Mitochondrial Mutations May Have Aided Brain Evolution

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Energetic cells may have boosted the brain
Did rapid mutation of cell powerhouses guide our neural evolution?

A good brain needs lots of energy in order to function, and human brains are exceptionally good. Now geneticists have found that humans may also be exceptional in terms of the energy output of our cells, and are wondering whether this is linked to our intellectual prowess.

Brains use more energy than one might expect. In humans this organ makes up only 2% of a person's body weight, on average. But it is estimated to account for about 20% of the energy used by the body at rest.

One solution to providing more energy is simply to have more cells. In the development of the human brain, "the obvious difference that everyone talks about is the huge increase in size," says John Kaas, a neuroscientist at Vanderbilt University in Nashville, Tennessee.

But there are limits to how much more power size can provide. Bigger brains come with additional overhead costs and problems with heat exchange. Something else must have helped to improve our brains.

Within each cell, tiny structures called mitochondria are responsible for producing the energy−carrying molecules known as adenosine triphosphate or ATP. ...

One solution to generating more energy in a single cell, therefore, is to increase its numbers of mitochondria. But in the brain, cells have long, thin arms called axons for connecting to other cells, and scientists suspect that these cannot physically accommodate ever larger numbers of mitochondria.

So where did our brain cells get the power they needed? Lawrence Grossman, a biologist at the Wayne State University School of Medicine in Detroit, and his colleagues think it may have come from improvements inside the mitochondria themselves.

Grossman and his team studied the genes for a protein in the electron transport chain known as complex IV, or COX. They compared the genetic sequence across many different mammalian species and found that the human lineage has undergone an exceptional number of changes.

For example, there have been 11 changes in the part of the DNA that codes for a certain protein subunit in the past 58 million years, compared with just one change in the 25 million years before that. None of the rodents, lemurs or other mammals that they examined showed more than two or three changes in the same time period.
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He suggests that these changes could have given human brain cells a serious evolutionary boost, by increasing the amount of energy available to them. He and his team describe their theory in Trends in Genetics1.

The group's findings fit with a growing body of evidence that our brains evolved with the help of a better energy supply. Research in modern primates has shown that there is a strong correlation between quality of diet and relative brain size, says Bill Leonard, who studies energetics at Northwestern University in Evanston, Illinois.

"Humans are an extreme example of this: they have very large brains and a high quality, energy−dense diet," he says.
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