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"Current Comments"

Some Comments on Pure and Applied Research--Stimulated by a List of Works Cited by Applied Chemists

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The difference between pure and applied research is something everyone understands until asked to spell it out. I suspect there is a subtle caste-like discrimination in this semantic difficulty. The popular belief is that the 'finer' minds go in for pure research. The less able plod along behind them 'applying' as they can. Perhaps this problem would not exist if theoretical research were semantically put down as merely 'non-applied' research.

Indeed this is precisely what happened during the Nixon administration. This was accomplished by a calculated game of "Newspeak". The consequences for the vigor of American research, both pure and applied, have been disastrous. This is true even if limited to its effect on morale.

Some reactions among scientists may have been pure sour grapes for being asked to "justify" their budgets in terms of benefits to society. But as more than one editorial writer has reminded us, if scientists will not speak up for science, who will?

It is not my purpose to argue basic versus applied research. I believe in both. It is important, however, to point out the fallacy in attempting to make a rigid distinction between them. The fallacy becomes especially dangerous when one attempts to make a similar distinction in the social and behavioral sciences. Some of the more alarming trends in social science research are the result of a hankering for quick results. This is implicit in expressions such as 'getting more bang for the research buck.'

The advance of science and technology is a continuum. What is applied research from one standpoint may be basic from another. Surely this must be one of the lessons to be learned from the field of technology assessment.

I wonder if the distinction between basic and applied, between the theoretical and the practical is a lingering class distinction, characteristic of certain countries more than others. Americans in particular respect the intellect, but distrust it as impractical. At the same time, we applaud the practical, but condemn it for being only that. We cannot pin down either one, and the confusion irritates us.

In the endless debate on the semantics of basic versus applied research, citation analysis may provide some interesting insights. For example, we have found that a large percentage of non-journal citations is a significant characteristic of some applied fields of science. In particular, recent work at ISI® suggests that non-journal citation is useful in distinguishing 'pure' and 'applied' chemistry.

Figure 1 lists the 33 publications most cited in applied chemical journals.

The items were picked by selecting from the 294 chemistry journals in the *Science Citation Index*® 115 journals in such applied fields as polymer chemistry, petrochemistry, agricultural chemistry, photographic science, etc. Shown for each item is the number of times it was cited by all journals indexed for the *SCI*®, by the major chemistry subfile of 294 journals, and by the 115 applied journals. The citation counts are for the year 1972.

The list in Figure 1 comes from a larger list of 83 such items. As a rule, about 20% of the references in science journals cite books and other non-journal items. For the chemistry subfile, we found that only 9.6% of the references cited non-journal items. For the applied chemisry file of 119 journals, however, the non-journal item citation rate jumps to about 45%.

It is fairly clear that applied chemistry takes a great deal from basic research. It might have been interesting had our data supported a similar assertion about the impact of technology on basic research. This would require a different approach. Perhaps we will be able to demonstrate this in fields like botany. In botany, technology's impact is quite evident in citation analyses now underway at ISI. We will report on them in the near future.

The reader who expected to find a list of highly cited papers or books in "applied chemistry" will be disappointed. We could publish a list of most cited articles published in applied journals. However, as several items in this list demonstrate, even that might not produce as 'applied' a list as one might expect. Engineering journals, for example, publish many heavily cited theoretical or basic articles. The characteristics of highly cited engineering journal articles is also a subject of another ISI inquiry. All of these studies are an attempt to uncover regularities in scientific activity. Perhaps these lists of highly cited papers do nothing for experts in the fields they cover. However, some readers indicate they provide some useful insights for those outside these fields.

Figure 1. Publications Highly Cited in Applied Chemical Journals.

	Times Cited 1972 by applied chemistry journals	by all chemistry journals	by all journals	Bibliographical Data
1.	46	214	5292	**Lowry O H** *et al.* Protein measurement with the Folin phenol reagent. *J. Biol. Chem.* 193:265, 1951.
2.	38	85	99	**Flory P J.** *Principles of polymer chemistry.* Cornell Univ. Press, 1953.
3.	37	49	82	**Levich V G.** *Physicochemical hydrodynamics.* Prentice-Hall, 1962.
4.	30	145	202	**Woodward R B & Hoffman R.** The conservation or orbital symmetry. [Die Erhaltung der Orbitalsymmetrie]. *Angew. Chem. Int. Ed.* 8:781, 1969; *Angew Chem.* 81:797,1969.
5.	26	36	66	**Bird R B.** *Transport phenomena.* Wiley, 1960.
6.	24	61	81	**Brunauer S, Emmett P H & Teller E.** Absorption of gases in multimolecular layers. *J. Amer. Chem. Soc.* 60:309, 1938.
7.	24	27	28	**Satterfield C N.** *Mass transfer in heterogeneous catalysis.* MIT Press, 1969.
8.	19	28	38	**Young L.** *Anodic oxide films.* Academic Press, 1961.
9.	19	25	35	**Mandelkern L.** *Crystallization of polymers.* McGraw-Hill, 1964.
10.	18	75	75	**Nicholson R S & Shain I.** Theory of stationary electrode polarography; single scan and cyclic methods applied to reversible, irreversible, and kinetic systems. *Analyt. Chem.* 36:706, 1964.
11.	18	22	25	**Perry J H.** *Chemical engineers' handbook.* McGraw-Hill, 1963.
12.	18	20	51	**Closs G L & Trifunac A D.** Theory of chemically induced nuclear spin polarization. *J. Amer. Chem. Soc.* 92:2186, 1970.
13.	18	18	117	**Carslaw H S & Jaeger J C.** *Conduction of heat in solids.* Clarendon Press, 1948, 1959, 1968.
14.	17	43	44	**Stockmayer W H.** On the estimation of unperturbed dimensions from intrinsic viscosities. *J. Polymer Sci C.* 1:137, 1963.
15.	17	29	35	**Brandrup J & Immergut E M.** *Polymer Handbook.* Wiley, 1966.
16.	17	28	33	**Reid R C & Sherwood T K.** *Properties of gases and liquids.* McGraw-Hill, 1966.
17.	17	24	31	**Danckwerts P V.** Continuous flow system. *Chem. Eng. Sci.* 2:1, 1953.
18.	16	214	375	**Pauling L.** *The nature of the chemical bond and the structure of molecules and crystals; an introduction to modern structural chemistry.* Cornell University Press, 1960.
19.	16	89	514	**Spackman D H, Stein W Y & Moore S.** Automatic recording apparatus for use in the chromatography of amino acids. *Analyt. Chem.* 30:1190, 1958.
20.	16	67	90	**Robinson R A & Stokes R H.** *Electrolyte solutions.* 2nd ed. Plenum, 1959.
21.	16	50	55	**Flory P J.** *Statistical mechanics of chain molecules.* Wiley, 1969.
22.	16	29	39	**Bond G C.** *Catalysis by metals.* Academic Press, 1962.
23	16	25	25	**Wilke C R & Chang P.** Correlation of diffusion coefficient in dilute solutions. *AICHE J.* 1:264, 1955.
24.	16	19	25	**Small P A.** Some factors affecting the solubility of polymers. *J. Appl. Chem.* 3:71, 1953.
25.	15	26	35	**Williams M L, Landel & Ferry J D.** Temperature dependence of relocation mechanisms in amorphous polymers. *J. Amer. Chem. Soc.* 77:3701, 1955.

Times Cited 1972	by applied chemistry journals	by all chemistry journals	by all journals	Bibliographical Data
26.	15	21	25	**Grubisic Z, Rempp R & Benoit H.** A universal calibration for gel permeation chromatography. *J. Polym. Sci. B.* 5:753, 1967.
27.	14	30	89	**Timmermans J.** *Physicochemical constants of pure organic compounds.* 2nd ed. Amer. Elsevier, 1965.
28.	14	28	28	**Bockris J O** *et al.* On the structure of charged interfaces. *Proc. Roy. Soc. A.* 274:55, 1963.
29.	14	15	27	**Prausnitz J M** *et al.* *Computer calculations for multicomponent vapor-liquid equilibria.* Prentice-Hall, 1968.
30.	13	22	57	**Palmberg P W & Rhodin T N.** Auger electron spectroscopy of FCC metal surfaces. *J. Appl. Phys.* 39:2425, 1968.
31.	13	15	15	**Petersen F E.** *Chemical reaction analysis.* Prentice-Hall, 1965.
32.	12	73	92	**Glasstone S** *et al.* *Theory of rate processes.* McGraw-Hill, 1941.
33.	12	58	81	**Bellamy L J.** *Infra-red spectra of complex molecules.* 2nd. ed. Methuen, 1958.