For bacteria, a small genome means some serious decluttering—even in the ribosome

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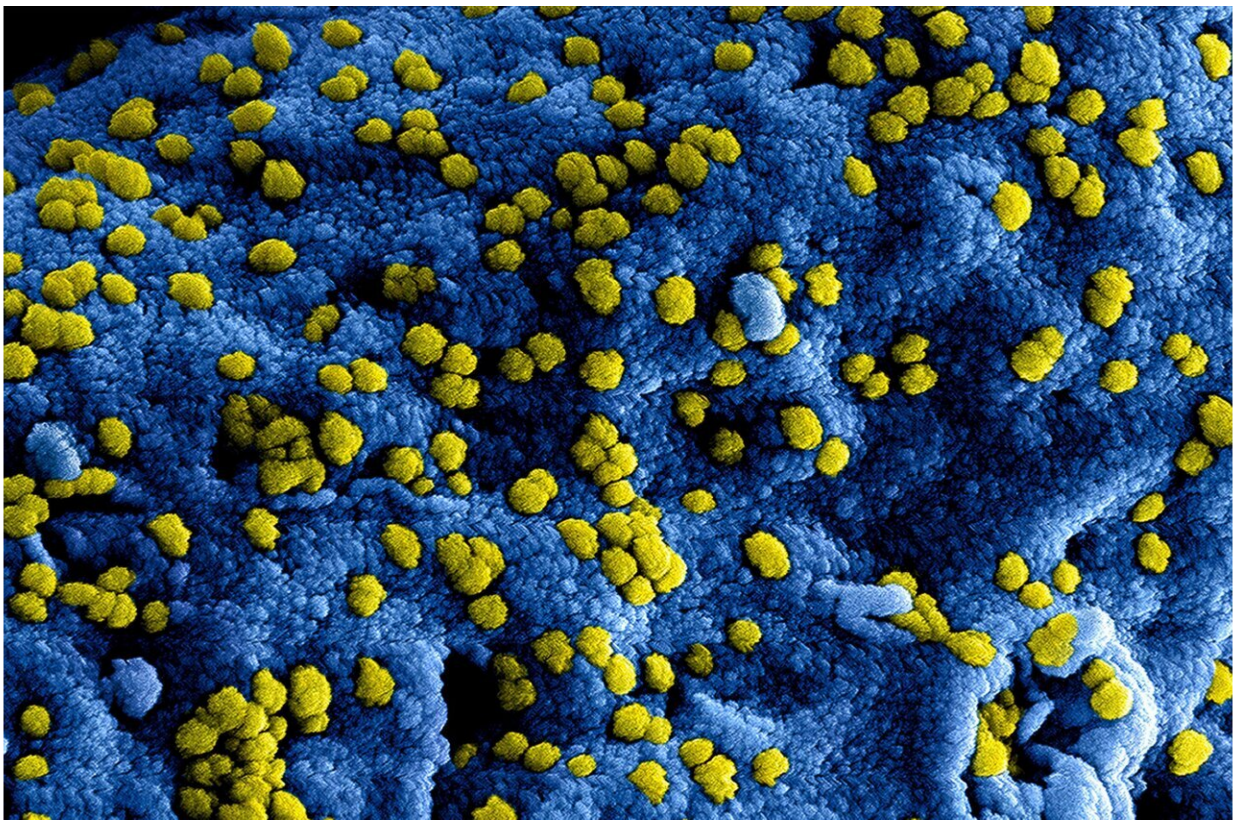

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Researchers from Skoltech, Lomonosov Moscow State University and the Kharkevich Institute for Information Transmission Problems have studied the genomes of some 200 strains of bacteria to determine which proteins in the ribosome, part of the key cell machinery, can be safely lost and why. The paper was published in the journal *Molecular Biology and Evolution*.

The ribosome is a universal cellular machine, present in all eukaryotes and prokaryotes, that builds proteins in a process called translation. The two major components of the ribosome, the so-called small and large ribosomal subunits, consist of ribosomal RNA (rRNA) molecules and ribosomal proteins.

The composition of these fundamental "protein factories" is fairly consistent across cells, but there is evidence that some bacteria function without a complete set of ribosomal proteins, so researchers have been looking to determine which of the proteins are truly essential for a working ribosome.

Skoltech professor and vice president for biomedical research Mikhail Gelfand and his colleagues analyzed ribosomal protein composition in 214 relatively small bacterial genomes. They identified a set of frequently lost proteins and showed that only nine ribosomal proteins were completely conserved, while each of the remaining 48 were lost in at least one strain from the dataset.

"Tiny genomes are characteristic of endosymbionts, bacteria that live within other bacteria or eukaryotic cells. In this non-changing environment and under weak selection they tend to lose non-essential (even if necessary for free-living bacteria) genes—similar to multicellular parasites that often miss entire organs. The ribosome has been assumed to be the most conserved organelle with a standard set of proteins; but if you have only 121 genes—the present bacterial record for simplicity—you cannot encode all fifty-something ribosomal proteins, so some of them have to be lost. We have demonstrated that the patterns of this loss are not random," Professor Gelfand says.

Apparently, ribosomal proteins of the small subunit were more likely to be retained than the large subunit proteins, and most frequently lost proteins were located on the ribosome surface, where they formed fewer contacts with other ribosome components. They were also incorporated in the ribosome late in evolution, so it seems that bacteria tend to practice the "last in, first out" approach when it comes to dropping ribosomal proteins.

The researchers also found that the three bacteria with the shortest genomes in the group lost the largest number of proteins; there was a correlation between genome size and number of retained ribosomal proteins. Yet since ribosomal proteins are in the cell's essential toolkit, they are generally among the last to leave a downsizing bacterial genome.

More information: Daria D Nikolaeva et al. Simplification of ribosomes in bacteria with tiny genomes, *Molecular Biology and Evolution* (2020). DOI: 10.1093/molbev/msaa184

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