Chemistry and Ethics – Perspectives from an Undergraduate Research Mentor and Teacher

Jetty L. Duffy-Matzner for Chair of Moral Values – March 2, 2009
Chemistry Department, Augustana College

On 3 December 1984, the Union Carbide subsidiary pesticide plant in the city of Bhopal, India; released 42 tons of toxic methyl isocyanate (MIC) gas. This event exposed more than 500,000 people to toxic gases. The first official immediate death toll was 2,259. A more probable figure is that 8,000 died within two weeks, and it is estimated that an additional 8,000 have since died from gas-related diseases.[1]

When chemists make mistakes, people normally die. This is the reality of working in a profession that provides the world with chemical weapons, nuclear bombs, pesticides, medicines, cosmetics, cleaning agents and clothing just to name a few items. Chemistry and other related sciences provide the tools and materials to live in our very comfortable, very clean and cost efficient little worlds. I can't even imagine where one would live that does not utilize, on a daily (if not minute by minute basis), the products provided by chemical industries. The federal Chemical Safety and Hazard Investigative Board (CSB) must investigate industrial accidents and funnel that information back into the chemical community so that people can learn from the mistakes of others. Chemists often live daily with the ethical dilemma that our work is dangerous and the potential for harm to self and others can be great, however the benefits for our society are even greater. Thus correct ethical and professional conducts are of great interest to our community.

There are many sources of ethical conduct for scientists in the literature and on the web. These range from ethical considerations for publications, to frameworks that deal with fraudulent research, NSF (National Science Foundation) rules of misconduct in science, to the ethics of teaching (to name but a few).[2] Since this discussion is aimed specifically at the interaction of ethical behavior and chemists let us examine the policies held by the ACS. The American Chemical Society was founded in 1876 and is the world's largest professional society. The ACS has a long tradition of setting and publicizing the bars for ethical conduct in the field of chemistry. In 1937 the society listed the following among its objectives, "the improvement of the qualifications and usefulness of chemists through high standards of professional ethics, education and attainment." The ACS has maintained specific guidelines for ethical and professional behavior of chemists since 1965.[3] Currently the ACS has adopted the "Chemical Professional's Code of Conduct" to guide its members in ethical and professional considerations. The Code of Conduct is listed below.

Chemical Professionals Acknowledge Their Responsibilities

To the Public

Chemical professionals have a responsibility to serve the public interest and safety and to further advance the knowledge of science. They should actively be concerned with the health and safety of co-workers, consumers and the community. Public comments on scientific matters should be made with care and accuracy, without unsubstantiated, exaggerated, or premature statements.

To the Science of Chemistry

Chemical professionals should seek to advance chemical science, understand the limitations of their knowledge, and respect the truth. They should ensure that their scientific contributions, and those of their collaborators, are thorough, accurate, and unbiased in design, implementation, and presentation.

To the Profession

Chemical professionals should strive to remain current with developments in their field, share ideas and information, keep accurate and complete laboratory records, maintain integrity in all conduct and publications, and give due credit to the contributions of others. Conflicts of interest and scientific misconduct, such as fabrication, falsification, and plagiarism, are incompatible with this Code.

To Their Employer

Chemical professionals should promote and protect the legitimate interests of their employers, perform work honestly and competently, fulfill obligations, and safeguard proprietary and confidential business information.

To Their Employees

Chemical professionals, as employers, should treat subordinates with respect for their professionalism and concern for their well being, without bias. Employers should provide them with a safe, congenial working environment, fair compensation, opportunities for advancement, and proper acknowledgment of their scientific contributions.

To Students

Chemical professionals should regard the tutelage of students as a trust conferred by society for the promotion of the students' learning and professional development. Each student should be treated fairly, respectfully, and without exploitation.

To Associates

Chemical professionals should treat associates with respect, regardless of the level of their formal education, encourage them, learn with them, share ideas honestly, and give credit for their contributions.

To Their Clients

Chemical professionals should serve clients faithfully and incorruptibly, respect confidentiality, advise honestly, and charge fairly.

To the Environment

Chemical professionals should strive to understand and anticipate the environmental consequences of their work. They have a responsibility to minimize pollution and to protect the environment.[4]

Chemists are trained in many aspects of their field as they progress from their bachelors to Ph.D. programs. A vast number of Ph.D. granting institutions now also offer to young graduate students a course in chemical ethics. At Augustana College, the chemistry and biology departments offer ethical considerations as part of our safety training for summer undergraduate students. This training is often more about the practicality of correct conduct vs. the ambiguity of the nature of ethical behavior (which is many things, but not black and white). Laboratory Assistants in the Chemistry Department also undergo safety training as well as training about professional and ethical conduct on a semester basis. They must agree to abide by and sign a document that lists the professional conduct expected of them while employed as assistants for the department. There is even currently a national on-line ethics center for students (undergraduate and graduate) that need advice about ethical problems and/or resources.[5]

This training has come to be part of the formal education of students in chemistry during the past ten years due to concerns that have arisen during the past two decades. Studies indicate that the lack of training in early stages of someone's professional careers may encourage poor professional decisions. A recent survey of scientists in the journal, Nature, indicates that scientists are more likely to compromise their scientific integrity due to perceptions of inequities in the distribution of resources in their early to mid-career years as they try to establish their research group in an ever increasing market for both publications, funding and students.[6]

I think that students need to be aware of the dangers that scientists can pose through their practice. Scientists are human and prone to error. I tend to place these errors into three categories: honest errors, errors of negligence and misconduct. The most important safeguard that scientists have is their own community. Scientists, who make mistakes (of either three categories but most importantly the third), will eventually be caught by their peers. Scientists rely on the peer review process for the sustainment of their careers through both proposal and prepublication review. Their peers will ensure that they don't receive further funding or a chance to further publish. While there are a number of texts available in general for chemical research ethics, there are relatively few available on-line. The National Academy of Sciences, National Academy of Engineering and the Institute of Medicine teamed up to produce one of the most cited books on ethics in chemistry. It is titled "On Being A Scientist: Responsible Conduct in Research." It relates the amazing joys and frustrations of science in an easy to read manner. I would like to quote from this book to more eloquently elaborate on how this community of scientists act to safeguard themselves.

> Scientists are people of very dissimilar temperaments doing different things in very different ways. Among scientists are collectors, classifiers and compulsive tidiers-up; many are detectives by temperament and many are explorers; some are artists and others artisans. There are poet-scientists and philosopher-scientists and even a few mystics.
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> —PETER MEDAWAR, Pluto's Republic, Oxford University Press, New York, 1982, p. 116.

Throughout the history of science, philosophers and scientists have sought to describe a single systematic procedure that can be used to generate scientific knowledge, but they have never been completely successful. The practice of science is too multifaceted and its practitioners are too diverse to be captured in a single overarching description. Researchers collect and analyze data, develop hypotheses, replicate and extend earlier work, communicate their results with others, review and critique the results of their peers, train and supervise associates and students, and otherwise engage in the life of the scientific community.

Science is also far from a self-contained or self-sufficient enterprise. Technological developments critically influence science, as when a new device, such as a telescope, microscope, rocket, or computer, opens up whole new areas of inquiry. Societal forces also affect the directions of research, greatly complicating descriptions of scientific progress.

Another factor that confounds analyses of the scientific process is the tangled relationship between individual knowledge and social knowledge in science. At the heart of the scientific experience is individual insight into the workings of nature. Many of the outstanding achievements in the history of science grew out of the struggles and successes of individual scientists who were seeking to make sense of the world.

At the same time, science is inherently a social enterprise—in sharp contrast to a popular stereotype of science as a lonely, isolated search for the truth. With few exceptions, scientific research cannot be done without drawing on the work of others or collaborating with others. It inevitably takes place within a broad social and historical context, which gives substance, direction, and ultimately meaning to the work of individual scientists.

The object of research is to extend human knowledge of the physical, biological, or social world beyond what is already known. But an individual's knowledge properly enters the domain of science only after it is presented to others in such a fashion that they can independently judge its validity. This process occurs in many different ways. Researchers talk to their colleagues and supervisors in laboratories, in hallways, and over the telephone. They trade data and speculations over computer networks. They give presentations at seminars and conferences. They write up their results and send them to scientific journals, which in turn send the papers to be scrutinized by reviewers. After a paper is published or a finding is presented, it is judged by other scientists in the context of what they already know from other sources. Throughout this continuum of discussion and deliberation the ideas of individuals are collectively judged, sorted, and selectively incorporated into the consensual but ever evolving scientific worldview. In the process, individual knowledge is gradually converted into generally accepted knowledge.

This ongoing process of review and revision is critically important. It minimizes the influence of individual subjectivity by requiring that research results be accepted by other scientists. It also is a powerful inducement for researchers to be critical of their own conclusions because they know that their objective must be to try to convince their ablest colleagues.

The social mechanisms of science do more than validate what comes to be known as scientific knowledge. They also help generate and sustain the body of experimental techniques, social conventions, and other ''methods" that scientists use in doing and reporting research. Some of these methods are permanent features of science; others evolve over time or vary from discipline to discipline. Because they reflect socially accepted standards in science, their application is a key element of responsible scientific practice.[7]

So if the scientific community is primarily the safeguard for ethical and professional conduct, does it contain a set of standards or conventionally accepted moral norms? The answer is profoundly - yes. If any one is interested in further discussions of misconduct in science and the need of scientists for a professional set of guidelines, I would like to invite you to read either my 2003 discussion of science in ethics paper or a short paper by Vincent Hammer that succinctly summarizes many of the same concepts.[8] Hammer points out several different types of scientific misconduct and the rules of the game that scientists in general follow, as well as further discussions of both external and internal review of scientific misconduct. There are five norms that display how scientists should behave that is widely accepted in the scientific community. CUDOS stands for Communalism, Universalism, Disinterestedness, Organized Skeptism and Originality.

Universalism requires that science be independent of race, color, or creed and that it should be essentially international. Communalism requires that scientific knowledge should be public knowledge; that the results of research should be published; that there should be freedom of exchange of scientific knowledge between scientists everywhere, and that scientist should be responsible to the scientific community for the trustworthiness of their published work. Disinterestedness requires that bona fide scientific research should not be manipulated to serve considerations such as personal profit, ideology, or expediency, in other words they should be honest and objective; it does not mean that research should not be competitive. Organized skepticism requires that statements should not be accepted on the word of authority, but that scientists should be free to question them and that the truth of any statement should finally rest on a comparison with observed fact. R. H. Brown[9]

Originality requires that scientific research be novel. An investigation that adds nothing new to what is already known and understood makes no contribution to science. Ziman[10]

Thus far in this discussion I have tried to make a somewhat universal case that scientists and chemists in particular do care deeply about a prudent, safe and efficient way to work within society and with each other to make this planet a better place for all of us to live. Chemists have worked within their society (and along with other scientists) to create documents that spell out proper conduct and ethical behavior as well as conventionally accepted moral norms. I would like to turn specifically to the responsibilities of my profession as a chemistry professor: particularly as a teacher and research mentor.

Since I teach at a small, private undergraduate institution I am sure that I can now hear the collective sigh of the audience at finally arriving at something members in the audience may relate more readily to. I doubt that it would surprise anyone, that a scientist (or any faculty member regardless of field) should feel the call to mentor young people as students in their classes. It might surprise some to learn that scientists feel it is their obligation to mentor both undergraduate and graduate students in a research setting, since the classroom is not indicative of our profession. I believe that it is the duty of a scientist to involve themselves and their students in some manner in the field or laboratory or clinic. Since these activities keep the professor active and challenged in their fields and provide the students with a very important opportunity to train with someone who has the motivation and desire to ensure a positive and rewarding experience for the trainee. Kristin Shrader-Frechette has the following to say on the subject:

> Professors are expected to contribute to the knowledge in their field, and to work with students to do so... Publications lead to evaluation of professional work. Researcher submitting their work for publication is thus comparable to pilots undergoing periodic testing. Both procedures enable professionals to keep their skills at a level necessary to fulfill their duties.[11]

Shrader-Frechette also goes on to mention some of the principles guiding the ethical conduct that should be instilled in the developing scientists. Among these is careful safeguarding against one's own bias and the unbiased use of research in general. One should leave the students with the passion to improve the quality of life for the present and future inhabitants of the earth. One should discuss one's findings to the public, other professionals and employers. One ought to engage in whistle-blowing when appropriate.[12] Many of our students will go on toward professional schools: medical, pharmaceutical, dental and graduate studies in the sciences. They need to have these values carefully implanted in their young and fertile minds before the stress and rigor of these programs. We have to remember that as Francis L. Macrina so eloquently states, "trainees emerge from their programs with an intellectual and ethical framework strongly shaped by their mentors. Indeed trainees often assume the traits and values of their mentors. Thus mentors are the stewards of scientific integrity."[13]

Clarice Yentsch and C.J. Sniderman published a list of mentor activities after interviewing many students.

1. Demonstrating a style and methodology of doing research
2. Developing an analytical approach to selection of significant questions and choosing appropriate approaches to solving them.
3. Discussing the concepts in any sub discipline, and the evolution of those concepts over time
4. Exploring and evaluating the literature of the discipline and the broader body of knowledge of which it is a part
5. Discussing the ethical basis for scientific research
6. Considering, analyzing and evaluating the work and conclusions of colleagues
7. Transmuting, by example and discussion, the skills required for effective scientific writing
8. Facilitating access to the research community
9. Illustrating the methodology and significance of networking[14]

Notice that even young professionals recognize the need for the frank discussion of scientific ethics with a mentor. Faculty mentors play a very important role in advancing a student's awareness of professional ethics. Students need to be more than just laboratory rats (cheap source of labor) or a means to achieving a publication record.

We tend to forget that students, the seed corn of our profession, are quite idealistic. If they start to feel collectively that the research enterprise is just a publication game, it will get very much harder to turn the best and brightest young minds on to science. There is already a fair amount of cynicism out there.[15] *Christopher A. Reed*

So as well as being teachers, research mentors are stewards of scientific ethics and proper conduct. They also play a very important role in ensuring the safety of their students, but what happens when things go wrong? Sheharbano (Sheri) Sangji was a 23-year-old research associate at UCLA. She died this January from injuries sustained from a laboratory fire. University investigators believe that on December 29th, Sheri was drawing a compound that ignites in air into a syringe. Apparently the plunger came out of the syringe barrel and the compound splashed over 40% of her body. Her hands, arms, and upper torso suffered severe burns.

The principal investigator is the mentor, the one setting the stage for how students and other young researchers act or behave in the lab, whether from a scientific or safety perspective, says Erika. Talley, director of EH&S at the College (and immediate past chair of the ACS Division of Chemical Safety). EH&S safety officials claim that this death didn't have to happen…. It is likely it could have been prevented had Sheri and those around her been more conscious of laboratory safety.[16]

I wish I could wholeheartedly agree with the sentiments behind this prelimary judgment, but I can't. Chemistry, like most aspects in life, has a risk assessment component to it. I can think of three different scenarios in which the plunger would have come out of the barrel and two of three are firmly rooted in operator error. Simple but important tricks of the trade that one should be trained in but in reality are difficult to spot unless you have a lot of practice. Do I worry about the safety of my research students? Of course I do! Do I do everything in my power to train them and brow beat the rules of proper lab procedure to ensure the safest possible working conditions? You bet I do! Have I had students who had to go to the emergency room due to laboratory accidents? Yes I have…. Could those have been prevented if I had been more safety conscious – I don't think so. At some point the students have control over their safety and the safety of others in the laboratory.

So we are back to the beginning of this discussion. Chemists live daily in a world that is balanced between both the dangers and the benefits of their careers. We aren't perfect and unfortunately mistakes happen. That doesn't mean that we are excused from the responsibilities of those choices. Rather it mean that we do everything possible to make correct choices and to train our students to make correct choices whenever possible.

"Do not be anxious then, saying, 'What shall we eat?' 'Or what shall we drink?' 'Or with what shall we clothe ourselves?' "…..
"But seek first His kingdom and His righteousness; and all these things will be added to you."
"Therefore do not be anxious for tomorrow; for tomorrow will care for itself. Each day has enough trouble of its own." Matthew 6:31-36

I get great comfort from Matthew 6:30-36. I live in a world that asks for more than to be clothed and given drink and fed. I live in a world that wants its' food to be transported and not spoil. I live in a world that not only wants a shirt but we want in a particular color and for it not to wrinkle easily. I live in a world that demands the products that chemistry can provide it. I also live in a world facing great environmental crises and chemists will be part of the solution for those problems. The gospel lesson imparts a powerful message in that our anxiety and fears about our lives can't control our lives. As a chemistry professor and parent, I want the best for my students and I will do everything in my power to make sure that their workplace is safe. I will also try to give my students a solid foundation in the chemical field in area knowledge and the ethical aspects of our profession. I know I am not perfect. But I also believe that in the end – I have to trust in a higher power that my students will use the knowledge that I give them to the best of their abilities - because they have had the best possible example that I can give to them.

References:

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2. National Science Foundation, *Misconduct in Science and Engineering Final Rule* (1991), *Framework for Institutional Policies and Procedures to Deal with Fraud in Research* (1989), *The Online Ethics Center for Engineering and Science*, *Teaching Research Ethics* (Poynter Center for the Study of Ethics and American Institutions.
3. http://www.acs.org
4. Chemist's Code of Conduct (1994) http://chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=membership%5Cconduct.html
5. http:www.onlineethics.org/index.html
6. B.C. Martinson, M.S. Anderson, and R. deVries; *Scientists Behaving Badly*. Nature, 435 (9), 2005.
7. Committee on Science, Engineering, and Public Policy; *On Being A Scientist: Responsible Conduct in Research.* National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. Washington, D.C.: National Academy Press, 1995.
8. Vincent N. Hammer, *Misconduct in Science: Do Scientists Need a Professional Code of Ethics?* (http://www.files.chem.vt.edu/chem-ed/ethics/vinny/www_ethx.html)
9. R.H. Brown, *The Wisdom of Science*. Cambridge, GB: Cambridge University Press, 1986.
10. J. Ziman, *An Introduction to Science Studies*. Cambridge, GB: Cambridge University Press, 1984.
11. K. Schader-Frechette, *The Ethics of Scientific Research*, p. 25. Rowman and Littlefield Publishers, Inc. Lanham, Maryland, 1994.
12. ibid, p. 83.
13. F.L. Macrina, *Scientific Integrity, An Introductory Text with Cases*. American Society for Microbiology, Washington, D.C.,1994, p. 15.
14. C. Yentsch and C.J. Snidermann, *The Woman Scientist - Meeting the Challenge for a Successful Career*. Plenum Press, New York, 1992. p. 145-159.
15. C.A. Reed, *Drowning in a sea of refereed publications. Chem & Eng. News*, 2001, p. 38.
16. J. Kemsley, *Learning from Mistakes. Chem & Eng. News*, 2008, (87), 8, p. 59

MORNING WORSHIP
Monday, March 2, 2009

Prelude *"Christ You are My Life"* Johann Pachelbel

Welcome/announcements

Invocation

Gospel: Matthew 6: 25-34

Hymn *"Earth and All Stars"* ELW #731, vv. 1, 4, 5

Message *"Ethics in the Disciplines: Chemistry"*
Dr. Jetty Duffy-Matzner

Lord's Prayer

Benediction

Postlude *"Earth and All Stars"* Keith Kolander

CAMPUS MINISTRY ANNOUNCEMENTS

CHAIR OF MORAL VALUES SERIES - *"Ethics in the Academic Disciplines"* series begins on Feb. 9th and continues on Mondays through Mar. 16th. The preachers will represent various departments on campus. There will be a panel discussion to wrap up this series on Mar. 19th in the 3-1 room..

SPRING BREAK SERVICE TRIP - Registration is beginning for the spring break service trip to flood-plagued Cedar Rapids, Iowa. Students will be leaving on Monday morning, March 23 and returning on Friday evening, March 27. Students will be staying in a local church and doing renovation/clean-up from the June 2008 flood. The

cost of the trip is $100 and it includes 2 meals/day and transportation to and from Cedar Rapids.
A Tetanus shot is recommended but not required. The chapel is willing to pay for gas if anyone is willing to drive to Cedar Rapids and back (about 5-5.5 hours)

CHAPEL STAFF - 09/10 - Applications are now available in the chapel office for chapel staff for next year. Please sign the sheet on the Narthex table and get an appl. from Carol in the chapel office. **Appls. are due back on Fri., March 13th.**

UNITY NIGHT- The first in a series of unity events is planned for Sat Feb.28th from 8-9 pm in the chapel. We are organizing the parts to it so that if you or your group would like to lead a song, or prayer please contact Drew Adam acadam06@ole.augie.edu Also if you wanted to help provide treats, refreshments, or just help promote this Unity Night by telling your organization or hanging up posters please feel free to let Drew know. Everyone is welcome!!

CHAPEL SCHEDULE

Tuesday (3rd)	Roman Catholic Mass, 10 am - Fr. Jim Mason
Wednesday (4th)	Holy Communion, 10 am - Jon Henkes, Adv.
Friday (6th)	Worship, 10 am - Darcy Haas
Sunday (8th)	Worship, 11 am - Pr. Paul
Monday (9th)	Worship, 10 am - CMV series - Gretta Melstad, Softball