

Multigenerational, epigenetic and evolutionary effects in human and environmental toxicology: from mechanisms to risk assessment

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Scientific evidence is indicating that environmental pollutants, including chemicals, biocides and plant protection products, may influence organisms beyond exposed generations by affecting the regulation of epigenetic mechanisms and triggering rapid micro-evolutionary processes. Yet, the disruptive potential in environmental toxicology remains to be further characterized, due to the limited fundamental knowledge of epigenetic, evolutionary and multigenerational effects in ecotoxicological model organisms. Furthermore, while these effects in humans and animal models are increasingly studied and the relevance of such effects for toxicological mechanisms is generally appreciated, their incorporation in the regulation of chemicals remains limited. Indeed, they present new challenges for risk assessment as their adverse outcomes may occur long after the exposure to certain environmental stressors and pollutants. Such delayed effects can significantly affect future generations, which are either exposed only during germline development or even not exposed to the initiating stressor at all (inter- and transgenerational effects). Scientific research reporting of multigenerational effects and evidence of trans-generational effects of pollutants is accumulating across a diversity of systems, however, little is known on the natural variation of epigenetic traits defining non-adversity. Furthermore, biological responses may also depend on population standing genetic variation and evolutionary history, and on phylogenetic constraints. It is thus difficult to extrapolate toxicological responses of natural and genetically diverse populations and communities from laboratory assays based on inbred or clonal organism/species. Therefore, it becomes urgent to acquire tools and methods to measure, anticipate, and even predict (epi)genetic and evolutionary ecotoxicological effects, the genetic of adaptation/maladaptation to environmental stress and the adaptive potential of natural populations, as well as to understand their consequences for ecosystems. Further research is needed to address a series of key questions: When can a chemical or a class of chemicals be classified as hazardous by causing significant (epi)genetic or evolutionary effects on humans and animals? Is it possible to develop standard test guidelines to assess such effects? Could effective and cost-efficient screening methods perform in model organisms be used to predict epigenetic and evolutionary effects of chemicals in higher organisms including humans for? How can multigenerational effects be assessed at the (epi)genetic level? In addition, epigenetic and evolutionary studies supported by new technologies, may provide substantial insight in how chemicals can alter regulatory processes at levels that do not necessarily result in overt toxicity but may significantly affect subsequent unexposed generations. Answering these questions and developing guidelines for the inclusion of epigenetic and evolutionary effects in risk assessment ideally requires a dialog from the early stages between scientists and stakeholders (see EVOGENERATE Work Group of the SETAC ERA AG). Therefore, this session, proposed by the EVOGENERATE Work Group, will address the development of new methods and model systems for the characterization of the (epi)genetic, evolutionary and multigenerational effects, hazard identification, both at short- and long-term, and the integration of epigenetic and evolutionary data in ecological and human health risk assessment. These methodologies and model systems should provide scientific guidance to support optimized decision making, through a sustainable trade-off between human demand on, and conservation of natural resources.