LETTERS TO THE EDITOR

Dear Sir:

The comments made by Pragier and Ronayne[1] appeared in an abbreviated form in *Nature*,[2] and one of us briefly replied.[3] We hope that a slightly longer comment will be appropriate here.

The authors discuss the different conclusions reached in their own citation study and the study by Langrish.[4] Both studies are about the "Industry–University Connection" as indicated by citations from *different* citing literatures.

Langrish used review articles about applied chemistry, whilst Pragier and Ronayne used review articles with a biological bias. Langrish found few citations to university-based work whilst Pragier and Ronayne found many.

The conclusions reached by Pragier and Ronayne are "... serious doubts about the value of citation analysis in providing data upon which science policy decisions can be made". In fact no doubts are raised—if review articles can be used in this way additional evidence is provided which demonstrates the usefulness of citations as indicators.

A proper conclusion is that research biologists draw upon university research whilst industrial chemists do not. This seems plausible in view of the basic nature of much university research.

Citations can provide useful information about connections between areas of scientific activity,[5,6] but the methodology needs to be well understood. Work has also been done showing correlations between citation counts using appropriate methods and "quality", a difficult to determine but obviously important property of research work.[7-9]

The methodology has not always been well understood, and in consequence there has been some uninformed criticism well exemplified by a recent exchange of letters in *Science*.[10] We have to put the Pragier and Ronayne article into this category with some regret because the information it contains, correctly interpreted, could be useful.

Unfortunately both Langrish and Pragier and Ronayne introduced a problem of another kind into their evaluations. They did not use "original" citation data. Rather they have implicitly adopted a sampling technique which relies on the presumed reliability of review articles. This same method has been used by Sengupta[11] in a series of articles on journal evaluation.

Until someone does a study that establishes a high correlation between the "review" method and the use of original citation data drawn directly from the *Science Citation Index*® or from the articles which produced the research, there can be no certainty about the value of citation analysis in establishing the industry–university connection. Thus, Pragier and Ronayne can be sceptical of Langrish's results, not because of any proven fault of citation analysis, but because the methodology is suspect.

When one uses original citation data, the construction of citation networks often enables you to see the milestone events in the development of science in a way that is difficult otherwise. Furthermore, in the case of industrial chemistry, we do not fully know the extent to which the journal literature relates to patents. The absence of a complete *Patent Citation Index* makes it difficult to obtain this knowledge. However, we do know that in the years for which it was available, interesting patent–journal connections could be perceived.

We should mention that there is a risk that citation analysis may fall into disrepute through uncritical or overenthusiastic use. It should be used only after the legitimacy of the application and the nuances of the method have been thoroughly studied and understood.

(1) G. Pragier and J. Ronayne, "A Criticism of the Use of Citation Analysis in Studying the Science-Technology Relationship", *J. Chem. Inf. Comp. Sci.*, **15**, 155–157 (1975).
(2) G. Pragier and J. Ronayne, "Science and Technology", *Nature (London)*, **254**, 100 (1975).
(3) A. E. Cawkell, "Citation Analysis", *Nature (London)*, **254**, 379–380 (1975).
(4) J. Langrish, "Technology Transfer; Some British Data", *Res. Dev. Management*, **1**, 134–135 (1971).
(5) E. Garfield, "Primordial Concepts, Citation Indexing, and Historiobibliography", *J. Lib. Hist.*, **2**, 235–249 (1967).
(6) A. E. Cawkell, "Connections between Engineering and Science", *IEEE Trans. Prof. Comm.*, PC-18(2), 71–73 (1975).
(7) W. O. Hagstrom, "Inputs, Outputs, and Prestige of American University Science Departments", *Sociol. Educ.*, **44**, 375–397 (1971).
(8) A. E. Bayer and J. Folger, "Some Correlates of a Citation Measure of Productivity in Science", *Sociol. Educ.*, **39**, 381–390 (1966).
(9) J. R. Cole and S. Cole, in "Social Stratification in Science", University of Chicago Press, Chicago, Ill., 1973, Chapter 2.
(10) See letters from S. A. Goudsmit and others with response by J. R. Cole and S. Cole, entitled "Citation Analysis", *Science*, **183**, 28–33 (1974).
(11) I. N. Sengupta, "Growth of the Biochemical Literature", *Nature (London)*, **244**, 75–76, 118 (1973).

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