Why, Michael Lynch wants to know, don't we look like bacteria?

Evolutionary biologists generally agree that humans and other living species are descended from bacterial-like ancestors. But before about two billion years ago, human ancestors branched off.

This new group, called eukaryotes, also gave rise to other animals, plants, fungi and protozoans. The differences between eukaryotes and other organisms, known as prokaryotes, are numerous and profound. Dr. Lynch, a biologist at Indiana University, is one of many scientists pondering how those differences evolved.

Eukaryotes are big, compared with prokaryotes. Even a single-celled protozoan may be thousands of times as big as a typical bacterium. The differences are even more profound when you look at the DNA. The eukaryote genome is downright baroque. It is typically much bigger and carries many more genes.

Eukaryotes can do more with their genes, too. They can switch genes on and off in complex patterns to control where and when they make proteins. And they can make many proteins from a single gene.

That is because eukaryote genes are segmented into what are called exons. Exons are interspersed with functionless stretches of DNA known as introns. Human cells edit out the introns when they copy a gene for use in building a protein. But a key ability is that they can also edit out exons, meaning that they can make different proteins from the same gene. This versatility means that eukaryotes can build different kinds of cells, tissues and
organs, without which humans would look like bacteria.

When explaining this complexity, most scientists have proposed variations on the same thing: natural selection favored it because versatility gave a reproductive advantage. But Dr. Lynch argues that natural selection had little to do with the origin of the eukaryote genome.

"Everybody thinks evolution is natural selection, and that's it," Dr. Lynch said. "But it's just one of several fundamental forces."

In a paper accepted for publication in the journal Molecular Biology and Evolution, Dr. Lynch argues that eukaryotes' complexity may have gotten started by chance.

Natural selection is the spread of genes as a result of their ability to raise the odds of survival and reproduction. But when the peculiar features of eukaryotes first arose as accidental mutations, Dr. Lynch argues, they were probably harmful.

Once an intron was wedged into the middle of a gene, a cell had to be able to recognize its boundaries in order to skip over it when making a protein. Some mutations to the intron made it difficult for the cell to recognize those boundaries. If the cell couldn't edit out the intron, it produced a defective protein. If natural selection had been strong in early eukaryotes, all introns would have been eliminated.

Evolutionary biologists have long recognized that natural selection is a matter of probability, not destiny. Just because a mutated gene raises the odds that an individual will reproduce is not a guarantee that it will spread in a population.

Think about flipping a coin. It has 50 percent chance of coming up heads or tails. If you flipped it twice, you wouldn't be surprised to get two heads. But you would be surprised if you flipped it 1,000 times and got 1,000 heads.

Likewise, natural selection works more effectively as populations get bigger. In small populations, it is not so reliable at spreading beneficial genes and eliminating harmful ones.

When natural selection is weak, genes can become more common simply thanks to chance.

The random spread of genes is known as genetic drift. Dr. Lynch argues that genetic drift is much stronger in eukaryotes than in prokaryotes. Several factors are responsible, including the bigger size of eukaryotes.
Even a single eukaryote cell may be 10,000 times as large as the typical bacterium. Far fewer eukaryotes can survive in a given space than prokaryotes, leading to smaller populations of eukaryotes.

Dr. Lynch argues that early eukaryotes experienced strong genetic drift. Their population may have shrunk. Natural selection became weak, and genetic drift became strong. Genes that were slightly harmful to the proto-eukaryotes became widespread.

Although these changes may have been caused by genetic drift, they created opportunity for natural selection to create adaptations. Exons could be spliced to create proteins adapted for different jobs. Genes could be switched on in different places, to help build new organs. Complex multicellular organisms -- like humans -- could emerge.

Natural selection has produced useful adaptations in eukaryotes. If it hadn't, Dr. Lynch said, "we wouldn't be here."

Prokaryotes never got the chance to evolve this complexity because their populations were so large that natural selection blocked the early stages of its evolution. "There was one lucky lineage that became us eukaryotes," Dr. Lynch said.

Dr. Lynch dismisses claims by creationists that complexity in nature could not be produced by evolution, only by a designer.

"In fact, a good chunk of what evolutionary biologists study is why things are so poorly designed," he said. "If we needed a bigger genome, there would be a brighter way to build it."

Photos: VERY DISTANT COUSINS -- Escherichia coli bacteria, better known as E. coli, left, are prokaryotes. Giardia lamblia, in orange below, is a eukaryote, as are humans. (Photographs by Photo Researchers Inc.)