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Gifts and Commodities in Chemistry

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Dedicated to the memory of Norman S. Care, late Professor of Philosophy at Oberlin College

Abstract: Using the quadrant model for scientific research developed by Donald E. Stokes, and the ideas of the gift and commodity economies, I discuss some important ethical questions raised by the commodification of scientific research. Even in pure research, the possibility of patents and private ownership of information challenges the traditional professional values of science. When the research has applications, as much of chemistry does, the ethical challenges are even greater. Finally, I consider some broader policy issues and introduce the idea of shared fate individualism as a way to analyze the knotty questions that arise.

Keywords: *ethics, gift economy, intellectual property, patents, shared fate individualism.*

1. Introduction

The chemist is both a "craftsman and a philosopher" (Knight 1992, p. 13). Chemistry derives from both the theoretical ideas of the alchemists and natural philosophers, and practical pursuits such as dying, tanning, and metallurgy. Beginning with its origins in the craft tradition, chemistry has been thoroughly entangled with the development and production of useful processes and materials. The enormously successful chemical industry, which began to develop in the middle of the eighteenth century with the large-scale production of acids, alkali, and gunpowder, has had a symbiotic relationship with academic chemistry. This close relationship is unusual; while we have a chemical industry, there is no corresponding ‘physical’, ‘biological’, or even ‘geological’ industry with a similar history. Over time, the close connection between what are traditionally called pure and applied research in chemistry and between industry and the academy has been both intellectually and economically beneficial to both sides and relatively free of tension. Recently, however, important concerns, especially ethical concerns, have been raised concerning the influence of corporate money on science (and other fields) (Shulman 1999, Brown 2000). These concerns involve the funding of academic research by private corporations; the increasing pressure, both internal and external, on university scientists to patent and commercialize the results of their research; and the large-scale privatization of knowledge in commercial databases. All of these practices have a long history, but the recent explosion of activity in each has raised new ethical problems.

Some of the ethical questions that result from the increasing commodification of knowledge highlight the tension between the moral ideals of pure research, particularly the ideal of prompt and open communication and the demands of the real-world commodity economy. The two-dimensional classification of research introduced by Donald Stokes (Stokes 1997) and the concepts of the gift and commodity economies (Hyde 1979, Baird 1997) provide the context for this discussion and its core will be the consideration of specific ethical questions, cases if you will, that arise in the current research environment.

2. Pure and Applied Research

The distinction between pure, or fundamental, and applied research is a familiar one, but as Donald Stokes has pointed out in his recent book, *Pasteur's Quadrant*, this bipolar classification does not really describe the practice of science. Instead of placing the various kinds of research along a linear scale ranging between pure and applied, Stokes proposes the quadrant model shown in Figure1.

		Consideration of Use?	
		No	**Yes**
Quest for fundamental understanding?	**Yes**	Pure fundamental research (Bohr)	Use-inspired basic research (Pasteur)
	No		Pure applied research (Edison)

Figure 1: Quadrant model for scientific research (Stokes 1997).

Along one axis, the research is classified in terms of the quest for fundamental understanding. Some research, such as that concerned with the deep meanings of the quantum theory, is entirely focused on fundamental scientific understanding, while much of what we usually call applied research merely uses the results of fundamental research for practical purposes. Stokes' great insight was to recognize that there is a second axis: consideration of use. While fundamental research in cosmology, say, really has no immediate uses, other quite fundamental research is motivated by practical considerations. Stokes uses Pasteur as his paradigm example. While Pasteur made many fundamental contributions to the developing science of microbiology, much of his work was motivated by the practical problems of French industry.

Stokes' scheme results in four broad categories of research, three of which he has named after famous people. The pure fundamental research done in Bohr's quadrant is what philosophers of science usually consider; it is much of the science done in universities. Edison's quadrant, the realm of applied research, is also familiar. This is the research done in industrial laboratories, application of fundamental principles to the development of useful products and processes. This is the chemistry of dyes and personal care products, the legacy of the craft tradition. The interesting quadrant is Pasteur's: use-inspired basic research. While Stokes uses Pasteur as his example, I think that much of chemical research lies squarely in this quadrant.

An excellent example is the work of Wallace Hume Carothers on condensation polymers at DuPont. While Carothers was looking for a way to demonstrate the existence of macromolecules using well-known organic reactions, a controversial hypothesis at the time, his work was inspired by the possibility of the development of commercial products. In the process he invented nylon, the first synthetic fiber (Hermes 1996, Hounshell & Smith 1988).

One of the distinctive features of chemistry as a science is its emphasis on synthesis, creating new substances (Rosenfeld & Bhushan 2000). Synthetic chemists are not only inspired by the challenges of making new molecules and developing new reactions but often also by the possibility that the new molecule will be useful, perhaps as a pharmaceutical or a material. Synthetic chemistry can fit into three quadrants. Some synthetic projects are undertaken just to make theoretically or aesthetically interesting molecules, such as the platonic solid analogues like cubane. Much synthesis, particularly that done in industry, is purely applied research; known reactions are applied to the development of practical products. However, a significant fraction of synthetic chemistry resides in Pasteur's quadrant – and not only because of the pressures of funding. The twin challenges of fundamental research and creating a useful product can be intellectually intoxicating.

As Stokes and others have pointed out, Pasteur's quadrant is increasingly where research, even in universities, is being done (Guston 2000, Davis 1999). The post-war implied contract between science and society as laid out by Vannevar Bush[1] is giving way to a new research policy that emphasizes productivity and technology transfer. In addition, the Bayh-Dole legislation that allows universities to patent the results of federally sponsored research has led to an explosion of entrepreneurial activity by university scientists, particularly in the biological sciences, but also in chemistry (Coppola 2001). Faculty are being encouraged both to patent their discoveries and to start their own companies to commercialize the products or to license them to existing companies. In addition, industry is coming to universities for basic research and faculty and administrators are delighted to accept the contracts to replace dwindling federal support. When the results of science become commodities, something is gained by society, but important things are lost by science because science, at least in Bohr's quadrant, operates ideally as a gift economy.

3. Gifts and Commodities

In his remarkable book, *The Gift: Imagination and the Erotic Life of Property*, Lewis Hyde distinguishes between the two economies in which we all live: the gift and commodity economies (Hyde 1979). Hyde's ideas have been nicely summarized and applied to science by Davis Baird (Baird 1997).[2] Transactions in the commodity economy are mutually beneficial, closed interactions: fee for goods, fee for service. We go to the grocery store and buy a quart of milk for the listed price, and both parties are happy. No further relationship (except perhaps that governed by a warranty) between buyer and seller is expected or desired. On the other hand, the gift economy is characterized by open interactions; people give each other advice; they do favors for each other; they coach and referee children's sports. Gift economies serve to bind people together and create mutual obligation. Commodity economies work under fairly strict rules that define and delimit mutual responsibilities and future obligations between the parties involved. Gift economies aim to initiate and maintain human interactions. One becomes a part of the gift economy by contributing something, by giving a gift. In the gift economy, those who are valued most are those who give the most. In the commodity economy, the most important people are those who have accumulated the most.

Pure science, the science done in Bohr's quadrant, operates largely as a gift economy. Scientists contribute their work and often a great deal of their time without any specific expectation of a financial return. They contribute intellectual and creative gifts to the community in the form of the results of their research: experimental procedures, data, interpretations, theories, *etc*. They contribute their time in presenting the results of their research at other institutions and at professional meetings without compensation, except perhaps for travel expenses and, in the best circumstances, a modest honorarium. Likewise, they referee articles and grant proposals: most of the essential peer review process in science is part of the gift economy. Some serve as editors of journals and books, again with little if any financial compensation. They receive in return similar gifts from other members of the scientific community, but there is no *quid pro quo*. To be a member of the scientific community therefore, one must contribute. The greatest scientists are those who contribute most, particularly in quality of work. For example, Linus Pauling was one of the greatest chemists of the twentieth century because his insights into the nature of chemical bonding are used daily by working scientists; they redefined chemistry.[3] On the other hand, Edison, who developed and adapted scientific discoveries into salable commodities from which he gained profit, but gave nothing back to the scientific community, earned the ire of Henry Rowland who once complained that the "spark of Faraday blazes at every street corner" (Moore 1982).[4] Rowland's angry comment serves to introduce the ethical tensions that shape this argument. I will use the quadrant model to organize the presentation and focus on specific cases since cases are probably the best way to consider ethical questions (Jonsen & Toulmin 1988).

4. Gifts, Commodities and Ethical Tensions in Bohr's Quadrant

At first glance, it might seem that research done in Bohr's quadrant is immune from the pressures and temptations of the commodity economy. The primary goal is fundamental understanding, and applications, if any, are far in the future. In today's information-based economy, however, private control of information can provide a competitive advantage. For example, knowledge of the human genome is clearly fundamental science that should be in the open literature. Shulman, however, quotes an estimate that eight thousand patents have been issued on human genes, or methods and techniques directly related to them had been issued as of 1999 (Shulman 1999, p. 180). There is clearly a battle over what kind of information can be privately owned.

To put this battle in a chemical context consider a well-known chemical transformation: the Grignard reaction.[5] This is clearly a fundamental reaction in organic chemistry; I suspect that every student who has taken a beginning organic laboratory course has done a simple example. (I think I made valeric acid.) Suppose Victor Grignard had obtained a patent on his new reaction in 1901 and collected a license fee from everyone who subsequently used it. What if he had been even more foresighted and applied for a broader, conceptual, patent, similar to those obtained by the famous inventor Jerome Lemelson, on all organometallic coupling reactions, even those yet to be discovered (Shulman 1999, pp. 165-176).[6]

Chemists whose research is in Bohr's quadrant would certainly agree that patenting the Grignard reaction is unethical behavior. Discovering and developing reactions is one of the fundamental tasks of chemistry and that knowledge should be promptly communicated to the rest of the chemical community. It should be part of the gift economy. But an inventor might respond: Why should not Grignard profit financially from his invention (other than through the Nobel prize, which he could not have envisioned)? Most, if not all, chemists would probably find the inventor's suggestion to be reprehensible. Of course, a reaction of such broad utility and fundamental significance should be available for all to use. As Jonas Salk responded to Edward R. Murrow concerning his new vaccine, "There is no patent. Could you patent the sun?" (Shulman 1999, p. 54).

What ethical principles can we use to justify our feeling that this is a paradigm case for the moral ideal of the gift economy as a governing ideal for science? Robert Merton has identified four essential characteristics of science: universality, communism, disinterestedness, and organized skepticism (Merton 1973). The two that are most relevant for the present discussion are communism and disinterestedness. By 'communism', Merton means that science is public knowledge (Ziman 1978); it must be communicated to the relevant community and then validated both by peer review and by further testing and use. Often a discovery is modified or corrected by other workers. Without a system of rapid and open communication, the communal aspect of science is lost. Further, science is difficult. Open discussion and verification are necessary to avoid serious error. The history of science is filled with cases of competent investigators misinterpreting their experiments (Graetzer 2000). But, to patent a discovery, you must file the patent application before publishing in the open literature. You have to keep your work secret to make sure that competitors do not get there first. Even more important, however, is the threat to science as a truth-seeking activity and to one of the core values of scientific ethics (Kovac 1996).

The principle of disinterestedness is also relevant here. By ‘disinterestedness’ Merton means that the data must be interpreted objectively; scientists should not have an inappropriate personal interest, such as a political agenda, in the outcome of their research. In Bronowski’s words, scientists must practice the "habit of truth" (Bronowski 1956). Famous cases, such as N-rays and polywater, show that self-delusion is a common failing, even among established scientists. The desire for commercial success might lead an investigator to interpret results incorrectly or to jump to conclusions. Money, rather than truth, becomes the goal.

The scientific community is built on trust. Scientists must be able to trust that other investigators have collected their data correctly, reported it accurately, and interpreted it objectively. Further, scientists must also be able to trust themselves. As Michael Polanyi has noted, the acquisition of knowledge is a skillful act of personal commitment that depends on a set of imperfectly defined personal criteria (Polanyi 1964). Unless those criteria include a high standard of personal ethics, science as a source of reliable knowledge will be compromised (Kovac 2000a).

Commercialization can also interfere with the peer review process. Suppose Chemist A is working on a research project that will soon lead to a patent application and receives a paper to review that contains results that will jeopardize the potential success of that application. Chemist A can use the peer review system unethically to delay the publication of this article in at least two different ways: (1) The review can be delayed until the patent application is filed, and (2) serious, but reasonable, objections to the publication of the paper can be raised causing significant delay as the paper is rewritten or additional data are collected. These same tricks can be played by scientists concerned about the priority of their discoveries, but the possibility of financial gain adds to the conflict of interest.

5. Ethics and Use-Inspired Research

Science in Pasteur’s quadrant provides the most interesting challenges because the ethical standards of pure research can be in tension with the legitimate objective of producing useful products. As nicely described by both David Baird and Lewis Hyde, the gift and commodity economies collide. While I cannot offer a complete discussion of the ethical problems that might arise, I will discuss two important ones, the conflicts of interest and commitment that arise when use-inspired research, either funded by a private company or in preparation for a commercial venture by the principal investigator, is done in an academic setting; and the effects of the increasing dependence on industrial funding on the direction of research.

I turn first to academic research funded by private companies. In most cases this is contract research in which funding is provided for a fairly specific project. Intellectual property rights are normally negotiated as part of the contract, specifically addressing patents and publications. I will leave aside these issues and instead focus on the involvement of graduate, and perhaps undergraduate, students in privately funded projects. The important ethical question that I want to raise is the extent to which involvement of a student in such contractual research is compatible with a quality graduate education (Bunnett 1988).

Graduate students are an integral part of academic research in chemistry. At its best, graduate education in chemistry is a kind of apprenticeship in a research group involving a close intellectual and personal relationship between the research mentor and the student. The student matures as a scientist while pursuing a project that is part of a larger research agenda conceived by the advisor.

Money is an important part of the picture. Equipment, supplies, and services are expensive, to say nothing of the tuition and stipends that students have come to expect as part of the bargain. While some students are supported by teaching assistantships and fellowships, research grants and contracts are an important source of student support in all major graduate chemistry departments. Keeping the flow of money into a research group high enough to support the work is a constant problem for an active research scientist. If that money comes from private contracts, then it is essential to keep the contractor happy by performing the required work in a timely manner.

On the other hand, education is a process that does not conform well to an external timetable. Students learn at different rates and must be allowed the freedom to make mistakes and to learn from them. Not only must students learn the appropriate background material, they also must develop the research skills to become independent scholars.

There can be an enormous tension between the need to fulfill the contractual obligations and the need to educate. The student can be used as a technician, a 'pair of hands', given regular assignments to perform experiments, and not allowed either the freedom to explore or to make mistakes or the responsibility to make even small decisions about the direction of the project or to interpret the data. While it may be most efficient for the research director to keep tight control of the project, the intellectual development of the student will be retarded.

Two other questions must be considered: (1) Does a contract research project provide both the depth and breadth to properly educate a student either at the M.S. or Ph.D. level? (2) Will the student have appropriate publication opportunities so that he or she can pursue a career? Each project and student must be evaluated individually. If the project really is use-inspired fundamental research, then the answer to both questions is likely to be yes. If, however, the project really is in Edison's quadrant, the answer may well be no. If the answer is no, is it then a breach of professional ethics to ask a student to complete such a project as the sole research requirement for his or her degree?

These same considerations apply to a research project that has the potential to lead to a patent and a commercial enterprise, but there are additional ethical questions for the research director involving conflict of interest and conflict of commitment. By 'conflict of interest', I mean inappropriate influences on good professional judgement. (Davis 1982) By 'conflict of commitment', I refer to the relative amounts of time that research directors spend discharging their various responsibilities. These concerns have been considered by a number of authors in recent years so my discussion will focus on the conflict between gift and commodity economies (Etzkowitz 1996, Zalewski 1997, Barinaga & Marshall 1992).

Commercialization of scientific discoveries, or any other creative product of the human imagination, involves a conflict between the two economies. There are several kinds of issues. Which values should take precedence? As noted above, for a scientist, the values of the gift economy are, in large part, also the values of the scientific community. As I have argued elsewhere, the gift economy is part of the moral ideal of science (Kovac 2000b). On the other hand, useful products only come to market through the commodity economy, so the commercialization of the results of scientific discoveries is essential to human progress, at least in a material sense. While it is important that creative scientists use their talents to solve important practical problems, whenever possible, I think that serious ethical problems arise when it becomes possible to earn a personal fortune. In this case, the interests of the scientific community and of society can be forgotten. If scientists become primarily interested in developing commercial ventures, curiosity-driven research, trying to find what Einstein called 'the secrets of the old one', will disappear, and the foundation of fundamental knowledge on which applied research depends may begin to crumble.

Norman Care has addressed this problem, though in a different context (Care 1987, 2000). In considering what it means to be an ethical individual in today's world, a world in which there are serious problems – among them hunger, disease, violence, and environmental degradation – Care develops a conception of individual responsibility that he calls "shared fate individualism". "The central idea in shared fate individualism is that morality required of competent individuals in circumstances such as those that characterize today's world that they place the value of *service to others* over the value of *self-realization* in deliberations on relevant serious life decisions" (Care 2000, p. 86). Shared fate individualism goes beyond the virtue of altruism in suggesting that there may be situations in which heavy sacrifice on the part of certain individuals with relevant abilities is not heroic, but simply required. Although shared fate individualism is a principle that should apply to all people, not just scientists, I think it helps address the ethical tension inherent in the commercialization of science. Using Care's ideas, pursuit of a commercial venture merely for the purpose of personal gain would be a less ethical course of action than developing a product or process that would benefit those in need even if personal wealth were a byproduct.

Freeman Dyson has written persuasively about this problem in several recent essays (Dyson 1993, 1997). Dyson suggests that one of the reasons that science is in trouble is because of the choice of research problems. "[Scientists] are responsible for the preponderance of toys for the rich over necessities for the poor in the output of our laboratories" (Dyson 1993, p. 524). Implicitly, Dyson has invoked the concept of shared fate individualism.

This brings me to the final issue: the effects of private funding on the direction of university research. An increasing dependence on private funding skews the direction of scientific research. "Toys for the rich" are often much more profitable than "necessities for the poor", so private funding of research will certainly favor their development. Moreover, federal research funding is increasingly directed at projects that have commercial potential. As university research becomes increasingly dependent on external funding sources and as the reward system for science faculty depends more and more on the amount of research funding raised, it will take either a principled or foolish researcher to undertake a socially useful research project that has little hope either of external funding or being profitable. As Dyson notes, "The free market will not by itself produce technology friendly to the poor. Only a technology positively guided by ethics can do it" (Dyson 1997, p. 49). Further, commercial pressures and inducements will move more and more academic research out of Bohr's quadrant and even out of Pasteur's quadrant into Edison's. If money replaces curiosity as the primary motivation for science (and scholarship in general) then the long-term future of the scientific community is in danger. I think these are the core ethical questions to be addressed in considering the conflict between gifts and commodities.

What can individual scientists do? First, the principle of shared fate individualism suggests that the development of a research program should be based on a sense of responsibility both to the scientific community and to the needs of society. Whenever possible, scientists should choose research areas and problems that are beneficial to the poor and try to get them funded. Second, they can try to influence research policy, both in their own institutions and nationally, by raising ethical questions. Brian Coppola and I have argued elsewhere that education is not a neutral activity; the individual decisions and actions of faculty contain moral lessons (Kovac & Coppola 2000). While we were mainly concerned with pedagogy, I think that the same arguments can certainly be made for research. (Of course, in a university, research is part of the educational activity.) The ethics of research must be concerned with both practice and policy. The choice of a research problem is, in part, an ethical decision. As Dyson so powerfully argues, science will be in trouble if it ignores the needs of all of society (Dyson 1993). Moreover, as the arguments made in this essay have made clear, science will also be in trouble if the moral ideals of the gift economy, and the 'habit of truth' that inspires research in Bohr's quadrant are not preserved.

6. Concluding Remarks

The two organizing ideas used in this essay, the quadrant model and the gift and commodity economies, are powerful tools for identifying and analyzing important questions in the ethics of science. Because of its historic and current connection with the practical, chemistry provides excellent cases through which to consider important ethical questions that arise from the commodification of science, including the influence of corporate funding and the pressures to patent and commercialize the results of university research. While the ethical ideals and principles of science can provide considerable guidance, I think we need to bring in more general ethical ideas, such as shared fate individualism, to resolve both the internal problems of the practice of science and the external problems of the relationship between science and society.

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Notes

[1] The essence of the postwar implied contract was nicely summarized by Guston & Kenniston (1994, p. 2): "Government promises to fund the basic science that peer reviewers find most worthy of support, and scientists promise in return that the research will be performed well and honestly and will provide a steady stream of discoveries that can be translated into new products, medicines or weapons."

[2] There are some remarkable insights into the nature of the gift economy in Wayne Booth’s recent book, *For the Love of It: Amateuring and Its Rivals* (Booth 1999).

[3] Scientists, like all human beings, are complex personalities. Even though their professional behavior might adhere to the ideal of the gift economy, their personal motivations are often less exemplary. Scientists are very competitive and are interested in status, power, and other personal rewards. The psychology of scientists is a fascinating subject, but outside the scope of this essay. I have written about the moral questions raised by Linus Pauling’s political efforts on behalf of the nuclear test ban treaty of 1963, for which he was awarded the Nobel Peace Prize (Kovac 1999). Some aspects of the personal competition between scientists have been explored in the recent play, *Oxygen* (Djerassi & Hoffmann 2001).

[4] It is important to recognize that even very applied fields such as industrial chemistry or engineering fit into all three quadrants. While much of engineering, for example, is practiced in Edison’s quadrant, there is a flourishing community of fundamental research in engineering and other applied fields that develops the knowledge and techniques that underlie the day-to-day practice. This fundamental research will primarily be in the gift economy, but is certainly subject to the same tensions that are the subject of this paper.

[5] In the Grignard reaction, a hydrocarbon in which one of the hydrogens has been replaced by a halogen, such as bromine or chlorine, is mixed with magnesium metal in dry ether. The resulting Grignard reagent can react with a wide variety of other organic molecules containing a carbonyl, a carbon with a double bond to an oxygen. The Grignard reagent is extensively used in organic synthesis.

[6] Among many other things, Lemelson claims to have invented the camcorder. What he actually did was patent the idea of a hand-held video camera that might also contain a videotape cassette, but never actually constructed such a device. Many of his patents were conceptual and not translated into specific products.

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