

MODELS IN PANTHER BIOLOGY AND RADIOBIOLOGY

PHILOSOPHY OF SCIENCE AS SCIENTIFIC CITIZENSHIP

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In his autobiography, Francis Crick (1988, 50–51) tells how, as a beginning graduate student, he was regarded by Nobel Prize winner and Cavendish Professor Lawrence Bragg. Bragg thought Crick was “a nuisance who didn’t get on with experiments . . . talked too much and in too critical a manner [and was] ‘rocking the boat.’” Can one make a case for behaving like Crick? And for saying scientists and philosophers of science, almost universally, have failed in their duties to “rock the boat” in the face of scientifically or ethically questionable research?

Answering in the affirmative, this paper outlines contemporary biological case studies (1) on the endangered Florida panther and (2) on the International Commission on Radiological Protection’s 2003 biological recommendations; (3) traces some flawed ways of thinking about philosophy of science and ethics; (4) sketches an alternative ethics of “scientific citizenship”; (5) argues that all scientists and philosophers of science have duties to be scientific citizens; (6) suggests ways research and education in science and philosophy of science must be reclaimed in the light of scientific citizenship; and (7) offers a brief conclusion.

The Ethics of Florida Panther Studies

Consider the case of the Florida panther, *Felis concolor coryi*. An endangered umbrella and keystone species, monitored through radiotelemetry collars since 1981, the panther is important for the survival of many other species in its habitat. East of the Mississippi, only about 75 panthers, including only 15–18 breeding females, live only in South Florida, mostly on public land (Comiskey et al. 2002; Land et al. 2002; McBride 2001, 2002; Seal et al. 1989, 62–63, 69, and 106; Kostyack, 2002, 6).

The panther is in trouble because the same poorly planned development that devastated the Eastern Everglades is now allowed in the Western Everglades. While US taxpayers are spending \$8 billion to restore the Eastern Everglades, since 1993 the US Army Corps of

Engineers (ACE) and the US Fish and Wildlife Service (FWS) have turned down no permits for developing the panther’s only habitat, in Western-Everglades. Successful permitting occurs in part because developers have hired a biologist touted as the “foremost expert on the Florida panther” (Agridpartners, 2001, 3), although his science has been called into question (Slack, 2002).

This conservation biologist and consultant-to-developers, now in charge of species-recovery programs elsewhere, has repeatedly defended Western-Everglades development (Agridpartners 2001; NWF, 2001), by using at least six scientifically and ethically questionable claims. These are that (1) regarding population, the Florida panther is healthy, robust, and can survive for at least 100 years (Maehr and Lacy 2002, 972; Maehr, 1997); (2) regarding genetics, there is no current inbreeding depression (Maehr and Caddick 1995; see Maehr et al., 2002a); (3) regarding prey, there are too few deer in its Western-Everglades habitat (Maehr and Lacy, 2002, 974); (4) regarding mortality, Florida highways are no big problem (Maehr, 2001, 1991); (5) regarding habitat, quality is determined by amount and quality of forests (Maehr and Deason, 2002); (6) regarding colonization, low-intensity private lands in central Florida are desirable (Maehr et al. 2002a, 187; Maehr 2001, 3–4; Maehr and Deason, 2002, 400). As a result of his claims, Everglades destruction is repeating itself. Marjory Stoneman Douglas (founder of “Friends of the Everglades”), where are you?

The consultant’s first, or healthy-population claim, is flawed because it is based on a Population Viability Analysis (PVA) that is nonempirical, premised on counterfactual conditions, and employs erroneous parameterization. For example, his PVA assumes that (a) half the population is made up of regularly-breeding females; (b) no habitat loss will occur; (c) there is equal random access to mates; (d) no genetic effects of inbreeding occur in the near term (100 years), and (e) no human impediments to movement exist, such as highways (Maehr et al., 2002b). Yet all five

PVA conditions are false for the Florida panther (McBride 2002, 2001; Kostyack, 2002, 5). For instance, the model assumes a constant mortality rate, but in each of the last four years, six or seven panthers (almost 10 percent of the total population) have been killed on Florida highways (Land et al., 2002), a doubling of annual highway deaths since 1999. The parameterization of the PVA model also errs because its estimates for initial population, reproduction rates, and kitten-survival rates all rely either on nonempirical guesses or on extrapolations from only a small part of the data. For example, the 80-percent survival is based only on several litters, is unsubstantiated by field data, and is controversial (McBride 2001; Comiskey et al. 2002; Slack, 2002). Such shortcomings can explain how the consultant is able to make such optimistic claims for an endangered, isolated species, with 15–18 breeding females—claims that give it greater fecundity and survival than even English sparrows.

His second, or genetics, claim is flawed because the consultant himself has done no genetics testing, and there has been repeated laboratory and field proof of inbreeding depression, given rampant problems like failure to breed and undescended testicles (McBride 2002, 2001, 5 and 9; Comiskey et al. 2002; FPWG 2000, pp.4-5; Land and Lacy 2000; Roelke et al. 1993; O'Brien et al., 1990). The consultant ignored the consensus of existing genetic evidence (Land and Lacy 2000; Roelke et al. 1993; O'Brien et al., 1990); trimmed the data; used a small sample size; then on the basis of the small sample (like looking for an electron with a flashlight), claimed his inability to find a statistically-significant difference as evidence of no inbreeding depression (Maehr and Cox, 1995). He confused the absence of evidence, after using the wrong test, as evidence of absence.

The consultant's third, or prey, claim is flawed because of his using a Park-Service model that grossly underestimates numbers of deer because it relies on surveys that used early-morning, plane over-flights with spotters, a technique that yields only 20 percent to 50 percent as many deer as using spotters in helicopters. Biologists already have shown that Florida-panther flights, using an infrared camera, could find twice as many deer as the methods used by the developer-consultant (Havens and Sharp, 1998).

The fourth, or mortality, claim is flawed because the consultant does not define, quantitatively, what he means in saying highways pose no big threat to panther mortality. He relies on pre-1999 data, yet because of all the Everglades development he has justified, annually since 1999 nearly 10 percent of the total panther population has been killed on Florida highways (Land et al., 2002).

The fifth, or habitat, claim errs because the consultant says the Everglades are too wet for panthers, and forest is its only vital habitat (Maehr 2001, 1997; Maehr and Lacy, 2002). But here he cooks his data through a representativeness bias. He looks at only 60 percent of panthers, those living in semi-forested areas north of I-75 (Comiskey et al., 2002); he excludes the 40 percent living south of I-75, where the habitat is a mosaic of prairies, marshes, and tree islands; then he concludes all panthers prefer forests. He also ignores spatial errors caused by the fact that each pixel, generated by panther radiotelemetry, has an average error of 224 meters (Maehr and Cox 1995; see Comiskey et al., 2002). In using these pixels, but in neither providing uncertainty bounds on his panther-position values nor including habitat information for 224 meters around the telemetry points, he overestimates forest importance and ignores the patchy landscape. Even worse, he uses only daytime telemetry for this nocturnal animal (Maehr and Cox, 1995), a temporal bias, then defines the daytime-telemetry (or resting) habitat as "preferred," and names all other areas "avoided" habitat. His highly equivocal definition of preferred habitat (as resting) thereby assumes that panthers don't prefer breeding, denning, and hunting habitat (Shrader-Frechette and McCoy, 1993, 213–14). Another glaring flaw in the habitat claim is his using crude satellite data (Maehr, 1997), depicting only forest cover, to allege that central-Florida pine forests are prime panther habitat. But what panthers need is the understory, for breeding/denning/ hunting, not the forest per se. Yet the consultant ignores the fact that many central-Florida pine forests have virtually no understories. Panthers use pine forests only during the early years after burning, when the understory is present (Dickson and Beier 2002, Dees et al., 2001).

The sixth, or colonization, claim (about private lands in central Florida) likewise errs because of the understory problem, the temporal

bias of daytime telemetry, the spatial bias of using only data north of I-75, and failure to take account of pixel uncertainty and variability—all representativeness biases that create a logical fallacy of composition. Moreover, patchy central Florida is useless to the panther, unless there are 200–300 square miles of contiguous lands per panther, few roads, and the required understory (McBride 2001, 6–7; McBride, 2002, 12–13), none of which are met in the Walt Disney World area of West Florida. But if not, on what basis does the consultant propose central-Florida colonization? He makes the untested claim that panthers can live solely on patchy private property, coexisting with “low-intensity land-use” (Maehr and Deason, 2002, 400). But this is a surprising scientific conclusion. (a) If the panther prefers the private land and human disturbance of central Florida, why did he move out of it to the remote public lands of the Everglades? (b) Why is there no evidence whatsoever of reproduction on these private lands or of breeding females being there (Kautz and Kawula 2000; McBride 2002, 12; FPWG, 2000)? How would one fit the hundreds of square miles of contiguous habitat required by breeding panthers into the patchy environment of central Florida? (c) How would panthers avoid being killed by hunters or their attacking livestock and humans, as in California? (d) What will highway mortality be on the many greater roads of central Florida? (e) If he is right about private land in central Florida, why do preliminary results of an ongoing Fish and Wildlife Conservation Commission (FFWCC) survey of potential panther habitat in central Florida (McBride, 2002), evaluating tract size, proximity and connectivity of tracts, prey base, human activity, and highway density, fail to support his view? Why do virtually all existing Florida panthers (7/8) live on public land (Slack, 2002, 24)? (f) If his recommended “private cooperation” among central-Florida private landowners, without government regulation, will work to protect the panther (Maehr, 2001, 3), why didn’t it work in the past?

Although these six claims reveal the consultant’s flawed panther science, why has he dominated panther-recovery and Western-Everglades policy? One reason is that peer reviewers of journals like *Wildlife Society Bulletin* and *Conservation Biology* (where the consultant published) did not expose his flawed science, probably because there are so few

panther experts east of the Mississippi. Also the consultant’s articles misled reviewers. He never admits, for example, using only daytime telemetry; one has to know the original FFWCC data source (Slack, 2002), where this fact is revealed. Likewise, he never admits using only panther data north of I-75. Instead, one has to examine the numbers and data points in his articles, then compare them to the original data set, published by the state (e.g., Land et al., 2002), to see what he omitted. Thus, a first ethical problem is the biologist’s misleading claims and omissions about the nature of his data, methods, and interpretations. Another ethical error is his not taking account of the ethical consequences of his flawed science, like his crude “forest” definition of panther habitat: letting financiers dredge, fill, and develop Western Everglades, whatever is not forest.

Of course, it may be accidental that the six erroneous claims (about panther population, genetics, and so on) all support developing Western Everglades and promoting private lands in Central Florida as panther habitat. Even if they are random scientific errors, the consultant has a third ethical problem, conflict of interest. After working on panther monitoring on the payroll of the FFWCC, and while using its data, and while currently leading endangered-species recovery programs in Kentucky, as a tenured UK faculty member, this consultant continues to collect large sums of money, testifying on behalf of developing the very habitat he was paid to protect. Landon Companies/Agripartners paid him a retainer of \$4,500 per month, \$54,000 per year, and he provided sworn expert opinion, describing his optimistic PVA results and his forest-centered evaluation of panther habitat. He argued that because the panther was so healthy, his client’s Everglades development would do no damage (Maehr, 2001, 1 and 6).

In the Daniels development case (Corps Permit No. 199130802), the panther lost more than 800 acres of priority habitat in Western Everglades, while a quarter of a million dollars was paid to consultants, the chief one being this conservation biologist, for permit testimony. The US FWS wanted compensation for loss of one third of this prime panther habitat, but the consultant’s testimony, based on his fractional valuation of forest patches, excluding all other landcovers, enabled no compensation whatsoever to be paid for loss of Florida

panther habitat, but only wetlands-mitigation for 94 acres (NWF 2002; Maehr 2001, 1 and 6; Thoemke and Payton 2001; Slack, 2001). He likewise testified for successful development projects of Wilkison and Associates in Naples, Florida (Thoemke and Payton, 2001, 1); for developers of the new Florida Gulf Coast University; and for golf-course McMansions like “The Habitat” development in Lee County. In February 2003, when Florida Rock Industries received mining permits on more than 6,000 acres of prime Everglades panther habitat (Slack, 2002, 8), he used his narrow, daytime-telemetry definition of panther habitat to argue the developer should pay for panther mitigation for only the 66 acres of forested wetlands, less than one percent of the total impacted (Slack 2002, 10; Kostyack, 2002). What would a court say if someone took away 1,000 acres from a farmer, then employed telemetry data from only the time the farmer was sleeping in his house, then said the farmer had to be compensated, for his farmland loss, only for the small area in which he actually slept?

Of course, someone may claim that the forest-habitat definition is just an honest scientific mistake. But if so, why did the consultant evaluate the same land inconsistently? When he assessed current panther habitat, sought by “dredge-and fill” Everglades-developers, he inconsistently assigned no value whatsoever to agricultural lands used by the panther for hunting prey, so that the developers could get it. But when he assessed proposed agricultural lands, to be used for mitigation of habitat loss, he assigned them positive value as panther habitat (NWF et al. 2001, 62–63; Kostyack 2002; Thoemke and Payton, 2001). This suggests an ethical lapse, twisting the truth for those who pay him.

He also misrepresents his work for developers and misrepresents his affiliations as purely academic in publications and in his panther advisory work. In 1998, the consultant testified on behalf of Everglades developers; less than three years later, he signed an affidavit stating that he had not testified for any developers in the “preceding 4 years” (Thoemke and Payton, 2001, 2). Was it a misrepresentation when he testified—on behalf of an Everglades-developer paying him \$54,000 per year—that “the impact of human activities on panther habitat and behavior is uncertain” (Agripartners 2001, 4 and 6; Maehr, 2001, 1)? Or when he said no

studies show panthers are “averse to human activity” (Maehr, 2001, 7 and 4)?

A sixth ethical problem is that the consultant appears to use scientific terms so as to mislead. He repeatedly describes habitat used only for resting, north of I-75, as “preferred panther habitat” when he should have said “preferred as resting habitat.” And why should he say panthers are able to “colonize” central Florida (Maehr et al., 2002a, 187), when he knows breeding females have never been documented there since monitoring began in 1981? Why would he characterize Western Everglades incorrectly, as a panther-population “sink,” “the land of the living dead” (Maehr, 1997), although many panthers live and breed there?

But the biologist-consultant gets away with these ethical and scientific problems, in part, because scientists, philosophers of science, peer reviewers, state, and federal officials do not speak out. Instead of setting the scientific record straight, the state agency in charge of panther monitoring chose him as lead author on several of its publications, but without disclosing his conflicts of interests. In 2001, when the National Wildlife Federation (Thoemke and Payton, 2001) blew the whistle on his conflicts of interest and requested their disclosure, the US FWS Supervisor (Slack, 2001) responded that no disclosure was necessary.

The Ethics of the ICRP Ecological Risk Recommendations

Just as “following the money” seems to account for ethically and scientifically flawed panther research, it also explains the flawed biological recommendations issued in 2003 by the International Commission on Radiological Protection. The ICRP, responsible for recommending global radiation-pollution protections standards (which are then adopted by individual nations), issued its first-ever environmental-protection recommendations (ICRP, 2003). Before 2003, there were no radiological protection standards for humans.

Despite the need for environmental protection against radionuclides, the ICRP scientific recommendations are flawed. (1) They omit all radiological protection of the abiotic environment, such as air and water. (2) They take an incomplete, reductionist approach to ecological risk assessment by ignoring all ecosystem-level structures and functions and instead addressing risks only to a few reference species.

(3) They focus only on modeled, not measured, doses to these reference organisms. (4) They define “reference species” in terms of no operational scientific criteria but instead characterize them pragmatically as those species chosen because the analysts know the most about them. (5) They make no recommendations to optimize radiological protection of the environment and keep exposure ALARA (as low as reasonably achievable), although optimization and ALARA are part of ICRP norms for protection of humans (ICRP, 1991).

In omitting abiotic protection, the ICRP errs because it ignores what is most easily, reliably, and empirically measured, air and water, and what is the “early-warning signal” for high species doses. The omission of ecosystem-level risks is problematic because state-of-the-art ecological risk assessment (ERA) includes two different levels of methods, the toxicological and the systems level. And the requirement of modeled, not measured doses to reference species is scientifically flawed because model results would be almost totally dependent on extrapolations chosen by the modeler. There are no empirical checks and balances; no replication of results; and no escape from subjective, nonempirical models because estimates will be only those the modeler judges “likely” (ICRP, 2003, par. 119), not those based on explicit confidence levels, with statistically measurable uncertainty bounds.

Fourth, the ICRP’s basing all its environmental protections on doses to some arbitrarily chosen “reference species” is scientifically indefensible because the ICRP gives no scientific definition of “reference species”; they are simply those about which modelers have the most information. In using reference species, the ICRP arguably sanctions science that amounts to the drunk looking for his watch under the streetlight. Why does the drunk look for his watch under the streetlight? Not because he lost his watch there, but because that is the only place he can see. Why does the ICRP sanction use of reference species? Not because they are species that are important for radiation protection, but because they are species about which we know something. The “reference species” concept also is scientifically flawed because it has no connection whatsoever to “sentinel,” “average,” “keystone,” “focal,” “umbrella,” or “most sensitive” species. Given no reliable biological survey of all major flora and fauna, given no

controlled radiobiological experiments on different species with vastly different radiosensitivities, given space-and-time bounding problems such as migration, and given radiation-dose values in the literature ranging over orders of magnitude, there is no way synergistic, cumulative, and indirect effects can be combined into a reliable estimate of dose (Moeller, 1997, 28).

Obviously the ICRP recommendations are scientifically flawed, but is there also an ethics problem? There is a representativeness bias, because all members of the committee were chosen, not by biologists, but by those responsible for radiation protection; because virtually all members of the committee had done research only on toxicological, not ecosystem, ERA; and because virtually all members had already written articles, usually for their nuclear-industry employers, in support of modeled, rather than measured dose. There also were violations of procedural justice, because the pro-nuclear chair of the committee, from Sweden, allowed no votes from the five committee-member scientists (one each from Canada, Norway, Russia, the UK, and the US). I was the US member.

When the US member requested basing all recommendations on the best science available, from top refereed journals, the chair instead defended using mainly nonrefereed “gray” literature. And when the US committee member asked the committee to require uncertainty analysis of estimated doses, the chair simply removed (from the report) the written admission that no uncertainty analysis was necessary. Although the ICRP said members of the scientific community would be able to comment openly on the report, it never put the document through peer-review. It asked for comments on the draft, posted on the ICRP website, but scientists’ comments were neither published nor posted on the website, and only the committee chair had access to them. When the US member tried to force scientific exchange on the draft, by publishing analyses of it in scientific journals, the chair claimed public comments on a mere draft report were inappropriate. But there was no other vehicle of communication. Besides, why would someone comment only on the final report, since it could not be easily changed? Prior to adopting the report, the US member called for a vote on the document, and both the chair and the ICRP told her the ICRP did not vote. The draft docu-

ment, in essentially the same form, was published in 2003, one month after the alleged comment period ended. It was published in a deliberately misleading way, listing all committee names, but without acknowledging that not all members had approved it.

Apart from these problems of ethical procedure, scientists and philosophers of science also are responsible for the consequences of flawed ICRP science. What will happen when environmental protections rely merely on models, not measurements? On gray literature, not the best scientific journals? On a largely nontransparent monitoring system controlled mainly by those who use and profit from nuclear pollution (Shrader-Frechette, 1996)? US nuclear weapons cleanup will cost a trillion dollars, the same as many Vietnams; hundreds of reactors must be expensively decommissioned throughout the world; and millions of nuclear workers and atomic veterans are loudly demanding compensation. It will be cheaper for government and industry to address these problems, if they have control of a nonempirical, nontransparent, partial set of radiobiological norms.

Both the panther and the ICRP cases suggest that to understand flawed science and ethics, one often can “follow the money.” They also suggest that, as philosophers and as scientists, we cannot always rely on international agencies, federal agencies, state agencies, peer reviewers, or fellow scientists, either to do good science or to use science in ethical ways. We ourselves must help take on these duties.

How Not to Think about Philosophy of Science and Ethics

At least one reason for the ethically and scientifically flawed ICRP recommendations and panther research may be that too much contemporary philosophy of science is divorced from ethics. Although in theory, the label “philosophy of science” suggests broad philosophical inquiries into science, in practice the label is taken to mean only “epistemology of science.” And even when philosophers of science do engage ethical issues, that ethics amounts to rearranging deck chairs on the Titanic. One wrong-headed approach, individualism, is no better for sciences such as ecology than it is for ethics. What most scientists and philosophers of science emphasize (when they give their grad students and post-docs the required NIH

or NSF course in research ethics) is individualistic bioethics: Individuals should not falsify data. Nor claim authorship when inappropriate, and so on, all of which is correct. But by fixating on the personal issues that are necessary, they ignore institutional issues that are required for good science. Focusing on the individual trees they ignore institutional forest of ethics.

What are some of these institutional issues? According to a January 2001 editorial in *Nature*, one issue is whether the university-industrial complex is “out of control” (Nathan and Weatherall, 2002, 1368), as typified by the Novartis deal with Berkeley and the Hoechst deal with Harvard, both of which give patent rights to industry donors for work they have not funded (see Shrader-Frechette, 1994). Another issue is preventing situations like hematologist Nancy Olivieri’s being sued for breach of contract, after she entered into a research contract with a drug company, then blew the whistle on damaging side-effects of company medication, side-effects that the company tried to keep quiet (Drazen, 2002, 1362). Still another issue is why philosophers and scientists neither keep informed nor speak up when politicians second-guess scientific conclusions, for political reasons, as when the Bush administration recently disbanded dozens of federal scientific advisory committees that came to scientific conclusions different from his own (or different from his donors).

After years of study, one federal scientific committee concluded the public is at risk from the genetic-testing industry and worked with FDA to develop regulations for the industry that, so far, has been free of oversight. But industry protested, so Bush did not renew the committee’s charter. In Latin-Americanese, he “disappeared” the committee. Paul Gelsinger, whose son Jesse died in a Pennsylvania gene-therapy experiment commented: “money is running the research show.” Another scientific committee, headed by Tom Burke at Johns Hopkins, recommended tighter controls on environmental chemicals, and Bush told him that he and fifteen of its eighteen members would be replaced, and the regulations dropped. They were replaced, virtually completely with chemical-industry lobbyists, lawyer, consultants, and CEOs, such as Dennis Paustenbach, who tried to defend PG&E against Erin Brockovitch’s charges that it contaminated California communities with chromium

(Musil, 2003). Is science for sale to the highest bidder or campaign donor? Is political science replacing laboratory science?

By ignoring such institutional issues of scientific ethics, the invisible elephant in the middle of the laboratory, and focusing largely on individual and personal issues such as authorship, philosophers and scientists fall into the same individualistic pitfalls as most medical ethicists. Most journals dealing with biomedical ethics address issues of individual doctor-patient relationship, like disclosure or informed consent, when they also should be concerned about why the Health Tracking Act of 2002 (HR 4061 and S 2054) has not passed, forcing government to track chronic diseases and their possible environmental causes. Why do people focus on individual human deaths from known causes, like the avoidable 30,000 auto deaths each year from drunk drivers, but ignore the same number of deaths mostly among children, caused by power-industry particulates (Shaefter, 2002)?

Minimalism, another wrong approach to philosophy of science and ethics, presupposes that, if we do only epistemology of science, we are exhausting the field of philosophy of science. Minimalist approaches ignore the ethics of science and the fact that it ought to be part of philosophy of science. Minimalists also assume that, if we do not lie, cheat, or steal, we are ethical. They ignore the fact that we are all members of familial, national, civic, and scientific communities, in whose problems and omissions, we are all complicit. Many scientists and philosophers of science are minimalists because they are communally and relationally challenged. Yet most of us would not say, in response to being called at work, after our child was seriously hurt at school, "I'm too busy to go to the hospital. I'm a scientist, and I don't have time for those 'outside' activities. I make my social contribution through my science." Just as such an answer would be appalling, in response to our child's being hurt, it also is appalling in response to things like inaction on Bush's roadless rule for national forests. It also sounds like the attitude of the entire Prussian Academy of Sciences, when it universally condemned Albert Einstein in 1933, for criticizing Hitler's violations of civil liberties. Ethics and philosophy of science do not always dictate what side one should take, like Einstein's, but they do dictate that we all have a moral responsibility to engage in what Iris

Marion Young (2000) calls "democratic deliberation" about science-related issues. People don't have the right to enjoy the benefits of membership in the scientific or philosophical community and, at the same time, to claim the right to be apolitical when that community is misrepresented

The Real Problem: Lack of Scientific Citizenship

But if individualism and minimalism don't work, what does? I call the alternative philosophy of science, "scientific citizenship," public citizenship for scientists and philosophers of science. It consists of participating in deliberative democracy (Young, 2000), in the ways we learned in eighth-grade civics class: by public speaking, public-interest research, reporting, surveying, whistleblowing, filing claims under the Freedom of Information Act, boycotting, picketing, demonstrating, suing, using initiative and referendum, fundraising, or responding to one of the 2500 draft environmental impact assessments written each year for public comment (Isaacs, 1992). If a financially strapped, single parent like Erin Brockovitch has the courage to be a scientific citizen, then better educated scientists and philosophers ought to be able to do at least as much.

Where were the Erin-Brockovitch biologists when Vice President Cheney said energy conservation was a "personal virtue" then tried to open up Alaska and arctic wilderness to oil and gas drilling? After Cheney's comment, the country's five top national laboratories released a report showing that energy efficiency programs could immediately reduce electricity demand by 20 to 47 percent (Nierenberg, 2001, 13). And where were the Erin-Brockovitch biologists when Senators John McCain and John Kerry proposed raising the CAFE (corporate average fuel economy) standards gradually over the next 13 years (Huffington, 2002, 41-42)? Both Democratic and Republican Congresspeople, beneficiaries of auto and oil-industry campaign donations, voted against better CAFE standards, even though the McCain-Kerry bill would have saved 2.5 million barrels of oil a day (Huffington, 2002, 41-42).

Scientific citizenship is not blind advocacy. It is keeping informed, sharing information, revealing bias, avoiding political naïveté, taking part in public debate, especially in areas re-

lated to your own areas of expertise. It would not be inappropriate advocacy to reveal the flawed science used by panther scientists or the ICRP radiobiologists. In most cases, scientific citizenship is nothing more than doing good science and acting as a philosophical watchdog on those who misuse science, especially in policy contexts. Most of us are critical of the way medical doctors fail to act as watchdogs on the policies of the AMA. But if so, we should be critical of the way biologists fail to act as watchdogs on the misuse of biology. What all these demands for scientific citizenship entail is taking responsibility. As Cassius says to Brutus in Act 1, scene 2 of *Julius Caesar*: “The fault, dear Brutus, is not in our stars/ But in ourselves, that we are underlings.”

Why All Scientists and Philosophers of Science Have Duties to be Scientific Citizens

Why are scientists and philosophers of science obliged to play a pro-active role in democratic deliberation, as scientific citizens? There are at least five reasons: ability, complexity, consistency, professional codes of ethics, and self-interest.

Scientists and philosophers of science have this special duty, first, because they are able to do what very few others can. Special abilities and special knowledge create special obligations.

Scientists and philosophers of science also have special duties because they are complicit in many harms done by science. We all know about this complicity in medical contexts. Most manufacturer-funded scientific studies on pharmaceuticals claim efficacy superior to other products, but in at least half the cases, the statistics are missing or inconclusive, yet peer-reviewed journals publish them anyway (Rochon et al., 1994). Journals did the same in the panther case. One way to compensate for our known and unknown failures is to make an effort to behave proactively, as scientific citizens.

Third, consistency further dictates duties to be scientific citizens. It is irrational to train students to do science and philosophy of science and not to train them to monitor the democratic conditions necessary for good science. To seek the end, good science, and not pursue the means, whistleblowing and watchdogging, necessary to achieve it, is irrational. Naive

people thought passing the 1964 Civil Rights Act would end racism, because they ignored the role we all must play, de facto, to ensure that the de jure law works. Yet we ignore the de facto work necessary to realize the de jure dictates of the National Environmental Policy Act (NEPA). Providing comments on draft assessments is necessary for the de jure NEPA to work. Our acting as advocates for good environmental assessment is necessary for NEPA to work.

Fourth, scientists have duties to be scientific citizens because their professional codes of ethics require just that. The code (revised 22 March 2002) of the American Institute of Biological Sciences (AIBS), for example, requires biologists to expose fraud, professional misconduct, conflicts of interest and to promote open exchange, among other things. If parties to the ICRP and Florida-panther research had followed these rules, many problems could have been avoided.

A final reason for duties to behave as scientific spokespersons is self interest. If scientists and philosophers of science do not behave as scientific citizens, then people will be less well educated about science. As a result, science will receive less funding, and the profession will do less well.

Reclaiming Scientific Research and Teaching

If we take scientific citizenship seriously, then we shall have to reclaim scientific and philosophical research and teaching. That reclamation will need to start with the recognition that although both science and philosophy, with care, can be objective, they are also, as Philip Kitcher put it, unavoidably social. But if so, scientists and philosophers of science must learn to practice what Kitcher (2001) calls “well-ordered science,” science subject to informed, pluralistic, democratic constraints. Well-ordered science requires researchers and educators to look out for ways that vested interests tilt the scientific playing field. It is not level, if the only factor associated with concluding that passive smoking is not harmful is whether an author is affiliated with the tobacco industry, even when one uses multiple logistic regression analyses controlling for article quality, peer review status, topic, year, and so on (Barnes and Bero, 1998). The playing field is not level, if a poorly-paid federal employee

is pitted against utility-industry attorneys each of whom recently charged \$5,000 per hour, for attempts to have the Clean Air Act declared unconstitutional (Moore, 2002, 58).

One way to help level the playing field is to expose alleged researchers who are merely well-funded “front groups.” The American Chemistry Council is not that but an anti-regulatory group spending more than \$4 million a year in lobbying and scientific writing. The American Crop Protection Association is a group of pesticide manufacturers funding writing and lobbying to block EPA’s regulation of pesticides. The Global Climate Coalition, like the Advancement of Sound Science Coalition, is a front group funded by the oil, automobile, chemical, and tobacco industry to oppose signing the Kyoto Accords (Beder, 2002, 237). The National Endangered Species Act Reform Coalition is funded by the utility industry to lobby against the Endangered Species Act. Responsible Industry for a Sound Environment is a pesticide-industry-funded group writing to discredit right-to-know provisions in pesticide regulations (Beder, 2002). The Forest Protection Society is funded by the logging industry to promote rainforest logging (Beder, 2002, 31). The Keep America Beautiful group is funded by the bottling and plastics industry to oppose bottle-deposit legislation (Beder, 2002, 30). The National Wetlands Coalition, funded by the oil and gas industry, has a logo that shows a duck flying over a wetland, but it lobbies and writes in favor of wetlands oil and gas drilling (Beder, 2002, 30). The American Council on Science and Health, funded by the chemical, oil, and pharmaceutical industries, commissions articles arguing for the nutritional value of fast food, the safety of growth hormones for cattle, and the safety of saccharin and pesticides (Beder, 2002, 28).

We all know that Dick Cheney met repeatedly with energy-industry officials to formulate the administration’s energy policy, but many don’t realize that he is still being paid deferred compensation by Halliburton. Or that Steve Griles, coal, gas, and oil industry lobbyist, as current Deputy Secretary of the Interior, continues to be paid nearly \$300,000 a year by his former lobbying firm, even though he is now supposedly working for everyone. Griles wrote the proposal allowing the coal industry to dump mining waste in streams instead of cleaning it up (Hertsgaard, 2003, 15–16). Gale Norton, cofounder of an anti-regulatory chem-

ical and mining industry lobby group, is now US Secretary of the Interior; Dick Cheney, Chair of Halliburton, an oil-services company, is now US Vice-President; James Connaughton, lobbyist for mining and chemicals industries, is now Chair of the White House Council on Environmental Quality; Don Evans, CEO of an oil and gas company, is now US Secretary of Commerce; Andrew Card, auto industry lobbyist, is now White House Chief of Staff; Ann Veneman, member of the board of directors for biotech company Calgene, is now US Secretary of Agriculture (Slater, 2002, 39). Monsanto lobbyist, Linda Fisher, is deputy director of the US EPA. Timber-industry lobbyist, Mark Rey, is US Undersecretary of Agriculture. Coal-industry lobbyist, Tom Sansonetti, is US Assistant Attorney General for Environment and Resources. Timber-industry and mining-industry lawyer, Rebecca Watson, is US Assistant Secretary of the Interior. Auto-industry lobbyist, Camden Toohey, is Special Assistant for Alaska, US Department of the Interior. GE VP, Francis Blake, is US Deputy Secretary of Energy. Energy-industry lobbyist, Deborah Daniels, is US Assistant Attorney General. Chemical-industry lawyer, Jeffrey Holmstead, is US EPA Assistant Administrator (Slater, 2002, 41).

All these appointments—and Bush’s “Clear Skies” air-pollution plan that allows three times more mercury emissions and 50 percent more sulfur dioxide emissions than current law allows (Slater, 2002, 42)—help show the need for scientific citizenship. These conflicts of interest may be explicable, once one understands that the oil, mining, timber, chemical, and electric utility industries together gave US President Bush \$44 million in his 2000 Presidential campaign (Hertsgaard, 2003, 15–16). And the appointments may explain why Bush reassigned 40 percent of the EPA staff that enforces criminal violations of environmental law to non-environmental work. Or why he annually refers 80 percent fewer criminal violations under the Toxic Substances Control Act than Clinton did. Or why EPA administrator Christie Whitman halved the number of Superfund sites scheduled for cleanup, then shifted the worst costs of cleanup from the industries responsible to the taxpayers (Slater, 2002, 43). If only one relatively small oil company, Occidental, spends \$2 million a year on lobbying, with 81 percent targeted for the GOP (Ota, 2002), then what

must the total amount be for all oil companies, indeed, all companies?

Ideological and ignorant environmentalists, of course, also get their science wrong, and Ernest Sternglass' misuse of statistics, in arguing against nuclear power, is a case in point. But they typically do not have the millions of dollars to get their flawed messages across. That is why the bias of corporate groups tends, by comparison, to be more massive. Would you like to head the panther recovery project for about \$22,000 a year, and have Jeb Bush overseeing your rejecting developers' permits? When BLM Montana director Martha Hahn reduced cattle grazing on some ecologically fragile federal land, and when BLM Desert Director Tim Salt protected endangered species on BLM desert lands in California, the Bush administration reassigned and demoted both. When manager of Utah's Escalante National Monument, Kate Cannon, cut back on cattle grazing to protect the habitat, she was demoted and reassigned to a deputy post at Grand Canyon. When head of the Forest Service's Pacific Southwest Region, Brad Powell, approved a plan to limit logging, grazing, of off-road vehicle use in the Sierra Nevada National Forest, he was demoted and reassigned to Missoula, Montana. When EPA ombudsman Robert Martin tried to enforce the Superfund Law, he was reassigned and demoted, and is now suing (Slater 2002, 40). When Dr. Robert Watson, an atmospheric scientist who chaired a prestigious international panel assessing climate change, pushed to limit emissions, the White House had him replaced, as leader, with an economist (Slater 2002, 42). Not to recognize the way political science can control science, and philosophy of science, is naive.

Most scientists know enough to warn their students about alleged scientific information published by those who do not believe in evolution. Yet they are less wary of other material, such as *Ecoscand* (1994), published by St Martin's Press, whose author was paid by the corporate-funded Competitive Enterprise Institute to write it. The corporate-funded Cato Institute, for example, explicitly pays scientists to discredit university-funded scientific research that challenges the safety of food additives, environmental carcinogens, pesticides, paints, and solvents (Moore, 2002, 58). Moreover, of the four most-cited think tanks, which include Cato, Heritage, and American Enterprise Institute, students need to know that

none is typically identified as industry-supported, when their "hire education" articles appear in newspapers and magazines (Moore, 2002, 58). If we would not teach science without a lab or field work, and if we would not teach philosophy of science without case studies, then we ought teach neither without also teaching students to protect and encourage what is necessary to have science in a democracy. Expecting to do good science and philosophy-of-science education, but ignoring how to do science in a democracy, is like expecting to run good experiments, but not feeding the lab animals.

One way to teach and do research as scientific citizens is to do more than merely autopsies on dead scientific theories. Philosophers of science and scientists also can do vivisection on existing theories. They can send federal agencies comments on one of the 2500 draft impact assessments (EIAs) completed each year, under NEPA. They can write science-related op ed pieces for local newspapers. They can review science-related books for the popular media. Along with helping students read critically and use only the best refereed journals, scientists and philosophers who are scientific citizens might:

Make one assignment requiring assessment of some science-related legislation before Congress and have students write congresspeople about it.

Teach a project-based EIA course where each student critiques a chosen EIA.

Begin class with five minutes of exposing scientific "hire education," such as biased think tanks.

Have students turn in synopses of New York Times science articles for each class.

Give students extra credit for reading and reporting on nonfiction by scientists like Paul Ehrlich, Richard Feynman, or Devra Davis.

Give students extra-credit for work with nongovernmental organizations (NGOs), such as the National Wildlife Association.

Use Katherine Isaacs' 1992 *Civics for Democracy*, to show students how to use their scientific and philosophical education in daily life.

Conclusion

If we cannot count on politicians, legislators, corporations, NGOs, and courts to achieve balance and objectivity in doing, re-

porting, and using science, then those who know science, and philosophy of science, must do so. Such scientific citizenship is difficult only because so few people take it on. Ralph Nader (“Foreword,” in Isaacs, 1992, vi) defined a real democracy as “a society where less and less courage and risk are needed of more and more people to spread justice.” An historian noted that only about seventeen percent of the colonial population supported the US revolution against the British; members of the merchant and industry class did not support it, because they feared a disruption of their profits

(Gromyko and Hellman, 1988). Yet the revolution succeeded mainly because that seventeen percent were committed. Thomas Jefferson did not say it was too difficult when he contributed all his farm wagons to the war effort, for hauling soldiers and supplies. Revolutionary soldiers did not say it was too difficult when they received no pay, had no uniforms, and sometimes had no shoes. In a democracy, we the people are the only ones who can do the work of democracy.

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