American Chemical Society Codes of Ethics: Past, Present, and Future

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Abstract: This article traces the evolution of the American Chemical Society (ACS) Code of Ethics from its inception to the present. It also discusses various supporting documents issued by the ACS which have some ethical content. The similarities and differences between the ACS code and several representative national and international codes are then explored. Finally, the strengths and weaknesses of the ACS code in providing guidance in finding solutions to current ethical problems are discussed.

Keywords: *Codes of ethics*, *American Chemical Society*, *environment*, *responsible conduct of research.*

1. Introduction

Codes of ethics reveal much about a profession; they tell us what it values and how it wants to be seen by the world. The code also helps to define the relationships within the chemical community, how professionals should ideally interact with each other, and shapes the relationship between the profession and society (Frankel 1999). A code of ethics formalizes the informal bargains that professionals make with themselves and with society and can be used as a guide in ethical decision making.

Tracing the evolution of a code shows how the profession responds to changes in circumstances, both internal and external. Chemistry has always been a science in the middle between the theoretical and the practical, between philosophy and craft. Chemists have developed substances that have greatly improved human life from pharmaceuticals to materials, but they have also been responsible for some of the worst environmental pollution. Chemists are employed in a wide variety of institutions from universities to production plants, so any code of ethics for chemists must account for the different responsibilities of these jobs. Crafting an appropriate code is a complex challenge.

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After a brief history of codes of ethics, I will trace the development of the American Chemical Society (ACS) code of ethics from its origin in 1965 as the Chemist's Creed to the present to show how the code has adapted to changing circumstances. The ACS code is supplemented by several documents concerned with more specialized topics and their ethical content is described and analyzed. There are many other codes of ethics for chemists developed by national chemical societies and by international organizations so it is instructive to compare the ACS code with a few representative codes to see the similarities and differences. The final two sections are an assessment of the ACS code that suggests some changes to better deal with contemporary ethical issues.

2. Brief History of Codes of Ethics

The Hippocratic Oath, historically taken by physicians, dates to the fifth through third centuries BCE, although the earliest surviving written version is from about 275 CE. The word profession is Latin for 'bound by an oath'. In ancient Rome one's profession was the occupation declared under oath to a tax collector. About 100 CE, the Hippocratic Oath became the required oath for physicians. The earliest code of medical ethics was proposed by Thomas Percival of Manchester, England, in 1794 which led to codes of ethics for the practice of medicine beginning about 1850 (Baker 1999). The word code also comes from Latin where it originally referred to any wooden board. Eventually the word came to refer to any paged book, or codex, and finally to a systematization of rules or laws (Davis 1999).

Although there is surprisingly little written about the history of codes of ethics, empirically we can see that codes began to proliferate in the mid-20th century as researchers struggled to respond to the scientific and medical atrocities of the Nazis (Metcalf 2018). Before World War II, the German Medical Society had promulgated a set of ethical guidelines for therapy and human experimentation but those had been negated by Adolf Hitler. At the war crimes trials in Nuremberg, the judges developed the ten-point Nuremberg Code which provides a basis for subsequent codes related to human and animal experimentation. Scandals such as the infamous Tuskegee experiment have led to further developments in biomedical ethics (Jones 1993). Professions other than medicine and law, including chemistry, began to write codes of ethics to formalize relationships within the profession and between the profession and society.

3. Evolution of the American Chemical Society Code of Ethics

Although the Federal Charter of the American Chemical Society, issued in 1937, lists among its objectives, "the improvement of the qualifications and usefulness of chemists through high standards of professional ethics, education, and attainments" (ACS 2016a), the Society did not adopt a formal code of ethics until 1965 when it issued 'The Chemist's Creed' (ACS 1965). The ACS Council Committee on Professional Relations and Status had been considering various versions of a code of ethics for several years, responding in part to a survey conducted in 1960 which showed that a majority of members thought having a code of ethics was a good idea. The August 1964 meeting of that committee considered a code of ethics that had been adopted by the Dayton Section in 1949. That code had originally been drafted by P. K. Rothemund who had advocated for registration for chemists after World War II. The document was further refined by Austin M. Patterson who was an editor of *Chemical Abstracts* (ACS News 1964). 'The Chemist's Creed' was adopted by the ACS Council a year later (ACS News 1965). The brief article in *Chemical and Engineering News* which reports the adoption of the document does not say why the title was changed from code of ethics to creed. Perhaps the committee and the council felt that a creed, which is a personal statement of values, was more appropriate than a code which is a set of rules. Although the vote was strongly positive, there was opposition. Those opposed to the new code argued that the provisions were too obvious and that anyone worthy of the label 'professional' automatically did what the statements promoted. It is interesting that 'The Chemist's Creed' is not mentioned in the Centennial History of the ACS (Reese 1976).

That relatively brief statement, 286 words in length, was revised and expanded in 1994 as 'The Chemist's Code of Conduct' (ACS 1994). The 1994 version underwent more minor revisions in 2007 and was given a new title, 'The Chemical Professional's Code of Conduct'. This latter code has been regularly revised, most recently in 2016. This section will examine the evolution of the formal statements on ethics as reflected in the three codes. Quotations in the rest of this section come from the three versions of the code.

'The Chemist's Creed' succinctly specifies the responsibilities of a chemist in eight areas: to the public, to the science, to the profession, to an employer, to the chemist him or herself, to employees, to students and associates, and to clients. Most of the statements are based on solid moral values such as truth telling, not cheating, and maintaining trust among professionals. For example, the chemist is admonished to "search for [chemistry's] truths by use of the scientific method, and to enrich it for the good of humanity". Further, the chemist should "maintain my professional integrity as

an individual" and "hold the highest ideals of personal honor". The rest of the Creed consists of similar broad statements of moral and professional ideals. One interesting provision, which came directly from the original Dayton code, is that the chemist should "live an active, well-rounded and useful life", a refreshingly broad perspective on the professional life.

A large fraction of chemists are employed in the chemical industry, so there are statements regarding obligations to employers, employees, and clients. Although chemists employed in universities or research laboratories do have employment issues, these statements are primarily directed at the industrial sector. The sections on employees and clients are quite reasonable; they should be treated with respect and dignity, both well-accepted moral values. The responsibility to employers, on the other hand, demands complete loyalty. The chemist must "serve him undividedly and zealously in mutual interest, guarding his concerns and dealing with them as I would my own". This aspect of the code is, at best, morally questionable because chemists must further the employer's objectives even if they find those goals to be illegitimate for practical, legal, or ethical reasons. This should be contrasted with the Code of Ethics of the National Society of Professional Engineers (NSPE 2017). Although engineers are expected to "act in professional matter for each employer or client as faithful agents or trustees", the primary duty of engineers is to the health and welfare of the public, and they are not to work with "any person or firm which they have reason to believe is engaging in fraudulent or dishonest business or professional practices".

'The Chemist's Code of Conduct', issued in 1994, expands the provisions contained in 'The Chemist's Creed'. It contains nine sections. The section on "Responsibilities to Myself" was eliminated although some of the provisions were moved to other sections. The section on "Students and Associates" was divided into two separate headings and a section on "The Environment" was added.

The section on responsibilities to the public was strengthened. It opens by stating, "chemists have a professional responsibility to serve the public interest and welfare". Further, "chemists should be actively concerned with the health and welfare of co-workers, consumers and the community". These proactive statements reflect an increased concern with public health and safety compared to the earlier negative statement, "discourage enterprises or practices inimical to the public interest or welfare".

The two sections on the "Science of Chemistry" and the "Profession" reflect core principles of professional ethics, including respect for the truth and ensuring that scientific contributions are thorough, accurate, and unbiased. There is also a nice statement of humility, "understand the limitations of their knowledge". There are additional important provisions on the responsible conduct of research, including keeping accurate laboratory records,

maintaining integrity, giving credit where it is due, and avoiding conflicts of interest. Finally, the document states that "scientific misconduct, such as fabrication, falsification, and plagiarism are incompatible with this Code". These are the three categories of scientific misconduct identified by the Office of Research Integrity (Steneck 2004).

The section on the "Employer" is significantly different from the corresponding section in 'The Chemist's Creed'. Instead of complete loyalty, chemists are required only to "promote and protect the legitimate interests of their employers", leaving the ethical judgment of what is legitimate to the individual. This statement is still problematic because the key term, 'legitimate', is not defined. For example, one of the legitimate interests of a corporation is making a profit. Are chemists obligated to protect that interest even if they judge that the company is selling products that are dangerous to humans or the environment, or using processes that generate more pollution than necessary? An additional problem is that there is no corresponding provision regarding protections for chemists if there is a disagreement as to what is a legitimate interest. This would vary depending on the employer, but the fate of many whistle blowers is usually not good (Glazer & Glazer 1989, Lubalin & Matheson 1999).

The fundamental message regarding employees, associates, and students is that they should be treated with respect. This is essentially the same as the responsibilities in 'The Chemist's Creed', but stated more clearly in the revised code. Two important additions to the section on students are statements that the tutelage of students is a trust conferred by society and that students should not be exploited. Because graduate education in chemistry is a kind of apprenticeship, this is an important protection. A senior graduate student can be very productive and is much cheaper to support than a postdoctoral research associate; there is a temptation to delay that student's graduation so that he or she can produce a few more articles.

The publication of *Silent Spring* by Rachel Carson in 1962 is often identified as the beginning of the environmental movement in the U.S. (Carson 1962). Events that followed include the founding of the Environmental Protection Agency in 1970. The toxic effects of chemical wastes at Love Canal in New York came to light beginning in 1976. Such incidents led to the passage of the so-called Superfund or The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980. The Bhopal disaster in India, in which 500,000 people were exposed to methyl isocyanate gas and other chemicals and about 4000 died, occurred in 1984. The Responsible Care program of the American Chemistry Council was adopted in 1988 (American Chemistry Council 2017). The Code finally reflected this concern with a section on the Environment which tells chemists to "understand and anticipate the environmental consequences of their work", and "to avoid pollution and

to protect the environment". This was an important advance that formally recognized the darker aspects of the chemical industry, although it is relegated to the end of the code suggesting to some that it is less important than the other provisions (Bensaude-Vincent & Simon 2008, p. 236).

The 2007 revision changed the name of the document to 'The Chemical Professional's Code of Conduct'. Most of the sections were not changed. The name of one section was changed from "Associates" to "Colleagues". That section and the section on employees were amended by adding language on avoiding bias based on grounds such as race, gender, ethnicity, disability, or other personal attributes. These additions reflected the increasing concern with bias in American society and were long overdue. The section on the environment was expanded to strengthen the language and to add provisions related to sustainable development. By 2007 the problem of limited resources, particularly of petroleum, and the need to consider the fate of future generations were broadly recognized and the Code reflected these concerns.

4. Supporting Documents

The ACS has developed several documents that supplement the code of ethics. Perhaps the most important of these is the 'Ethical Guidelines to Publication of Chemical Research' (ACS Publications 2015). In 1982 the editors of the ACS journals established a sub-committee to draft a set of ethical guidelines because they felt that the informal teaching by mentors or research groups, and the experience in preparing manuscripts was not systematic. The two core principles that guided the sub-committee were honesty and fairness (Bunnett 1983). The initial draft, presented to the Board of Editors in mid-1983, has been regularly updated and is a comprehensive statement of ethical publication practice which includes detailed guidelines for editors, authors, and reviewers and a brief section for authors publishing in the popular literature.

Probably the most important guideline for editors is that they give each manuscript unbiased consideration, judging it solely on its scientific merit and the quality of the presentation. Editors also need to avoid conflicts of interest and should allow another responsible person, such as an associate editor or a member of the editorial advisory board, to handle a manuscript from a close collaborator or former student or a manuscript on a topic that is close to the editor's own area of research. The same principles apply in the choice of reviewers. All of these provisions follow from the core principle of fairness. Finally, the whole process must be confidential.

For authors, the standard is completeness and accuracy in reporting the procedures, data, and conclusions as concisely as possible. Any professional reading the article should be able to understand what was done and to reproduce the work. If images are included, they must be free from misleading manipulation, something that is currently much easier to do with modern digital technology. The author must also cite the relevant prior work and identify other sources of information such as personal communications. It is also important to identify any unusual hazards in the reported procedures and to indicate that appropriate standards for experimentation on animal or human subjects have been followed, if necessary. Occasionally, an author will criticize previous work, which is acceptable, but this criticism must not be personal.

Fragmentation, dividing a larger article into smaller pieces, is to be avoided, although it is permissible to publish a preliminary short communication followed by a detailed article. Submitting the essentially same article to two different journals at the same time is a breach of ethics. Plagiarism is an even more serious offense. Authorship guidelines are described in detail. A coauthor is someone who has made a significant scientific contribution to the work and shares responsibility for the results. Other, more minor, contributors should be acknowledged. It is also essential that financial and other conflicts of interest be disclosed. Chemists and other scientists are increasingly involved in commercial ventures and the publication of a positive result related to that venture might be financially lucrative.

The peer review system is an essential part of the publication process and all chemists have a professional obligation to participate. As with editors, the core ethical principle for reviewers is fairness. They should only agree to review manuscripts they are scientifically qualified to judge and they should review them objectively respecting the intellectual independence of the author. Reviews should be completed in a timely manner and judgments about the manuscript must be properly supported. If the reviewer needs to criticize a manuscript, that criticism should never become personal. Conflicts of interest should be avoided and the review process must be held confidential.

The guidelines for both authors and reviewers contain an interesting provision. Both are asked to inform the editor of "concerns with respect to manuscripts that report research that, based on current understanding, can be reasonably expected to provide knowledge, products, or technologies that could be directly misapplied by others to pose a threat to public health and safety, agricultural crops and other plants, animals, the environment, or materiel". There is, however, no corresponding provision in the guidelines for editors as to what they should to do with such concerns. The 'The Chemical Professional's Code of Conduct' requires that chemists be "actively concerned with the health and welfare of co-workers, consumers, and the com-

munity", and to "protect the environment", but it, too, does not provide any guidance as to what chemists should do if they have concerns that a substance or a process is dangerous.

The final section provides a few guidelines for chemists writing for the popular literature. First, they are admonished to be accurate and unbiased. The guidelines recognize that in writing for a lay audience, it will be necessary to simplify and to use more common words rather than precise technical language, but it is still important to strive for accuracy. The final provision is quite important. Chemists should not announce a discovery to the public unless it is secure enough to publish it in the scientific literature and that the discovery should be submitted to a journal as soon as possible so that it can be subjected to peer review. This provision is there, in part, to protect the public, but also to discourage such practices as 'publication by press conference'. A good example of this was the announcement of cold fusion in March 1989, a discovery that has yet to be verified (Close 1991).

The 'Professional Employment Guidelines', first issued in 1975 and revised regularly since then, are not primarily concerned with ethics, per se, but rather with good employment practices (ACS 2004). They do include statements opposing discrimination in employment and physical and verbal harassment. Some of this is prohibited by law, but the ACS guidelines go beyond the law and make a strong moral statement. They also make contact with the Code of Conduct in urging the chemical professional and the employer to minimize risks to the environment.

Similarly, the 'Academic Professional Guidelines' establish standards for academic institutions for the education of the next generation of chemists (ACS 2016b). There are sections concerning faculty, students and postdoctoral associates, departments and institutions. These guidelines also include a statement opposing discrimination as well as a statement that chemical scientists should maintain "high standards of honesty, integrity, ethics, and diligence in the conduct of teaching, research, and professional activities". There is also an emphasis on developing a culture of safety in the department. Although faculty members and departments are expected to develop an atmosphere in which students can learn and mature into working professionals, there is no explicit statement on the importance of ethics. For example, faculty are expected to serve as mentors, but the importance of modeling ethical professional behavior is not mentioned.

The final document is 'Scientific Integrity in Public Policy', which concerns the interaction between science and government (ACS 2014-2017). It includes sensible recommendations regarding the ideal way that Federal agencies and Congress should solicit and use scientific information. Scientists and engineers have an obligation to provide accurate and unbiased information and should avoid, or at least disclose, conflicts of interest.

5. Comparison with Other Codes

It is instructive to compare the ACS Chemical Professional's Code of Conduct with similar codes adopted by other organizations, both national chemical societies and international organizations. There are hundreds of such codes (OPCW 2015a) so I have to be selective. I will compare and contrast ACS code with those of two other chemical societies, the Royal Society of Chemistry and the German Chemical Society, two countries with important chemical industries, and two recent international codes, the 'Hague Ethical Guidelines', developed under the guidance of the Organization for the Prohibition of Chemical Weapons, and the recent 'Global Chemists' Code of Ethics'.

The Royal Society of Chemistry of the United Kingdom (RSC) has developed a detailed document entitled 'Professional Practice and Code of Conduct' (RSC 2013). It begins by listing three overarching behaviors, broad categories that are then used to organize the rest of the code. They include: (1) inclusivity – respect, (2) integrity – rigor, and (3) leadership – responsibility. These categories certainly correspond to important moral principles including trust, respect for other humans, truth telling, and also to the need for strong leadership within the chemical community to ensure that the ethical principles are upheld.

The first section of the code presents general ethical considerations, such as chemists "should never engage in an action that conflicts with their integrity or that of the Royal Society of Chemistry" and "have a duty to serve the public interest, and maintain and enhance the reputation of the profession". This is language quite similar to that found in the ACS Code. The remaining sections primarily concern industrial chemists. Among the topics are employer responsibilities, self-employment and consultancy, trade union membership, presenting legal evidence, and tribunals and inquiries. The latter three topics are not discussed at all in the ACS code. There are sections that cover education, environment, health and safety, and other legislation and communications. The guidelines for industrial chemists are broadly similar to those in the ACS code, but little is said explicitly about research ethics, which is a more prominent part of the ACS code.

Chemists in the UK, however, can turn to the 'Code of Practice for Research', issued by the UK Research Integrity Office, an independent agency offering guidance to universities and other research organizations (UKRIO 2009). This is a detailed guide covering all aspects of research. There is also a statement on research integrity of the Royal Society which sets out standards for all scientists in the UK. It articulates four key principles for ethical conduct: excellence, accountability, transparency, and responsiveness. For each principle there are guidelines for both researchers and institutions. For ex-

ample, researchers are encouraged to strive for excellence and institutions are expected to create an environment where "the honest and ethical conduct of science is an expected norm". This is one of the strengths of this document. As I have previously argued, developing a culture of ethical behavior in a research group and an academic department is crucial to the cultivation of virtue (Kovac 2013a).

In contrast to the long and detailed codes of the RSC and the ACS, the Code of Conduct of the German Chemical Society is brief, less than a page in length (OPCW 2015). It is a statement of principles emphasizing the responsibility of chemists to society, the economy, the environment, and particularly to future generations. There is also a statement regarding the responsibility of chemists to fight against the misuse of chemistry, including the production of chemical weapons. Finally, there is an explicit statement that the code is binding on all members of the society. The code of the Royal Society of Chemistry contains a similar statement, something that is lacking in the ACS Code.

In 2015 representatives from various national chemical societies developed the 'Hague Ethical Guidelines' under the guidance of the Organization for the Prohibition of Chemical Weapons (OPCW), the international organization that oversees the provisions of the Chemical Weapons Convention (OPCW 2015b). These guidelines are written from the perspective of the OPCW, emphasizing the need to prevent the misuse of chemicals, particularly as weapons, but they also provide a strong statement on the relationship between chemistry and society. The core element of the 'Hague Ethical Guidelines' is, "achievements in the field of chemistry should be used to benefit humankind and protect the environment". This is followed by a statement regarding the importance of sustainability so that the needs of future generations are not compromised. The remaining sections of the guidelines address education, awareness and engagement, ethics, safety and accountability, oversight, and exchange of information. The statements on accountability and oversight are particularly concerned with ensuring that chemicals do not fall into the hands of those who would misuse them for illegal, harmful, or destructive purposes.

In 2016, a group of scientists from 18 countries gathered in Malaysia to draft the 'Global Chemists' Code of Ethics' (ACS 2016c). The workshop was convened by the ACS Office of International Activities. This idealistic statement urges chemists to be "role models, mentors and advocates of the safe and secure application of chemistry to benefit humankind and preserve the environment for future generations", echoing the language of the 'Hague Ethical Guidelines'. The statement on the environment emphasizes the importance of environmental sustainability and the proper use and disposal of chemicals and instruments. The sections on research and scientific writing

and publishing continue the theme of benefitting humankind and protecting the environment while maintaining the highest standards of integrity. Finally, there are statements regarding safety and security that elaborate the principles put forth in the 'Hague Ethical Guidelines'.

The two international codes are concise statements of moral ideals. They reflect increased contemporary concerns with protecting the environment and the possible misuse of chemicals. They also attempt to portray chemistry in the best possible light, as a science committed to benefitting society. Chemists have long been concerned with the public perception of their science (Bensaude-Vincent & Simon 2008; Schummer *et al*. 2007). Although chemists have produced substances that have improved the human condition, these substances were often dismissed as 'artificial' and inferior to the 'natural' substances they replaced. They were often produced by processes that generated waste products that polluted the environment, in plants that occasionally had accidents resulting in many deaths.

Two important differences between the two international codes and that of the German Chemical Society, on the one hand, and those of the ACS and the RSC, on the other, are the emphasis on preventing the misuse of chemicals and on protecting the environment. Both the ACS and RSC codes are silent on the issue of preventing the misuse of chemicals. Both contain statements on the environment but they are much less prominent.

6. Discussion

Mark S. Frankel has identified three types of codes of ethics: aspirational, educational, and regulatory (Frankel 1989). All of the codes discussed in this article are largely aspirational, statements of the ideals to which chemists should aspire. Some of the codes, that of the German Chemical Society, the Hague Ethical Guidelines, and the Global Chemist's Code of Ethics, stop there. The ACS and the RSC codes add some educational and regulatory aspects, although neither is as detailed as the Code of Ethics of the National Society of Professional Engineers (NSPE, 2017). The ACS and RSC codes explicitly recognize the different roles that chemists play: although some of the provisions apply to all chemists, others, such as the responsibility to clients, apply only to those involved in consulting.

All professional codes are embedded in a larger moral landscape because all professionals simultaneously belong to several communities each with its own set of responsibilities (Kovac 2013b). Some of these responsibilities are explicitly recognized in the ACS code but others are not. We are all citizens of a national society with a history and with goals and ideals. With citizenship

comes obligations. Second, almost all chemists are employed by an institution, a college or university, a government or private research laboratory, a government agency, or a corporation. Each of these has its own culture and expectations. Because a large fraction of chemists are employed by industry, the influence of the institution is very important, and both the ACS and RSC codes have several provisions that are primarily directed at industrial chemists. A further complication is that the chemist might be a manager, or even a company president, with responsibilities to a board of directors or the company shareholders. Many academic chemists are also entrepreneurs who are involved in start-up companies so there is a potential conflict of interest between their academic and commercial obligations. Another possible responsibility is the source of funding for the research being conducted which might impose constraints. Fourth, all chemists are members of the human community and have the same moral obligations as all other people. Simultaneous membership in these different communities can certainly give rise to moral dilemmas. For example, when does chemist's moral responsibility as a member of the larger human community take precedence over obligations to an institution or country? The moral landscape might be further complicated by the scientists religious beliefs and practices. Because chemistry is a secular pursuit, I will not consider the moral demands of particular faith traditions, but it is important to remember that religious beliefs can strongly influence certain moral decisions.

Some of these complications are recognized, at least implicitly in the ACS Code and the supporting documents. As noted, obligations to employers are included and the first provision of the code states the obligations of chemists to serve the public interest, although it is left to individuals to decide exactly what the public interest is and how best to serve it. Similarly, the section on the environment only tells chemists to "understand" the impacts of their work and to "recognize" the need to develop sustainable processes. The ACS statement on the environment has been strongly criticized by Bensaude-Vincent and Simon (2009, chap. 14) who point out that it is the last provision in the code and therefore seems to be the least important. They contrast its 'prudence' with the more 'precautionary' stance of the European Union's REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) which establishes a central database of information about chemicals to ensure that particularly hazardous materials are properly controlled or even banned (European Commission 2006). They call for a new culture of chemistry in which chemists consider all the consequences of their research. Roald Hoffmann has made a similar plea (Hoffmann 1997). It is not enough to synthesize a molecule to solve a particular problem. One must also consider the whole life of that molecule and try to determine what negative effects it might have in other contexts.

An example of the tensions between prudence and precaution and between commercial interests and health and environmental safety is the pesticide chlorpyrifos, marketed by Dow Chemical under the trade name Lorsban. Chlorpyrifos is an organophosphate closely related to nerve agents which is why it is so effective as an insecticide. It was banned by the EPA for most residential use in 2000 and environmental groups in the US have been trying to have the compound completely banned since 2007 (Pesticide Action Network 2006). Research has shown that chlorpyrifos can harm the developing brains of fetuses and children who eat food from plants treated with this compound. Dow Chemical has published an extensive report in which it throws doubt on the various studies that show adverse effects (Dow 2017). Farmers who find the compound useful are also opposed to a ban. A precautionary attitude would suggest that the compound be taken off the market because of the suggestion of harm and also because of its similarity to chemical weapons. On the other hand, a risk-benefit analysis might conclude that the needs of agriculture were great enough to compensate for a small number of health problems. Although several EPA reports have documented the potentially serious health effects of chlorpyrifos, it has yet to order a complete ban on its use.

If a Dow or an EPA chemist looked to the ACS Code for guidance on this question, what help would he or she get? The Code tells chemists that they should "promote and protect the legitimate interests of their employers", while understanding "the health, safety, and environmental aspects of their work". The ACS Code does not display a moral 'red flag'. Selling chlorpyrifos is a legitimate interest of Dow, at least from the perspective of company management and the shareholders. The individual chemist might disagree that selling a potentially dangerous product is a legitimate interest. The chemist might also decide that as a human being, he or she has a responsibility to oppose the marketing of the product either within the company or more publicly. As noted earlier, the ACS code does not provide any ethical protection for the whistle blower. Based on a strict reading of the code, as long as the chemist understands that there are potential health or environmental effects, nothing further need be done. This ambiguity seems to me to be at least morally problematic. The 'Hague Ethical Guidelines' are a bit stronger because of the similarity of chlorpyrifos to chemical weapons, but Dow certainly argues that the agricultural use of the compound is not a misuse of its product, so invoking the Hague Guidelines does not seem to solve this potential moral problem. There are many other examples of this tension, such as flame retardant chemicals in clothing and furniture (Slater 2012), where the economic interests of chemical companies are in conflict with health or environmental concerns.

7. Conclusion

It is unreasonable to expect any code of ethics to solve complex moral problems, particularly those that involve the different moral communities that chemists inhabit. Each situation requires a careful ethical analysis. Because ACS members have a wide variety of roles, it is also important to have the kinds of provisions that are in the current code. On the other hand, anyone reading the ACS code will come away with the impression that the most important ethical issues for chemists are interpersonal relationships such as those between employer and employees. Both the ACS code and the RSC code are mainly inward looking, concerned with the image of chemistry and how chemists treat each other. Although these issues are important, I would argue that they need to be subsidiary to the important ethical issues of our time such as integrity in research and the impact of chemistry on society.

It is important for the ACS Code to put more emphasis on the problems of today's world and the need to protect future generations. A revised ACS code would be both more relevant and useful if it communicated to the chemistry community and to society that chemists recognize the ethical issues concerning the relationship between science and society as crucial in today's world (Mehlich *et. al*. 2017). The code also needs to come to terms with the pressures of the contemporary research environment which seem to lead to more and more breaches of research integrity (Kovac 2015). Both the 'Hague Ethical Guidelines' and the 'Global Chemists' Code of Ethics' put the responsibilities to benefit humankind and to protect the environment up front, emphasizing their importance. A revised ACS Code should use these statements as a model for a provision regarding the relationship between chemistry and society. Although research integrity is mentioned in the current code, that statement needs to be strengthened to emphasize the centrality of responsible conduct of research to the trust that is the central value of science.

As Don Gotterbarn notes, the process of writing a code of ethics and then getting it approved is always political (Gotterbarn 1999). Within the ACS there are a variety of constituencies that are likely to have strong opinions about the language of the code. For example, representatives of the chemical industry will have a different view of provisions regarding the environment than chemists who work for regulatory agencies like the EPA. Another tension is how much specificity to put into a code. The most recent version of the ACS code contains a clause that cautions chemists to avoid bias and lists several possible sources of bias. When a code contains a list of specific groups, there is the possibility that a particular group will feel left out. This is where aspirational codes containing only broad principles have an

advantage. The disadvantage, of course, is that broad principles are open to interpretation.

The ACS has revised its code of ethics several times since 1965 to respond to changes in both the chemical community and society. The last major revision was in 2007. In light of the problems of today's world, it seems that it is time for the society to once again take a careful look at its ethical standards. Any revision effort should take advantage of the growing research literature on ethics in chemistry which has confronted many important contemporary ethical questions. The code also needs to be supplemented by educational materials. The Guidelines of the ACS Committee on Professional Training explicitly call for instruction in ethics as part of an undergraduate education (ACS CPT 2015). Federal funding agencies also require ethics education for graduate students. Such education would be facilitated by the development high-quality, easy-to-use educational materials that focused on the ethical problems faced by chemists and used the ACS Code of Ethics as a resource. The combination of a revised code with a strong philosophical basis and supporting educational materials would make the ACS a leader in professional ethics world-wide.

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