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What is the difference between a virus species and a virus? The same as the difference between *Homo sapiens* and you

Qual é a diferença entre uma espécie de vírus e um vírus? A mesma diferença existente entre *Homo sapiens* e você

¿Cuál es la diferencia entre una especie de virus y un virus? La misma diferencia existente entre un *Homo sapiens* y usted

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There is widespread confusion about the difference between a virus "species" and a "virus". Letters are written between otherwise polite virologists, pointing out how this person or that does not understand the difference; papers are published in *Archives of Virology*, the official "voice" of the International Committee for Taxonomy of Viruses; and journals continue to make the same errors that they have been making in this regard. As someone once told me, "No one should discuss politics, religion, or virus taxonomy in polite company". This is probably true, but the clarification of terms is a necessity for compulsive people, including scientists. We like to have things organized (a useful personality flaw) until it comes to taxonomy, whereupon we say, "What is the difference? Who cares?". The answer is that we must care.

The purpose of taxonomy is to sort things into categories that we can understand and which are useful for teaching. No one would put an elephant and a cut rose in the same category (unless the categories are "Alive" and "Not alive," and then what about a dead elephant?). Carl Linnaeus (1707-1778), also known as Carl von Linné (Carolus Linnaeus), was a Swedish botanist, physician and zoologist who provided the foundation for modern biological nomenclature and taxonomy. Linnaeus liked things "neat" (which is not to say "correct"), and he was not satisfied with the unwieldy names used at that time for biological entities. He brilliantly and consistently applied a single system to all sorts of living things, a system that we call "binomial nomenclature", which had been developed by Gaspard (or Caspar) Bauhin almost 200 years earlier. There are, for example, more than 800,000 recognized species of insects on earth, more than all other animals and plants combined. Of these, nearly half are beetles, making up one-fifth of the 1.5 million recognized species. As J. B. S. Haldane said, "If one could conclude as to the nature of the Creator from a study of his creation it would appear that God has a special fondness for stars and beetles". Linnaeus showed us the way to sort out such potential untidiness.

In the partly logical, partly biological system that Linnaeus created, kingdoms are the broadest categories of taxonomic organization. Based on increasing levels of divergence, there are phyla (singular: phylum), classes, orders, families, genera (singular: genus), and species. Groups of organisms at any of these ranks are called "taxa" (singular: taxon) or "taxonomic groups". The "binomial" aspect provides latinized names at all levels, the most commonly used being the genus and species levels, such that we have *Homo sapiens* for humans, *Canis lupus familiaris* for dogs, and so on. Each species of mammal, bird, insect, plant, and so forth has its own taxonomic name, so that one cannot confuse a human and a dog, irrespective of whether they could both be classified as "land mammals". A canid may be a "dog" in English-speaking areas and "cão" in other places, but it is *Canis lupus familiaris* everywhere (and if a "poodle" being a subspecies of "wolf" does not tell you something about the difference between taxonomy and the real world, nothing will).

Stephen Jay Gould, an American paleontologist, evolutionary biologist, historian of science and baseball fanatic (a good hobby for compulsive people), who developed the theory of "punctuated equilibrium" with Niles Eldredge, said that "Taxonomy (the science of classification) is often undervalued as a glorified form of filing – with each species in its prescribed place in an album; but taxonomy is a fundamental and dynamic science, dedicated to exploring the causes of relationships and similarities among organisms. Classifications are theories about the basis of natural order, not dull catalogues compiled only to avoid chaos"[1].

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At this time, taxonomy is a branch of biology rather than a necessary peculiarity. Why then do so many otherwise intelligent people have so much difficulty understanding taxonomy and applying it to their work? I do not know, but I am certain that many scientists have a nonsensical indifference to taxonomy, even going as far as responding irately to the necessity for neatness. Most people find that organization is more functional than disorganization. Taxonomy, the hierarchical classification of living things, is certainly not only for the obsessive-compulsive among us; it goes beyond "neatness". Taxonomy is a rational method for putting things in order so that we can understand where something fits (or does not fit) with other things. We could classify mammals as sea mammals and land mammals, fish as large or small, rodents as edible or inedible, and so on, but of what use would that be?

Whereas one can use any type of organizational system that works, one cannot simply go about renaming genera and species for one's personal convenience. That would be counterproductive because no one else would know what you are talking about. The taxonomic system currently in use is a universal system; it does not vary from place to place.

Taxa are lists of names. Taxonomists even change them from time to time as additional information is accumulated. Taxa are categories or "non-concrete entities". They do not exist, except as names on lists of names; they are wholly imaginary, expressions of the mind, not physical entities. Formations of taxa are subjective. We form them from genetic information and biological peculiarities, which reflect this genetic information. If there were no taxa, the names of the individuals placed in them would not disappear. Those individuals are real, they exist, and they have particular characteristics. For example, João is a common masculine name in Brazil. It is the name of a certain individual, not the name of the species (*Homo sapiens*) to which he belongs. His family name may be Silva, but he is still placed taxonomically in the species *Homo sapiens*. *Homo sapiens* is the taxon in which humans have been placed by taxonomists. The person is João Silva. He is not a taxon, he is a person. It does not matter that João Silva has blond hair, is two meters tall, weighs 100 kilos, has one blue and one brown eye, and was able to read at the age of two years. Those are individual characteristics and they do not affect João's taxonomy. You may take João to a football game, but you cannot take *Homo sapiens* anywhere. You may purchase ice cream for João, but you need not bother to purchase ice cream for *Homo sapiens*; it cannot eat – it does not exist. You may call João for dinner, but if you stand in the street and shout "Dinner, *Homo sapiens*", the local mental health unit may pay you a visit. Besides, all of the children playing outside might come to your door to be fed – they are all of the same species.

Species have no characteristics or substance. They cannot be held, fed, or fertilized, and their genomes cannot be sequenced. They have no genomes, no measurements, and no defined characteristics. It is only individuals placed in a particular taxon that can be defined. This is an important concept when applied to viruses or to any other biological entity. Viruses are real and taxa are merely names.

If one captures a free-tailed bat in Brazil, let us say a member of the species *Tadarida brasiliensis*, one has captured a free-tailed bat, not a *Tadarida brasiliensis*. Because a taxon does not exist, it cannot be captured. You will not be able to obtain funding to study a species, although you might be funded to study members of a species. Likewise, you may identify a virus, but you cannot identify a virus species. Viruses have a number of diagnostic properties; the taxon does not. Species are defined by taxonomists. Van Regenmortel and others have defined a virus species as "a polythetic class of viruses constituting a replicating lineage and occupying a particular ecological niche"[2,3]. That is, a species is a taxonomic class.

To ignore proper taxonomy is to ignore history; it is also to ignore the similarities and differences between living things, the evolutionary insights of classification. It means choosing chaos over neatness. Virologists, bacteriologists, parasitologists, mycologists, mammalogists, ornithologists, ichthyologists, and just about everyone else sort their subjects of study and separate them into related categories. To do otherwise – to not sort things and then try to make sense of the resulting pile of unrelated items – may be the first indication of the need for psychiatric help. People who collect postage stamps, coins, books, beer bottles, autographs, or any of hundreds of other things know what I mean; many of these people are otherwise normal.

When you write a scientific manuscript about your favorite deadly disease agent, rest assured that you do not have to be a taxonomist. The first time you mention your microscopic friend, provide the genus and species names and then never mention them again. It is really simple and it adds depth to your paper. The reader immediately knows in which section of the brain to store this information and can then move on to read your paper with greater understanding. Taxonomy is one way in which you let the world know you know what you are doing. Alternatively, if you do not know what you are talking about the world will know that also[4]. Taxonomy may not be important within the greater view of the world but it is useful.

A problem with bacteriology, parasitology and mycology is that these fields do not have common names for all their organisms. Therefore, they have to write the name of the species (the taxon) as causing disease or otherwise being studied. We have proposed a solution to their problem[5] but we virologists already have a solution to the question of viruses – if investigators writing about viruses will pay attention to the proper use of words.

In sum, no one can isolate *Ilheus virus* (for example); that is a species, as indicated by the italics. Within the species *Ilheus virus*[6] are two viruses, Ilheus virus and Rocio virus, as indicated by the lack of italics. You may isolate, diagnose, sequence the RNA of, or otherwise study either virus but you cannot isolate, diagnose, sequence the RNA of or otherwise study a taxon. The proper way to write the name of a virus and to indicate its taxonomy is to say, for example, "We isolated Ilheus virus (family *Flaviviridae*, genus *Flavivirus*)". Simple enough.

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