virus, often referred to as the Pakistan Brain. Several years later, in 1988, one of the more common viruses, Jerusalem, was released. Within the next several years, viruses became more frequent. By 1990, they were enough of a widespread problem that there was a high demand for an anti-virus software program. The first such program was released in 1990 by Symantic – commonly known as Norton Anti-Virus. With a new method of detection and eradication, viruses required a more advanced code: a system that would allow them to outsmart the anti-virus software. From this, the polymorphic virus was created in 1991.

The polymorphic virus mutated, with each new infection, enough to avoid detection while still keeping the primary code of infection intact. Virus occurrences soared, increasing by 420% from December of 1990 to the beginning of 1992. In 1995, the release of Windows 95 had many believing that viruses would soon be eliminated. However, instead of making viruses weaker, Windows caused the creation of more virulent viruses, known as macro viruses that could exist in Windows format. Soon after, the first virus to affect Java code was created. By 2000, viruses had become able to transmit themselves in attachments through email and Internet Chat Relays. To date, there are more than 50,000 known viruses currently in circulation. Many can send themselves through computers without attachments, hiding in HTML code, bury themselves in System resources and bypass or disable anti-virus software.

What is a Computer Virus?

Computer viruses can vary greatly from one another, but they are based in computer code – or a series of ones and zeros. Though not all computer viruses are malicious, most tend to "infect" computer systems and overwrite or damage the software in an attempt to spread itself and comprise the system. Viruses can be based in a number of formats: Java code, HTML code, hidden applets, text documents and several other things. In short, it is a computer program that is able to attach itself to disks or other files and replicate itself repeatively, often without the users knowledge. Although most viruses damage a system, it is not necessary for the definition of a virus.

Types of Computer Viruses

Since viruses first became widely used, several variants have been created. The following table illustrates the most common types found today:

Name	**Description**
Anti –Anti-virus Virus	Anti-antivirus viruses attack, disable or infect specific anti-virus software. Also: Retrovirus
Armored Virus	Any virus that tries to prevent analysis of its code. It can use one of many methods to do this.
Bimodal Virus	A virus that infects both boot records as well as files.
Boot Sector Infector	A virus that places its starting code in the boot sector. When the computer tries to read and execute the program in the boot sector, the virus goes into memory where it can gain control over basic computer operations. From memory, a boot sector infector can spread to other drives (floppy, network, etc.) on the system. Once the virus is running, it usually executes the normal boot program, which it stores elsewhere on the disk.
Cavity Viruses	A virus that overwrites a part of its host file without increasing the length of the file while also preserving the host's functionality in order to limit or deter detection.
Companion Virus	Companion viruses use a feature of DOS that allows software programs with the same name, but with different extensions, to operate with different priorities. The virus creates a program with a higher priority, ensuring its running instead of the original program.
Direct Action Virus	A virus that immediately loads itself into memory, infects files, and then unloads itself.
Dropper	A carrier file that is used to hide the virus until it can be unloaded onto a system.
Encrypted Virus	An encrypted virus's code begins with a decryption algorithm and continues with scrambled or encrypted code for the remainder of the virus. Each time it infects, it automatically encodes itself differently, so its code is never the same. Through this method, the virus tries to

	avoid detection by anti-virus software.
Fast Infector	Fast infector viruses, when active in memory, infect not only executed programs, but also those that are merely opened. Thus running an application, such as anti-virus software, which opens many programs but does not execute them, can result in all programs becoming infected.
File Viruses	File viruses usually replace or attach themselves to COM and EXE files. They can also infect files with the extensions SYS, DRV, BIN, OVL and OVY. File viruses may be resident or non-resident, the most common being resident or TSR (terminate-and-stay-resident) viruses. Many non-resident viruses simply infect one or more files whenever an infected file runs.
Logic(Mail/Time) Bomb	A logic bomb is a type of trojan horse that executes when specific conditions occur. Triggers for logic bombs can include a change in a file, by a particular series of keystrokes, or at a specific time or date
Macro Virus	A macro virus is a malicious series of instructions designed to simplify repetitive tasks within a program. Macro viruses are written a macro programming language and attach to a document file (such as Word or Excel). When a document or template containing the macro virus is opened in the target application, the virus runs, does its damage and copies itself into other documents. Continual use of the program results in the spread of the virus
Master Boot Sector Virus	Master boot sector viruses infect the master boot sector of hard disks, though they spread through the boot record of floppy disks. The virus stays in memory, waiting for DOS to access a floppy disk. It then infects the boot record on each floppy disk DOS accesses.
Memory Resistant Virus	A virus that stays in memory after it executes and infects other files when certain conditions are met.
Multipartite Virus	Multipartite viruses use a combination of techniques including infecting documents, executables and boot sectors to infect computers. Most multipartite viruses first become resident in memory and then infect the boot sector of the hard drive. Once in memory, multipartite viruses may infect the entire system.

Mutating Virus	A mutating virus changes, or mutates, as it progresses through its host files making disinfection more difficult. The term usually refers to viruses that intentionally mutate, though some experts also include non-intentionally mutating viruses.
Overwriting Virus	An overwriting virus copies its code over its host file's data, thus destroying the original program. Disinfection is possible, although files cannot be recovered. It is usually necessary to delete the original file and replace it with a clean copy.
Polymorphic Virus	Polymorphic viruses create varied (though fully functional) copies of themselves as a way to avoid detection from anti-virus software. Some polymorphic virus use different encryption schemes and requires different decryption routines. Other polymorphic viruses vary instruction sequences and use false commands in the attempt to thwart anti-virus software. One of the most advanced polymorphic viruses uses a mutation-engine and random-number generators to change the virus code and its decryption routine.
Program Infector	A program infector virus infects other program files once an infected application is executed and the activated virus is loaded into memory.
Resident Virus	A resident virus loads into memory and remains inactive until a trigger event. When the event occurs the virus activates, either infecting a file or disk, or causing other consequences. All boot viruses are resident viruses and so are the most common file viruses.
Self-Encrypting Virus	Self-encrypting viruses attempt to conceal themselves from anti-virus programs. Most anti-virus programs attempt to find viruses by looking for certain patterns of code (known as virus signatures) that are unique to each virus. Self-encrypting viruses encrypt these text strings differently with each infection to avoid detection.
Self-Garbling Virus	A self-garbling virus attempts to hide from anti-virus software by garbling its own code. When these viruses spread, they change the way their code is encoded so anti-virus software cannot find them. A small portion of the virus code decodes the garbled code when activated.

Sparse Infector	A sparse infector viruses use conditions before infecting files. Examples include files infected only on the 10th execution or files that have a maximum size of 128kb. These viruses use the conditions to infect less often and therefore avoid detection.
Stealth Virus	Stealth viruses attempt to conceal their presence from anti-virus software. Many stealth viruses intercept disk-access requests, so when an anti-virus application tries to read files or boot sectors to find the virus, the virus feeds the program a "clean" image of the requested item. Other viruses hide the actual size of an infected file and display the size of the file before infection. Stealth viruses must be running to exhibit their stealth qualities.
Trojan Horse Program	A Trojan horse program is a malicious program that pretends to be a benign application; a Trojan horse program purposefully does something the user does not expect. Trojans are not viruses since they do not replicate, but Trojan horse programs can be just as destructive.
Worm	Worms are parasitic computer programs that replicate, but unlike viruses, do not infect other computer program files. Worms can create copies on the same computer, or can send the copies to other computers via a network. Worms often spread via IRC (Internet Relay Chat).
Zoo Virus	A zoo virus exists in the collections of researchers and has never infected a real world computer system

Artificial Life: A New Perspective

The traditional definitions of Artificial Life and Artificial Intelligence describe approaches to simulated environments. In most works, Artificial Life is the name given to the disciple of studying natural life by recreating biological processes from scratch in a computer system. Similarly, Artificial Intelligence describes the study and creation of computers able to perform tasks, which are currently done better by humans. However, for the remainder of this discussion, the term "Artificial Life" will not describe the traditional study. Instead, as most computer viruses were not created with the intent to study biological processes, but rather as a malicious tool, the term "Artificial Life" will be used to describe "Life" artificially created. In order to answer the question of whether anything is life, artificial or organic, we must first define what we mean by life. Although there is no consensus on what it means to be an organism, most scientists agree that the following 7 properties are shared by all organisms, and therefore constitute life. First, an organism must have an organized physical form. Its structure must consist of parts that work together as a whole to perpetuate its existence and ensure its survival. Secondly, an organism must have the property of homeostasis. It must be an entity, separate from its environment, maintaining relative internal stability through regulatory processes. Next, living things must also interact with its environment, responding and adapting to external stimuli. Additionally, they must have a metabolism - a method of converting energy from the environment into material that can be used for its own growth and maintenance. Following from that, an organism must be able to grow, not just on a population level through reproduction, but also on an individual level, expanding, changing and developing as it matures. It must also be able to reproduce itself and perpetuate the existence of its species.

Lastly, it must have the ability to evolve. In order to be considered a form of life, it must possess a system of passing on its genetic material with the possibility of mutation in order for its progeny to change, enabling the species to adapt to the current environment, a mechanism for ensuring its survival.

What constitutes a Biological Virus?

Biological viruses are fragments of DNA or RNA that have detached from genomes of organisms. They are acellular, so they do not consist of cells as organisms do, but instead are made up of a protein sheath called a capsid, which envelopes the nucleic acid. An outside layer of proteins, lipids and glycoproteins surrounds the capsid, and further protects the genetic material within it. This structure, called a virion, takes on a helical (rod-like) or isometric (spherical) form. Although viruses reproduce, they cannot reproduce on their own, for they lack the ribosomes and enzymes needed for protein synthesis and energy production, functions involved in the replication of nucleic acids. Instead, they inject their DNA or RNA into a host cell, which reproduces the nucleic acid for them. Bacteriophages, viruses that infect bacteria, are the most common viruses. The structure of bacteriophages consists of a head, the part of the capsid that contains the nucleic acid, a neck, whiskers, a tail, base plate and tail fibers. They can reproduce through one of two methods: the lyctic cycle, or the lysogenic cycle. In the lytic cycle, the phage reaches for a bacteria cell through its tail fibers, and attaches itself to a receptor protein of the host's cell wall by its base plate. Its tail tube then contracts and pierces the bacteria cell, injecting its genetic material into the cell like a syringe. This causes the host cell to cease replication of its own genetic material and to start the replication of the phage's genetic material. Through the processes of replication, transcription and translation, the host cell produces virus proteins, which lead to the production of new viruses, all inside the cell body. Eventually, so many viruses are produced that the virus enzymes force the bacteria's cell wall to rupture, releasing the new viruses to infect other cells. In the lysogenic cycle, the phages are said to be dormant in that they do not force the host cell to reproduce their genetic material directly. Instead, their DNA or RNA is integrated into the host cell's genome. This way, the cell can continue to live and divide itself, but it replicates the phage's genetic material in doing so, kept safe for future use. The integrated virus nucleic acid remains dormant until it decides to force its host cell into the lytic cycle, when the host cell is running low on energy and the survival of the virus is best ensured by finding a different host.

Biology and Computers: Where the Two Meet

Although some deny biological viruses to be a form of life, looking at the similarities between computer and biological viruses helps shed light on whether computer virus can be classified as a form of life. As mentioned before, the possession of an organized physical form is one of the criteria for life. While the structure of a virus includes a capsid with a surrounding protein layer, it is essentially just a strand of genetic code made of nucleic acid, which is the basic structure of all earth-based life – the building blocks and instruction code for every part of the organism. Computer viruses, although not composed of nucleotides, are built up from a similar type of code. Both types of viruses can be reduced to a complex, but simply put together, coding structure.   Additionally, both sorts of viruses are homeostatic in that they maintain their own, independent internal structure. Computer viruses are able to exist on their own by working off of their given code structure. Although they can only do damage in a computer system, the system is not necessary for their existence or task performance. Similarly, biological viruses can maintain their own internal environment. Both have the ability to manipulate and more generally interact with the outside environment. They work in the same manner as parasites, destroy and/or feeding off of the surrounding resources. For organic viruses, this interaction is the destruction of host cells as they infect the cells and provoke the hosts to cease replication of its own DNA and begin replication of the virus' DNA. For computer viruses, the interaction is in the form of overwriting and altering the code to other files, also destroying them in the process. Furthermore, they are both deficient of a metabolism. In this respect, they differ from the definition of life, but share this quality with each other. Organic viruses do not metabolize – they do not perform cellular respiration, fermentation, photosynthesis, or any other forms of metabolism employed by organisms. This again stems from their simple structure: because they consist entirely of proteins and nucleic acids, not cells, they do not possess the organelles necessary to perform any of the aforementioned processes, and instead depend on other organisms to supply the energy for their only real need: reproduction. Similarly, computer viruses do not convert their own energy, for they have no need of sustenance, but do depend on the electrical energy of its computer system for its spread. Therefore, while neither type of virus converts energy independently, they direct outside energy to their advantage, forcing either their host cell or computer system to use its energy to advance the reproduction of the virus. Moreover, neither exhibits individual growth and development; although both demonstrate growth through reproduction – utilizing the external system to replicate themselves. As mentioned before, biological viruses utilize the internal mechanisms of their host cells, injecting their genetic material into them which programs the host cell to make copies of the virus. Similarly, computer viruses use the email system to transmit, replicate and spread themselves, sometimes overwriting other existing code. Lastly, both evolve through intended and accidental mutation. Computer viruses often hold code that creates random mutations during each reproductive cycle in a similar manner to how biological viruses mutate due to organized gene crossing. Also, organic viruses can undergo accidental mutation due to radiation, mismatched coding and other processes. Computer viruses are often subject to un-intended mutation from random computer interference or incorrect coding.

Fork in the Road: The Differences in the Two Viruses

However, computer viruses also have properties that diverge from those of organic viruses. First of all, unlike organic viruses, which have capsids, embodying their genetic code, the structure of computer viruses consists only of their code itself, and the manifestation of that code. The origin of computer viruses is also very different from organic viruses and in this lays their most fundamental difference. Because organic viruses were created through natural processes and computer viruses through artificial processes, it is this property that marks one as being life, while the other a possible form of artificial life. They also differ in the system they infect. Biological viruses, existing in our organic terrestrial world infect organic material; cells ranging from bacteria cells, to plant cells, to animal cells. Computer viruses, on the contrary, infect the files of their virtual world in cyberspace. Their main difference, however, is that, unlike organic viruses, computer viruses can exist outside this system. If an organic virus had no host cell to store and replicate its genetic material, the virus would not only fail to reproduce, but its genetic material would degenerate, ceasing the virus' existence. The computer virus, on the other hand, can exist, and even replicate outside of the computer system, on a disk, for instance. In this way, computer viruses posses an attribute of life that organic viruses do not.

Conclusion

Of the seven properties of life, computer viruses display all but two: metabolism and individual growth. Organic viruses, which some scientist debate as being life, are missing three qualities: metabolism, individual growth and an aspect of homeostasis. In a sense, computer viruses are thus more alive that organic viruses. In Earth's history, the study of life has been narrowed to organic, carbon-based life forms. However, as our knowledge of life grows and our ability to create living processes develops, the properties that once were considered essential to life must be questioned. Life as we know it must be distinguished from life as it could be. Growth and metabolism are two properties of life here and now, or Earth-based life, but their necessity must be questioned when looking at classifying all life. Should the limitations of growth and metabolism within a virtual reality – one occupying no space – exclude the possibility of life? Computer viruses exhibit some of the most fundamentals of all things considered alive. Despite their artificial origin, many viruses have grown beyond the initial code of the programmers – adapting and evolving in order to survive. Some display what could seem to be a protection or image of their "self." They have the ability to find hidden systems, recognize anti-viral software and explore different computer systems. Perhaps computer viruses cannot be classified as life under the current definition, but a close examination reveals that, despite their wanting of certain features, they act and develop as most life forms, even more so than biological viruses. In an attempt to create artificial systems to mimic natural life, programmers have managed to create alternative life. Though not all computer viruses are advanced, those more advanced, the ones discussed in this paper, should constitute simplistic Artificial Life: life, or a creature displaying life qualities, artificially created.

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