Virus in the Room

Two Tales of Symbiosis
by Welkin Johnson

As biologists, we divvy the biological realm up into domains using a formula that frankly, smacks of nepotism, bestowing three glorious domains upon our closest relatives—the Eucaryota, the Archaea, and the Bacteria—while committing an injustice to the so-called viruses, lumping them together in a miscellaneous catch-all category (“viruses,” from Latin for poison and other noxious substances) with contemptible disregard for phylogeny or any true measure of diversity.

Imagine that viruses, like Dr. Seuss’s Truffula Trees, had a vocal advocate like The Lorax. Undoubtedly, through the agency of their outspoken mouthpiece, they would protest these gerrymandered borders and laugh at our skewed notions of biological diversity. After all (the viruses would argue), just consider the platypus, the coelacanth, the earthworm, and the bacillus. All these organisms have double-stranded DNA genomes, whose lengths all fall within roughly the same order of magnitude, which they replicate using evolutionarily customized versions of what amounts to the same basic enzymatic apparatus. How boring! How unimaginative! Now consider this (the viruses go on to say): the giant Mimivirus, 1,256 nm of girth enfoldiing >1,000,000 base pairs of DNA, and the tiny Circovirus, with a mere 1,800 bases of single-stranded DNA tucked inside a 20-nm-wide shell, are neither more nor less related to one another than either one is to an elephant! (For those who are not familiar with the elephant, it is a relative of the platypus, the coelacanth, the earthworm, and the bacillus).

Let us thumb through the catalogue of viral genomes: here we find the familiar double-stranded DNA, including both linear and circular genomes, but also some with not-so-familiar twists—poxviruses, for example, covalently closing both ends of their linear double-stranded DNA genomes. We also find an abundance of themes not found anywhere among the domains of cellular life: thus, there are viruses with single-stranded DNA genomes, and viruses with single-stranded RNA genomes, the latter including some that are negative-sense, some positive-sense, and some part positive and part negative (ambisense). Additionally, there also viruses with double-stranded RNA genomes, and if that isn’t bizarre enough, there are viruses with segmented RNA genomes (to which the influenza virus, whose virions incorporate a precise complement of eight different RNA segments, will bear witness).

Equally impressive are the Reoviruses, with genomes composed of a dozen different segments of double-stranded RNA. Replicate that! And there are retroviruses, whose genomes are sometimes RNA (in the virion), and at other times double-stranded DNA (upon entering a host cell). Hepadnaviruses, possible cousins to the retroviruses, have gapped, double-stranded DNA genomes with a bit of RNA thrown in, which they, too, convert to DNA by means of reverse transcriptase.

This diversity of genome styles each comes with its own uniquely tailored replication system dictated in part by the need (shared by all viruses) to generate mRNA (because all viruses rely on host cells for translation). Importantly, there is very little if any phylogenetic evidence for a common ancestry connecting all the different viral types, or for grouping viruses together. Attempts to prove the existence of a last universal common ancestor of all viruses may be folly, as it is entirely possible that no such ancestor ever existed (that is, what we lump together as “viruses” actually represent uniquely evolved biological entities that happen, just by chance, to have taken on obligate intracellular parasitism as a mode of existence). At best, and by stretching the limits of phylogenetic comparisons, some of the RNA viruses can be combined into hypothetical “supergroups.”

The tables thus turned, the viruses demand a fair redistricting, with the viral realm to include no fewer than seven domains to our three. They also ask that we wear nametags, since they are having trouble remembering how to tell an elephant from a bacillus.