Revolutionary new view on heritability in plants

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Complex heritable traits are not only determined by changes in the DNA sequence. Scientists from the University of Groningen Bioinformatics Centre, together with their French colleagues, have shown that epigenetic marks can affect traits such as flowering time and architecture in plants. Furthermore, these marks are passed on for many generations in a stable manner. Their results were published in *Science Express* on Thursday, 6 February 2014. It seems that a revision of Genetics textbooks is now in order.

We've all been taught that DNA is the physical foundation of heredity. Our genes are spelled out in the four famous letters A, T, C and G, which together form the genetic code. A single letter change in this code can lead to a gene ceasing to function or failing to work properly.

The fact that the functioning of our genes is also affected by epigenetic marks has been known for decades. For example, the nucleotide cytosine (the C in the genetic code) can be changed into a methylcytosine. This cytosine methylation, which is one type of epigenetic mark, is typically associated with repression of gene activity.

Epigenetic inheritance

'While in mammals epigenetic marks are typically reset every generation, in plants no such dramatic resetting takes place. This opens the door to epigenetic inheritance in plants: epigenetic changes that are

acquired in one generation tend to be stably passed on to the next generation', explains Frank Johannes, assistant professor at the GBIC and co-lead scientist for the *Science* Express study. Johannes's French colleagues have produced inbred strains of the model plant *Arabidopsis*, in which the epigenetic marks vary between strains although the DNA sequence is almost identical. Nevertheless, these strains show marked differences in appearance, which are passed on to later generations.

Complex traits

In the new study, Johannes and his French colleagues have successfully linked variation in epigenetic markers to complex traits such as flowering time and plant architecture in these *Arabidopsis* strains. They employed techniques that are typically used by geneticists to locate the DNA regions with sequence variations that contribute to complex traits. These are called quantitative trait loci or QTLs.

Breakthrough

Johannes: 'We used the same method to locate regions in the DNA, not with different sequences but with different epigenetic marks that contribute to certain traits in the plant.' It is the first time that epigenetic differences have been unequivocally shown to contribute to heritable traits. 'This is a breakthrough, because it changes the way we view genetics. And it may even be of huge economic importance.'

Commercially interesting

Although the *Science* Express paper is based on heritability over just seven generations, other results with the *Arabidopsis* strains show that epigenetic traits are stably inherited for at least 20 generations. Johannes: 'Such stable traits can be of interest to plant breeders. Apart from

variations in the gene sequence, epigenetic variation may contribute to commercially interesting traits.'

Evolution

The epigenetic markers may also affect evolution, independent of DNA sequence. 'They cause variation on which natural selection can act', Johannes explains. As such, traits caused by epigenetic variation may make an independent contribution to changes in a species. 'Our findings were made using inbred strains, but we also have evidence that we can find some of the same epigenetic QTLs in wild populations of this species as well.' This suggests it is not just a laboratory artefact but something that plays a role in nature.

Revision textbooks

Johannes points out that 'because epigenetic inheritance differs between plants and mammals, it is by no means certain that similar processes play a role in mammalian populations like humans.' But the textbooks on plant genetics are now due for revision in any case.

More information: Mapping the Epigenetic Basis of Complex Traits *Science Express*, 7 February 2014. www.sciencemag.org/content/ear … 2/05/science.1248127

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