Beyond DNA: integrating inclusive inheritance into an extended theory of evolution

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Current evolutionary approaches reduce heredity to the sole genes. However, evidence is accruing that various forms of non-genetic information are transmitted across generations and thus participate to evolution. In a paper published in Nature Reviews Genetics, an international team encompassing three members of the federation de Recherche 3450 (EDB, UMR 5174 CNRS-Université Paul Sabatier-ENFA and SEEM, USR 2936 CNRS) call for a more inclusive paradigm integrating all forms of non-genetic heredity into a single theory of evolution. It is the party taken by the TULIP Labex project to which three of the authors take part.

Reproduction is the essence of life. It requires the transmission of information, be it genetic or not, across generations. As Wallace and Darwin understood, evolution only affects the variation that is transmitted across generations (i.e. that is inclusively héritable). Today, evidence is accruing that heredity also implies the transmission of variation in gene expression, ecological and cultural inheritance.

Examples of non-genetic inheritance include bird song dialects which are known to be often transmitted independently from genetic variation and can lead to the isolation of reproductive groups and speciation, as well as the transmission of artificially created variation in rodent maternal behaviour through epigenetic changes in the expression of genes of receptors to sexual hormones in the absence of any mutation (fig.).

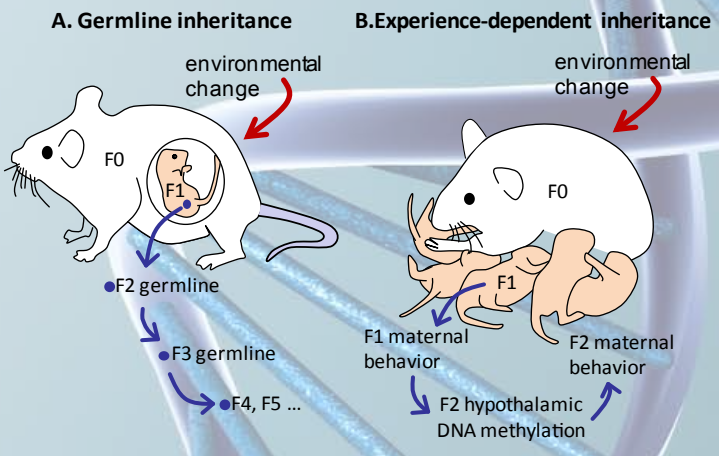

Fig. Two forms of epigenetic transgenerational inheritance.

it is the complexity of the interactions between the various inheritance systems that creates the richness of the evolutionary processes and produces biodiversity. It is proposed to incorporate non-genetic inheritance into the ecological and evolutionary approaches, to broaden the current synthetic theory of evolution resulting from the merging genetics and Darwinism in the 1940s. Going beyond the dogma of the "everything is genetic" by taking into account all forms of inheritance may constitute a major step forward in the sciences of evolution.

This broadened vision of heredity places the study of the ecological and evolutionary mechanisms at the centre of the study of biodiversity. It is striking to note that research on the field of biodiversity mainly focuses on the description of the patterns of species distribution, and neglects the study of the mechanisms that produce and maintain it. Only a deep understanding of the ecological and evolutionary processes of biodiversity will enable us to act in the directions chosen by the society. The future of the human societies is at stake.

A study using males dusted in green of pink as in this picture suggested the existence of cultural transmission in the fruit fly. After having observed three times a pink male copulating then a green male being rejected by females, an observer female showed mating preference for pink males (or vice versa). These experiments suggest that cultural heredity may exist even in non-social invertebrates.
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