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Variegation and Paramutation, lords of epigenetics

In diploid organisms, each cell contains one copy of paternal chromosomes and one copy of maternal chromosomes. At each cell cycle, chromosomes undergo DNA replication and are segregated at mitosis, so that the same genetic information is transmitted to two daughter cells. Although multicellular organisms arise from multiple mitosis rounds of a single zygotic cell, they form organs with different shapes and functions, which are acquired during development and maintained afterward in adults.
"Epigenetics" mostly refers to heritable traits over rounds of cell division that do not involve changes in the genome DNA sequence, but rather involve changes in gene expression levels that are inherited across cell division. Epigenetic cell memory across mitosis is achieved through DNA methylation, histone modifications and chromatin remodeling. Within this context, I will explain what is variegation in the fruit fly Drosophila melanogaster and I will illustrate how this unique tool helped geneticists to gain insights on epigenetic cell memory. In addition, I will present recent data obtained in the lab demonstrating the role of RNAs in Epigenetic cell memory.
Perhaps the most extreme examples of epigenetic inheritance are paramutations. A paramutation is an interaction between two alleles of a gene, through which one allele induces a modification of the other allele without modifying the DNA sequence. A paramutagenic allele confers its epigenetic properties to a paramutated allele, which stably retains these properties across meiosis in subsequent generations, even in the absence of the paramutagenic allele. Moreover, a paramutated allele becomes paramutagenic, as it can in turn transitively confer its epigenetic properties to another allele introduced by crosses. Although well characterized in plants, stably-inherited paramutations had not, until now, been described in animals. Here I will present a fully penetrant and stable paramutation recently characterized in flies. I will provide evidence that the intergenerational transmission of this paramutation involves small RNAs maternally desposited in the female gametes.
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