# Chemistry In Action!

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# Science Communication For All

**Rainer Glaser**
**Department of Chemistry at the University of Missouri-Columbia, USA**
**glaserr@missouri.edu**
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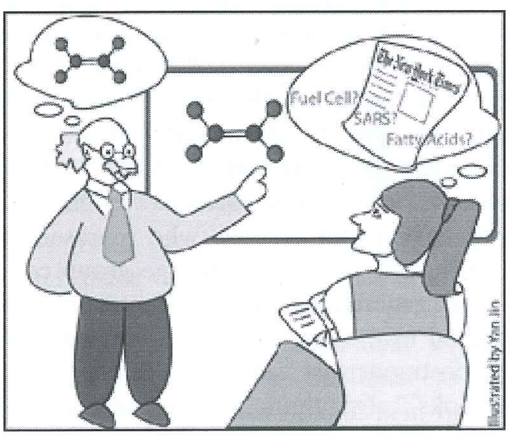
*The IUPAC Committee on Chemistry Education is concerned with good practice in chemical education at all levels and the public appreciation of chemistry. The Committee believes that the following article is a helpful contribution to these subjects. The views are the author's own and are not a part of IUPAC's strategy.*

In his Rede Lecture on *The Two Cultures* in 1959, Charles Percy Snow argued that "persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern" and he concluded that this is "serious for our creative, intellectual, and, above all, our normal lives. It is leading us to interpret the past wrongly, to misjudge the present, and to deny our hopes of the future. It is making it difficult or impossible for us to take good action." In the following decades science progressed with political and public support. Yet, the gap between scientific and humanistic cultures grew larger and societal resistance to real and perceived adverse consequences of science grew from grass-roots activism to well-organized movements. Current concerns about science are exemplified in a conference that The Center for Science in the Public Interest hosts this summer in Washington, D.C., on "Conflicted Science: Corporate Influence on Scientific Research and Science-Based Poli cy."




Fear of science is not a recent phenomenon and it is normal in the sense that humans approach everything new with some apprehension. What is new, however, is that scientists now also are worried. Martin Rees, the United Kingdom's Royal Astronomer, warns in his book *Our Final Hour* how terror, error, and environmental disaster threaten humankind's future. Such concerns were also expressed at the National Organic Symposium of the American Chemical Societyóheld in Bloomington, Indianaóthat I attended and where I wrote this essay. On 10 June 2003, Peter Schultz of the Scripps Research Institute presented a compelling lecture on the synergistic use of biology and chemistry to make "organisms with expanded genetic codes." The natural amino acids and the DNA bases no longer are enough; organisms can now be "synthesized" containing say 25 customized amino acids or more than the usual 2 base pairs. The first question after the talk was about possible biohazards of this research. Had Rees known about this research, he surely would have added a chapter to his book.

## The Need for Engaging the Public in Science Communication

Stewart Brand, cofounder of the Global Business Network, boldly states that "Science is the only News . . . human nature doesn't change much; but science does, and the change accrues, altering the world irreversibly." Science is pervasive in all aspects of modern society and Brand's statement captures the crucial fact that science is growing at an incredible speed. Much of the science important for a person's life in the 21st century will be discovered *after the person has left formal education.* The preparation of students for life-long learning has to become more than a catch phrase, it has to become the highest goal. From this insight derives the mandate to promote science communication in society.

> *"the press will possibly play the central role in how scientifically driven transitions are approached and handled in the future."*

The traditional intelligentsia utterly failed to recognize this essential need and, instead, have propagated postmodernist myths about science, which were so wonderfully exposed by Paul Gross and Norman Levitt in their book *Higher Superstition*. In his book *The Third Culture* John Brockman calls for creating a culture to replace traditional intellectuals and to communicate science and science-based philosophy. Brockman explains in his book and at edge.org that "the third culture consists of those scientists and other thinkers in the empirical world who, through their work and expository writing, are taking the place of the traditional intellectual in rendering visible the deeper meanings of our lives, redefining who and what we are."

In his editorial "Public Engagement with Science" that appeared in *Science* (14 February 2003), Alan Leshner wrote that "we need to engage the public in a more open and honest, bi-directional dialogue about science, technology, and their products, including not only their benefits but also their limits, perils, and pitfalls. *We need to respect the public's perspective and concerns, even when we do not fully share them* (emphasis ours), and we need to develop a partnership that can respond to them." To do so requires informed engagement by the public and, as Bill Moyers pointed out in his article on "Journalism and Democracy" in *The Nation* (7 May 2001), "the press will possibly play the central role in how scientifically driven transitions are approached and handled in the future." Are the media ready to meet this challenge? Is the public ready to engage in science communication? The second question probably is the critical one since the media respond to public demands. To prepare the public for responsible and bi-directional science communication presents a formidable pedagogical challenge for modern college education. Can it be met?

## The State of Undergraduate Science Education

U.S. Census data show that in the last 35 years the number of college age (18-24) Americans remained roughly the same, about 26 million. In the same time, the number of college students in that age group has increased steadily from about 6 million in 1970 to about 9 million in 2000; a 50 percent increase. Data compiled by the Committee for Professional Training of the American Chemical Society show that during the same time period the numbers of M.S. and Ph.D. degrees awarded has remained essentially the same, about 2000 degrees of each type every year. The number of B.S. degrees fluctuated significantly; first climbing quickly from about 8000 in 1970 to over 10 000 in 1980, then declining to less than 8000 in 1990. In the last decade the numbers have gone up again to well above 11 000. Chemistry as a major did not gain from the added numbers of college students, but instead barely held its ground.

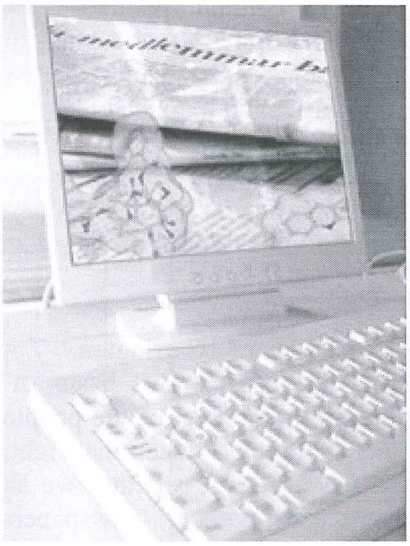
> *The CIITN project involves teaching chemistry to science majors in the context of real-world issues . . .*

Despite the static interest in chemistry, the audience for U.S. college chemistry education has changed dramatically. This is because the share of young people entering college went up from 20 percent in 1970 to about 35 percent today. This is a positive trend and broader access to education for larger segments of society is desirable. The proportion of those required to take chemistry has remained the same and, consequently, chemistry instruction has become even more of a challenge for students *and* for faculty.

One of my recently retired colleagues, after perfecting his style over 35 years of enthusiastic teaching at the University of Missouri (MU), said on various occasions that he "cannot make it any easier any more." A number of factors have contributed to a gradual erosion of educational standards in college science teaching: more students in larger classes, who represent almost twice the percentage of that age group compared to two generations ago; students arriving less prepared from high school; and students exposed to a postmodernist academic climate. Simplified textbooks, algorithmic testing of isolated and simple items, norm-based grading, and the pressure toward grade inflation have camouflaged this process.

There is a dilemma here that needs to be confronted, and soon. The problem cannot be solved via content simplification and traditional pedagogical strategies. Reality is complex rather than simple. There is the chemistry of the combustion of fossil fuels, it is simple and it should be taught rigorously. The complexity of the topic emerges in addressing environmental, economic, and political consequences of societal energy needs. The chemistry of pesticides is slightly more involved and it should be taught in detail. The complexity of this and other health-related topics emerges in discussions about what exposure levels are considered safe for humans and the decision- making process in establishing such levels. The chemistry of sugars, proteins, and fats is somewhat demanding, but it is necessary to understand the complexities of dietetics. If chemists will again dare to teach their science in its full complexity, students will appreciate the efforts and society will take a gigantic step toward science communication for all!

## "Chemistry is in the News" Rises to the challenge



Students need to learn to recognize and to construct these connections. They have to be prepared to evaluate evidence, to appreciate quantitative data, and to understand what they mean. Students need to be able to locate additional data on their own, and then, finally, to make judgments that are sound on many levels: economic, political, philosophical, ethical, and moral. Just 10 years ago, any attempt at implementing systemic change to meet such ambitious goals would have failed for lack of access to media and information and because of problems with course organization, management, and communication. But these barriers no longer exist! Most universities provide phenomenal online access to information for all students and support for course management and communication tools. The combination of this infrastructure with pedagogical strategies that eschew zero-sum outcomes provide extraordinary opportunities. The Chemistry is in the News (CIITN) project at the University of Missouri-Columbia capitalizes on these opportunities and prepares young citizens to comprehend and actively engage in science communication.

The CIITN project involves teaching chemistry to science majors in the context of real-world issues and helping students connect real-world social, economic, and political issues to the teaching of chemistry. CIITN activities include the study, creation, and peer review of online projects based on actual news articles from the popular press.

Because the CIITN project relies on online media, a taxonomy was established of news-media-based learning activities to provide a conceptual framework for their description (see table). Ideally, one wants to engage students in a full range of cognitive skills. The various levels of the CIITN project meet this challenge. The implementation and integration of Level-1 to Level-5 of CIITN activities has been accomplished. Students working in small groups were exposed to news items that consisted of an actual recent newspaper article, editorial comment, and questions. The students studied 10 to 12 instructor- created news items, created one news item, and reviewed a number of student-created news items.

These CIITN activities served several purposes. First, the activities made connections between organic chemistry and societal issues and explicit problems therein, and they required students to think critically about these connections. This provided an authentic learning task in which students were actively engaged with the course content. Second, the activities increased communication and interaction among students and between students and the instructor, making a large lecture course seem less impersonal. Third, the activities helped develop skills central to scientific inquiry (data mining) and valuable for students' educational and career goals (e.g., collaboration, communication, and research). Overall, the CIITN activities create a more effective learning environment within a large lecture course and in doing so they promote students' learning of chemistry.

## Taxonomy of News-Media-Based Learning Activities

| Level | Activity | Quality Review | Resource | Outcome |
|---|---|---|---|---|
| 1 | Read News Article | None | Online news media | Knowledge Comprehension Application Analysis Synthesis Evaluation |
| 2 | Read News Items Editorial & questions | Instructor Review | Online Database & Software Tools | |
| 3 | Read & Create News Items | Instructor Review | | |
| 4 | Read & Create & Judge News Items | Internal Peer Review | | |
| 5 | Read & Create & Judge News Items | External Peer Review | | |
| 6 | Read & Create & Judge News Items | International Peer Review | | |

Level-5 involves an external peer-review process in which students taking similar courses at different universities review each other's projects. Aside from the additional management effort, Level-4 and Level-5 activities differ significantly: the evaluators no longer know the evaluees, both have been instructed in different places in slightly different ways, and, most of all, their backgrounds and experiences may be greatly different. Indeed, the students would benefit the most if some of the views held by the different groups were in conflict. External peer review contributes to the development of the students' ability to present their own positions and hear, understand, and respect other points of view. Hence, through Level-5 activities students develop an appreciation of diversity and learn what it means to be a "good citizen." In collaboration with Dr. Susan Schelble, Level-5 CIITN activities involving inter-state collaborations between student groups in Missouri and Colorado were implemented in the winter semesters of 2002 and 2003.

Level-6, which has not been implemented yet, involves border-crossing peer review, a powerful strategy for adding a global dimension to newsmedia- based learning activities. In this level, peerreview results would be incorporated into the course grade and the students would need to be aware of the international perspective of their projects. The ultimate challenge of this level is the requirement of international collaboration in the preparation of the group projects. Level-6 activities present an opportunity to help students to become "good global citizens. " The importance of this opportunity is highlighted in Thomas Friedman's column, published 1 June 2003 in the *New York Times*, in which he explains why so many people are upset with America. His thesis: "America has begun to touch other people's lives more than their own governments do and therefore people all over the world want to be able to vote on American power." Modern Americans need to understand this aspect of being global citizens.

In a letter to Edward Carrington, Thomas Jefferson wrote in 1787, "The basis of our governments being the opinion of the people, the very first object should be to keep that right; and were it left to me to decide whether we should have a government without newspapers or newspapers without a government, I should not hesitate a moment to prefer the latter. *But I should mean that every man should receive those papers and be capable of reading them* (emphasis ours)." The informed citizen is essential to democracy and, today, Jefferson's mandate requires scientific literacy. The political goal therefore has to be science communication for all and the most promising strategy would involve instruction in science communication for students in their early years of undergraduate college education.

CIITN has been funded by the University of Missouri System, the University of Missouri-Columbia, *The New York Times*, and The Camille and Henry Dreyfus Foundation. It is currently funded by the Department of Undergraduate Education of the U.S. National Science Foundation. The CIITN team includes Dr. Rainer Glaser, professor in Chemistry at MU; Dr. James Groccia, director of the Program for Excellence in Teaching at MU; Dr. Susan Schelble, professor in Chemistry at the University of Colorado-Denver; and a group of graduate students Martin Wu, John Sui, Kathleen Carson, and Brian Hodgen at MU and Eric Lupo at UCDóthat brings exceptional interdisciplinary breadth of talents and perspectives to the instructional design and the assessment of the project. This team is dedicated to affecting a systemic change in college science education in the years to come and we are seeking international collaborators with a shared vision and interest to play constructive roles. We invite interested parties to contact us.

*Dr. Rainer Glaser <glaserr@missouri.edu>, is a professor in the Department of Chemistry at the University of Missouri-Columbia.*
**www.missouri.edu/~chemrg**
**http://ciitn.missouri.edu**

**Dr Glaser was one of the plenary speakers at Eurovariety 2013, University of Limerick, 3-5 July 2013.**

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## The latest form of the Periodic Table (see p. 21 for the latest elements)

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H | | | | | | | | | | | | | | | | | 2 He |
| 3 Li | 4 Be | | | | | | | | | | | 5 B | 6 C | 7 N | 8 O | 9 F | 10 Ne |
| 11 Na | 12 Mg | | | | | | | | | | | 13 Al | 14 Si | 15 P | 16 S | 17 Cl | 18 Ar |
| 19 K | 20 Ca | 21 Sc | 22 Ti | 23 V | 24 Cr | 25 Mn | 26 Fe | 27 Co | 28 Ni | 29 Cu | 30 Zn | 31 Ga | 32 Ge | 33 As | 34 Se | 35 Br | 36 Kr |
| 37 Rb | 38 Sr | 39 Y | 40 Zr | 41 Nb | 42 Mo | 43 Tc | 44 Ru | 45 Rh | 46 Pd | 47 Ag | 48 Cd | 49 In | 50 Sn | 51 Sb | 52 Te | 53 I | 54 Xe |
| 55 Cs | 56 Ba | | 72 Hf | 73 Ta | 74 W | 75 Re | 76 Os | 77 Ir | 78 Pt | 79 Au | 80 Hg | 81 Tl | 82 Pb | 83 Bi | 84 Po | 85 At | 86 Rn |
| 87 Fr | 88 Ra | | 104 Rf | 105 Db | 106 Sg | 107 Bh | 108 Hs | 109 Mt | 110 Ds | 111 Rg | 112 Cn | 113 Uut | 114 Fl | 115 Uup | 116 Lv | 117 Uus | 118 Uuo |
| | | | 57 La | 58 Ce | 59 Pr | 60 Nd | 61 Pm | 62 Sm | 63 Eu | 64 Gd | 65 Tb | 66 Dy | 67 Ho | 68 Er | 69 Tm | 70 Yb | 71 Lu |
| | | | 89 Ac | 90 Th | 91 Pa | 92 U | 93 Np | 94 Pu | 95 Am | 96 Cm | 97 Bk | 98 Cf | 99 Es | 100 Fm | 101 Md | 102 No | 103 Lr |