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1994 And all that: ecology in a calorimeter! ☆

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Organisms in the natural environment often have to cope with low substrate concentrations or periods better characterised as starvation for a particular or for several different nutrients. For example, in the marine environment, heterotrophic micro-organisms are often considered to be starved of energy. In addition to non-optimal conditions for growth and survival of the organisms caused by the level of nutrient supply, there may appear physical or chemical stress factors, such as non-optimal temperature, osmotic potential or redox potential or accumulation of toxic substances. To increase even more the constraints on the organisms, both the chemical and the physical characteristics of the environment may fluctuate at a varying frequency as well as amplitude. As energy is needed for almost any type of biological activity used to meet different environmental conditions, and because the available energy may also be limited, the strategy of energy regulation and the efficiency of energy utilisation is of utmost importance for the survival and growth of the different organisms and for the competition or co-operation between these organisms constituting any natural habitat. Consequently, the capacity and strategy in regulating the energy flow will have an impact on the composition and behaviour of the ecological community and, thereby, on the total energy flow in the community.

Included in the environmental changes that may cause an altered energy flow, on both an intra- and inter-organismic level, are man's activities in causing pollutants of different biological toxicity to be distributed to the environment.

Calorimetry has proven a useful tool for measuring the energy flow in natural samples. The advantage of calorimetry is that it measures the total energy flow; under certain conditions this can also be measured using respirometry. In contrast

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to calorimetry, however, respirometry is restricted to aerobic conditions and to metabolism in which only oxygen is the final electron acceptor. The advantage of calorimetry in this respect is its non-specificity. By combining calorimetry with other specific methods, several different and important goals may be reached in studying the energy flow in natural environments. For example:

(i) Different types of energy metabolism may be distinguished, e.g. fermentative and aerobic respiratory metabolism can be separated by combining calorimetry and respirometry.

(ii) The importance in quantitative terms of identified or hypothetical energy metabolisms can be evaluated by comparing the calculated enthalpy change of the actual metabolic reaction with the calorimetrically measured heat change.

(iii) Changes in the energy flow may be correlated directly or indirectly to structural changes in the flora or to chemical or physical alterations in the ecosystem in question.

Although the rate of heat production is an expression of the total metabolic activity, it is important to consider that a decreased rate of heat production may not necessarily mean a decreased level of metabolic activity. Instead a reduced rate of heat production may be due to an altered energy metabolism, such as increased fermentation relative to respiration. When evaluating calorimetric data it is also of utmost importance to take into account the fact that measured heat changes may include substantial heat changes caused by side reactions of physical and/or chemical nature. In addition, the experimental design may greatly influence the measured heat change due to disturbance of the ecological community and/or changes in the degree of side reactions. Sample handling is indeed a problem not restricted to calorimetry, but extends to any method used to measure activities in the natural environment. These comments are not meant to frighten, but instead to be seen as a challenge, the ambition being to increase our knowledge of the ecosystem and of its response to man's activities by novel methodological approaches.

The different points to which I have been trying to draw your attention were all covered in the session "Ecology" at the 9th ISBC Conference in Berlin/Schmerwitz, May 1994, by several oral or poster presentations. The contributions to these Proceedings give examples of the diverse range of approaches in studying ecology in an energetic perspective and its potential for increasing our knowledge of the function of ecosystems. An important application of these studies is found in the field of environmental protection. New methods and approaches are needed in toxicity studies and for the development of toxicity test systems. Several of the presentations show or indicate the potential of the applicability of calorimetry in combination with other methods to determine the influence of toxicants or of eutrophication on different ecosystems. I believe that this is one of the most both important and powerful applications of our present and future efforts.