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The Commodification of Academic Research

SCIENCE AND THE MODERN UNIVERSITY

Edited by Hans Radder

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CHAPTER 4

Financial Interests and the Norms of Academic Science

David B. Resnik

1. Introduction

MODERN SCIENCE IS a business: a big business. Every year, private corporations, government agencies, universities, and private foundations spend hundreds of billions of dollars on research and development (R&D). The amount of private money invested in science has risen steadily since the 1980s and has outpaced the amount of public money spent on science. Today, about 60 percent of the world's R&D is sponsored by industry, and about 35 percent is sponsored by governments. In 2004, the United States spent approximately $368 billion on R&D, $122.7 billion of which was federally funded R&D, and $245.4 billion of which was non-federally funded (mostly private). Though the United States is by far the world's leader in government R&D funding, other countries are catching up, including European nations like the United Kingdom, France, Germany, and the Netherlands, and Asian powers like Japan, China, India, and Singapore. Private companies invest in R&D in order to make a profit. Governments invest in R&D to stimulate scientific and technological innovation, which leads to economic growth and development. Advances in science and technology were responsible for the major economic changes in the last two hundred years, including the Industrial Revolution, computer revolution, and the biotechnology revolution (Resnik 2007).

Scientific research is not cheap. Gone are the days when an amateur scientist working out of his own laboratory could make a significant contribution to human knowledge. Today, most research projects cost anywhere from several hundred thousand dollars to several million dollars, and some projects cost much more than that. The Human Genome Project cost $3 billion over a ten year period, and the Space Station Freedom cost $30 billion. Pharmaceutical companies spend, on average, about $500 to discover, test, and develop a new drug.[1] The costs of defense-related R&D are even higher: since the 1980s, the United States has spent over $100 billion on national missile defense. Most research is conducted by professional scientists (principal investigators, postdoctoral fellows, graduate students, and technicians) working in university, industry, or government laboratories. All of these people require compensation for their time and effort. Although a career in science is not as lucrative as a career as a plastic surgeon or investment banker, many scientists reap handsome financial rewards from research, including salary from universities or other organizations, consulting fees from companies, stock and equity, honoraria, and revenue from licensing of intellectual property (Resnik 2007).

Even though scientific research could not take place without huge investments of public and private funds, money can have a corrupting effect on science. In the last two decades, many different scientists, scholars, consumer advocates, and political leaders have expressed strong concerns about the relationship between science and financial interests. Evidence is accumulating that financial interests can threaten the quality and integrity of scientific research (Krimsky 2003). Numerous studies have shown that industry-sponsored research tends to favor the company's products (Lexchin et al. 2003). For example, Friedberg et al. (1999) found that 95 percent of industry-sponsored articles on drugs used in cancer treatment reported positive results, as opposed to 62 percent for nonindustry-sponsored research. Ridker and Torres (2006) found that 67 percent of industry-sponsored studies of cardiovascular treatments favored the new treatment over the currently accepted treatment, as opposed to 49 percent of the studies sponsored by nonindustry sources. There are some well-documented cases of companies suppressing data, cooking or manipulating research data, intimidating researchers who want to report adverse results, and engaging in other practices that interfere with the quality and integrity of science. There also cases where scientists with financial interests related to their research have committed fraud, engaged in insider trading, failed to mention significant risks to human subjects, failed to report adverse events in clinical trials, or participated in other practices that violate ethical or legal duties (Resnik 2007).

Thus, money in science is like a double-edged sword: money is a necessary fuel for research, but it can also threaten the norms of science. In this chapter, I will explore the relationship between financial interests and the norms of academic science.[2] I will begin my inquiry by providing an account of science's epistemic and ethical norms. After briefly describing some of the financial interests related to research, I will explain how these interests can affect the norms of science. I will conclude by making some recommendations for dealing with financial interests in scientific research.

2. The Norms of Science

Science is a social activity governed by various norms (Kitcher 1993, 2001; Haack 2003). There are two very different senses of the term "norm" that pertain to the study of science. In the first sense, a norm is the normal behavior of a group of people. The norms of science, in this sense, simply describe scientific behavior. Sociologists of science, such as Robert Merton (1973) and Harriet Zuckerman (1984) have studied norms that govern scientific behavior.[3] Merton argued that four norms—communalism, universalism, disinterestedness, and organized skepticism—describe and explain a great deal of scientific behavior (Radder, this volume, chap. 10). In the second sense of "norm," a norm is an ideal standard for decision making and behavior. The norms of science, in this sense, prescribe scientific conduct. Many different philosophers of science, such as Kuhn (1977), Quine and Ullian (1978), Laudan (1986), Longino (1990), Thagard (1993), and Kitcher (1993) have developed prescriptive accounts of scientific norms. Although philosophers of science do not all agree on science's prescriptive norms, most accept the idea that science has norms. Philosophical accounts of scientific norms are based on a conceptual analysis of key scientific and ethical concepts, such as knowledge, justification, explanation, moral obligation, human value, and so on.

In this chapter, I will present my own version of academic science's norms, which I have defended elsewhere (Resnik 1998, 2007). My account is prescriptive, not descriptive. I happen to believe that most of the norms in my account also do a good job of describing scientific conduct, but I will not press that issue here. What is important, as far as I am concerned, is that the norms of academic science have social mechanisms of enforcement (Gibbard 2003). By that I mean that

(1) scientists recognize that they ought to obey norms, and they feel compelled to obey them; (2) scientists publicly defend norms; (3) scientists are rewarded for adhering to norms or punished for deviating from norms. Scientists who demonstrate originality, rigor, objectivity, and other normative ideals may receive forms of positive reinforcement, such as publication, career advancement, prizes, and so on. Scientists who deviate from norms without an explanation or excuse may be subject to criticism, disapprobation, or punishment. For example, honesty (discussed below) is one of science's most important norms. Scientists are honest most of the time, but they are not always honest: scientists, like all people, tell lies from time to time (and some scientists tell big lies!). However, since honesty is a norm, a scientist who is caught lying on a grant application or paper may be investigated for misconduct or even face criminal prosecution.[4] Science has mechanisms in place to enforce the norm of honesty.

My account of norms is also teleological: I hold that scientific norms are justified insofar as they promote the collective aims (or goals) of academic science.[5] Science has general epistemic goals, such as truth, knowledge, and explanation; and general practical goals, such as prediction, control, and problem solving. The norms of science promote the aims of science directly or indirectly. For example, honesty directly promotes the pursuit of truth, because the most effective way to obtain truth is to be honest. Truth may sometimes emerge at the end of a process involving lies and deceptions, but honesty is generally the best way of getting to the truth. Giving credit where credit is due in science (discussed below) promotes the goals of science indirectly by encouraging cooperation and trust among scientists, because scientists are not likely to collaborate if they believe they will not receive proper credit for their work. Social responsibility (discussed below) promotes the goals of science by helping to secure public support for science, because the public will not support research that it regards as dangerous and irresponsible.

One can think of scientific norms as a system of hypothetical imperatives: to achieve a goal, one should follow a rule (see fig. 4.1). For example, to bake a cake, one should follow a series of rules contained in the recipe. To be a good driver, one should obey the rules of the road. To do good science, one should adhere to various norms such as honesty, openness, precision, testability, etc. Some norms, such as honesty, objectivity, and testability, are common to all scientific disciplines. Others apply only to particular disciplines. For example, rules for controlled clinical trials apply to biomedical research, but not to physics or astronomy.

One of the criticisms of general norms of conduct is that they are too abstract to guide particular decisions (see Radder, this volume, chap. 10). One way to overcome this problem is to develop specific rules to implement general norms (Beauchamp and Childress 2001). Specific rules are more closely connected to particular decisions than general norms (see fig. 4.1). For example, there are a variety of methodological and ethical rules that help to implement honesty, such as prohibitions against data fabrication and falsification or procedures for dealing with data outliers. Individual scientists follow these more specific rules when they make decisions concerning the recording of data or data analysis.

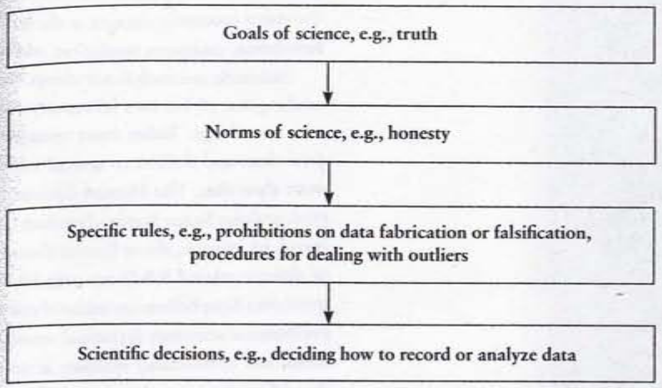

Fig. 4.1. Scientific Goals, Norms, Rules, and Decisions *(Arrows indicate direction of justification)*

Finally, my account of the norms of science fits within a movement in contemporary philosophy known as social epistemology (Goldman 1999; Solomon 2007). According to this perspective, knowledge development is inherently a social activity, and key epistemic concepts, such as justification, warrant, and truth, cannot be adequately understood without reference to a community of inquirers. The norms that guide knowledge development are rules that are necessary for the community to function well in achieving epistemic goals, such as truth, explanation, and so on. To function well, the community must have a high degree of trust and an effective division of epistemic labor among its members, as well as financial and legal support from the broader community, i.e., society (Resnik 1996). Though skepticism is important in developing new ideas and testing and confirming theories and hypotheses, science cannot move forward without support from society and a high degree of trust among people working within the same lab or university or collaborators at different institutions (Hull 1990; Radder, this volume, chap. 10).

So what are some of the norms of academic science? Science has epistemic norms, which apply to decisions concerning research design, testing and experimentation, data analysis and interpretation, and the acceptance of scientific theories and hypotheses. Other writers have called these norms by various names, such as criteria of theory-choice, epistemic values, theoretical virtues, and so on (Lycan 1990). Some of the most important ones are:

- Testability: Theories and hypotheses should be testable.
- Objectivity: Methods, theories, and hypotheses should minimize social, political, economic, personal, or other biases.
- Precision: Methods, theories, and hypotheses should be clearly defined and precise.
- Empirical support: Theories and hypotheses should be well supported by the empirical evidence.
- Reproducibility: Tests, procedures, observations, and experiments should be repeatable.
- Predictive accuracy: Theories and hypotheses should make accurate predictions.
- Explanatory power: Theories and hypotheses should be able to unify diverse phenomena into a coherent explanatory scheme.
- Conservatism: Theories and hypotheses should cohere with other well-established ideas, beliefs, or principles.
- Novelty: Theories and hypotheses should express original ideas.
- Simplicity: Theories and hypotheses should be simple, parsimonious, elegant.
- Fruitfulness: Theories and hypotheses should lead to new areas of investigation and inquiry.

Science also has ethical norms, which apply to many different decisions concerning interactions with other scientists and with society, such as research design, data analysis and interpretation, publication, peer review, collaboration, education, laboratory management, media interactions, and the treatment of research subjects. With some notable exceptions, e.g., Shrader-Frechette (1994), Resnik (1998), and Cranor (1993), philosophers of science have paid more attention to science's epistemic norms than to science's ethical norms. However, highly publicized scandals, ethical controversies, and concerns about the influence of money on science justify greater attention to the ethical norms of science from philosophers. Some of science's most important ethical norms include:

- Honesty: Don't lie or cheat in science; avoid deception.
- Openness: Share data, ideas, methods, tools, and results; be open to criticism and suggestions.
- Carefulness: Exhibit due care in experimental design, record keeping, data analysis, manuscript drafting and editing; avoid careless errors.
- Credit: Give credit where credit is due.
- Freedom: Allow scientists to explore and criticize ideas without fear of intimidation, censorship, or repression.
- Confidentiality: Protect confidential information related to personnel matters, human subjects in research, unpublished research, peer review, trade secrets, etc.
- Respect for persons and property: Treat colleagues, students, collaborators, and property with respect; do not exploit, harm, or harass people; do not destroy or steal property, including intellectual property.
- Respect for research subjects: Treat animal and human research subjects with appropriate care and concern; protect and promote human and animal welfare in research; protect the rights of human subjects in research.
- Respect for the law: Know and obey laws and regulations that pertain to research, such as human and animal research regulations, laboratory safety regulations, conflict of interest rules, etc.
- Social responsibility: Strive to benefit society and to prevent or avoid harm to society through research, public education, civic engagement, and advocacy.

Before concluding this section, I shall make a few additional comments about academic science's norms. First, the distinction I have drawn between ethical and epistemic norms is useful for the purposes of classification, pedagogy, and policy development, but it does not cut very deep. Since knowledge development is inherently social, even norms that most people would regard as ethical function to advance the epistemic goals. For example, fair credit allocation, which most people would classify as an ethical norm, helps to foster cooperation and trust among researchers, which helps to promote knowledge development. Though allocation of credit guides practical decisions made by scientists, it has an epistemic component as well.

Second, the norms sometimes conflict with each other. For example, the epistemic norms conservatism and novelty conflict when a new and impressive theory in particle physics conflicts with well-established theories, beliefs, and principles. The ethical norms openness and respect for research subjects conflict when an anthropologist must decide whether she will publish some research that could have an adverse impact on the community on which it is based. Sometimes scientists can settle a conflict among norms by appealing to the goals of science: when norms conflict, choose the option that best promotes the epistemic aims of science. However, because science has many different epistemic aims, which are incommensurable, there is no algorithm for settling conflicts among science's epistemic norms (Kuhn 1977; Lycan 1990; Resnik 1998).

Third, the norms sometimes conflict with broader social norms. For example, suppose a scientist has signed a confidentiality agreement with a company that requires her not to divulge company secrets. She has a legal duty, under the agreement, to keep company information confidential. Suppose she discovers, however, that the company is hiding important information about the risks of one of its drugs from the public. She may have to decide whether to obey the law (and maintain her loyalty to the company) or to prevent harm to the public. To resolve a conflict like this one, scientists must consider not only what is best for science but also what is best for society (Shrader-Frechette 1994; Resnik 1998).

Because the norms of academic science sometimes conflict with each other and with social norms, they are best understood as prima facie guides to epistemic or practical conduct, rather than as absolute rules. That is, other things being equal, scientists should adhere to the norms. Deviations from a particular norm can sometimes be justified by appealing to other norms.

3. Financial Interests in Scientific Research

Though I have already mentioned some of the financial interests in research, it will be useful to distinguish between some of the different types of interests. The first distinction is between the financial interests of individual scientists and the financial interests of organizations involved in research. The financial interests of scientists include: salary, consulting fees, honoraria, cash awards, stock or equity, and intellectual property (patents or copyrights). Usually, the best way that a scientist can promote his or her financial interests is to do good research. A scientist who is a successful researcher can advance his or her career, increase his or her salary, obtain lucrative deals with companies, speaking invitations, and so on (Krimsky 2003).

The second distinction is among the different types of organizations involved in research. These include private corporations, universities or colleges, hospitals or medical centers, government agencies, private foundations, and professional associations. The financial interests of private corporations include profit and

financial strength. Private companies can promote these interests by sponsoring research that leads to successful products or services. The successfulness of a product or service depends on the size and strength of the market for the product or service. Pharmaceutical companies, for example, tend to shy away from developing drugs for markets where there are fewer than 300,000 patients (i.e., a rare disease), or markets where the patients don't have much money to buy drugs, such as markets for diseases that afflict the developing world (Resnik 2007).

Universities also have financial interests in research. In the last two decades, universities have become increasingly commercialized (Krimsky 2003). Universities receive funding from private companies to conduct research. Companies also provide significant gifts to universities, such as new buildings, endowed professorships, or new equipment. Universities own intellectual property and have technology transfer offices. Many universities own stock in companies involved in research, or they are associated with private foundations that own stock. Universities (or private foundations) help to provide capital for faculty start-up companies. Universities also have an interest in obtaining contracts or grants from funding agencies or private companies, and they reward faculty who bring in money from contacts or grants.

The financial interests of hospitals or medical centers include profit (if for-profit) or financial strength (if nonprofit). Hospitals and medical centers may own stock, have contracts with companies, or own patents. They may also use their involvement with research as a marketing tool to attract patients.

Even professional associations, such as the American Medical Association (AMA) or the American Chemical Society (ACS) may have financial interests. For example, professional societies have an interest in maintaining financial stability. To do this, they may accept money from companies to help support conferences or continuing education programs.

4. How Financial Interests Affect the Norms of Science

Are financial interests bad for academic science? Many people seem to think so (see M. Brown, Kleinman, Fuller, and van den Belt, this volume). While there is nothing inherently unethical or epistemologically problematic about having financial interests, trouble can occur when financial interests and the norms of science pull in opposite directions. Financial interests can cause people, companies, or institutions to deviate from epistemic and ethical norms. Deviations can occur intentionally, when people deliberately violate scientific norms to achieve a financial goal. For example, a scientist who lies on a grant application to strengthen his grant proposal would be intentionally violating the norm of honesty. Though intentional violations of norms probably happen on a regular basis, it is likely that many (perhaps most) of the deviations from norms caused by financial interests are unintentional. For example, a scientist who owns stock in a drug company that is sponsoring her research may overestimate the benefits of the company's drug or underestimate its risks, because the financial interest clouds her judgment. The effect of the financial interest would be subconscious: she might not even be aware of how her judgment has been affected. Though money can cause scientists to deviate from science's descriptive norms, this does not mean that money also affects science's prescriptive norms. Norms can still function as prescriptive ideals even when people fail to meet them (Resnik 2007).

While it is possible for scientists to continue to hold some types of norms in high regard even when many of their peers deviate from them, the corrosive effect of money could eventually undermine academic science's prescriptive norms by changing the culture of academic science (see Kleinman, M. Brown, van den Belt, this volume). The actual practice of science would deviate so far from the prescriptive norms that these norms would lose any substantial influence. For example, many sports have been transformed from amateur activities to professional ones as a result of the influence of money. This transformation has, in many cases, come at the expense of norms associated with amateur sports, such as fair play and good sportsmanship. Though it is conceivable that academic science could be changed in the same way that some sports have been transformed, I am not yet convinced that this will happen, provided that universities, policy makers, and scientists take appropriate steps to protect the academy from the influence of financial interests. At the conclusion of this article, I will make some recommendations for keeping these corrupting influences at bay.

To explain how money can have an impact on scientists' adherence to epistemic and ethical norms, I will use a model of the steps of scientific research that should be familiar to most readers. The steps are: (1) problem selection, (2) literature review, (3) hypothesis generation, (4) experimental design and protocol development, (5) observation/testing, (6) recording data, (7) analyzing data, (8) interpreting data, (9) peer review, (10) publication of research, (11) replication of research, and (12) acceptance by the scientific community. The model combines the account of scientific reasoning developed by philosophers, such as Hempel (1966) and Giere (2005), with the description of scientific practice provided by scientist/scholars, such as Ziman (2000). The model is an idealization, of course, because scientists often deviate from it. They sometimes skip some steps, add other steps, or do steps out of sequence. Nevertheless, the model is still a useful way of representing, analyzing, and discussing the process of scientific research. I will refer to some of the steps in the model when discussing the impact of money on science.

There is not sufficient space or time in this chapter to explore all of the different ways that financial interests can impact the process of research. I refer the reader to Resnik (2007) and Krimsky (2003) for more on this. I would like to briefly discuss how financial interests can affect scientists' adherence to norms.

4.1. Skewing the Publication Record

There are many different ways to skew the publication record. One of those ways is to control the problems that are studied. Because research is so expensive, those who provide funding (the sponsors) determine what will be studied. Although many studies have shown a strong connection between the source of funding and the outcome of research, the reason for this connection is best explained by factors other than the money itself, which will be discussed below. While the source of funding does not necessarily bias the outcome of a particular study, it can bias the research record (i.e., the sum of published results) by setting the agenda. For example, if a pharmaceutical company decides to develop Drug X, it can invest money in sponsoring ten studies of Drug X. If the company had not made this decision, then there may have been no studies of Drug X. Thus, in this trivial way the company can affect the research record. To reduce the imbalance of funding favoring a company's drug or treatment, the government should fund studies that compare different drugs (or treatments) to the company's drug.

A more serious concern is that the company might decide to publish only the studies that favor its drug, which can violate objectivity, honesty, credit, and other norms (Resnik 2007). There are some notable cases where this has occurred, such as Merck's decision to delay publication of studies showing that its drug Vioxx increased the risk of cardiovascular problems. Though companies are required to submit their data to regulatory agencies, they are not required to publish their research. Thus, a company could skew the research record by suppressing research that does not favor its product(s) and by publishing research that does. A company can take other steps to skew the record, such as publishing the same favorable study twice (i.e., duplicate publication) or breaking a large favorable study into several articles for the purposes of publication (i.e., salami science). An expert who reviews the literature pertaining to the company's drug or conducts a meta-analysis will be misled by the research record. It will appear that the

Table 4.1. Skewing the Publication Record

Study	*Result*	*Published*	*Notes*
1	Negative	No	
2	Positive	Yes	Published twice
3	Negative	No	
4	Positive	Yes	Divided into 3 publications
5	Negative	No	
6	Positive	Yes	Published twice
7	Negative	No	
8	Negative	No	
9	Positive	Yes	Published once
10	Positive	Yes	Published once

Total positive publications: 9

published studies conclude that the drug is safe and effective, when, in fact, an equal number of unpublished studies draw the opposite conclusion (table 4.1).

One of the ironies of modern research is that if someone used this tactic with data points in a research article, they would have committed a type of fraud/misconduct known as data falsification. When you conduct a study, you should publish all of the data, not just the data that support your hypothesis. Private companies can get away with deception, however, because society has not yet adopted laws or regulations forcing them to publish all of their research. However, time may be running out for companies that try to suppress negative results, since most biomedical journals now require that clinical trials be registered in a public database known as a clinical trial registry (DeAngelis et al. 2004). If a company wants to publish a study that favors its drug, the study must come from a registered clinical trial. A clinical trial registry contains important information concerning the trial, such as the drug (or the biological or medical device) under investigation, the sponsor, experimental design, the population being studied, research sites, when the trial begins, and when it closes. Unfortunately, most trial registries do not include crucial items of information, such as the data and results, which researchers need to assess the safety and efficacy of the product under investigation. To counteract attempts to distort the research record, and also to promote honesty, openness, and objectivity, clinical trial registries should include data and results. Moreover, companies should be required to register all clinical trials to obtain approval for their products (Resnik 2007).

4.2. Cooking the Data

Cooking the data occurs when one designs an experiment to achieve a predetermined outcome. The experiment is not a true test, but one that is used to bolster the hypothesis. Cooking the data undermines adherence to many different epistemic norms, such as objectivity and testability, as well as some ethical norms, such as honesty and openness. One way of cooking the data is to deliberately ignore a particular outcome in one's experimental design. It is a truism of commonsense epistemology that if you don't look for something, you are not likely to find it. In scientific epistemology this occurs when a test is not designed well enough to detect a particular effect. The mere fact that you don't find an effect does not prove that the effect does not exist: absence of evidence is not the same as evidence of absence. For example, suppose that a company designs a clinical trial to measure a variety of health-related outcomes such as blood pressure, heart rate, blood sugar levels, nausea, headaches, kidney function, liver function, and so on, but the company deliberately fails to include an important variable, such as the drug's effect on muscle function, because animal studies indicate this might be a problem with the drug. When the trial is complete, it will not produce any evidence that the drug has an effect on muscle function, because this type of evidence was not sought. The data generated by the company may be sufficient to convince regulators and physicians that the drug is safe, when, in fact, the drug may not be safe. The biomedical research community may eventually obtain evidence that the drug impairs muscle function from adverse event reports or comparative clinical trials. In the meantime, many patients may suffer adverse effects from the drug unnecessarily while the company profits (Resnik 2007).

This problem can also occur when someone designs a study so that it lacks sufficient statistical power to detect an effect. In hypothesis testing, this particular problem is known as a type II error (failure to reject the null hypothesis when the null hypothesis is false). For example, suppose that a pesticide company has decided to generate some data on the effect of its chemical on human subjects to convince a regulatory agency to loosen the restrictions on the pesticide. The company's goal is to demonstrate that the pesticide has no adverse effect on human beings at a particular level of exposure. Suppose, also, that the company measures all relevant adverse effects but that the sample size is not large enough to demonstrate that some of these potential effects are statistically significant. Although this strategy may allow the company to achieve its corporate goals, it would commit the same type of methodological blunder that occurs when one fails to measure a particular effect (Lockwood 2004).

To prevent research sponsors from cooking the data, or committing other methodological (and ethical) transgressions, it is important for independent scientists (i.e., scientists without financial relationships to the company) to have meaningful input into research design. Research design must be thoroughly reviewed by regulatory agencies, institutional review boards for human subjects research (IRBs), and other independent parties with an obligation to assess the quality of the research. Companies should make their research plans and protocols available to the public before research begins and after it is complete. Research sponsors should disclose and justify changes in research plans or protocols. These steps will help to promote adherence to epistemic and ethical norms.

4.3. Misconduct and Fraud

Financial interests can also affect scientific research by causing researchers not just to cook the data, but to commit misconduct, which can also lead to charges of fraud.[6] The U.S. government defines misconduct in research as data fabrication or falsification or plagiarism. Fabrication is defined as "making up data or results and recording or reporting them"; falsification is defined as "manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record"; and plagiarism is defined as "the appropriation of another person's ideas, processes, results, or words without giving appropriate credit" (Office of Science and Technology Policy 2000). Misconduct does not include honest errors or differences of opinion.[7] The rate of misconduct in research is thought to be low. Using confirmed cases of misconduct, Steneck (2000) estimated that the rate of misconduct on federal grants is 1 per 100,000 researchers per year. This method probably underestimates the rate of misconduct because many cases are not reported or investigated. In a survey of over 3,000 scientists by Martinson et al. (2005), 0.3 percent of respondents admitted to committing misconduct in the last three years (1 per 1,000 per year). The survey may also underestimate the rate of misconduct because people who commit misconduct may not be willing to confess to it on a survey.

Even if the rate of misconduct is very low, misconduct is still a very serious problem when it occurs. Misconduct in science can have a negative impact on the research record, journals, collaborators, institutions, entire research fields, and the public. Consider the wide-ranging effects of the fraud committed by Seoul University stem cell researcher Woo Suk Hwang. Some of Hwang's colleagues began to have suspicions about a paper Hwang and collaborators published in *Science* in May 2005 on therapeutic cloning. The results of the paper, if correct, would have represented a tremendous breakthrough in human embryonic stem cell research and would have put South Korea on the map as a center of stem cell research. Soon after the paper was published, Hwang became a national hero. Hwang's colleagues tipped off some journalists and the editors of *Science* about problems with the May 2005 paper, and the university began an investigation. The investigation of Hwang's research revealed that Hwang had also fabricated data on another stem cell paper published in *Science* in 2004, and that he had violated ethical standards for authorship and informed consent for egg donation for the experiments. In May 2006, Hwang and five collaborators were indicted on charges of fraud and embezzlement. Due to the importance of Hwang's research, the case made headlines around the world. This misconduct case had adverse effects on people associated with Hwang, Seoul University, the journal *Science*, and the field of stem cell research. In addition, many people in South Korea felt betrayed and ashamed (Resnik et al. 2006).

What is the relationship between financial interests and misconduct? While there is no direct evidence that unchecked financial interests cause misconduct, there are good reasons to believe that financial interests are a risk factor for misconduct (Resnik 2007). Since virtually all researchers have financial interests, one of the keys to discouraging misconduct is to ensure that the appropriate checks and balances are in place in the institutional settings in which science is conducted. Since the research environment can encourage or discourage deviation from scientific norms, it is important to understand how that environment affects conduct.

In academic research, there is tremendous pressure on investigators to obtain government grants or contracts, since investigators usually cannot do research, or may lose their job, if they do not secure funding from outside sponsors. To obtain grants and renew grants, researchers must generate data. Researchers often need preliminary data to convince reviewers that their proposal is worth funding, and they also need data to convince reviewers that their funding should be renewed. This pressure to produce data affects people at all levels, from laboratory directors, to principal investigators, to junior researchers, to postdoctoral fellows, down to graduate students and technicians. Many of the researchers who have committed misconduct involving federal grants or contracts have admitted to succumbing to the pressure to produce results (Shamoo and Resnik 2009). The pressure to produce becomes even more intense if the research involves intellectual property, trade secrets, or company funding, or has the potential to launch a scientist's career.

Financial pressures exist in industrial science as well (see Carrier, this volume). Industrial scientists also desire to produce results to keep their job, earn money or a promotion, and so on. Company executives often make decisions that promote profits but compromise scientific integrity (Ziman 2000). However, much less is known about industrial science than academic science due to the secrecy that pervades this environment. Businesses treat information about their operations as propriety, and take full advantage of trade secrecy laws (Resnik 2007). Though I will focus on academic science in this chapter, it is important to realize that a great deal of research occurs not on university campuses but in private laboratories.

Preventing misconduct is not easy, since people who sincerely desire to cheat the system will always figure out ways to do it. Fortunately, genuine scoundrels are very rare in science. Most cases of misconduct probably occur when ordinary researchers succumb to temptations or pressures. The best way to prevent ordinary researchers from committing misconduct is for research institutions to promote ethical conduct through education, training, and policy development. Institutions should take steps to help relax some of the pressures in the research environment and to help researchers cope with the stress of competition for career advancement and scarce resources, such as basing personnel decisions on factors other than the quantity of publications or amount of money generated. Other strategies for preventing misconduct include random audits of data, the use of electronic record-keeping systems, and access to ethics consultation for researchers (Shamoo and Resnik 2009).

4.4. Spinning the Data

"Spin" is a pejorative term for putting a particular slant, twist, or bias on something, such as a newsworthy event or a government report. The term emerged in the 1990s to describe how politicians and public relations officials would try to present information in a light most favorable to their interest. Spinning can occur in science during the analysis and interpretation of data. Spinning is contrary to several norms of science, including objectivity, honesty, social responsibility, carefulness, and accuracy.

After a study is complete, scientists analyze and interpret the data. Although most laypeople think of data analysis as objective, it often is not. There may be more than one way to analyze the data, and different statistical methods may yield different results. A research sponsor may choose a method of data analysis that is most favorable to its product. In one well-known case relating to data analysis, Boots Pharmaceuticals sponsored a study comparing its thyroid medication to other generic versions of the medication. The investigator leading the study, Betty Dong, concluded that the company's drug was more expensive but not better than competing drugs. The company tried to prevent Dong from publishing these results, claiming that her analysis of the data was flawed. The company conducted its own analysis of the data, which showed that its drug was superior to the other drugs. Dong eventually published her analysis, despite the company's objections (Bok 2003; Krimsky 2003; Resnik 2007).

Data interpretation can be even more problematic than data analysis. An interpretation of data is a claim about the scientific and practical significance (or meaning) of the data. What do the data prove, disprove, or fail to prove or disprove? What do the data suggest or imply? Philosophers of science frame data interpretation problems as questions concerning the relationship between the observation and theory.[8] This way of thinking about data interpretation leads to a well-known conundrum in the philosophy of science developed by W. V. Quine and Pierre Duhem known as the Quine-Duhem thesis (aka the underdetermination of theories): there are indefinitely many theories that are logically consistent with the evidence produced by scientific experiments (Quine 1986). Thus, the evidence never proves only one theory is correct, since another theory may also be consistent with the evidence. The Quine-Duhem thesis is more than a mere philosophical problem, because real scientists often have disputes about data interpretation (Ziman 2000). Scientists who agree on the details of a particular experiment and regard the data as valid (i.e., legitimate, credible) may still subscribe to different interpretations of the data.

Data interpretation becomes even more problematic when one moves from scientific to practical significance, because one adds practical indeterminacy to the scientific indeterminacy. The practical significance of data depends on its potential impact on different human values, such as health, safety, the economy, etc. People may disagree about the practical significance of research results because they disagree about how the results will impact human values, or they disagree about the relative importance of different values. Suppose, for example, that a company has sponsored a study on a new blood pressure medication, and the study shows that the medication is more effective than other medications at lowering blood pressure, but that the medication also has a variety of side effects such as headaches, dizziness, fatigue, and decreased sexual function. People may disagree about the significance of this new drug if they have different opinions about the drug's side effects. For example, one person might consider the new drug to be safe, while another might regard the drug as unsafe because of its effects on sexual function. The drug's effects on sexuality might be important to one person but not another. Because people have different understandings of "harm," "benefit," "risk," and "safety," they may disagree about the significance of new drugs.

Companies can take advantage of the uncertainty of data interpretation to present their products in the most favorable way possible. In the blood pressure example discussed above, a company might claim that its drug is the best available treatment for high blood pressure, when the evidence shows, at best, that its drug has a variety of different benefits and risks. Now there is nothing inherently wrong with a company trying to interpret the data in a light most favorable to its product. Companies are in business to sell their products, and a little marketing is acceptable. However, companies (and scientists with financial interests in companies) often go way beyond putting a positive face on the data and engage in exaggeration and hyperbole. A salient example of this type of problem occurred when a panel convened by the National Institutes of Health (NIH) reviewed the literature on cholesterol-lowering drugs known as statins and recommended that the threshold for prescribing statins be lowered from 130 mg/dl of low density lipoprotein (LDL) to 100 mg/dl for patients without heart disease, and from 100 mg/dl to 70 mg/dl for patients with heart disease. This recommendation, if followed, would greatly increase the number of people taking statins and would result in increased profits for pharmaceutical companies. Eight out of the nine members of the panel had undisclosed financial relationships with companies that manufacture statins. Researchers and physicians argued that the benefits of lowering the threshold for prescribing statins were questionable. Consumer groups and ethicists objected that conflicts of interest had biased the panel's decision making (Lenzer 2004).

In some ways, making exaggerated claims about a product is less dangerous than cooking the data or skewing the research record, because these claims are often easy for experts to spot: experts often cannot tell whether data have been fabricated or cooked. An expert (or educated reader) usually will be able to see through a company's spin tactics and assess the true benefits and risks of a product. However, ordinary consumers usually lack these skills. To help ordinary consumers and experts, journal editors and reviewers should be on the watch for exaggerated claims. They should require authors, especially authors with conflicts of interest, to carefully substantiate claims concerning the practical significance of their research. Journal editors should also publish editorials, critiques, or commentaries to counterbalance overstated claims by company-sponsored researchers.

4.5. Inappropriate Authorship

Financial interests can also have an impact on authorship practices and undermine adherence to norms, such as credit, honesty, and objectivity. Authorship is a key part of science's reward system, and the quest for authorship motivates most researchers (Merton 1973; Hull 1990). The quality and quantity of one's published research is usually the decisive factor in decisions concerning hiring, promotion, and tenure in science. People who publish often are more likely to succeed in science than those who do not. Authorship should be granted on the basis of one's contribution to the research. Responsibility and credit should go hand-in-hand: a person who is responsible for conducting the research should receive credit for his or her work; conversely, a person who is not responsible for the research should not receive credit for doing it (Shamoo and Resnik 2009). Responsibility should be the basis for authorship for two reasons. First, it is unfair to grant authorship to people who do not deserve it, or to fail to grant authorship to people who do deserve it. Second, if there are problems with the research, such as errors or suspected fraud, it is important to know who can be held accountable for addressing the problems. There have been numerous cases of suspected research misconduct where authors have tried to evade responsibility by claiming that they had nothing to do with the problematic part of the research. To avoid this problem, all authors should at least know all of the other authors as well as their roles in the research. Authors do not need to be familiar with the details of work that they have not done, but they should at least understand how the different parts of the research fit together (Shamoo and Resnik 2009).

Many journals have adopted authorship guidelines that they display in the information for authors. The International Committee for Medical Journal Editors (ICMJE), an organization representing six hundred biomedical science journals, has adopted the following guideline for authorship:

> Authorship credit should be based on 1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published. Authors should meet conditions 1, 2, and 3. . . . Acquisition of funding, collection of data, or general supervision of the research group, alone, does not justify authorship. All persons designated as authors should qualify for authorship, and all those who qualify should be listed. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content. (ICMJE 2007)

The ICMJE also recommends that people who make contributions to an article but do not qualify as authors be listed as "contributors" at the end of the article, and that the article clearly states the responsibilities of different authors. For example, if a person made a substantial contribution by helping to design the experiment(s), then this should be indicated in the article; if a person drafted the article, this should be indicated, and so on (ICMJE 2007).

Because authorship has such great value among scientists, it is often the source of controversy and foul play. There are two main problems related to authorship in science: (1) granting authorship to people who have not made significant intellectual contributions to the research, i.e., honorary authorship, and (2) failing to name people as authors who have made significant contributions, i.e., ghost authorship (Shamoo and Resnik 2009). Honorary authorship often happens because people want, expect, or demand to be named as authors even though they have not made significant contributions. Honorary authorship might be granted to help a colleague in his or her quest for tenure or promotion, to thank a collaborator for providing data, reagents, or tissue samples, or to appease a lab director who expects to be named as an author on all articles coming out of his lab (Shamoo and Resnik 2009).

One of the main reasons ghost authorship occurs is that pharmaceutical companies use this tactic to publish articles. For an article to receive widespread recognition, it is important for it to be associated with a prestigious researcher at a university or academic medical center. Pharmaceutical companies have paid academic researchers money to sign their names on articles that they have scarcely read, much less written. All of the work has been done by company scientists, whose names may not be mentioned at all. The academic researcher is an author in name only, when the real authors are invisible "ghosts." Companies want to hide the ghost authors so that they will not have to disclose the company scientists' conflicts of interest and so the article won't appear to be biased (Hargreaves 2007).

There is a straightforward way to deal with these authorship problems: journals should develop and strictly enforce authorship policies. As noted earlier, many biomedical journals have adopted authorship policies. Journals that have not stated their authorship policies should do so immediately. In addition, journals should develop some way to enforce their policies, such as random audits to verify authorship, and penalties for violations.

5. Conclusion and Recommendations

In this chapter, I have explored some of the ways that financial interests can affect the norms of academic science. I have explained how financial interests can undermine scientists' adherence to honesty, openness, carefulness, credit, objectivity, and other epistemic and ethical norms. Like other authors who have contributed to this volume (e.g., J. Brown, M. Brown, Kleinman, Radder, Fuller), I hold that financial interests can corrupt the norms of academic science. This conclusion is painfully obvious to most people who are familiar with contemporary scientific research. What is not so obvious is how scientists and society should respond to financial and commercial influences in the academy. This is a difficult problem with no simple solutions. There are no simple solutions because it is not possible to remove financial interests from science. Research costs a great deal of money, and someone must pay this bill. Some have suggested that since private money is the source of most of the problems related to financial interests in research, the solution is to decrease or eliminate the amount of private funding of academic science (Brown 2000; J. Brown, this volume; Krimsky 2003).

I am not convinced that keeping private money out of the academy would be a very useful or workable solution. First, government-funded research has its own problems related to financial interests. Government-funded scientists will still compete for grants, jobs, prestige, and intellectual property. Indeed, most of the major misconduct scandals (that we know about) have involved government-funded research, not private research (Shamoo and Resnik 2009). Second, it is doubtful that private money can be eliminated from universities without causing major disruptions to research programs, university budgets, graduate education, and academic-industry collaborations. Private industry funds more than 10 percent of all research conducted at academic institutions in the United States, many government-funded research projects involve collaborations with private industry, and private companies give numerous gifts to universities (Bok 2003). To maintain universities at their current level of funding and research activity, governments would need to replace the billions of dollars that would be lost if private money were eliminated or drastically reduced. It is unlikely that the public will be willing to pay for this bill.

Since money—even private money—is an indispensable part of modern academic science, the only realistic way of dealing with financial interests in research is to live with them as best as we can. Scientists and society should adopt strategies for managing financial interests and minimizing their impact on the norms of academic science. Some of these are as follows:

- Disclosure of financial interests to all relevant parties (journals, research institutions, etc.)
- Use of independent committees to manage financial interests that pose difficult problems for research
- Prohibition of financial relationships that are too problematic to manage

- Promotion of education, training, and mentoring in research ethics for scientists, research staff, and students
- Development of research ethics policies at institutions, funding agencies, journals, private companies, and other organizations involved in research, such as authorship and publication standards, misconduct definitions and procedures, conflict of interest rules, etc.
- Requiring all clinical trials to be registered with a clinical trial registry; incorporating all the information about the trial one would need to evaluate it, including data and results
- Government funding of clinical trials that compare different medications or treatments to offset data generated by private companies
- Publishing editorials and commentaries to counterbalance research claims made by industry
- Refining intellectual property laws and policies to manage the proper balance of private versus public control of intellectual property (cf. Radder, this volume, chap. 10)
- Strengthening the research exemption in patent law
- Auditing research records
- Easing some of the pressures to produce data
- Supporting committees and other organizations that are responsible for overseeing scientific research, such as institutional review boards, animal care and use committees, biosafety committees, and so on
- Assessment of clinical trial research design by independent scientists
- Careful review of research contracts with pharmaceutical companies to avoid suppression of publication or unreasonable delays of publication

Adopting these strategies will not prevent financial interests from having an adverse impact on the norms of academic science, but they should help to preserve it in its current form and stop the slide toward Gomorrah.

NOTES

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1. This number is disputable. According to industry estimates, it costs $800 million, on average, to bring a single new drug to the market (Pharmaceutical Research and Manufacturers Association 2007). Some scholars have challenged this figure, however, arguing that the costs are closer to $200 million (Goozner 2004). I am simply splitting the difference with my $500 million estimate.

2. By "academic science" I mean science as practiced by people in an academic setting, such as a university. Most science scholars focus on academic science, but it is worth noting that there are different types of science that do not share the academic ethos, such as industrial science and military science (Ziman 2000).

3. I recognize that Merton is regarded as passé by many contemporary sociologists of science. Latour and Woolgar (1986), Jasanoff (1998), Collins and Pinch (1998), and many other scholars eschew talk of "norms" in favor of "interests." Though Merton has fallen out of favor in current sociology of science, he has admirers in the philosophy of science, such as Hull (1990), Kitcher (1993), and Haack (2003). Call me old-fashioned, but I still regard talk of norms as fruitful and insightful. See also Radder, this volume, chap. 10.

4. Some of the more infamous cases of research misconduct in the last few years include South Korean stem cell scientist Woo Suk Hwang's fabrication of digital images and data in support of articles on therapeutic cloning on human embryos, University of Vermont clinical researcher Eric Poehlman's fabrication and falsification of data on numerous grant applications and publications pertaining to research on female hormones, and Bell Laboratories physicist Jan Hendrick Schön's fabrication and falsification in dozens of articles (Shamoo and Resnik 2009).

5. Individual scientists also have goals, but these are not the goals of science (Kitcher 1993). Individual scientists may pursue scientific goals, such as truth or explanation, but they may also pursue personal goals, such as career advancement or prestige.

6. "Fraud" has different senses in the research ethics literature. In the informal sense, "fraud" simply means dishonesty or deception. In the technical, legal sense, "fraud" is an illegal act of deception. Scientists who are found to have committed misconduct may also face fraud charges (Resnik 2003).

7. Some governments, universities, and organizations use definitions of "misconduct" that go beyond fabrication, falsification, or plagiarism, and include acts such as interfering with a misconduct investigation or wanton violations of human or animal research rules (Resnik 2003).

8. The difference between observations and data is that data are recorded observations. There are also different types of data: primary data, secondary data, and even tertiary data. The primary (rough, original) data are the recorded output of a test or experiment. In some sciences, such as astronomy or genomics, the primary data are so large and complex that they must be reduced to something more manageable. The goal of data reduction is to reduce the amount of data without losing significant informational content. But the reduced (or secondary) data may still be reduced or analyzed even more, which leads to tertiary data.

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