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Ethical Problems in Radiation Protection

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TITLE/ TITEL: Ethical Problems in Radiation Protection.

SUMMARY: In this report the authors survey existing international radiation-protection recommendations and standards of the ICRP, the IAEA, and the ILO. After outlining previous work on the ethics of radiation protection, professional ethics, and the ethics of human radiation experiments, the authors review ethical thinking on seven key issues related to radiation protection and ethics. They formulate each of these seven issues in terms of alternative ethical stances: (1) equity versus efficiency, (2) health versus economics, (3) individual rights versus societal benefits, (4) due process versus necessary sacrifice, (5) uniform versus double standards, (6) stakeholder consent versus management decisions, and (7) environmental stewardship versus anthropocentric standards.

SAMMANFATTNING: Författarna ger en översikt av ICRP: s, IAEA: s och ILO:s rekommendationer för strålskydd. En översikt ges av tidigare arbeten inom området strålskyddsetik, professionell etik och etiska frågor vid experiment med strålning på människor. Sju viktiga frågor av etisk natur tas upp: (1) jämställdhet versus effektivitet, (2) hälsa versus ekonomi, (3) individens rättigheter versus samhällets fördelar, (4) en rättvis process versus lidande, (5) uniforma versus dubbla standarder, (6) arbetarens medgivande kontra ledningens beslut, (7) antropocentriska versus miljöcentrerade standarder.

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ABSTRACT 2
INTRODUCTION 3
INTERNATIONAL RADIATION PROTECTION STANDARDS 3
1. ICRP publication no. 60 3
2. IAEA fundamentals for radiation 4
3. IAEA fundamentals for radioactive waste 5
4. IAEA fundamentals for the safety of nuclear installations 6
5. ILO Convention 1151 7
6. European Union – protection of workers and public 7
7. European Union – protection of individuals in medicine 8
PREVIOUS WORK ON ETHICAL ASPECTS OF RADIATION PROTECTION 8
PROFESSIONAL CODES OF ETHICS 9
ETHICS AND HUMAN RADIATION EXPERIMENTS 11
KEY ETHICAL ISSUES 11
1. Equity versus efficiency: the justification principle 11
2. Health versus economics: the optimization principle 15
3. Individual rights versus societal benefits: the dose-limitation principle 17
4. Due process versus necessary sacrifice: liability principles 19
5. Uniform versus double standards: public and worker risks 21
6. Stakeholder consent versus management decisions: controlling 23
exposures 23
7. Environmental stewardship versus anthropocentric standards 26
CONCLUSIONS 28
REFERENCES 29

Ethical Problems in Radiation Protection

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ABSTRACT

In this report the authors survey existing international radiation-protection recommendations and standards of the ICRP, the IAEA, European Union and the ILO. After briefly outlining previous work on the ethics of radiation protection, professional ethics, and the ethics of human radiation experiments, the authors review ethical thinking on seven key issues related to radiation protection and ethics. They formulate each of these seven issues in terms of alternative ethical stances: (1) equity versus efficiency, (2) health versus economics, (3) individual rights versus societal benefits, (4) due process versus necessary sacrifice, (5) uniform versus double standards, (6) stakeholder consent versus management decisions, and (7) environmental stewardship versus anthropocentric standards.

As the discussion of these seven issues reveals, ethical issues in radiation protection are neither simple nor one-sided. They require detailed factual and normative analyses. Nevertheless, the insights of ethical theories also provide a number of ways in which current recommendations and standards for radiation protection could improve. They could be more equitable, more protective of human health and human rights, including due process and consent, more cautious in recommending worker exposure standards that are more lenient than public standards, and more protective of environmental welfare.

INTRODUCTION

The United Nations and its daughter organizations such as the International Atomic Energy Agency (IAEA) have devoted many efforts to protecting humans and the environment from ionizing radiation. The Universal Declaration of Human Rights, adopted in 1948 (UN 1988), stated in article 3: "Everyone has the right to life, liberty and the security of person."

In establishing ethical principles for radiation protection, the International Radiological Protection Commission (ICRP) has been prominent ever since the commission began in 1928 (ICRP 60 1991). In part because of the Chernobyl reactor accident and because of national and international efforts to deal with radioactive waste, the ethical issues in radiation protection are receiving increased national and international interest. The ICRP and IAEA have published several international radiation-protection recommendations since 1990, and the authors think a review is timely to summarize the present ethical thinking in the radiation field.

INTERNATIONAL RADIATION PROTECTION STANDARDS

1. ICRP PUBLICATION NO. 60

The recommendations of ICRP today have a profound influence on radiation protection all over the world. The latest recommendations were issued as publication no. 60 (ICRP 60 1991). This document elaborated a conceptual framework for radiation protection based on ethics, experimental work, and risk assessment. An important presumption of the ICRP conceptual framework is that even small doses of radiation may produce some deleterious effects. The three main principles of the ICRP for proposed or continuing radiation-protection practices are:

a) the justification principle

b) the optimization principle

c) the dose-limitation principle.

The justification principle prohibits practices involving additional radiation exposures unless they produce sufficient societal benefits. The optimization principle requires managers to keep radiation exposures as low as reasonably achievable (ALARA), taking into account economic and social factors. The dose-limitation principle limits exposure of individuals to radiation. Because medical exposures are intended to be as low as possible and to provide a direct benefit to the patient, ICRP recommends in publication 60 that no one apply dose limits to medical exposures. As part of the process of justifying radiation exposures, the ICRP also implicitly uses the "substitution principle." For example, in medical diagnoses of offspring of pregnant women, the ICRP recommends use of ultrasound rather than X-rays.

The system of radiological protection that ICRP recommends for intervention is based on two additional principles:

d) The proposed intervention should do more good than harm,

e) One should optimize the form, scale, and duration of intervention.

Although the ICRP does not employ the term "precautionary principle," it does use the concept, at least implicitly (Persson 1997). In fact, the whole philosophy of protection against stochastic effects is based not on proved harm from radiation, because hereditary damage from radiation has never been demonstrated conclusively, either in humans or at low doses. Rather, the ICRP and other agencies believe that adopting the linear, no-threshold hypothesis is reasonable, if one wishes to take ethical precautions in a situation of uncertainty. This hypothesis is, however, now being challenged by the Health Physics Society. The society states that quantitative risk assessment below individual doses of 50mSv (5 rem) per year or 100 mSv (10 rem) lifetime should be avoided because of insufficient epidemiological data about health risks at such low exposure levels (Mossman 1996).

2. IAEA FUNDAMENTALS FOR RADIATION

On 15 June 1995, the Board of Governors of the IAEA adopted safety fundamentals relating to radiation protection and the safety of radiation sources (IAEA 1996b). These fundamentals are mainly ethical, and they are partly based on the protection principles given in ICRP publication 60 (ICRP 60 1991). According to (IAEA 1996b) the primary aim of radiation protection is to provide appropriate standards of protection and safety for humans without either unduly limiting the benefits of practices giving rise to radiation exposure or incurring disproportionate costs in the case of intervention. This aim is expressed by two specific protection and safety objectives:

Protection Objective: to prevent the occurrence of deterministic effects in individuals by keeping the doses below the relevant threshold and to ensure that all reasonable steps are taken to reduce the occurrence of stochastic effects in the population at present and in the future.

Safety Objective: to protect individuals, society and the environment from harm by establishing and maintaining effective defences against radiological hazards from sources.

These objectives are achieved by the application of the following eleven principles:

1. A practice shall be justified on the grounds that it produces sufficient benefit to the exposed individual(s) and to society to offset the radiation detriment it may cause.

2. For justified practices, other than those involving medical exposures, restrictions on the dose that individuals may incur (dose limits) are required in order to ensure that no person be subject to an unacceptable risk attributable to radiation.

3. For any source, except for therapeutic medical exposure, the doses, the number of people exposed, and the likelihood of incurring exposures should all be kept as low as reasonably achievable.

4. All reasonably practicable measures shall be taken to enhance operational safety and to prevent radiation accidents and mitigate their consequences, should they occur.

5. Any proposed intervention shall do more good than harm.

6. The form, scale, and duration of any intervention shall be optimized so that the net benefit is maximized.

7. Sources shall be located, taking into account those factors, which affect exposure, or potential exposure, of individuals and populations.

8. The design and construction of nuclear facilities shall ensure that a source is suited for reliable, stable and easily manageable operation that ensures protection and safety. For this purpose, consideration must be given to defence in depth, human factors, system testing, and feedback of operational experience.

9. The operation and use of sources shall be based upon procedures and conditions of operation, which promote safety, and security of the source, optimization of radiation protection, and which reflect the lessons learned from operational experience.

10. The government shall establish a legal framework for regulation of practices and interventions, with clear allocation of responsibilities, including those of a Regulatory Authority.

11. Parties responsible under the legal framework shall, as appropriate, provide for radiation protection and safety, verify its effectiveness, and prepare adequate emergency plans.

3. IAEA FUNDAMENTALS FOR RADIOACTIVE WASTE

Many of the hazards of radioactive waste are similar to those associated with other toxic waste. Because of the possibility of exposure to ionizing radiation, people and the environment need an acceptable level of protection against radioactive waste. People should pay particular attention to controlling the various ways by which humans might be exposed to radiation and to ensuring that such exposure is within established national requirements. (The principles of radioactive waste management have a bearing on protection against radiation and are therefore included in this article.)

In March 1995, the Board of Governors of the International Atomic Energy Agency adopted safety fundamentals relating to radioactive waste management (IAEA 1995b). These fundamentals are ethical in nature and based on the protection principles given in ICRP publication no. 60 (ICRP 60 1991). According to IAEA the objective of radioactive waste management is to deal with the waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations. The following nine principles were adopted by the IAEA:

1) Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health.

2) Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment.

3) Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.

4) Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.

5) Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.

6) Radioactive waste shall be managed within an appropriate national framework, including clear allocation of responsibilities and provision for independent regulatory functions.

7) Generation of radioactive waste shall be kept to the minimum practicable.

8) Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.

9) The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.

4. IAEA FUNDAMENTALS FOR THE SAFETY OF NUCLEAR INSTALLATIONS

The principles of the IAEA fundamentals apply to the measures necessary to minimize the risks to nuclear site personnel, the public, and the environment from the effects of ionizing radiation. The following are IAEA safety objectives (IAEA 1993):

1) General nuclear safety objective: To protect individuals, society and the environment from harm by establishing and maintaining in nuclear installations effective defences against radiological hazards.

2) Radiation-protection objective: To ensure that in all operational states radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable, and to ensure mitigation of the radiological consequences of any accidents.

3) Technical-safety objective: To take all reasonably practicable measures to prevent accidents in nuclear installations and to mitigate their consequences should they occur; to ensure with a high level of confidence that, for all possible accidents taken into account in the design of the installation, including those of very low probability, any radiological consequences would be minor and below prescribed limits; and to ensure that the likelihood of accidents with serious radiological consequences is extremely low.

To achieve these objectives, says the IAEA, measures need to be taken to control radiation exposure in all operational states to levels as low as reasonably achievable and to minimize the likelihood of an accident that might lead to the normal control of the source of radiation. Nevertheless, accidents can happen. Measures are therefore required to ensure that any radiological consequences are mitigated. Such measures include on-site accident management procedures and off-site intervention measures in order to mitigate radiation exposure after an accident has occurred. The greater the potential hazard from an uncontrolled release of radioactive material, the lower the likelihood must be of its occurrence.

5. ILO CONVENTION 1151

ILO Convention no. 115, concerning the protection of workers against ionizing radiation (ILO 1966), also contains some ethical principles. This convention came into force 17 June 1962. Article 5 of the Convention states the main protective objective: "Every effort shall be made to restrict the exposure of workers to ionizing to the lowest practicable level, and any unnecessary exposure shall be avoided by all parties concerned."

6. EUROPEAN UNION – PROTECTION OF WORKERS AND PUBLIC

The European Union (EU) Standards, for the protection of workers and the general public against ionizing radiation (EU 1996), are partly even stricter than the ICRP Recommendations. Article 10 of the EU Standards states, for example: “As soon as a woman informs the undertaking, in accordance with national legislation and/or national practice, the protection of the child to be born shall be comparable with that provided for members of public. The conditions for the pregnant woman in the context of her employment shall therefore be such that the equivalent dose to the child to be born will be as low as reasonably achievable and that it will be unlikely that the dose will exceed 1 mSv during at least the remainder of the pregnancy. As soon as a nursing woman informs the undertaking of her condition she shall not be employed in work involving a significant risk of bodily radioactive contamination."

7. EUROPEAN UNION – PROTECTION OF INDIVIDUALS IN MEDICINE

This Directive (EU 1997) supplements the Standards mentioned in section 6. The Directive shall apply to the following medical exposure:

(a) the exposure of patients as part of their own medical diagnosis or treatment;
(b) the exposure of individuals as part of occupational health surveillance;
(c) the exposure of individuals as part of health screening programmes;
(d) the exposure of healthy individuals or patients voluntarily participating in medical or biomedical, diagnostic or therapeutic, research programmes;
(e) the exposure of individuals as part of medico-legal procedures.

This Directive shall also apply to exposure of individuals helping other persons undergoing medical exposure.

PREVIOUS WORK ON ETHICAL ASPECTS OF RADIATION PROTECTION

The Swedish KASAM Committee (the Swedish National Council for Nuclear Waste) has discussed the ethical aspects of nuclear waste as reported by Persson (1990). They arranged in 1997 a seminar called "Ethical Action in Face of Incertainty".

Since the latest ICRP recommendations in publication 60 (ICRP 60 1991), Silini (1992), Wallace (1993), Maushart (1994), Prêtre (1994), and Shrader-Frechette (1994b) have assessed some of the ethical issues related to radiation protection. Silini (1992) asks whether the present system of radiation protection is founded on sound ethical principles. His answer is "yes," but he proposes clarifications in the meaning of the justification principle; inclusion of environmental, as well as human, protection in the standards; and worker protection equal to that of the public.

Wallace (1993) concludes that the policy-formulation process for the use of ionizing radiation in Australia is neither unethical nor completely satisfactory. He proposes ways to strengthen ICRP recommendations and provide for more public control of radiation protection. Maushart (1994) emphasizes the importance of global acceptance and use of the present radiation-protection principles. He points out the lack of uniform standards across the planet.

Prêtre (1994) connects the three ICRP protection principles with four key ethical concepts: responsibility, respect for life, justice, and common good. He shows that, in general, the ICRP principles of radiation protection reflect all four concepts. Shrader-Frechette (1994b) argues against extremist positions in radiation protection, and she criticizes both environmentalists who unrealistically favour zero risk, as well as industrialists who are too lax about radiation risk. She argues for ethical improvements in dealing with radiation risks that are uncertain, inequitably distributed, imposed involuntarily, or not compensable in full.

Ethical issues in radiation protection have also been dealt with in notes by Persson (1996a) and Shrader-Frechette and Persson (1997).

An international workshop on ethical issues in radiation protection was held in Stockholm in 1999 and published as an SSI-Report 2000:08 (SSI 2000). The workshop concluded that ethical theories are relevant to the current recommendations and standards for radiation protection. Radiation protection is not only a matter for science. It is also a problem of philosophy. In order for protection regulations to be respected, it must correspond to widely accepted ethical values among those who are affected by the regulations. The workshop covered the following issues: Problems in present protection policy, ICRP protection policy - A historical perspective, radiation risk - What we know and what we believe, Present ICRP recommendations, Ethical values in the context of ICRP recommendations, Collective responsibility for invisible harm, Environmental protection - Ethical issues, The global change of values, and Procedural justice and radiation protection.

Radiation protection and the ethics of worker exposures were dealt with by Persson and Shrader-Frechette (2001). After reviewing international recommendations and national standards for occupational radiation exposures, the article summarizes the major ethical theories so as to analyze which theories various ICRP principles presuppose. It also shows how proponents of each ethical theory would support or criticize various radiation principles and practices. Finally the article discusses four ethical issues crucial to the debate over workplace standards for radiation: (1) how to respond to the uncertainty over effects of low-dose exposures; (2) the conditions under which worker consent legitimates higher exposures; (3) whether there ought to be a double standard for worker, versus public, exposures; and (4) whether ethics allows money-for-health tradeoffs in radiation protection. The article concludes with several recommendations about how to make occupational exposure to radiation more ethically defensible.

PROFESSIONAL CODES OF ETHICS

The American Health Physics Society (HPS) has issued a code of ethics (Health Physics Society 1994). Its principles are intended as guidelines by which members may determine the propriety of their conduct in relationships with employers, co-workers, clients, governmental agencies, other professionals, and the public. Eight of the nine HPS principles concern factors that could affect radiation protection:

* Members shall strive to improve their professional knowledge and skill.

* Each member shall be a judge of his/her competence and will not undertake any assignment beyond his/her abilities.

* Members shall never compromise public welfare and safety in favor of an employer's interest.

* No employment or consultation shall be undertaken which is contrary to law or the public welfare.

* Members will gladly accept every opportunity to increase public understanding of radiation protection and the objectives of the society.

* Professional statements made by members shall have sound scientific basis. Sensational and unwarranted statements of others concerning radiation and radiation protection shall be corrected, when practical.

* Members shall protect the sources of confidential communications, provided that such protection is not in itself unethical or illegal.

Recently the Executive Council of IRPA (International Radiation Protection Association) has put forward some principles intended to aid the Associated Societies in maintaining an ethical level of professional conduct (discussed at a Forum at the 10th International Congress of the Internal Radiation Protection Association, Hiroshima, May 14-19, 2000 and published at website of IRPA "www.irpa.net"):

- Societies shall strive to improve the professional knowledge and skill of their members;
- Societies shall encourage members to reflect in their conduct the highest standars of integrity and fairness;
- Societies shall base all statements on valid science;
- Societies are encouraged to accept opportunities to increase public understanding of radiation protection.

The participants of the IRPA-10 Forum agreed on the need to develop a set of principles that could serve as Code of Ethics for IRPA societies with the objective for them to adapt it to specific situations and to set up the necessary requirements for their members. Practically it was decided to review all relevant existing codes and to establish a mechanism by which a Code a Ethic could reasonably be adopted by Societies at the next IRPA 11 Congress in Madrid in 2004.

ETHICS AND HUMAN RADIATION EXPERIMENTS

Reports on human radiation experiments have highlighted the ethical issues in this field of research. The IAEA (1996a) has argued that the exposure of humans for medical research is not justified unless it is:

a) in accordance with the provisions of the Helsinki Declaration and follows the guidelines for its application prepared by the Council for International Organizations of Medical Sciences and the World Health Organization, and

b) subject to advice of an Ethical Review Committee (or any other institutional body assigned similar functions by national authorities) and to applicable national and local regulations.

In a guest editorial in Health Physics, Mossman (1995) has reviewed US radiation experiments, especially during the Cold War. He raises a number of questions: Is it appropriate to scrutinize past scientific investigations in the light of current standards, when such studies were conducted in a different political climate? Is the process of informed consent adequate in addressing the needs of the subject? Are current federal regulations and policies adequate to protect human subjects in research settings?

Mossman recommends that strategies to protect informed consent (in the face of ethnic, cultural, and language barriers) be incorporated into the regulatory framework. He also says that risk comparisons may be of value in putting the radiation risk into perspective, and he recommends establishing a federal commission to address national radiation-protection issues.

The European Union has in its Directive on health protection of individuals in relation to medical exposures (EU 1997) included rules for the exposure of healthy individuals or patients voluntarily participating in medical or biomedical, diagnostic or therapeutic, research programmes.

KEY ETHICAL ISSUES

Among the many ethical issues concerning radiation protection, seven are crucial. The remainder of the article discusses them in order.

1. EQUITY VERSUS EFFICIENCY: THE JUSTIFICATION PRINCIPLE

The justification principle, a cornerstone of ICRP and IAEA ethical philosophy, expresses an important ethical principle: that one must always justify any additional radiation exposures in terms of the benefits the exposures bring. In other words, only good reasons justify additional exposures. The justification principle also allows one to exchange societal benefits for individual radiation exposures. As such, it sanctions a utilitarian ethics, an ethics whose fundamental ethical principle is to maximize benefits to the majority of people. Because the justification principle allows benefits to society to offset radiation detriments to individuals, it is somewhat controversial. Proponents of egalitarian ethical theories (whose fundamental ethical principle is equal treatment or equal protection of all people) would argue that utilitarian benefits to a group could almost never, if ever, offset detriments to individuals because they are fundamentally unfair. They would say that, unless the exposure gainers somehow compensate the losers, the radiation exposure is unethical because it is discriminatory.

Egalitarian ethical theorists believe that utilitarian value judgments are open to criticism because they can sanction using members of some geographical or temporal minority so as to benefit the majority, and because they can condone using persons as means to the ends of other persons (Silini 1992, pp. 11ff.; Shrader-Frechette 1991, pp. 117ff.). In its Safety Fundamentals, for example, the IAEA explicitly proposes egalitarian ethical standards and sanctions treating future generations equally with present ones. It proposes radiation protection standards for future people that would be acceptable if they were imposed on present people (IAEA 1996b, pp. 4, 8). However it is not clear that the ICRP recommendations and the IAEA standards would actually result in spatial and temporal equity, in treating all people equally, because the justification principle sanctions a utilitarian tradeoff for exposures. Also it is not clear that, in practice, it is possible to follow purely egalitarian standards. In the case of permanent geological disposal of high-level radioactive waste (see, for example, The Radiation Protection and Nuclear Safety Authorities 1993, pp. 14, 21-28; NRC 1995), for instance, complete and perpetual containment is not likely because the waste canisters will remain intact only for several hundred years. As a result, permanent disposal will place the greatest health and safety risks on members of future generations, both because of radiological toxicity and chemotoxicity (Hedelius and Persson 1992; Buchheim and Persson 1992). Thus permanent disposal implicitly may sanction a risk distribution that violates temporal equity. If these temporal inequities occur, then permanent disposal of nuclear waste inadvertently may sanction using future people as means to the ends of those in the present, even though policymakers wish to keep future radiation risks below those that are acceptable in the present time (see, for example, RPNSA 1993, p. 24).

Most ethical or moral philosophers -- and especially egalitarian theorists -- have argued that it is ethically unacceptable to use other people as means to some end. All people ought to be treated as ends, not merely as means to satisfy the desires of others, not merely as objects. Introducing a new practice at the cost of unreasonably high individual risks to individuals who derive no benefit is also in conflict with the demand of Kant (1994, pp. 95-98) that we should not use other persons as means to reach our goals.

There are also good grounds for believing that all people ought to receive equal treatment with respect to societal risk, equal consideration of their interests. Some of these reasons are that the comparison class, present and future people, is all humans, and all humans have the same capacity for a happy life. Another reason for egalitarian distributions of radiation risks is that free, informed, rational people would likely agree to prima facie principles of equal rights or equal protection. (Prima facie principles are those that hold, in the absence of compelling arguments to the contrary. Although they are not absolute, they express a strong presumption in their favor.) Moreover, prima facie principles of equal treatment provide the basic justifications for other important concepts of ethics and are presuppositions of all schemes involving consistency, justice, fairness, rights, and autonomy. Finally, the idea of law presupposes equality of rights; "law itself embodies an ideal of equal treatment for persons similarly situated" (Blackstone 1969, p. 121; Rawls 1971; see Beardsley 1964, pp. 35-36; see also Berlin 1964, p. 33; Frankena 1975, pp. 250-251; Marcovic 1978, p. 93; Vlastos 1962, pp. 50, 56; Pennock 1974, pp. 2, 6).

Egalitarians would argue that, if all people in all regions and generations have equal, prima facie rights to life and therefore to bodily security, as the most basic of human rights, then allowing one group of people to be put at greater risk -- without adequate compensation and for no overriding, morally relevant reason -- amounts to violating their rights to life and to bodily security. Indeed, if there were no obligations to equalize the burden of risk imposed on one generation or one segment of society for the benefit of another generation or segment of society, then no one would have any authentic bodily security. There could be no authentic legal rights. Using a utilitarian justification, one group or one generation could simply do whatever it wished to any victimized minority or generation. This is why justice, at its most fundamental level, is fairness (see Rawls 1971, pp. 3-53; see Jonas 1984). Of course, treating everyone exactly the same is impossible; that is why ethics does not require one to provide precisely the <u>same</u> treatment to all people. Rather, even egalitarians believe that one may treat people differently, as a result of a number of factors, for example: as a reward for merit, as compensation, as an incentive, or as a provision for special needs. In other words, although egalitarians believe there is no ethical requirement always to treat everyone the same, one needs to have *relevant moral grounds* for treating people differently (Shrader-Frechette 1984, pp. 221-222; see Frankena 1962, pp. 10, 14; see Taylor 1969, pp. 94-97; Rawls 1971, p. 586; and Sen 1977, vol. 2, p. 288).

Utilitarian proponents of permanent geological disposal of nuclear waste, however, might argue that there are relevant moral grounds for treating present and future people differently. They might claim that utility, efficiency, or the greater good requires building permanent geological repositories. Egalitarians probably would respond that, because society accepts prima facie principles of political equality, the burden of proof is on the person who wishes to discriminate, who wishes to provide unequal treatment to different communities, people, or generations. Indeed, the US National Academy of Sciences (NAS) affirmed an even stronger position regarding duties to future generations: "Moral intuition tells us that our descendants deserve a world that we have tried to make better" (Parker 1990, p. 16; see Shrader-Frechette 1984, pp. 220-221, 222ff.; see also Cox and Ricci 1989, pp. 1026-1027; see also Frankena 1975, pp. 252-257).

From this brief discussion of egalitarian versus utilitarian ethical theories, it is clear that many of those in the latter group would support the justification principle. However many egalitarians, those in the former camp, would argue that the justification principle of the ICRP and the IAEA does not adequately protect individuals and their rights to equal treatment. The justification principle might prescribe reaching the happiness of some people through the misery of others, as Silini (1992) puts it. Moreover, egalitarian ethical theorists might argue that, so long as ICRP standards require one to keep differences in radiation dose levels "reasonable," rather than lowered, and so long as they require one to give no compensation to victims of very high doses, they do not promote equity. If effects of radiation are cumulative, it would seem that repeatedly lowering acceptable exposures would be the only way not to impose greater radiation risks on future people. Indeed radiation standards have become stricter, over time. Also, because there is great "variability in the appearance of stochastic damage among members of a population," and because "susceptibility to cancer is not uniform" (Silini 1992, pp. 144-145), there are certain to be inequitable distributions of radiation risk. Indeed most risk, cost, and benefit calculations are, to some degree, arbitrary, insofar as they depend on the chosen population and distribution (Baram 1981; Ashford 1981). Economic pressures also are likely to control the way one defines an inequity as reasonable or not. Because the justification principle sanctions a tradeoff between equity and efficiency (with only the dose limits as a constraint), it may not provide adequately for equity. As one author puts it, "if there is no control then there is nothing to guarantee that individual exposure levels are 'fair'.... the concept [of equity] remains vague" (Lochard and Grenery-Boehler 1993, p. 15).

Many utilitarians, of course, would likely agree with the justification principle on the grounds that it promotes efficiency and the common good, and that absolute equality of protection is unattainable (see Maxey 1988, pp. 4-5). The US Advisory Committee on Human Radiation Experiments (1994; Faden 1995), for example, used a cost-benefit balancing and argued against notifying radiation-experiment victims whose experiment-induced risk was lower than 1 in 1000 for their lifetimes (see Gordon 1996, p. 35). Utilitarian ethical theorists argue that such notification and compensation for very small risks could be costly to society. Utilitarians also would argue that, if one is unwilling to trade some equal protection (against radiation risks) for societal utility, then one is an uncompromising, unrealistic ideologue (Gross and Levitt 1994, p. 160).

As already suggested, one possible alternative to ever-stricter radiation standards might be to devise some scheme to compensate victims of unavoidable and inequitable radiation-risk impositions. Such a scheme might compensate future people for the increasing threats to them and to the gene pool. A later section of this article will discuss compensation, liability, and due-process rights. At present, however, it is important to note that a possible way of resolving the ethical controversy between egalitarians and utilitarians, between proponents of equity versus efficiency with respect to radiation standards (between dose-limits and justification principles), might be to use procedures of compensation and consent to "make up" for any inequity in radiation protection.

Whether one argues for increasing the strictness of radiation standards -- as egalitarians would do -- or for compensating victims of radiation -- as utilitarians would do -- egalitarians would argue that future genetic damage cannot be justified merely on grounds of expediency (see Snihs 1994). A similar debate between egalitarians and utilitarians arises in connection with the optimization principle.

2. HEALTH VERSUS ECONOMICS: THE OPTIMIZATION PRINCIPLE

The optimization principle requires one to optimize radiation protection, to keep exposures as low as reasonable achievable (ALARA), taking into account social and economic factors. As prominent nuclear authors put it: "The principle of optimization acts to correct unreasonable protection costs and ensures that efforts to achieve a 'rational' reduction of exposures are 'profitable'" (Lochard and Grenery-Boehler 1993, p. 21). Thus the optimization principle is not really best described as one that optimizes protection, because it takes economics into account (see Silini 1992; Persson 1995a, 1995b). One satisfies "optimization" when exposures are "as low as reasonably achievable, economic and social factors being taken into account." This formulation seems more like a tradeoff between protection and economics rather than an optimization of protection. Also because the principle is so vague -- in allowing merely that economic and social factors be "taken into account," but not specifying the degree to which they should be taken into account -- quite contradictory radiation standards could be based on it (see Silini 1992; Prêtre 1994). As French experts note, the vagueness in the optimization principle is one reason that most countries prefer to base their measures of radiation control on compliance with dose limits rather than on some sort of optimization of protection that takes social and economic factors into account (see Lochard and Grenery-Boehler 1993, p. 16).

Just as egalitarians and utilitarians are likely to disagree over whether to trade equity for efficiency in radiation-protection standards, so also they are likely to disagree over the degree to which one ought to exchange health or safety for economic gain in determining radiation protection. On the one hand, those who argue for the tradeoffs and for the primacy of economic considerations in determining radiation exposures maintain that the greater good depends on economic profitability overall (Ray 1993, pp. 91, 187; Jaeschke 1981; Crandall 1981; Lochard and Grenery-Boehler 1993, p. 21; see Hiam 1991). They are correct that some benefits can compensate for small risks associated with the non-medical or industrial uses of radiation. They also are correct that some strict pollution controls and environmental regulations often can cause greater overall harm than more lenient controls and regulations (see Keeney 1990).

Utilitarians and neoclassical economists point out that the social costs of more stringent risk standards include reduced productivity and profit, and therefore reduced funds available for new jobs, for expansion of markets and services, and for provision of other health, education, and welfare benefits (Ray 1993, pp. 162ff.). For example, the costs of notifying and compensating all victims of US radiation experiments -- especially those subject only to a very small risk -- could be quite high (see Advisory Committee 1994; Faden 1995). Likewise, the costs of completely securing the disabled Chernobyl reactor could be quite high. At present, the distribution of fuel-containing masses is subcritical at the reactor, but the Nuclear Energy Agency (NEA/OECD 1994a, p. 74) warns, "criticality cannot be ruled out if in the future water or water-containing fluids collect around the fissile materials." The NEA noted that a "criticality-like event occurred in June 1990 in Room 304 and was quenched by the addition of gadolinium-containing solutions." The NEA also notes that, at Chernobyl, water drips into the sarcophagus, and water levels have increased inside the sarcophagus, where high humidity is a threat to the functioning of electrical cables and junctions that power monitoring equipment. Despite such apparent safety threats, decision-making regarding Chernobyl is, in large part, held hostage to economics. Utilitarians would argue that the dominance of economic considerations is unavoidable.

On the other hand, many egalitarians believe that money-for-safety tradeoffs are often unacceptable. As Judith Jarvis Thomson puts it, some harms are so serious that no amount of money could possibly compensate the victims or their survivors (Thomson 1986, p. 158). They are incompensable. Because duty requires people to "square accounts" with those they harm, many egalitarians believe that there can be no money-for-safety tradeoffs in cases involving incompensable losses such as death. This is one reason the Nuremberg Tenets for experimentation require consent of all subjects and victims, not just consent of high-risk subjects and not just consent of those for whom the risk is not societally efficient (see WMA 1964).

Egalitarians and others who argue for the primacy of health in determining radiation exposures argue that people should be accountable to those they put at risk, apart from whether such accountability is profitable. Moreover, they argue that if economic considerations ought to take precedence over health considerations, then the economic accounting ought to be complete and consistent: Risk imposers ought to compensate those they threaten and to consider such compensation a cost of doing business. They ought not merely take into account the benefits of not imposing stricter radiation standards. Egalitarians also argue that risk imposers often fail to "pay their own way." In the US, for example, nuclear waste storage costs (and other government subsidies) run up to $20 billion annually (Kendall 1991), but the tax (for waste disposal) paid by nuclear utilities generates only about $600 million annually (NEA/OECD 1994a, p. 46). Egalitarians say that, once risk imposers pay the full costs (e.g., waste disposal, compensation) of doing business economically, by compensating those who bear higher radiation risks, then it will be easier to optimize both safety and efficiency (see Thomson 1986 and Gewirth 1982). At present, however, provided that the dose limits are met, the ICRP optimization principle allows for uncompensated tradeoffs of health and safety on behalf of economic considerations. The allowance is consistent with Bernard Cohen's (1990, p. 51) claim that "the sensible attitude is not to worry about a little extra radiation." Such an ethical philosophy invites at least two responses: Sensible for whom? Sensible because it saves money for whom at whose expense?

3. INDIVIDUAL RIGHTS VERSUS SOCIETAL BENEFITS: THE DOSE-LIMITATION PRINCIPLE

Just as egalitarians disagree with utilitarians over whether to give priority to equity over efficiency, and over whether to give priority to health over economics, similar battles occur over whether to give priority, in radiation protection, to individual rights or to societal benefits in deciding whether to limit doses or exposures.

Egalitarians tend to be proponents of individual rights to protection against radiation exposure. Alan Gewirth, for example, argues there are basic human rights to things such as equal treatment and bodily security. Because bodily security and equal treatment are necessary to human action, humans have rights to them, and no agent can deny them except on pain of self-contradiction (Thomson 1986; Samuels 1981; Gewirth 1982, pp. 41-78). Other ethical theorists argue for basic human rights on the grounds that they are self evident (see Nozick 1974, p. ix); that they are the product of institutional rules (Hart 1955); that they arise from human interests in certain things (McCloskey 1965); that they are essential to human dignity (Maritain 1944); or that rational, unbiased people would agree to them (Rawls 1971, pp. 54-192). Rights theorists claim that human rights exist, independent of whether or not governments recognize them or enforce them (Yoder 1993, p. 131; UN 1988).

Apart from the reasons that egalitarians defend rights, for most of them, such rights impose a strong presumption against any potential violator. Gewirth argues, for example, that every human being has a basic and absolute human right not to have cancer inflicted on him by the action of other persons as well as a basic human right to informed control over the conditions that are relevant to the possible infliction of cancer (Gewirth 1982, pp. 181-196; see Samuels 1981). He argues that humans have these rights because they are essential to well being and because informed control is essential to the freedom necessary for human action. Manufacturers, employers, and government officials, says Gewirth, all have a duty to recognize this right, especially because, according to the US Office of Technology Assessment (OTA), 80 to 90 percent of cancers are environmentally induced and theoretically preventable (Gewirth 1982, p. 182; US OTA 1981, pp. 3, 6ff.). Trading risk of cancer for economic benefits is not acceptable, says Gewirth, because human life is not a commodity to be bought, sold, or bid on a market (Thomson 1986; Samuels 1981; Gewirth 1982, p. 193).

The obvious question raised by the egalitarian account of rights to equal protection (against additional radiation exposure) is how far such rights extend. Using the concept of rights, some egalitarians conceivably could argue that government or industry ought not be allowed to impose even a minimal risk on people without either their consent or compensation (MacLean 1986). An extreme version of the egalitarian view is that there is no level of de minimis risk that is acceptable, at least not without compensation or consent. The Delaney Clause to the US food-additive amendments, for example, mandates a zero-risk level and prohibits directly adding any amount of carcinogens to food (Abelson 1993). For US hazards not related to food, the de minimis level of societal risk that can be imposed on the public, without any government regulation, is $10^{-6.}$ (The risk imposes on each person an average annual chance of death of one in a million.) The de minimis level for workplace risks is approximately 10^{-3}.

Proponents of uniform de minimis standards -- who tend to follow utilitarian ethical theories -- argue that zero risk is unachievable and unrealistic (see Hurst 1981; Abelson 1993); that economic efficiency requires such standards (Lewis 1990, p. 26; Taylor 1980, p. 866; see Gross and Levitt 1994, pp. 155, 157); that society's resources for radiation protection are not infinite (see Lindell 1980, p. 113); that people accept comparable (or greater) risks than radiation (Lewis 1990, p. 219; see Abelson 1993); and that regulators should ignore small radiation risks because they are less than background levels (Hull 1995).

Egalitarian opponents of uniform standards argue that because the public is more averse to some threats, like cancer, different standards (including zero risk) are necessary for different risks. They also argue that because everyone has rights to protection against any unnecessary danger (Samuels 1981, p. 279; Gewirth 1982; and Thomson 1986), all societal and workplace risks should be kept as low as possible, perhaps below the de minimis level. They say that uniform standards frequently are too lenient in protecting only "average" persons rather than especially sensitive individuals such as children (NRC 1993; Shrader-Frechette 1991, pp. 71-72, 113-114, 122-134). Opponents of de minimis radiation standards also argue that, just because risks to one individual are small, does not mean risks to the entire population are small (Sumner and Gilmour 1994). Bo Lindell, of the Swedish Radiation Protection Institute, made a similar point; when a whole population is exposed to a small risk, it is almost certain that someone will die. These deaths, says Lindell, are not the only costs of allegedly small radiation risks. He notes that one should have a "cautious attitude rather than belligerently crying for de minimis" (Lindell 1989, p. 212).

De minimis and utilitarian positions of the ICRP may be incomplete because nowhere in any of its principles or recommendations -- about occupational or public radiation exposures -- does the ICRP mention human rights. A recent report published by the US National Academy of Sciences (NRC 1996, ch. 2), however, emphasized that there are three fundamental concepts (fairness, prevention of risks, and rights) that are "often missing" from the formulation of risk problems and that lead to disputes about risk. If the National Academy is correct in its emphasis on rights as crucial to risk characterization, then ICRP discussions of radiation risk may need to include rights.

In proposing that radiation-exposure standards be based on the principle of doing more good than harm (ICRP 60 1991, p. 75; see IAEA 1995a, p. 12; 1996b, p. 7), the ICRP principles and IAEA standards pay little attention to the fact that sometimes basic human rights -- rights to equal treatment -- require intervention or particular practices, even if the amount of good accomplished for society is minimal. The ICRP and IAEA rationale for balancing good over harm and for ignoring individual human rights is the law of diminishing returns: Reducing risk exposures becomes more expensive as one approaches zero risk, and the marginal gains from avoided doses become negligible.

In response to the utilitarian charge that small risks are negligible and therefore not violations of human rights, egalitarian ethical theorists might respond, "Negligible for whom?" Certainly not for people who do not benefit from the radiation exposures and who bear increased risks simply because others do not want to spend the money necessary to prevent such exposures or to compensate for them. Calling small radiation exposures negligible may also be questionable because, in lieu of a rights-based distribution of additional radiation exposures, victims might receive some sort of compensation or other benefit. The problem is thus not whether to choose radiation standards that recognize individual rights or that maximize the common good, but whether to choose to compensate those whose rights might be jeopardized.

4. DUE PROCESS VERSUS NECESSARY SACRIFICE: LIABILITY PRINCIPLES

As a recent Nuclear Energy Agency report (NEA/OECD 1994b, p. 7) noted, nuclear experts now recognize the importance of "the social dimension of radiation protection." This social dimension includes public and ethical concerns such as equity, consent, and compensation for radiation risks and exposures. One important issue is the ethical justification for reparation or compensation for radiation risks. Another issue is whether those exposed to radiation deserve full and strict liability for the risks they bear. "Stochastic effects are believed to occur, albeit with low frequency, even at the lowest doses" of radiation (ICRP 1991, p. 67). As a result, many expert groups, including the ICRP, maintain there is not likely a threshold in the dose-response relationship for radiation (ICRP 1991, p. 16; see also pp. 17, 69; UNSCEAR 1994; NRPB 1995). Because of the ICRP assumption that the linear, no-dose model of radiation effects is correct, citizens exposed to additional radiation, often without their consent, can argue that it is a risk for which they should receive full liability protection. Their argument is that, because some individuals likely will contract cancer or die as a consequence of any additional radiation exposure, they deserve liability protection, particularly if they receive no benefits from the exposure or do not consent to it.

In response, some utilitarian ethical theorists maintain that citizens do not need full liability coverage for radiation exposures/accidents as a consequence of pollution from the commercial nuclear fuel cycle, because the government would provide disaster relief, if it were necessary, after a catastrophic nuclear accident (Schmidt and Bodansky 1976, p. 145). They also argue that the probability of a nuclear accident that would exceed current liability limits is remote (Schmidt and Bodansky 1976, p. 145). Hence, they believe limited nuclear liability violates no rights to due process of law (see Cohen 1990, p. 283).

In the case of liability for exposures in the distant future, some experts argue that because permanent geological disposal of nuclear waste irrevocably imposes risks on future people, the need to compensate or to repair damage to future generations is impossible to meet (Persson 1990, p. 353). Still other scientists claim we can address due-process rights of future people by discounting future radiation-induced harms and by establishing a trust fund for victims of future nuclear exposures (Lewis 1990, p. 36). Other experts argue that, for small risks, no compensation is necessary (see Advisory Committee 1994; Faden 1995). Frequently during the period (1940s-1970s) of nuclear testing in the western US, government officials used yet another argument against compensating victims of avoidable radiation exposures. They spoke of Nevada as a "sacrifice" area (see Gallagher 1993) whose experiences were necessary for national security and for the good of the country (see US Congress 1994a, 1994b; US DOE 1995; Gordon 1996).

A number of ethical theorists, especially egalitarians and members of the NEA Steering Committee (see Reyners and Reye 1993), argue that limiting nuclear liability (through award ceilings or through time frames as short as 10 years) is unethical. They maintain that such limitations violate rights to due process, rights of innocent people to recover damages from those who have harmed them (see Thomson 1986; Gewirth 1982). Utilitarians who favor award ceilings, like industry spokespeople in the UK, Japan, or the US, however, maintain that the ceilings still allow for government to compensate potential victims of radiation or nuclear accidents. They say that the UK Parliament or the US Congress, for example, can award compensation for damages that extends beyond the liability limit (Cohen 1990, p. 283). Their utilitarian ethical justification for liability limits may be questionable on several grounds. First, the provisions for possible government compensation do not guarantee compensation to radiation victims, but only allow it as a possibility. As a consequence, government does not guarantee citizens' due-process rights, but only affirms that their recognition is possible. Second, in the past, as in the US, the government has not awarded compensation to most radiation victims, simply because it would have been too costly to do so, as in the case of the 500,000 US servicemen exposed to nuclear-weapons fallout; the civilian "downwinders" harmed by fallout from above-ground nuclear testing; or the residents harmed by emissions and effluents from government uranium-enrichment facilities (see Wigley and Shrader-Frechette 1994; Shrader-Frechette 1994a, pp. 1-5, 132-133, 162-166). This past behavior does not inspire confidence in possible government compensation schemes. Third, if citizens do not need full protection from radiation-related accidents (see Cohen 1990, p. 283), then why does the nuclear industry need full protection from liability claims resulting from a serious accident? An asymmetry appears here: Why does industry deserve/need protection when taxpayers do not?

Some experts on radiation protection, such as Lauriston Taylor, the "Father of American Health Physics," argue for full compensation for radiation victims on the pragmatic grounds that lawsuits for radiation injury waste inordinate amounts of time and money. He also maintains that court decisions about radiation injury often amount to using a legal, rather than a scientific, vehicle to set dose-response standards. Taylor claims that it would be more humane to avoid such litigation and expense and instead to provide free treatment and compensation to those injured (Taylor 1980, p. 865).

5. UNIFORM VERSUS DOUBLE STANDARDS: PUBLIC AND WORKER RISKS

The ICRP principles also raise several ethical issues because they sanction higher dose limits for workers than for members of the public. ICRP recommendations for dose limits on occupational exposure are for 20 mSv (2 rem) per year, averaged over defined periods of 5 years, with the restriction that dose in a single year not exceed 50 mSv (5 rem). The effective dose limits for members of the public, on the other hand, are for an average of 1 mSv (0.1 rem) per year, averaged over 5 years, with the restriction that dose in a single year not exceed 5 mSv or 500 mrem (ICRP 60 1991, pp. 40, 72; IAEA 1994, pp. 97-98; see IAEA 1995a, 1995c). As these standards indicate, the occupational exposure could be as much as 50 times greater than the public exposure and still be within ICRP dose limits.

Utilitarian ethical theorists would be likely to sanction such a double standard (for workers and the public) on grounds of efficiency, whereas egalitarians would be likely to oppose it, on the grounds that workers deserve protection equal to that accorded members of the public. The utilitarian argument in favor of the double standard is that, all things being equal, because radiation workers receive higher wages for risky work, this "compensating wage differential" justifies their bearing greater risks than members of the public. According to the theory behind the differential, the riskier the occupation, the higher the wage required to compensate the worker for bearing the risk, all things being equal (Baier 1986, pp. 66-67; Viscusi 1983, pp. 38ff.; Brown 1980, pp. 113-134; McLean et al. 1978, pp. 97-107; Viscusi 1979; see Shrader-Frechette

1991, pp. 71-73; Johnson 1981). Moreover, proponents of the double standard argue that imposition of the higher workplace hazards also is defensible because radiation workers have consented, with knowledge of the risks involved, to perform the work for the agreed-upon wage.

Opponents of the double standard for radiation risk, often egalitarian moral theorists, argue that society cannot protect children adequately against radiation if their parents are radiation workers who are vulnerable to reproductive and genetic effects whose consequences may be borne by their offspring. They argue that all people deserve equal protection from radiation risks, simply because they are human beings (Silini 1992). They say that the ICRP should promote credible, consistent standards for all people (see Vanmarcke 1994). Also, they point out that most workers who have risky jobs have not given authentic free informed consent to the higher risks (see Gallagher 1993). As a consequence, they say radiation workers are not truly free to avoid the most dangerous jobs. They argue that the people most likely to give legitimate informed consent to workplace radiation hazards are those who are well educated and possess a reasonable understanding of radiation risks, especially their long-term and probabilistic effects. They are people who are not forced, under dire financial constraints, to take jobs that they know are likely to harm them. Sociological data reveal, however, that as education and income rise, people are less willing to take risky jobs. The data reveal that those who do take risky jobs are primarily those who are poorly educated and financially strapped (Wigley and Shrader-Frechette 1994; Eckholm 1977, pp. 31-33; Berman 1978). Numerous case studies reveal that the poorest workers with the least education are typically employed in the most dangerous jobs (see, for example, Jones-Lee 1976; Eckholm 1977; Shrader-Frechette 1991, pp. 71-73).

Even if people in dangerous jobs were very generously compensated, and even if they had perfect information about the dangers of their jobs, very likely their limited employment opportunities and their lack of economic and social freedom would mean they could not make a wholly voluntary choice to work in a risky job. Unlike well-educated and financially secure people, they would essentially have the choice between a risky job and no job at all, unless they wanted to leave their homes and move elsewhere. For example, in the US most uranium miners are native Americans who face high levels of poverty and unemployment and low levels of education and opportunity. Egalitarians would claim these miners have not freely and voluntarily chosen exposure to risks from "radon daughters," alpha-emissions from radon, a radioactive element formed by the radioactive decay of radium (US DOE 1995; Mossman 1995; US Congress 1986, 1987, 1994a; Gordon 1996). For all these reasons, it is problematic to claim that, in exchange for higher wages, workers in risky occupations have given genuine free informed consent to their high-risk workplaces.

Another difficulty with the attempt to justify the double standard for worker and occupational radiation exposure is that often there is no real compensating wage differential, contrary to what Adam Smith believed. Rather, although all workers in risky jobs might, as an aggregate, receive higher wages for more dangerous jobs, once the workers are disaggregated into groups, the compensating wage differential often disappears. For workers who are not white, who are not unionized, who are not male, who are not college educated, and who are not young, there is no differential. For workers who are white, unionized, male, college educated, and young, there is a differential. When the two groups are aggregated, it appears that there is a compensating wage differential. Disaggregation shows, however, that for the very people who bear most of the inequitable burdens of society, there is no real compensating wage differential (Graham and Shakow 1981; Graham et al. 1983; see Gallagher 1993). Because there is not, it is quite difficult, ethically speaking, to justify the double standard of radiation protection for workers, especially for workers who may not receive adequate compensation and liability protection.

6. STAKEHOLDER CONSENT VERSUS MANAGEMENT DECISIONS: CONTROLLING EXPOSURES

Just as much ethical debate focuses on worker consent to higher radiation risks, so also there is controversy over whether members of the public need to give consent to radiation exposures and risks. Should experts and regulators -- members of the scientific community -- define and evaluate radiation risk because they have most of the "supply of wisdom" about radiation protection (Cohen 1990, p. 156; Taylor 1980, p. 855)? Should experts have this privilege because members of the public often are technically unsophisticated or prejudiced (see Laudan 1994)? Are members of the public victims of "nuclear phobia" (Mitchell 1984; see Drottz-Sjöberg and Persson 1993; Hull 1995), or "radiophobia" (Oberhofer 1989; Prêtre 1989; see Oughton 1994)? Do experts have the right to impose insignificant radiation risks on the public, just because they are insignificant (Mossman 1995, p. 758) or because citizens may have been misled through sensationalistic media, "prophets of doom" who supply "deliberately deceptive information about radiation matters" (Taylor 1980, pp. 857-859, 867; Cohen 1990, p. 45)? Or, should experts respect citizens' concerns about radiation (Drottz-Sjöberg and Persson 1993), and help ensure that stakeholders and potential victims of exposures also have a voice in radiation-protection and decisionmaking (NRC 1996; Wallace 1993; Freudenburg 1988; Fiorino 1990, 1991, 1995; see Fischer 1990)? Have experts failed to communicate radiation risks accurately (see Lochard 1994)?

In the area of risk definition, scientists tend to rely on the paternalistic prerogative of experts, in part because they claim that the definitions of irrational, ignorant, or risk-averse laypersons could impede social progress (Hull 1995; Laudan 1994; Gross and Levitt 1994, p. 167; Douglas and Wildavsky 1982; Taylor 1980). They also claim that risk-averse laypeople desire unrealistic standards of radiation protection. They say that laypeople fail to realize both that most radiation risks do not come from nuclear technology and that, for example, people typically double their radiation exposure if they are frequent air travellers (Lewis 1990, pp. 8, 219). Many sociologists, proponents of "cultural theory," claim that cultural biases, such as anti-authoritarian attitudes, egalitarian views, or societal alienation explain lay aversion to radiation-related risks (see Douglas and Wildavsky 1982). Even the recent US Advisory Committee on Human Radiation Experiments has given scientists, managers, and advisors, rather than potential risk victims, the prerogative of assessing acceptable risk. The panel said the US could allow intentional secret releases of radiation, affecting the public, provided an "independent panel" approves the releases (Advisory Committee 1994; Faden 1995; Mossman 1995; Gordon 1996).

Other scientists and moral philosophers (egalitarians) argue, in response, that rational risk definition, evaluation, and behavior are not expert prerogatives. They say risk is not primarily a matter of scientifically defensible outcomes -- because risks such as radiation affect public welfare. Because they are matters of public welfare, egalitarians say that risks are also matters of just procedures, values, and public "deliberation" (NRC 1996; Gordon 1996; Cranor 1993; Shrader-Frechette 1991). Moreover, say egalitarian moral philosophers, scientists are often wrong in estimating risks like those of nuclear power. They say risk is a multivariate or multidimensional concept, not just a probability. Moreover, they say that lay risk aversion cannot be explained through the cultural biases of the public (Sjöberg 1995). Public perceptions, they argue, are the product of rights to self determination in situations of technical uncertainty.

Besides, say egalitarian moral philosophers, there are no well-established hazard frequency records for new risks, like those created by radiation, so the public should help decide what protection from radiation is appropriate. Also, they claim that, in defining and estimating threats, scientists have well-known heuristic prejudices, such as overconfidence biases, that should be subject to public scrutiny (Cooke 1992; Kahneman et al. 1982; Fischhoff 1981). For example, US scientists conducting radiation experiments on citizens, without their consent, argued that because the risk was small, they needed to obtain no consent (Mossman 1995, p. 758). Later deaths and injuries among downwinders have shown that scientists were overconfident in judging the fallout risks as small. Social scientists also have shown that nuclear proponents err when they accuse mass media and laypeople of overestimating radiation risks. Indeed, they argue there is no quantitative evidence for such overestimation, except for overestimation of the abilities of "responsible authorities" (Freudenburg et al. 1996). Social scientists also have shown that different levels of education regarding technology cannot explain alleged differences between lay and expert views of radiation risks (Sjöberg and Drottz-Sjöberg 1994, pp. 47, 81; Freudenburg 1993; Freudenburg et al. 1996), and hence there appear to be no strong scientific bases for experts' overconfidence in their own views.

Given overconfidence bias in some nuclear risk assessments, egalitarian ethical theorists believe it is especially important to evaluate radiation risks through participatory democracy as well as by scientific fiat. Although scientific information is necessary for sound risk definition and evaluation, it is not sufficient (see Wallace 1993). Evaluation of radiation protection also requires ethical decisions about issues such as how safe is safe enough, how safe is fair enough, and how safe is voluntary enough. All these issues, in part, are matters of citizens' democratic rights to self determination, not merely scientists' prerogatives, both because they are questions of values, not just science, and because they affect public welfare (Mossman 1995; Gordon 1996; Gross and Levitt 1994, pp. 234, 248). As A.B. Wallace (1993, p. 10) puts it, "Just as scientists' risk estimates may need to be treated with something less than reverence, the 'unscientific' views of the public may need to be treated with something less than contempt." Lauriston Taylor makes a similar point. "Radiation protection is not only a matter for science. It is a problem of philosophy, morality, and the utmost wisdom" (Taylor 1980, pp. 852, 854).

Giving stakeholders and workers, rather than merely regulators and operators the right to define and manage acceptable radiation protection is also important because many stakeholders are likely to be disadvantaged in a more paternalistic system. Economically, educationally, or socially disenfranchised people are less likely than others to be able to give genuine free informed consent to public and workplace risk (MacLean 1986; Rescher 1983). Indeed, US victims of radiation experiments (without consent) tended to be poor, black, Native American, children, sick, or members of other vulnerable groups (US Congress 1994a, 1994b). Having public or labor representatives speak for these disenfranchised people, rather than allowing regulators and managers to make their radiation-protection decisions, likely would enhance their welfare, their understanding of risks, and their consent to them. In other words, just as free informed consent is required in cases of medical ethics, so also there are grounds for requiring it in cases of radiation ethics. And just as medical patients who are unwilling or unable to speak for themselves have others to protect their rights to free informed consent, so also it is arguable that radiation workers and the public ought to have their own representatives to protect their rights to free informed consent.

The ICRP does say that "close links between the management and the representatives of the workforce have a major role to play" in radiological protection (ICRP 60 1991, p. 57). It notes that "one common responsibility of the operating management is to provide access to occupational services dealing with protection and health....The protection service should provide specialist advice and arrange any necessary monitoring provisions, both inside and outside the installation" (ICRP 60 1991, p. 59). Nevertheless, in cases involving industrial or workplace exposure to radiation, the ICRP stops short of sanctioning workers' and the public's rights to know as well as their rights to free informed consent (see IAEA 1996b, p.13).

The IAEA standards do require that "workers, through their representatives where appropriate, have been consulted and their agreement obtained on the need for a temporary change" in radiation exposure limits (IAEA 1996a, p. 43). Nevertheless the requirement does not speak of "free informed consent" but only "agreement obtained." Moreover the worker agreement is to the need for a change, not to the decision actually to make a change in exposure standards. Finally, the agreement does not require the consent of the worker, but only representatives' consent and only "where appropriate."

One possible way to promote greater consent in the area of radiation protection would be to include representatives of (or spokespeople for) stakeholders on radiation-protection committees. These representatives could include citizens' groups and workers; they could serve, for example, on the main ICRP Commission and on the four ICRP committees. Currently none of these groups is represented. Likewise, because there are no representatives of stakeholders', citizens', or workers' groups in the IAEA; having such representatives there would also promote consent. Guaranteeing such avenues of information and consent may be part of what is necessary "to promote a radiation safety culture" (IAEA 1995a, p. 15; 1996b, p. 14). It may be part of what is necessary to provide the "openness and co-operation" so often emphasized by the ICRP and IAEA (IAEA 1996a, p. 8).

7. ENVIRONMENTAL STEWARDSHIP VERSUS ANTHROPOCENTRIC STANDARDS

So far, discussions of the ethics of radiation protection have focussed on humans. Do existing standards for protecting humans actually protect non-human biota as well? The ICRP answers "yes":

The Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk (ICRP 60 1991, pp. 3-4).

Seeking to determine the degree to which existing radiation-protection principles and standards also safeguard the non-human environment, the IAEA undertook a study of the effects of ionizing radiation on plants and animals. Given that the exposures presupposed current radiation standards, the IAEA (1992, p. 2) report concluded that, although some plants and animals would receive proportionately higher doses than humans, nevertheless these doses would not cause "any noticeable deleterious effect on the population [of plants or animals] as a whole." The basis for the IAEA conclusion was that society values non-human species only as populations, whereas it values human species as both populations and individuals. Although current radiation standards might harm non-human individuals, the report concluded that they would harm no non-human population, as a whole. The reasoning behind the IAEA conclusion appears to be that because humans have rights to protection, therefore radiation ought to harm no individual. The IAEA suggests, however, that because non-human organisms do not have rights to protection, people are obliged only to avoid radiation-induced mutations that could destroy biotic populations and cause species extinction. Nevertheless, the IAEA also maintains that its safety objectives are "to protect individuals, society, and the environment" (IAEA 1996b, p. 6).

Do ICRP recommendations and IAEA standards actually protect the environment? The major source of controversy in the IAEA argument for ignoring the genetic effects on populations of radiation-induced mutations is that there is a "double standard." The IAEA considers the selection and disappearance of harmful genetic information in the non-human population a good thing, but in the human population, it believes selection to be a bad thing. The IAEA ignores the painful experiences of the selection process at the individual non-human level, but it focuses on them and tries to avoid them at the human level (see Whicker and Schultz 1982, p. 125). The question is whether humans ought to ignore the pain and suffering imposed on non-human animals at the individual level. Non-human animals do not qualify as rights holders or as beings possessing a number of important characteristics such as linguistic ability or free will. Nevertheless, higher animals experience pain. Also, the organisms' pain and suffering, induced by particular radiation exposures, might be avoidable. Both their pain and the avoidability of some exposures suggest a more reasonable radiation standard might be one proportional to the radio sensitivity of the organisms in question, rather than the "double standard" of the IAEA. As just suggested, this double standard begs the question of whether there are ethical obligations to protect non-human individuals.

A second area of controversy is that the IAEA report assumes that harm to non-human individual organisms will not cause damage to non-human populations -- a problematic assumption. On the contrary, damage to individuals, in the form of stochastic effects causing cancer or hereditary injury, is damage that can undermine the health of the *gene pool* and its fitness. Tracking the viability of populations, alone, as most radiation researchers do, is too crude a way to determine the effects of radiation. As R. K. Appleyard (1960, p. 228; see Jenkins et al. 1995) put it, "the genetic control of response to irradiation does not, however, end with general viability. The radio sensitivity of organisms is known also to be subject to very great changes in both directions, by factors exceeding 10, through apparently single mutational events." Severe impairments -- such as deformities or chlorophyll deficiencies -- can occur as a result of the passage of a single particle of ionizing radiation through the shoot or the root meristem of plant seeds; such single-particle hits can cause "multiple chromosomal aberrations" and therefore "irreparable damage to the genetic apparatus" (Horneck 1994, p. 751; Kovan 1995; NRPB 1995).

Perhaps the most controversial assumption in the IAEA report is the value judgment that because plants and animals have worth as populations rather than as individuals, therefore it is acceptable for damage to them to exceed harm to humans (IAEA 1992, p. 52; see NCRP 1991, pp. 51ff.). This value judgment should be outside the limits of a report that claims to examine only the effects of ionizing radiation on plants and animals. The authors of the IAEA report attempt to justify their value judgment by claiming that it represents an "anthropocentric view" (IAEA 1992, p. 52). Anthropocentric views, however, are those that contribute to, or focus on, human welfare. If radiation causes damage to species needed for agriculture, medicine, or community resilience, then this ecological damage also could harm humans. Hence the alleged anthropocentric position of treating plants and animals as valuable, but only in populations, may not be defensible on anthropocentric grounds.

Considering the shift of ethical values that have occurred in the world, Persson (1996b) argues we may now be at a point in history when it is timely and when there also exist scientific reasons to set up a protection policy equivalent to the ICRP Principles for protection of humans justification, optimisation and dose limits) for the protection of environment (including animals) against the harmful effects of radiation.

ICRP Main Commission has recently set up a Task Group on environmental radiation protection. Work on environment protection principles is also going on in the IAEA.

CONCLUSIONS

As the discussion of these seven issues reveals, ethical issues in radiation protection are neither simple nor one-sided. They require detailed factual and normative analyses. Nevertheless, the insights of ethical theories also provide a number of ways in which current recommendations and standards for radiation protection could improve. They could be more equitable, more protective of human health and human rights, including due process and consent, more cautious in recommending worker exposure standards that are more lenient than public standards, and more protective of environmental welfare.

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THE SWEDISH RADIATION PROTECTION INSTITUTE (SSI) is a government authority with the task of protecting mankind and the living environment from the harmful effects of radiation. SSI ensures that the risks and benefits inherent to radiation and its use are compared and evaluated, and that knowledge regarding radiation continues to develop, so that the risk to individuals is minimised.

SSI decides the dose limits for the public and for workers exposed to radiation, and issues regulations that, through inspections, it ensures are being followed. SSI provides information, education, and advice, carries out research and administers external research projects.

SSI participates on a national and international level in the field of radiation protection. As a part of that participation, SSI contributes towards improvements in radiation protection standards in the former Soviet states.

SSI is responsible for co-ordinating activities in Sweden should an accident involving radiation occur. Its resources can be called upon at any time of the day or night. If an accident occurs, a special emergency preparedness organisation is activated. Early notification of emergencies is obtained from automatic alarm monitoring stations in Sweden and abroad, and through international and bilateral agreements on early warning and information.

SSI has 110 employees and is situated in Stockholm.

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