

# **Theories of Virus Origin**

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# Three main hypotheses have been articulated

1. The progressive, or escape, hypothesis states that viruses arose from genetic elements that gained the ability to move between cells;
2. the regressive, or reduction, hypothesis asserts that viruses are remnants of cellular organisms; and
3. the virus-first hypothesis states that viruses predate or coevolved with their current cellular hosts.

# The Progressive Hypothesis

- According to this hypothesis, viruses originated through a progressive process.
- Mobile genetic elements, pieces of genetic material capable of moving within a genome, gained the ability to exit one cell and enter another.
- To conceptualize this transformation, let's compare the replication of retroviruses, the family of viruses to which HIV belongs with retrotransposons.
- Like retroviruses, certain classes of retrotransposons, the viral-like retrotransposons, encode a reverse transcriptase and, often, an integrase.
- With these enzymes, these elements can be transcribed into RNA, reverse-transcribed into DNA, and then integrated into a new location within the genome.
- We can speculate that acquisition of a few structural proteins could allow element to exit a cell and enter a new cell, thereby becoming an infectious agent.
- Indeed, the genetic structures of retroviruses and viral-like retrotransposons show remarkable similarities.

# The Regressive Hypothesis

- In contrast to the progressive process just described, viruses may have originated via a regressive, or reductive, process.
- Microbiologists generally agree that certain bacteria that are obligate intracellular parasites, like *Chlamydia* and *Rickettsia* species, evolved from free-living ancestors.
- Indeed, genomic studies indicate that the mitochondria of eukaryotic cells and *Rickettsia prowazekii* may share a common, free-living ancestor.
- It follows, then, that existing viruses may have evolved from more complex, possibly free-living organisms that lost genetic information over time, as they adopted a parasitic approach to replication.
- Viruses of one particular group, the nucleocytoplasmic large DNA viruses (NCLDVs), best illustrate this hypothesis.
- Because of the size and complexity of NCLDVs, some virologists have hypothesized that these viruses may be descendants of more complex ancestors.

# The Virus-First Hypothesis

- The progressive and regressive hypotheses both assume that cells existed before viruses. What if viruses existed first?
- Recently, several investigators proposed that viruses may have been the first replicating entities.
- It is postulated that viruses existed in a precellular world as self-replicating units.
- Over time these units, they argue, became more organized and more complex.
- Eventually, enzymes for the synthesis of membranes and cell walls evolved, resulting in the formation of cells.
- Viruses, then, may have existed before bacteria, archaea, or eukaryotes.
- Most biologists now agree that the very first replicating molecules consisted of RNA, not DNA. We also know that some RNA molecules, ribozymes, exhibit enzymatic properties; they can catalyze chemical reactions.
- Perhaps, simple replicating RNA molecules, existing before the first cell formed, developed the ability to infect the first cells.
- Could today's single-stranded RNA viruses be descendants of these precellular RNA molecules?