Medical Xpress

Does your DNA really change in space?

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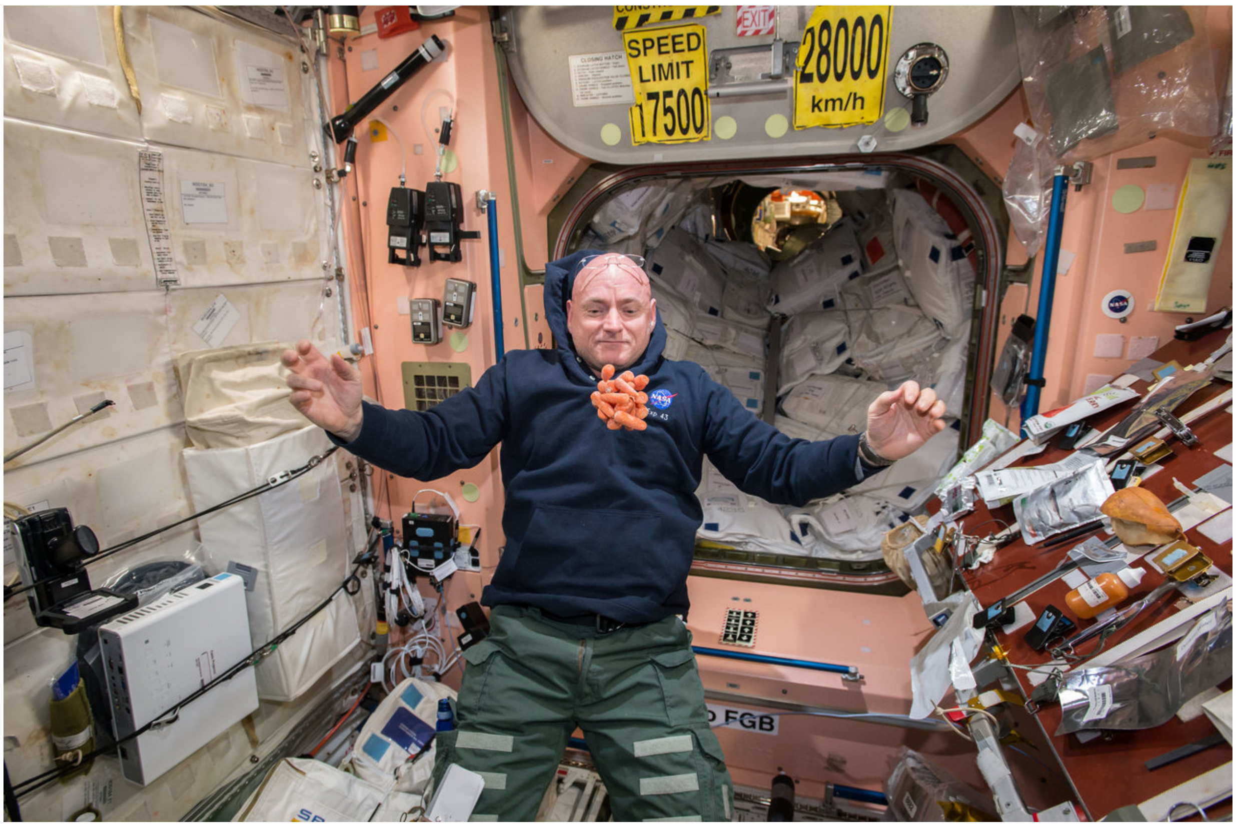

Kelly having a carrot snack in space. Credit: NASA

Results from an important NASA experiment – in which astronaut Scott Kelly spent one year in space while his identical twin brother Mark stayed on Earth – have started to come in. Last week, a number of media outlets reported that Kelly's genome has changed by roughly 7% as a result of being in space.

This seems remarkable. Research has shown that the rate of gene mutation during spaceflight could never produce a 7% change in the genome in a year. There is a 2.6% difference between the human and chimpanzee genomes, and this took 26m years to develop. Even with the eight-fold increase in the rate of genetic mutations you may get in space – this has been reported for animals subjected to similar levels radiation – it would take more than eight million years to accumulate a 7% change in the genome. Importantly, this would be a whole new species.

So what actually happened to Kelly's DNA in space? Unsurprisingly, the reports claiming that 7% of it changed had misinterpreted a press release from NASA, issued on January 31, 2018. It stated that "researchers now know that 93% of Scott's genes returned to normal after landing. However, the remaining 7% point to possible longer term changes."

NASA swiftly responded the day after CNN ran the story (now corrected). They emphasised that the 7% difference referred to "gene expression" – how genes are turned on and off – rather than the entirety of the DNA. In other words, the astronaut's genome did not change, but which genes were actively being used did.

The science

The genome is like a set of instructions written in DNA. By expressing different genes, our bodies follow these instructions to make molecules like RNA or proteins – each of which carries out a different biological task. The change in gene expression, as NASA pointed out, is entirely expected given that we know that human physiology alters in space. Which genes are actively being used (or expressed) control and are responsive to such physiologic alterations.

The preliminary data suggested that significant changes include alterations in genes associated with the response to oxygen and carbon dioxide levels. Changes linked with a reduced ability to make energy (our cells turn nutrients into chemical energy) and bone were also reported, as were alterations linked to an increased ability to fight infection and maintain DNA.

The suggestions appear to fit with what we would predict. It also correlates with what we have seen in the past in spaceflown animals (NASA maintains a repository of this animal gene expression data called NASA GeneLab).

Scott and Mark Kelly. Credit: NASA

It is highly likely that gene alterations associated with oxygen use and the ability to fight infection are due entirely to astronauts being in an enclosed environment. As in a submarine, ambient oxygen levels on the International Space Station are different than on the surface of the Earth. Changes in gene expression allow astronauts to adapt to this new environment.

Similarly, just as new students bring a variety of bacteria and viruses to school with them, so do new astronauts and equipment arriving at the International Space Station. Therefore we expect there to be an increased expression of genes that enable fighting infection. These are known and longstanding issues with spacecraft – we can deal with them partly by keeping objects and surfaces clean to high standards.

Drug discovery

The reported changes in ability to make energy and bone and maintaining our genome are more interesting and potentially concerning. Decreased ability to produce energy and bone, making us weaker, are seen both with age and spaceflight. However, we currently do not entirely understand the molecular reasons for this, or how to combat it. Once the specific genes that are displaying altered expression are published, it may be possible to work out the causes of these gene expression changes and test the ability of current drugs to prevent them.

The increased expression of DNA repair genes, enabling us to maintain our DNA, could be a result of increased levels of radiation in space – causing DNA damage and genome changes.

When the study is peer reviewed and published, we can also compare it to other results. The Japanese Space Exploration Agency published results demonstrating whole genome gene expression changes observed in a group of ten astronauts in 2016 (though not twin pairs). We can also compare them with gene expression changes in animals and gene expression changes on Earth-based analogues for spaceflight, like bed rest.

Should these gene changes appear similar to those previously reported, then it raises the likelihood that ongoing animal studies will manage to identify drugs that counteract harmful effects of gene expression. Hopefully, these will work not just in animals, but also in astronauts.

Until the data are published, it remains unclear exactly how many changes in the genome occurred in Kelly during his year in space. But it was certainly more than in his Earth-bound twin.

The potential impact of this research clearly is huge, as NASA and other space agencies plan to venture further into space than the International Space Station soon. If astronauts are to go all the way to Mars, they will suffer even higher doses of radiation and go through an even higher numbers of changes in the genome.

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