What toxicants can teach us about metabolic organisation

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Organisms that are exposed to chemicals respond with changes in their life-history behaviour. These unlucky organisms may, for example, show a deviating growth curve compared to their unexposed relatives, and differ in the timing and rate of their reproduction. Clearly, such changes must reflect underlying changes in their energy budget. It is therefore essential to view toxicant effects as the response of a stressed system, where metabolic processes change under the influence of toxicants. The study of toxicant effects on (non-mammalian) organisms is the realm of eco-toxicology. Unfortunately, a process-based view is rare among ecotoxicologists, who generally appear to prefer a more descriptive view of toxic effects. In contrast, scientists working on metabolic organisation usually have little interest in toxicants. However, I will argue that the combination of energy budget theory and toxicants is a fruitful one for both fields. Firstly, existing theory on dynamic energy budgets can be applied to the practical problems of dealing with the enormous number of man-made chemicals, and aid in assessing their impacts on human and environmental health. Regulatory decisions require extrapolation from the results of laboratory tests to populations under field conditions, and any sensible extrapolation requires a thorough understanding of the system. Secondly, and more interesting scientifically, chemical stress offers a unique opportunity to test the allocation rules of energy-budget theory. Because of the huge diversity of chemicals, and their wide range of toxicity mechanisms, the organism can be stressed in far more (and far more specific) ways than with natural stressors such as food limitation.

The application of DEB theory to toxicants has become known as DEBtox. DEBtox started as a pragmatic simplification of DEB theory to be able to work with the data from standardised toxicity tests. However, in the last five years, we have taken the development of DEBtox further to analyse full life-cycle tests and mixtures of toxicants. The comparison of theoretical predictions to (dedicated) experimental data sets confirmed the usefulness of DEB theory, but also revealed limitations and raised new research questions. In this lecture, I will reflect on the history of DEBtox, provide an overview of the recent developments on life-cycle analysis and mixtures, and focus on the avenues that need to be explored in the near future.