

LSD and Chemistry

When one is fortunate enough to get an award, he can hardly but wonder why. And when the one additional feat he must achieve is to prepare a talk and have it published (unrefereed), he must wonder at the wisdom of the grantor. After all, how long a talk is required by the generous SAMA gift (tax-free at that)? At his academic rate of pay about one month would be appropriate. Yet his friends face him (and hopefully will scan his ideas) and he'd like to have some friends left.

Nor is a "retrospective show" reasonably to be expected. A brief glance at a beloved painter's work, a line or two from a much-studied poet, a whiff of a nostalgic perfume may discharge a deluge of delightful impressions. But "contributions to chemical education?" Hardly. After thousands of students, hundreds of journal and book pages, dozens of previous speeches, what is left to discuss? And if some of these held good ideas, how can one credit them? There are a dozen men at this dinner who helped make CHEM Study and Harvey Mudd College what they are, and hundreds more not here. If I have contributed to teaching, who should be surprised, with G. N. Lewis, Joel Hildebrand, Ray Ewell, and Luke Steiner in the "genetic" lineage. But don't leave now, I'll think of something. But new? I doubt it.

When that wonderful invitation arrived in July 1971, a title for the speech and article was requested at once—9 months before delivery, 14 months before general viewing. Conceived in delight (as in many 9 month cases) parturition finds a certain uncertainty in the original intent. Why "LSD and Chemistry?"

Perhaps I had felt that both were out-of-date with present students. LSD may be, indeed most of us hope it is. But increases in beginning chemistry enrollments of 40%, and almost no falling off at any level, suggest that chemistry profs will be busy for the foreseeable future. And, if the profs live up to their claims of the broad educational values of chemistry, so will their graduates also be busy. After all, it is doubtful that molecules will soon cease to be an important frame of reference. Even the economists are in on the act now. Paul Samuelson attributes his Nobel prize in economics

to inspiration from a statistical thermodynamics course he took.

Or perhaps both LSD and chemistry seemed to be "a drug on the market." Stretching the analogy even further some say both are dominated by a black market. Black for chemists in poor employment prospects, clogging of the PhD and post-doc pipelines, and a simultaneous drop in grant funding. It does seem clear that the halcyon sixties are gone in more ways than the passing of the decade. Particular programs like graduate fellowships and science faculty fellowships are slashed. But research funding is not in that category yet and, according to NSF, NIH, and Army representatives in Boston, their budgets are holding up so far. Further, though the academic hiring season has definitely slipped from February–March to April–July, unemployment does not appear to be rising, and the most serious problem is the unusual number of post-docs "stored" in graduate schools. Two more years should tell how "black" the market really is, but the decrease in entering students in the more demanding graduate schools should have two effects. It will help restore the pipeline to more normal flow and appreciably increase the level of attainment in the second rank graduate schools. A tertiary effect of the present market may well be to squeeze out some of the marginal graduate, and, indeed, undergraduate chemistry programs. Whether austerity will lead to osterization or auspicious change is clearly still a question.

As an absolute minimum, it is essential for every chemistry department explicitly to inform its students as to the best available data and projections, rather than to leave collection of employment data by students to chance, rumor, and the anecdotal approach. My own opinion is there is no place to run. The medical school situation is on the verge of being catastrophic (60,000 applicants for 12,000 positions). Law school is approaching a similar state. Non-scientific studies are more crowded than chemistry. The best bet for every student is to study what is most interesting to him, and to keep those famous options open. Outguessing a market of any color, five, even two years, hence, requires more than a rigorous statistics course.

But actually what I had in mind a year ago had nothing to do with LSD, the drug. Rather the L was to remind me of Lavoisier—an interesting man, perhaps the first man to lose his head over chemistry. (Or should I say, in these "lib" days, the first person?) History is a bit ambiguous here (written, as usual, by the survivors), but it was perhaps his chemical discovery that moist tobacco was preferable to dry tobacco that led to the decapitating charge of "watering the people's tobacco." By usual faculty standards he was a great success: a member of many committees including

The Cover

The 1972 ACS Award in Chemical Education sponsored by the Laboratory Apparatus and Optical Section of the Scientific Apparatus Makers Association was presented to J. Arthur Campbell at the 163rd Meeting of the ACS at Boston in April of this year. Professor Campbell, a Past-Chairman of the Division of Chemical Education, Codirector of the Chemical Education Materials Study project, and author of several general chemistry texts has been a consistent, constructive, substantial contributor to world-wide chemical education for over three decades. This paper is a condensation of his SAMA Award address.

hygiene, coinage, taxes, casting of cannons (already the military-industrial-university complex), writer of books, correspondent of many scientists, liberal. Yet he died an unlucky death at 51 on a trumped-up charge. Remembered for his reevaluation of the phlogiston theory, he might better be remembered for his outstanding ability at designing, performing, and interpreting experiments. Or perhaps, even more, for his ability to transfer learning from one "field" to another.

And it is here that one of the greatest lacks in every educational system lies. Almost no teachers deliberately teach for transfer. One decade the emphasis may be on basics, the next on dynamics, the next on environment. The swings could well be less (and the effect greater ten years, and longer, later) if transfer received 5–10% of our efforts in every class, not just in a lecture or two mentioning its desirability. Few, even of our advanced chemistry students will be chemists. Yet chemistry uses powerful tools to look at a wide variety of human problems. Showing the relations of the "purely chemical" to physics, biology, geology, psychology, sociology, economics, and the humanities (all at least partially related to molecular behavior) stands a better chance of producing an educated student than the more common set of courses covering each separate compartment. Psychologists have shown transfer is not easy. So let's teach for it *à la* Lavoisier.

The S stands for Socrates, another unlucky man and not a "good" faculty man at all. Chemically he's known for making hemlock famous; though, as with many famous chemicals, few chemists know the composition. Ugly, disputatious, impoverished, cantankerous, author of no books, stubborn, he is best known as a teacher who refused to give answers. Instead, he forced his colleagues to provide answers and evaluate them until only one remained. This he then chose as correct. How wise it would be if chemists

also let students discover that past scientists made errors, that history is not merely chronology, that progress is linear only in retrospect and more like a "drunkard's walk" in actuality, that current theories and facts can be read. And that, on the other hand, processes of learning, research, and interpretation are enhanced by questioning, by discussion, by being pushed (and pushing others) to the wall of decision, not just from the front to the back of a textbook.

And D is Democritus, the luckiest, by far, of the three. Lived to age 90, wealthy, traveled (7 years in Egypt), and widely credited with one of the greatest of human ideas—the atomic discontinuity of matter. Yet it is here that his greatest luck may lie. He is remembered, not because he convinced either his colleagues, his descendants, or the world, but because he turned out to be right. His equally learned, equally persuasive, and equally admired contemporaries who argued counter to him are known by few. His reputation is based on the luck of his choice. Indeed, since the Vedic literature of India put forward similar ideas some 300 years prior to Democritus, he may not even have originated many of "his" ideas. Perhaps he picked them up in Egypt. But we should not argue with luck, just admire it, and, just as much, admit its role in scientific progress.

Too often the student acquires the worst traits of these three: from Democritus presentation of a single point of view with little experimental evidence, from Socrates stubbornness and insistence on sharing the hemlock all around, from Lavoisier good intentions and bad luck. A better LSD prescription for a good trip in chemistry includes learning the importance of experimental data and transfer of learning from Lavoisier, the questioning of all possibilities from Socrates, and luck from Democritus. With such a triumvirate of traits no chemist need ever be a drug on any market.