# Never mind the selfish gene – ribosomes are the missing link

January 7 2015, by Robert Root-Bernstein And Meredith Root-Bernstein

Ribosomes: squiggly and yummy. Credit: crobin, CC BY

Since the discovery that DNA encodes genetic information, research on the evolution of life has focused on its genetic origins. Following this "genes-first" approach, Oxford University evolutionary biologist Richard Dawkins has argued in his book The Selfish Gene that cells and organisms evolved simply as packages to ever-more efficiently protect and transmit genes.

But this genes-first point of view ignores much. All cells share three organelles, or internal structures, besides gene-containing chromosomes: ribosomes which contain the machinery for translating genetic information into the proteins that perform the cell's work; a cell membrane that selectively permits materials in and out; and acidocalcisomes, which store and regulate the ions that drive the chemical reactions of life.

We challenge the "selfish gene" concept, proposing instead that if a cellular component is "selfish" it must be ribosomes. Cells – and DNA itself – evolved, we argue, to optimise the functioning of ribosomes. That upends everything we think we know about the evolution of cellular life and ribosomes themselves.

## What does DNA want?

We came to this idea through a father-daughter collaboration that began when Meredith was re-reading Robert's 1989 book Discovering. Half-way through, Meredith looked up and asked: "What does DNA want?"

Though it may sound strange to anthropomorphise a molecule, in fact this is a discovery strategy suggested in Robert's book. What's more, scientists often express the selfish gene theory in scientific short-hand as: "DNA wants to replicate itself."

Chemists use a different metaphor when they anthropomorphise molecules. They say that molecules "want to be in their lowest energy conformation". This means that, like people, energetic molecules move through many positions, but they always return to a resting position.

The resting position of DNA is very tightly curled up with its genes inaccessible. Resting DNA is so stable that it can protect its genes for 10,000 years or more, allowing scientists to recover DNA from frozen mammoths. This is not a molecule yearning to disperse its genes, but one that wants to conserve them by remaining curled up in a knot.

We reasoned that the cellular structure that wants to copy genes and turn them into the proteins that make up functioning cells is ribosomes. The resting state of a ribosome is: "I'm ready to translate DNA into proteins." Ribosomes "want" to convert genes into working molecules.

## What do ribosomes want?

The big question, by analogy to the "selfish gene" theory, then became: Might ribosomes "want" to make copies of themselves? If ribosomes wanted to copy themselves, then they would harbour the means to do so.

To understand what would be required for ribosomes to copy themselves, a bit of information about ribosome structure and function is necessary. Ribosomes are composed of proteins and RNA, which is structurally similar to DNA and exists in three distinct forms. One is ribosomal RNA, or rRNA, which forms a structural scaffold upon which proteins arrange themselves to form a functional ribosome "machine". This "machine" uses the other two types of RNA to make proteins. Messenger RNA, or mRNA, transcribes the genetic information from DNA and carries it to the ribosome. Transfer RNA, or tRNA, translates the mRNA message into amino acids, which are strung together on the ribosome to make a protein.

If a ribosome "wants" to makes copies of itself, the rRNA forming the structure at the core of the ribosome machine would have to be functional. For this to be true, the rRNA must contain three things. First, it must contain the "genes" encoding its own ribosomal proteins so as to be able to form a working "machine". Second, it must contain the mRNAs needed to carry its own genetic information to the "machine". Finally, it had to encode the tRNAs necessary to translate the mRNAs into proteins.

In a recent paper in the Journal of Theoretical Biology, we have shown that rRNA does contain vestiges of the mRNAs, tRNAs and "genes" that encode its own protein structure and function. Ribosomes are not simply the passive translators of genes as described in textbooks. We believe they are the missing link between simple pre-biotic molecules and the single-celled LUCA, the Last Universal Common Ancestor, considered to be the first living thing on Earth.

DNA evolved to conserve and protect the information originally encoded in rRNA. Cells and organisms have evolved to optimise the replication of ribosomes, and ribosomes are almost the same across all species. Maybe the selfish ribosome puts a new spin on feeling kinship with other creatures. We are all just different kinds of homes to ribosomes.

**More information:** Meredith Root-Bernstein, Robert Root-Bernstein, "The ribosome as a missing link in the evolution of life," *Journal of Theoretical Biology*, Volume 367, 21 February 2015, Pages 130-158, ISSN 0022-5193, dx.doi.org/10.1016/j.jtbi.2014.11.025.



Source: The Conversation