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Comment on the state of development in applied calorimetry in 1994 ☆

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Judging by the papers presented during the session on "Applied Calorimetry" at the 9th ISBC Conference, there appear to be two general subdivisions of calorimetry: (1) the development of new biocalorimetric methods and their combination with other techniques for a specific purpose; and (2) the application of pre-existing biocalorimetric methods to some analytical purpose, usually combined with some other technique for which the biocalorimetry provides corroborating evidence.

Of the papers presented, one was clearly developmental/analytical in that it represented a new approach to a difficult problem. The other papers all appeared to be analytical, in that calorimetric methods were combined with other methods (respirometry, ATP yield or utilization, CO_2 production, etc.) in the demonstration of a particular phenomenon. Of the analytical papers, two dealt with subjects that could be related to industrial biotechnology, two with microbial physiology, one with mammalian tissue culture physiology, two with mammalian tissue or cell physiology, and one with a calorimetric investigation of a medical diagnostic parameter. The remaining paper dealt with whole-body calorimetry.

One common concept of "applied calorimetry" is that of something amenable to practical use, as in the "fermentation" industries (biotechnology) or medicine. As only four of the above ten papers appeared to qualify in this respect, it is apparent that projects with an academic appeal are of greater interest or concern than are those having a direct practical application. The scope of the papers is impressive. In general, this appears to be true of all the papers presented at the Conference.

A major difficulty of direct calorimetry lies in knowing what to attribute the heat production to. Frequently, investigators have a good idea from previous non-

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thermometric experiments as to the source of the heat (e.g. known chemical reactions, or heats of solution), thus resulting in thermodynamic calculations constituting indirect calorimetry. The measurement of the expected heat production by direct calorimetry provides a possible verification of what is thought to be happening physically or chemically. Alternatively, the problem can be approached from the other direction, where heat production is measured under controlled conditions, and the investigator then attempts to account for this by indirect calorimetric calculations. These two approaches can lead to differences in interpretation (controversies) and to an interest in resolving them. Because of the nature of the papers presented, there did not appear to be any real controversies arising out of this section of the conference. In some respects this was unfortunate.

Hopefully, during the 10th ISBC Conference, to be held in Switzerland, some very basic questions with respect to biological energetics will be addressed which were not addressed during the present Conference. Some of these might be:

1. Is the use of electron equivalencies better than C-mol equivalencies in constructing equations representing anabolism?
2. How much of the energy of ATP that is generated during catabolism becomes incorporated in the cells and other products formed during the growth process?
3. What is the entropy of a unit mass of cells?
4. What are the appropriate thermodynamic properties of the substances included in anabolic, catabolic, and growth process equations? It is generally agreed that ΔH_f values should be those of a one molal concentration at hypothetical infinite dilution, but how about ΔG_f and ΔS_f values? For example, a ΔG_f value of a hypothetical one molal concentration at unit activity is not acceptable because it is often not a realistic concentration. This value will be more negative at lower concentrations.
5. Should we include phosphorus and sulphur in unit carbon formulae? To do so would probably be unnecessary from the biotechnology point of view, but would we get more accurate growth process equations as a result and would we learn more from this?
6. What is the best method for determining efficiencies of growth? It there a method that can be used for both aerobic and anaerobic growth processes?
7. Does CO_2(aq) play a significant role as an electron acceptor in the metabolism of highly reduced substrates? How does this affect the energetics?
8. Batch cultures and continuous cultures offer different environments for growth processes. Are their energetics significantly different for the same substrates?

The above questions notwithstanding, from the range of calorimetric activities displayed at the 9th ISBC Conference, it is clear that all kinds of phenomena are being investigated, and that we may look forward to the next conference with great interest.