Environmental 'memories' passed on for 14 generations

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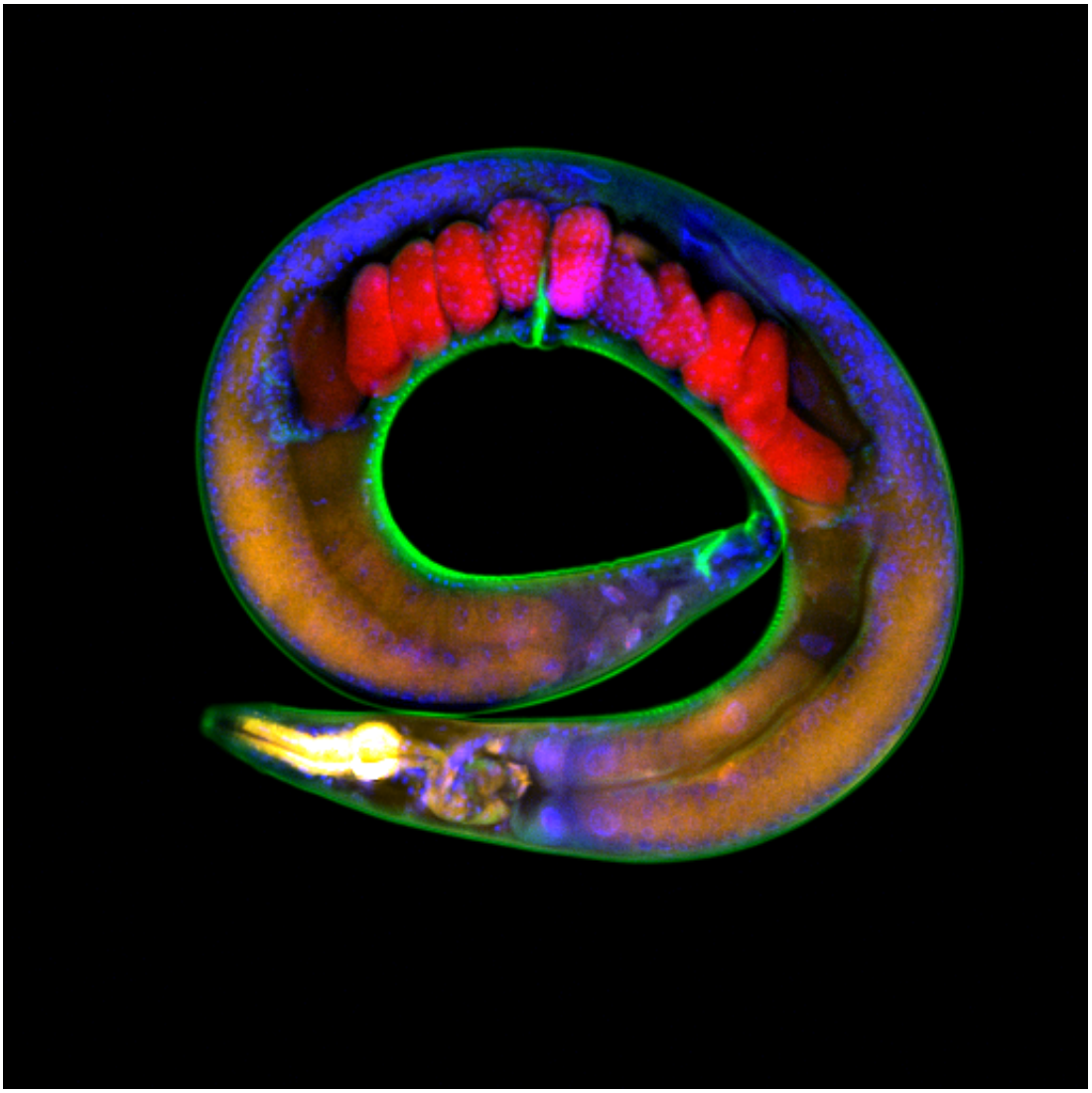

C. elegans worm. Credit: Adam Klosin, CRG

Scientists at the Centre for Genomic Regulation (CRG) in Barcelona and the Josep Carreras Leukaemia Research Institute and The Institute for Health Science Research Germans Trias i Pujol (IGTP) in Badalona, Spain, have discovered that the impact of environmental change can be passed on in the genes of tiny nematode worms for at least 14 generations—the most that has ever been seen in animals. The findings will be published on Friday, April 21, in the journal *Science*.

Led by Dr Ben Lehner, group leader at the EMBL-CRG Systems Biology Unit and ICREA and AXA Professor, together with Dr Tanya Vavouri from the Josep Carreras Leukaemia Research Institute and the Institute for Health Science Research Germans Trias i Pujol (IGTP), the researchers noticed that the impact of environmental change can be passed on in the genes for many generations while studying *C. elegans* worms carrying a transgene array - a long string of repeated copies of a gene for a fluorescent protein that had been added into the worm genome using genetic engineering techniques.

If the worms were kept at 20 degrees Celsius, the array of transgenes was less active, creating only a small amount of fluorescent protein. But shifting the animals to a warmer climate of 25 degrees significantly increased the activity of the transgenes, making the animals glow brightly under ultraviolet light when viewed down a microscope.

When these worms were moved back to the cooler temperature, their transgenes were still highly active, suggesting they were somehow retaining the 'memory' of their exposure to warmth. Intriguingly, this high activity level was passed on to their offspring and onwards for 7 subsequent generations kept solely at 20 degrees, even though the original animals only experienced the higher temperature for a brief time. Keeping worms at 25 degrees for five generations led to the increased transgene activity being maintained for at least 14 generations once the animals were returned to cooler conditions.

Although this phenomenon has been seen in a range of animal species - including fruit flies, worms and mammals including humans - it tends to fade after a few generations. These findings, which will be published on Friday 21st April in the journal *Science*, represent the longest maintenance of transgenerational environmental 'memory' ever observed in animals to date.

"We discovered this phenomenon by chance, but it shows that it's certainly possible to transmit information about the environment down the generations," says Lehner. "We don't know exactly why this happens, but it might be a form of biological forward-planning," adds the first author of the study and CRG Alumnus, Adam Klosin. "Worms are very short-lived, so perhaps they are transmitting memories of past conditions to help their descendants predict what their environment might be like in the future," adds Vavouri.

Comparing the transgenes that were less active with those that had become activated by the higher temperature, Lehner and his team discovered crucial differences in a type of molecular 'tag' attached to the proteins packaging up the genes, known as histone methylation.

Transgenes in animals that had only ever been kept at 20 degrees had high levels of histone methylation, which is associated with silenced genes, while those that had been moved to 25 degrees had largely lost the methylation tags. Importantly, they still maintained this reduced histone methylation when moved back to the cooler temperature, suggesting that it is playing an important role in locking the memory into the transgenes.

The researchers also found that repetitive parts of the normal worm genome that look similar to transgene arrays also behave in the same way, suggesting that this is a widespread memory mechanism and not just restricted to artificially engineered genes.

More information: Klosin et al. Transgenerational transmission of environmental information in C. elegans. *Science*. April 21 2017. science.sciencemag.org/cgi/doi … 1126/science.aah6412

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