tiveness had not been achieved, says John Forrest, chief executive of Britain's National Transcommunication Limited (NTL) and a panel member. "Esprit results have tended to remain in the preserve of R&D departments, often leaving the rest of the company and especially top management in ignorance of what has been achieved," the report said.

The panel recommended a complete overhaul of the EC's programs. Esprit and RACE should be replaced with a program divided into a few areas that have precise, easily understandable goals, such as redesigning Europe's air traffic-control system. Unlike most existing EC collaborations, made up of companies with similar skills, projects in the new program would be "vertically integrated." Participants would include basic researchers, development teams, manufacturing experts, and even end-users of the technology.

Similar calls for change came from a survey last year of reactions to Esprit among the top dozen or so European electronics companies conducted by Jens Moritz, a senior director in the R&D department of Siemens, Germany's electronics giant. His report concluded that "a new program should continue the trend towards applications, in particular bringing users and suppliers together in projects driven by application." A planning task force assembled last year by the EC, and chaired by Hans Günther Danielmeyer, head of research at Siemens, joined in the chorus. "The role of technology users needs to be increased....It is essential for global competitiveness to think and to organize 'vertically integrated,' " its report said.

NTL's Forrest says that the EC's response to his panel's proposals has been a "deadly silence." One reason is probably inertia, but that may change. In January, the EC research commissioner, Filippo Pandolfi, departed, and research into information technology and communications was transferred to industry commissioner Bangemann. One of his first moves has been to shift the whole Esprit project into the directorate responsible for industry. The goal: to improve links with potential end-users of high-tech research.

Already, the guidelines provided in the latest call for proposals asked for tight, well-focused projects with vertically integrated partners. And Esprit officials say there will be more emphasis on clusters of projects working toward a well-defined aim. One model is the 20-project Open Microprocessors Initiative launched last year, and others are planned in liquid-crystal displays and high-performance computing.

Europe's industrial researchers have had a lot of fun pursuing interesting topics they might not otherwise have been able to without help from Brussels. But the new message, says one EC official, is: "Stop playing, now it's for real."

–Daniel Clery

CHEMISTRY

European Elites Envy American Cohesion

CAMBRIDGE, UK—Ask a dozen of Europe's top chemists how European chemistry is faring and where the hot research groups are, and you'll get a dozen different answers. But try asking them the same questions toward the end of March and you are likely to get no answers at all, because many of Europe's chemistry elite will be on the other side of the Atlantic, at the American Chemical Society's (ACS) spring meeting. The diversity of responses—and the nonresponses during March—say a lot about the state of chemistry in Europe.

European chemistry has a distinguished history, helped by the fact that eight of the 10 largest chemical companies in the world are based on the continent and have pumped hundreds of millions of dollars into their own and university labs over the years. And many of Europe's leading chemists express optimism when asked about the future of the discipline. Take University of Birmingham organic chemist Fraser Stoddart, who is working in one of the hottest fields, self-assembling molecules: "Chemistry is doing exceptionally well in Europe," he says. Or listen to Dieter Seebach of the Swiss Federal Institute of Technology: "Europe," he says, "is doing excellently compared with both the United States and Japan."

There's some evidence to back up those impressions. Europeans have carried off 23 of the 55 the Nobel Prizes for chemistry awarded since 1960.* And European groups including those led by Harry Kroto at Sussex University and Wolfgang Krätschmer at the Max Planck Institute of Nuclear Physics in Heidelberg, helped establish the fast-moving field of buckyball chemistry. But the jewels of European chemistry are scattered widely across the continent. "We see excellence in particular fields in laboratories all over Europe," says Nobel Prize–winner Jean-Marie Lehn, whose own lab at the University Louis Pasteur in Strasbourg is at the forefront of self-assembling molecules. "It is difficult to say [what Europeans do best] because research is so varied," he adds.

One reason European chemistry is fragmented is that there's no central funding body like the U.S. National Science Foundation to focus money on the top labs. There are few major European centers of excellence in basic research—of the likes of Caltech, Berkeley, and the Massachusetts Institute of Technology—that are strong across most subdisciplines of chemistry. Instead, each country has its own national research bodies that spread resources around dozens of labs. And there's no European equivalent of the ACS to provide a continent-wide sense of community, nor a European chemistry journal.

*1962: John Kendrew and Max Perutz (UK); 1963: Giulio Natta (Italy) and Karl Ziegler (Germany); 1964: Dorothy Hodgkin (UK); 1967: Manfred Eigen (Germany) and Ronald Norrish and George Porter (UK); 1969 Derek Barton (UK) and Odd Hassel (Norway); 1973: Ernst Otto Fischer (Germany) and Geoffrey Wilkinson (UK); 1975: Vladimir Prelog (Switzerland); 1977: Ilya Prigogine (Belgium); 1978: Peter Mitchell (UK); 1979: George Wittig (Germany); 1980: Frederick Sanger (UK); 1982: Aaron Klug (UK); 1987: Jean-Marie Lehn (France); 1988: Johann Diesenhofer, Robert Huber, and Hartmut Michel (Germany); Richard Ernst (Switzerland). In addition, Australian John Cornforth (1975) spent his entire career in the United Kingdom.

Country Scorecard

Rank	Nation	Papers	Nation	Cites/paper
1	USA	94,237	USA	4.47
2	USSR	47,870	Israel	4.01
3	Japan	42,229	Switzerland	3.92
4	Germany*	36,859	Netherlands	3.48
5	United Kingdom	26,685	Canada	3.37
6	France	21,342	Sweden	3.36
7	India	15,719	Denmark	3.11
8	Canada	13,430	United Kingdom	3.00
9	Italy	12,508	Australia	2.98
10	Spain	10,566	New Zealand	2.96
11	Poland	8408	Ireland	2.94
12	Netherlands	6872	France	2.88
13	Peo. Rep. China	6178	Germany*	2.87
14	Australia	5716	Hong Kong	2.80
15	Czechoslovakia	5681	Italy	2.75
16	Switzerland	5197	Japan	2.64
17	Sweden	4440	Austria	2.51
18	Hungary	3570	Belgium	2.32
19	Belgium	3316	Norway	2.22
20	Egypt	3067	Greece	2.13

*The listings for Germany include the papers and citations of the German Democratic Republic and the Federal Republic of Germany together. The paper and citations per paper for each, 1981–91, are as follows: F.R.G. 23,547 papers, 4.01 citations per paper; G.D.R. 5,389 papers and 1.60 citations per paper.

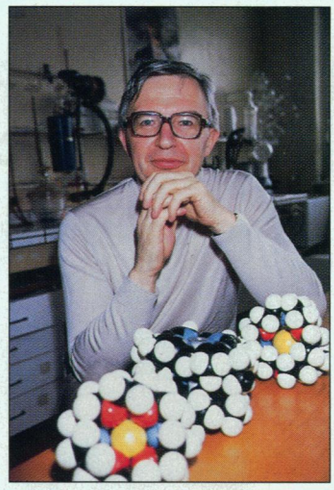
A closer look at publication statistics reveals some of the problems. Data produced for *Science* by the Institute for Scientific Information in Philadelphia indicate that in terms of output and impact—the average number of times chemistry papers are cited—European nations as a whole fall behind the United States (see "Country Scorecard"). Citation data for individual institutions tell a similar story: Highly cited papers are produced all over Europe, but papers from these elite European centers are cited on average less frequently than those from top U.S. institutions (see chart on this page).

Europeans might argue that these data simply reflect the fact that American researchers tend to read and cite American journals and American papers more frequently than those from abroad. But, says Kroto, Europe does have some disadvantages. He sees the sheer number of researchers in the United States as the major stumbling block for Europe to compete. "There are more people, better off [in the United States]," he says. "Compared with the United States, our universities are not doing too well."

All this leads researchers like Stoddart and Kroto to argue that it's time to establish a European chemical society that would do for European chemists what the ACS does for their U.S. colleagues. The nearest things Europe has at present are the European Communities Chemistry Committee (ECCC) and the Federation of European Chemical Societies (FECS). The two organizations have different members and goals, however. The ECCC consists of the national societies of the community's member nations and, according to the organization's secretary, Evelyn McEwan, its main aim is to "look after the interests of chemists at the European level." FECS, on the other hand, includes non-EC countries, such as Israel and eastern European nations, and is mainly concerned with the promotion of the science of chemistry.

For those who advocate either beefing up these bodies or creating a whole new pan-European society, the main role for such an organization would be to publish a European journal of chemistry that would rival the *Journal of the American Chemical Society*. Researchers such as Stoddart have argued for such a journal for years, but no one has yet taken the plunge, and for good reason. A European chemistry journal would have to compete not only with a plethora of small-circulation commercial and "national" chemistry journals, but also with two existing top-rated journals: *Angewandte Chemie*, published by VCH Publishers Inc. under the auspices of the German Chemical Society, and the UK Royal Society of Chemistry's *Chemical Communications*. Lehn suggests that a European journal could exist alongside *Angewandte* and *Chemical Communications*, but at least some rationalization of the smaller journals might be needed. Says Manfred Reetz, director at the Max Planck Institute for Nuclear Research in Mulheim: "Each relevant country would have to 'sacrifice' one of its own present journals."

So far, the idea of a European society and journal has not gone much past the discussion stage. And even if Europe's chemists were to organize themselves on a continental scale, true Europeanization of the discipline would require much greater central funding of research—a prospect that most top chemists view with mixed feelings. The reason: The EC can play a valuable role in suporting intra-European fellowships and helping less scientifically developed countries raise their standards, but researchers who have dealt with the Brussels bureaucracy almost invariably come away frustrated. "The inefficiency with which Brussels handles applications for grants, etc. strongly suggests some innovative thinking [is needed]," says Per Ahlberg of Gothenberg University in Sweden. To solve this problem, Lehn for example, argues for decentralized management of EC research programs.



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Highly cited. Jean-Marie Lehn.

The recent change at the top of the EC's science programs—in particular research commissioner Antonio Ruberti's efforts to reach out to scientific groups for help in running the programs (see page 1734) —may make European chemists more favorably disposed toward Brussels. Add to that the growth of programs such as COST (European Cooperation in the Field of Scientific and Technical Research), a 22-nation collaborative research effort that now includes seven chemistry projects, and the prospects for greater European collaboration in chemistry in the next few years begin to look distinctly brighter.

–David Bradley

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Citation rankings. Some small European countries do well in terms of citations per paper *(left)*. European institutions with the highest average citations per paper *(right)* rank below the top U.S. institutions *(below)*. Citation counts were conducted for *Science* by ISI's research department, which surveyed papers published between 1988 and 1992 in journals of chemistry and multidisciplinary journals such as *Science* and *Nature*. Rankings include only institutions that published more than 250 papers.

America's Top 5

Rank	Name	Papers	Citations	Cites/ Paper
1	Harvard University	937	8465	9.03
2	Natl. Inst. of Standards & Tech.	393	3513	8.94
3	Caltech	821	6817	8.30
4	Yale University	749	5953	7.95
5	University of Chicago	713	5606	7.86

Europe's Top 25

Rank	Name	Papers	Citations	Cites/ Paper
1	Fritz Haber Inst.	457	2532	5.54
2	Max Planck Inst. Coal Research	379	1832	4.83
3	University of Cambridge	1809	8531	4.72
4	University of Strasbourg 1	810	3807	4.70
5	Max Planck Inst. Biophys. Chem.	257	1204	4.68
6	Swiss Federal Inst. Tech (ETH)	1372	6396	4.66
7	University of Basel	453	2112	4.66
8	University of Southampton	743	3344	4.50
9	Centre d' Études Nucléaires (all)	385	1702	4.42
10	University of Bristol	849	3738	4.40
11	University of Lausanne	426	1867	4.38
12	University of Mainz	897	3862	4.31
13	Philips Res. Labs (worldwide)	356	1535	4.31
14	University of Oxford	1574	6722	4.27
15	KFA Jülich GmbH	449	1910	4.25
16	University of Florence	488	2445	4.24
17	State University of Gronigen	672	2832	4.21
18	University of Frankfurt	488	2038	4.18
19	University of Zurich	410	1711	4.17
20	University of Sussex	714	2928	4.10
21	University of Exeter	396	1608	4.06
22	University of Bielefeld	410	1651	4.03
23	Catholic University of Nijmegen	600	2406	4.01
24	University of Liverpool	484	1918	3.96
25	University of Constance	335	1323	3.95