Reflections on Chemistry and Electrochemistry after Fifty Years of Practice

by Larry R. Faulkner

Ed. Note: *These comments were presented at the ceremony commemorating Honorary Membership in The Electrochemical Society for Allen J. Bard and John B. Goodenough, University of Texas at Austin, Texas, November 23, 2013. See related articles in this issue on pages 13 and 84.*

Let me begin simply by congratulating our two awardees today. As a former president of this university and of the Society, as one of the graduates of the University and an Honorary Member of the Society, indeed, even as a student of one of the awardees, and as a friend of both, I take a special pride in this particular recognition of their marvelous achievements, manifested over sterling careers. Science enjoys few like either of them. Congratulations, John. Congratulations, Al.

And let me add a note of welcome to everyone in the audience. There are, of course, colleagues here from across the University, but others have come from outside the institution, even from elsewhere in the country. For our visitors, I will just say that this is an exciting university with marvelous assets and energy. I hope you can experience some of its qualities while you are here. Electrochemical science and technology have been among its strengths for many decades, in substantial measure because of the powerful intellects and the fostering collegiality of Allen Bard and John Goodenough.

Just about exactly fifty years ago – this month, as I recall – I walked into the office of the chemistry department chairman at SMU and asked to become a chemistry major. It was among my better decisions. The fit has proven to be perfect. I have loved the science and its history. I have loved its relevance to the world at large. I have even loved the fact that chemists are workaholics. It's notable, in fact, that when I went to see the department chairman back in 1963, it was about eight o'clock in the evening. The light was on in his office, as it was practically every night. While he didn't warmly welcome my interruption, he still helped me – and Professor Harold Jeskey became an important mentor and a lifelong friend.

Given the convergence of this anniversary with my duties of the moment, I would like to take this time to offer some reflections on the present and future of our field – on the urgencies and obligations before it. The word "chemistry" will be used as a label for the field, but I mean to include all of chemical science and technology. In these last fifty years, I have watched chemistry change tremendously – in scale and application, certainly in the catalogue of knowledge, but also in public perception. The DuPont motto back in the early 60s was "Better Living Through Chemistry," and the public had every confidence that it rang true. The word "chemistry" was a synonym for "magic." But there was not yet much understanding of environmental impact. That was still around the corner, awakening broadly in the very late 60s and early 70s. The 70s showed us both edges of the chemical sword, just as we came to see two edges to quite a few other blades. We were naïve back then about many things, from the powers of science to the powers of presidents.

Naïveté took a real beating from the late 1960s through the 1970s. Words and phrases that had generally evoked common pride, trust, and optimism – like "government," "the presidency," and "military service" – became much more neutral, or even negative, in the public perception. The words "chemical" and "scientific" were casualties of the times, too. DuPont found a different motto. But just as naïveté gave way to alarm and suspicion, they, in turn, have gradually given way over decades to something more mature. Even though our national life – or really now, our global life – is subject to ridiculous fads of favor and disfavor, responsible citizens seem mostly to have learned that anything of real power – anything that can yield great benefits – also carries serious risk. There is always a negative side requiring attention and mitigation.

While the ignorance of long ago might have given us a bit of bliss, this fuller perception of our science girds us and our leaders for the challenges that lie all around. Realism about both benefits and risks provides a basis for truly responsible exercise of the power inherent in our knowledge. The public view of chemistry matters enormously, for chemistry is the science by which people manage their use and stewardship of the material world. And this issue – the use and stewardship of the material world – is the great challenge of our time. It will remain so beyond the time given to any of us here. Global population has more than doubled over the 50 years since 1963, from just over 3 billion to 7 billion, and a much larger fraction has been brought from poverty into fair prosperity. Earth is groaning under the strain of legitimate hopes of individuals in every society.

Here is the big question: *How can we wisely make use of the Earth's resources to provide fulfilling, secure lives for the Earth's people, now and indefinitely into the future?* All of the words are important: "*wisely make use*," "*fulfilling, secure lives*," "*for the Earth's people*," "*now*," "*indefinitely into the future*." This is surely a challenge of policy and politics, and of economics and business, but it is without doubt a challenge of chemistry wherever the material world is actually touched. How can we intelligently and efficiently extract, transform, preserve, and re-use resources? How can we understand environmental impact comprehensively and manifest well-chosen mitigations? How can we use less of critical materials in the interest of serving more of the globe – or serving it longer? How can we find synthetic substitutes to a larger spectrum of natural resources in short supply? Embedded in these questions are chemical problems for generations of scientists and engineers. And we can be sure that relevant problems will not cease to arise. No one is going to solve the global material challenges with any single breakthrough or

(continued on next page)

(continued from previous page)

policy. The thing to do is to be ever conscious of those challenges, to roll up our sleeves, and to try to make a serious contribution as ideas and opportunities present themselves.

But by no means should we allow ourselves to be overwhelmed. Thanks to science, especially to chemistry, life is tremendously better for most of the people on Earth than it was even a few decades ago. Spreading prosperity has created problems, of course; but the answer is to address them. History shows that humankind is enormously resourceful. Faced with problems, people find solutions. Science is a great and powerful tool for doing just that, perhaps the greatest and most powerful ever devised. And as long as the use and stewardship of the material world remains the central global issue, chemistry will be the central science.

Although I have opened here with an emphasis on the big scene, on the grand exigency, on the utility of our science and its responsibilities to humankind, I don't want to neglect the art of chemistry. It remains important to find out why and how chemistry happens and why molecular systems function as they do. As the science advances, our global understanding and our capabilities move forward, too, sometimes with great leaps, sometimes in the recognition that we used to be operating with wrong ideas altogether.

There are at least three reasons for carrying forward with a healthy program of fundamental chemical research: First, the science is lovely and captivating. The very art of it justifies effort. But just as important, the art is what first draws students in. Second, we cannot afford just to keep on not knowing what we don't know. After all, this is the core science behind the physical well-being and viability of humankind. Third, we can identify matters that we do not yet understand, but that we can clearly perceive to be central to capabilities of enormous, lasting importance. Many relate to energy conversion, certainly including the elusive secrets of electrocatalytic reduction of oxygen to water or electrocatalytic oxidation of simple fuels other than hydrogen. Self-repair in chemical systems is another mystery with great leverage on future technology. You can make a list of your own, I'm sure. In matters like these, fundamental science is the only way to lay a foundation that can really support the eagerly-sought capabilities (as well as other benefits that we have not yet imagined).

Inside chemistry, there is, of course, electrochemistry, a special domain to everyone here. Its historical roots are deep, extending almost to the boundary between alchemy and the beginning of the true science. The earliest discoveries of Volta, Galvani, and Davy are now more than two centuries back ... and we have been working on batteries and fuel cells ever since! Since electrochemical science and technology is the area where practically everyone in this room is most likely to make contributions, let me dwell specially on it for a moment. Anyone who has worked in electrochemistry knows that electrochemical systems are composed, in roughly equal measures, of elegance and exasperation. We have chosen to study the incredibly difficult, to be sure. If electrochemical systems were not so important, many fewer investigators would have worked on them these past two centuries. The systems are intrinsically complex, both spatially and dynamically; moreover, the most important processes take place in tiny portions of the total space, where observation and characterization are so difficult.

But with sometimes stunning ingenuity, investigators have probed and learned. The body of knowledge and theory surrounding electrochemical phenomena is remarkably elaborate, given the intrinsic difficulty of the research. There is considerable elegance in what we already know. And there remains inspiring elegance in the very idea that electrochemistry affords control and observation of the most fundamental chemical act: the addition or subtraction of electrons, one-by-one, to molecules, ions, and atoms. If only we had a better view! But over my fifty years in science, the view has dramatically improved. Tools of great power have been invented, and still better ones must be on the way. Despite the exasperation, keep probing in electrochemistry. The payoff can be very large – in terms of art, in terms of scientific understanding of broad significance, in terms of technology, in terms of this century's central issue: the use and stewardship of the material world.

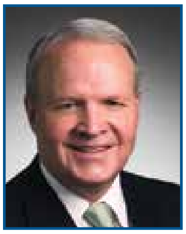
This year marks another anniversary: the 200th of Sir Humphry Davy's finest discovery: the great Michael Faraday, who began his long career at the Royal Institution in 1813 as Davy's assistant. Faraday was a bookbinder's apprentice before that. Although Davy was himself a historic, groundbreaking scientist, his preeminent contribution was, by far, finding and developing Michael Faraday. It's a lesson to all of us who teach and develop younger talent. And that brings us back to these men whom we honor today. They are known everywhere as decent, generous, and collegial, and I believe that those qualities are great amplifiers of their influence.

Science, in the end, is a social enterprise. Many outside seem to perceive science as wholly built on intellect and logic, perhaps by automatons without souls. The truth is that scientific progress depends in very great measure on softer attributes of worthy individuals and organizations, such as trust, instinct, communication, and motivation. To be sure, scientific insight is indispensable, both to discovery and to the construct of understanding. But broad influence in science – the ability to promulgate ideas in the community – expands immeasurably for scientists of great insight who also manifest humanity and humility.

No better exemplars will be found than these two honorees. John Goodenough and Allen Bard, we are enormously proud of you at the University of Texas – and with these Honorary Memberships, the Electrochemical Society expresses pride on behalf of your electrochemical colleagues at large. Everyone in this room wishes each of you deep satisfaction, not just from your scientific achievements, but also from your long careers of worthy contribution, throughout which you have taught, aided, and inspired countless colleagues.

Thank you all for listening today. ■

About the Author



Larry R. Faulkner is President Emeritus of The University of Texas at Austin and retired President of Houston Endowment. He previously served on the chemistry faculties of Harvard University, the University of Illinois, and the University of Texas. He is a former president of the Society and is both an Acheson Awardee and Honorary Member. He was a doctoral student of Allen Bard and later co-authored *Electrochemical Methods* with Professor Bard.