

What's Different, Ethically, About Nanotechnology?: Foundational Questions and Answers

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Abstract Whether nanotechnology is ethically unique and “nanoethics” should be treated as a field in its own right remain important, contested issues. This essay seeks to contribute to the debates on these issues by exploring several foundational questions about the relationship of ethics and nanotechnology. Ethical issues related to nanotechnology exist and adoption of a defeasible presumption that such issues amount to old ethical wine in new technological bottles appears justified. Such issues are not engendered solely by intrinsic features of the nanotechnology field, but also by contingent features of the social contexts in which work in the field unfolds. The sets of factors that engender ethical issues related to nanotechnology are combinations of social-contextual and technical elements. While there do not appear to be any qualitatively new nanotechnology-related ethical issues, nanotechnology is different, ethically, from other fields of technical inquiry in at least two ways. To avoid diluting ethical concern about nanotechnology and revival of the noxious notions of autonomous technology and technological determinism, thinking, writing, and speaking about ‘nanoethics’ should yield to thinking, writing, and speaking about ‘ethical issues related to nanotechnology in society.’ Finally, nanotechnology

practitioners should become familiar with the ethical dimension of their work.

Keywords The relationship between ethics and nanotechnology · Ethical issues related to nanotechnology · Unique and new ethical issues raised by nanotechnology · Nanoethics · Ethical issues related to nanotechnology in society · Criteria for a field of applied ethics to be a field in its own right · Intrinsic features of a technical field · Contingent features of a field’s social contexts · Autonomous technology · Technological determinism · Ways nanotechnology differs, ethically, from other fields of technical inquiry · Paradigm shift · The ethical dimension of nanotechnology work

Introduction

In recent years, scholars have explored various ethical issues and implications of nanotechnology [1, 2]. One by-product of this work has been that the question of the extent to which nanotechnology differs ethically from other domains of technical activity has been posed and debated. This paper focuses on several foundational questions relevant to that debate, such as: (1) are there ethical issues related to nanotechnology? (2) does nanotechnology raise unique ethical issues? (3) should nanoethics be recognized as a distinctive subfield of applied ethics? and (4) are nanotechnology-related ethical issues engendered by intrinsic features

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of nanotechnology? Hopefully, the discussion of these and related questions that follows will contribute to that debate, help clarify the general relationship of ethics and nanotechnology, and put subsequent consideration of specific nanotechnology-related ethical issues on a firmer footing, such that they can be more clearly articulated and effectively analyzed.

Are There Ethical Issues Related to Nanotechnology?

Many if not most scholars who have pondered the question ‘are there ethical issues related to nanotechnology?’ have answered it in the affirmative. However, to answer that question unambiguously requires clarity about a related meta-ethical question: ‘what is an ethical issue?’

Before answering the latter question, let us get clear about what is meant by ‘an issue.’ According to one source, ‘an issue’ is “a point or matter of discussion, debate, or dispute” ([3], p. 957); for another, it is “a point or matter in contention” ([4], p. 1119); for a third, it is “a point in question or a matter that is in dispute; a point, matter, or dispute, the decision of which is of special or public importance” ([5], p. 757). In what follows, ‘an issue’ means *a contested matter about which disputants differ in judgment or belief*.

An ‘ethical issue’ is an issue on which disputants’ differences in judgment or belief stem from differing assessments of the matter made from an ethical perspective.¹ An ‘ethical perspective’ is one in which action assessment hinges on the assessor’s beliefs about its likely consequences for the well-being of parties affected or likely to be affected by it, or on belief that the action is intrinsically good or right, evil or wrong, or obligatory.²

Thus, ‘the infliction of physical suffering on a prisoner of war in order to extract information from him or her’ and ‘physician-assisted suicide’ are ethical issues. To designate them thus is not, however, to judge them ‘ethical’ in the positive sense that is the opposite of the negative sense connoted by ‘unethical.’ Rather, it is

¹ ‘An ethical perspective’ is to be understood here as ‘a perspective of ethics,’ and to be contrasted with, say, ‘a legal perspective’ or ‘an aesthetic perspective.’

² In some cases the assessment might be of a closely related practice or policy instead of an action.

to claim that matters thus designated fall *within* the domain, purview, or scope of *ethics*, as opposed to falling *outside* that domain, as most aesthetic issues and some legal issues do. Since they fall within the domain of ethics, ethical issues are ones on which it is appropriate to bring to bear the concepts and principles of ethics in order to make judgments about the moral acceptability of related actions.³

‘Ethical issues related to nanotechnology’ are ethical issues related to nanotechnology R&D or manufacturing activity, or to the diffusion, regulation, or use of nanotechnology materials and final products. For example, consider the matter of nanotechnology researcher conduct when working with a material newly available at the nano-scale, and the matter of regulatory administrator conduct when a new nanotechnology product, believed by experts to pose a non-trivial but publicly unrecognized or underappreciated risk of harm to humans, is under consideration for release to the market place. Both matters qualify as ethical issues related to nanotechnology and are appropriate targets of ethical scrutiny.

The community of nanotechnology practitioners is neither oblivious nor indifferent to ethical issues related to nanotechnology. In fact, there is evidence that many more nanotechnology practitioners believe there are significant ethical issues related to nanotechnology than do not. A 2005–06 survey of researchers working at 13 nanotechnology research laboratories belonging to the U.S. National Nanotechnology Infrastructure Network⁴ revealed that 50.1% of the respondents *somewhat* or *strongly agreed* that there are “significant ethical issues related to nanotechnology,” compared with 26.9% who *somewhat* or *strongly disagreed* with that proposition (McGinn [6]: 104). The same survey yielded another important finding: that among researchers who agree

³ For the present writer, whether an issue is properly termed an ethical issue, *i.e.*, one that falls within the domain of ethics, hinges ultimately on whether the playing out of related actions or practices bears significantly on the well-being and protectable interests of affected parties.

⁴ The National Nanotechnology Infrastructure Network (NNIN) is a network of U.S. university-based nanotechnology research laboratories that is supported in part by the U.S. National Science Foundation (NSF). Hereafter, this survey, whose focus was the views of nanotechnology researchers about ethical issues related to their work, will be referred to as ‘the NNIN ethics survey.’ See R. McGinn [6].

that such issues exist, there is little indifference to ethical issues related to nanotechnology.⁵

In a number of scholarly articles about ethics and nanotechnology, authors have listed or alluded to various ethical issues related to nanotechnology, or have argued that there must be such issues.

For example, in an article section entitled “Issues in Nanoethics,” Allhoff wrote, “I want to present briefly some of the ethical issues that nanotechnology allegedly raises.” He proceeds to list a wide array of issues, under the following headings: “legal and regulatory issues,” “research funding and priorities,” “equity and distributive justice,” “environmental health and safety,” “toxicity,” “therapy/enhancement,” and “privacy” (Allhoff [7]: 189–193). While some of these items are reasonably regarded as ethical issues, e.g., the risk of harm to researchers and to the environment posed by some nanomaterial or nanotechnology, others seem more accurately termed ethical *concerns* that are related to ethical issues, e.g., privacy. Yet others seem more like non-ethical social issues than ethical issues per se, e.g., “patent law” (Allhoff [7]: 189). It was to avoid vagueness and conflation that care was taken above to indicate clearly what ‘an ethical issue’ means in this paper, and to characterize referenced ethical issues as neutrally as possible.

Instead of writing about ethical “issues” related to nanotechnology, Grunwald references various ethical “questions” posed by developments in nanotechnology, including “questions of the acceptability and comparability of risks,” “questions of the *distribution* of the opportunities for the use of as well as the spatial and temporal distribution of the opportunities and risks of nanotechnology,” and “questions of monitoring and of data protection” (Grunwald [8]: 192 and 194) What Grunwald calls “ethical questions” posed by developments in nanotechnology are closely related if not identical to what I termed ‘ethical issues related to nanotechnology.’

Swierstra and Rip refer to certain “well-known ethical issues, say privacy and new ICT, or point-of-care diagnostics and professional-medical responsibilities,”

as ones that, while not new to nanotechnology, “can become more pressing” with the rise and progress of nanotechnology (Swierstra and Rip [9]: 3). Clearly they believe that there are ethical issues related to nanotechnology.

Van de Poel distinguishes between “types of ethical issues, like privacy and enhancement,” and “the concrete ethical issues as they arise during the further development of nanotechnologies” (van de Poel [10]: 26). Thus, for him, the existence of specific ethical issues is not in question, only at what points and in what forms they manifest themselves.

Clarity would be well served by distinguishing ethical *concerns*, *protectable interests of stakeholders*, and *issues*. Thus, ‘privacy’ is an ethical concern, ‘privacy preservation’ is a protectable ethical interest, and ‘the violation of human privacy with nano-devices’ is a specific (nanotechnology-related) ethical issue. That said, it is clear that many scholars and nanotechnology practitioners believe that there *are* nanotechnology-related ethical issues, be they abstract or concrete, and actual or potential.

Does Nanotechnology Raise Unique Ethical Issues?

Having established what is meant by ‘ethical issues related to nanotechnology,’ cited evidence that a number of scholars and many nanotechnology researchers believe that there *are* significant ethical issues related to nanotechnology, and listed a few issues identified as such by scholars, the following question naturally arises: *does nanotechnology raise unique ethical issues?*

This question is tantamount to asking whether there are qualitatively new *kinds* of ethical issues that *only* nanotechnology raises. Some scholars ask a closely related question: “does nanotechnology raise new ethical issues?” Van de Poel notes that this question “has already raised a lot of discussion.” (van de Poel [10]: 31) The latter question is a slightly weaker but more determinable question than ‘does nanotechnology raise unique ethical issues?’ Granted, if nanotechnology raised an ethical issue of a kind not previously raised by any other technology, that issue would be (qualitatively) “new” (at least in relation to technology) at that point in time. But it could turn out that the same kind of ethical issue was also raised at a later time by another, yet-to-be-developed technology.

⁵ Among respondents who *somewhat* or *strongly* agreed that significant ethical issues related to nanotechnology exist, 61.5% were *quite* or *very* interested in them, while only 7.8% were *slightly* interested in them and .8% were *not at all* interested (McGinn [6]: 106).

If so, then looking back on the situation at a point in time after the second technology had emerged, one could say that at the point when nanotechnology first raised the issue, it *was* new, but that it eventually proved *not* to be *unique* since nanotechnology turned out not to be the only technology that raised it. Thus, one *can* know when a new-technology-related ethical issue first appears whether it is qualitatively new, but can *never* know at any given point in time that a then-new ethical issue will prove to be raised *only* by the technology that first raised it, hence be unique to that first technology. For this reason, in what follows, the question to be considered is the determinable one: ‘does nanotechnology raise qualitatively new ethical issues?’⁶

Biotechnology, encompassing both the activity and its products, appears to have raised some qualitatively new ethical issues, ones that had not arisen previously in any other field of technical inquiry. Examples of qualitatively new ethical issues arguably raised for the first time by biotechnology include: pre-determination of the sex of human offspring via various technical means; creation of new forms of plant and animal life via r-DNA splicing techniques; and, eventually, human reproductive cloning via somatic cell nuclear transfer. There are vigorous disputes over the permissibility of such undertakings, stemming from differing assessments of related actions and practices from an ethics perspective, whether it be consequentialist, deontological, or mixed in nature.

Does nanotechnology raise any qualitatively new ethical issues? Barring a valid deductive argument demonstrating that a particular technology (or family of technologies) *cannot* raise any qualitatively new ethical issues, it is impossible to know a priori that there is no matter related to that technology that can

engender an unprecedented kind of ethical issue. Nevertheless, in the case of nanotechnology, based on the examples given and arguments made to date in support of the claim that there *are* such issues, the answer appears to be that there are no grounds for thinking that such issues exist.

Thus far, the ethical issues cited by some scholars and activists as newly raised by nanotechnology all seem to be instances of ‘the usual generic suspects,’ such as risk of privacy violation, creation of a non-trivial risk of harm to humans or the natural environment, preservation of a safe workplace, and access to the fruits of publicly funded R&D activity. None of these issues, or any other with which the writer is familiar, is qualitatively new and raised by nanotechnology. The same generic issues emerged in earlier technological contexts having nothing to do with nanotechnology.

But might nanotechnology raise qualitatively new ethical issues when some of its more exotic projected developments emerge? Arguably the most promising domain within which to look for qualitatively new kinds of ethical issues raised by nanotechnology is the area encompassing ‘NBIC convergence’ work, i.e., work building on the projected convergence of research in four technical fields: nanotechnology, biotechnology, information sciences, and cognitive science.⁷ For example, one can envision, through eventual application of the fruits of NBIC R&D activity, the emergence of what might be termed a new, hybrid form of human existence. This would be one in which humans have a range of nano-devices with monitoring and communication capabilities, including ones having to do with human cognitive functioning, permanently implanted in them as neonates. This would ostensibly be done for health-preservation, illness-prevention, or performance-enhancement purposes. Suppose that this imaginable practice became the norm in a society, rather than being a rare exception or something reserved for seriously ill or economically affluent patients.

⁶ van de Poel distinguishes “two different notions of ‘newness’” of technology-related ethical issues. “[O]ne is that an ethical issue is new if it is not raised by an existing technology or not dealt with in another field of applied ethics” (van de Poel [10]: 31). (Note: it is likely that he meant to write “...if it is not raised by an existing technology *and* not dealt with in any other field of applied ethics”). His second notion is that “an ethical issue is new if we (still) lack adequate normative standards to deal with it” (*ibid.*). This is a more problematic sense of “new,” since, under it, whether or not a technology-related ethical issue qualifies as “new” depends on judgments being made about whether existing normative standards are “adequate...to deal with it.” The vagueness of this criterion invites the proliferation of nanotechnology-related ethical issues deemed “new,” something not in its favor.

⁷ According to Grunwald, “New questions are also posed by the fact that previously separate lines of ethical reflection converge in the field of nanotechnology” (2005: 187). However, he does not appear to identify any such specific new questions, referring only to “the integrative and cross-sectional nature of many ethical challenges” posed by nanotechnology. He also writes of “new topics and questions” being “concentrated in nanotechnology,” but with no greater specificity (*ibid.*: 198).

This imaginable development might seem to engender one or more novel ethical issues. However, on further reflection it appears that none is qualitatively new. For example, the arguably ethical issue of cognitive and physical enhancement by technical means has already been raised in the context of biotechnology, through genetic engineering and pharmacological means. If the implantation of a range of nano-devices into neonates for health monitoring purposes is reserved for beings whose families can tap sufficient economic resources, two familiar ethical issues are implicated: the distribution of access to medical resources, and whether it makes sense to speak of a moral right to health care, here preventive rather than therapeutic in nature. The ethical issue of whether parents have an ethical responsibility to effect such implantation in their newborns is a special case of the general ethical issue of parental ethical responsibility to spare their (and other parents') children preventable harms. Deciding to effect such implantation in one's newborn in order to prevent medical harm is at bottom no different than deciding to have one's child vaccinated to protect her/him (and her/his school mates) against diseases like diphtheria and pertussis. That miniature technological devices are involved in one case and drugs in the other does not alter the kind or type of ethical issue involved.

What do the authors cited above, who believe that there *are* ethical issues related to nanotechnology, say about whether nanotechnology raises *qualitatively new* ethical issues?

Swierstra and Rip are somewhat elusive on this question. On the one hand, they state, seemingly in a deflationary vein, that “there might not be a specific nano-ethics,” (2007: 3) a claim that seems to express doubt that there are qualitatively new ethical issues raised by nanotechnology and/or that novel ethical concepts or principles are required to deal with whatever ethical issues nanotechnology raises. On the other hand, after allowing that “there might be ethical issues somewhat specific to nanotechnology,” they immediately add, “We think there are” (*ibid.*: 16).

But what are these “ethical issues somewhat specific to nanotechnology”? Swierstra and Rip do not explicitly designate any specific issues as qualitatively new ethical issues raised by nanotechnology. Rather they *argue* that there must be some without listing any. They contend that there must be such issues because “nanotechnology introduces new

ambivalences and enhances existing ones” (*ibid.*). One of these “ambivalences” is the fact that “at the nanoscale, the small size (of particles) creates unexpected new properties,” ones that “can create new and unexpected benefits as well as potential problems.” This is apparently one of the “nano-specific issues” (2007: 3) that the authors recognize, although do they not term it a ‘nano-specific *ethical* issue.’ They characterize this “nano-specific issue” thus: “how size matters” (*ibid.*). But while this “ambivalence” is a fact about the behavior of elements at the nanoscale, perhaps even only at the nanoscale, the present writer fails to discern any ethical issue related to this ambivalence that is qualitatively new and raised by nanotechnology. That an ambivalence may be new and perhaps unique to a technology does not by itself show or imply that that technology raises any qualitatively new ethical issue.

The second ambivalence Swierstra and Rip identify is “the delegation of agency to nano-enabled technology like smart dust and active systems in general,” more generally to “smart devices” (2007: 3 and 17). While this is a seductive *façon de parler*, no genuine delegation of agency from the human being to a smart nano-device would occur. The latter would not “do something...on its own accord” (17). For example, if there is any delegation of agency on the part of a person who is voluntarily implanted with smart nano-devices or whose blood is injected with tumor-targeting “nanoworms,” the delegation is not to the reactive nanoproducts but to the designer and/or doctor who prescribed them. Such devices only “do” as programmed by their designers, perhaps in collaboration with medical researchers. Similarly, “smart dust”—extensive arrays of information-gathering nanosensors—could eventually make torrents of valuable local or global information of various sorts available, leading lay individuals or professional experts to make or recommend decisions to alter individual or societal behavior to realize desired outcomes. While the imagined applications of various kinds of smart nanodevices are sometimes stunning, and while the familiar ethical issues of informed consent, risk of privacy violation, and equity of access are likely to rear their heads once again, no qualitatively new ethical issues allegedly raised by such devices or arrays have been identified to date.

In short, while Swierstra and Rip believe that there are “ethical issues somewhat specific to nanotechnology”

and claim “that there are some nano-specific issues: in how size matters, and when agency is delegated to smart devices,” they do not identify any specific, qualitatively new ethical issues (in either the normative or meta-ethical branches of ethics) raised by nanotechnology.

Allhoff and Lin argue that “some [ethical] issues are emerging that appear unique to nanotechnology, namely the new environmental, health and safety (EHS) risks arising [from] nanomaterials.” (Allhoff and Lin [11]: 183) This claim is unpersuasive. These may be new *instances* of risks of the same sort raised by other technological materials, but they are not a new *kind* of ethical issue. They are new *examples* of a well known *category* of risks that various scientific and technological materials, products, and processes have posed, are posing, and will pose in the future: viz., risks to environmental safety and human health. Hence, these issues are not qualitatively new issues raised (only) by nanotechnology.

Grunwald takes a fairly strong position on the ‘newness’ question, stating that “Technical enhancement of human beings themselves—if this would be possible at all—would in any case pose a series of new ethical questions” (2007: 196). He goes on to claim that “Nanotechnology, in combination with biotechnology and medicine, opens perspectives for fundamentally altering and rebuilding the human body” (2007: 197). However, the only allegedly qualitatively new ethical questions he goes on to identify are these: (1) “how far human beings... *should*...go in remodelling the human body, and to what end(s) this should or could be done” and (2) whether aging and death should be “acknowledged as a predetermined initial condition of human existence” or be “seen as conditions which are, whenever possible, to be abolished” (*ibid.*). While efforts will probably be made to enlist nanotechnology to remodel the human body and combat aging, and while it is clear that, as Grunwald states, “ethical reflection is needed in this field” (2007: 198), these are not qualitatively *new* questions first raised by nanotechnology. After all, the ethical issues of how far humans should go in remodeling the human body and of whether aging and death should be accepted or combatted were previously raised by other technological developments, such as cryogenic preservation, organ transplantation, genetic engineering, cosmetic surgery, and nutritional supplements.

Godman adopts a mixed position about the question of whether there are qualitatively new ethical issues raised by nanotechnology. On the one hand, she seems to contemplate the possibility that there might be such issues: “If nanotechnology truly affords all the new and intriguing technological possibilities as it promises to do, one would suspect an arrival of new challenges to our society and its values” (Godman [12]: 392). On the other hand, she devotes a good part of her essay to showing that taking what she calls “the uniqueness approach”—i.e., trying to identify qualitatively new ethical issues raised only by nanotechnology—is problematic. Among the problems Godman sees with taking this approach is that “...people thinking in the pattern of the uniqueness approach” are apt to “[zero] in on unlikely scenarios such as a Drexlerian ‘grey goo scenario’” (2008: 395). The problem with this claimed tendency, she contends, is that preoccupation with “these scenarios [will] over-shadow other ethical issues that may be more important but not as unique to nanotechnology.” The phrase “not as unique” implies that Godman believes that there *are* ethical issues unique to nanotechnology and that they are unique to differing degrees.⁸ However, she does not identify any specific qualitatively new nanotechnology-related ethical issues of any degree of uniqueness.

The upshot is that none of the authors discussed above has identified a qualitatively new ethical issue raised by nanotechnology or made a compelling argument that any such issue exists. Therefore, the present writer’s response to the question ‘does nanotechnology raise qualitatively new ethical issues?’ is skepticism based on available evidence and argument coupled with adoption of a defeasible presumption: *that the nanotechnology-related ethical issues claimed to be new (and sometimes unique) amount to old ethical wine in new technological bottles.* To the best of my knowledge, no scholar has yet identified any specific qualitatively new ethical issue raised by nanotechnology, or by nanotechnology taken in conjunction with other “technologies that converge at the nano-scale,” to borrow a phrase from the subtitle of this journal. Of course, this presumption can be invalidated at any time and would be

⁸ Interestingly, just as Godman speaks of ethical issues related to nanotechnology as being unique to different degrees, Swierstra and Rip refer to ethical issues as being ‘specific to nanotechnology’ to different degrees, e.g., “somewhat specific to nanotechnology” (Swierstra and Rip [9]: 16).

abandoned if any persuasive new example or compelling argument were to be put forward.

Should Nanoethics Be Designated a Distinctive Subfield of Applied Ethics?

In light of the answer just given to the ‘qualitatively new ethical issue’ question, a third question can now be addressed: should nanoethics be regarded as a distinctive field of applied ethics or, in the words of Allhoff and Lin, as “a field in its own right” (2006: 182)? Besides providing an example of an allegedly new ethical issue raised by nanotechnology (2006: 183), Allhoff and Lin offer what four “good reasons for believing nanoethics to be a distinct field” (*ibid.*). Let us examine each.

Their first reason might be called ‘the argument from widespread substantial investment’:

“...nanoethics... commands a significant amount of attention and money, thought far less than the amount poured into nanotechnology. In the U.S. the NNI [National Nanotechnology Initiative] currently sets aside approximately \$43 million for the ‘identification and quantification of the broad implications of nanotechnology for society, including social, economic, workforce, educational, ethical, and legal implications.’ So, it would certainly be strange that there would be so much invested by various government agencies, universities, publishers and other organizations globally, if nanoethics were not a distinct or intelligible field.” (Allhoff and Lin [11]: 183)

This reason is not persuasive. The amount of money invested in an intellectual endeavor in no way justifies the belief that it is a “distinct or intelligible field.” The feeling that a substantial level of investment in nanoethics would be “strange” if it wasn’t such a field is equally beside the point. After all, such investment might be motivated by prudential or political-economic considerations, not by intellectual conviction about the distinctness of nanoethics as a field of inquiry. Whether something is a “distinct... field” depends on properties of the field itself and the kinds of issues it raises compared with those of other fields of applied ethics, not on how much various organizations invest in it or how that investment is

perceived by observers. At most, substantial investment in a new area of inquiry might show that the investing organizations *perceive* or *believe* it to be a distinct field; but it cannot show that it actually *is* a distinct field.

Second, Allhoff and Lin claim that it is

“unclear why we should accept the litmus test that, to be a true discipline, nanoethics must either raise new ethical issues or larger ethical issues than other technologies.” (2006: 183)

The disjunctive “litmus test” that the authors reject *is* flawed. While its first element has merit—if, that is, “new” here means “qualitatively new kind of”—the second is problematic. Its meaning is unclear. Does “larger ethical issues” mean that they have a larger domain of impact, or an impact that is quantitatively larger in magnitude, or that these issues are in some qualitative sense more important? Given this flaw, the disjunctive litmus test referenced by the authors does not compel assent. But the fact that nanoethics does not qualify as a distinctive field under a flawed litmus test is not a compelling positive reason for regarding nanoethics as a distinct field or field in its own right. Another defeasible presumption needs underscoring: that a new area of ethics inquiry is not to be designated or treated as a distinct field in its own right *unless and until* there is a compelling reason for doing so. Thus far that condition no such reason has been adduced.

Third, Allhoff and Lin argue that

“to the extent that nanotechnology is a convergence of many disciplines in the first place, it should be no surprise that nanoethics is a convergence of many ethical issues as well. So, even if a new area of ethics requires raising new or larger issues, that standard may no longer apply with the discovery or creation of nanotechnology, which uniquely draws from other disciplines like no other discipline before it.” (2006: 183–184)

The fact that a new field (at a new scale) may arguably ‘draw from’ other long-established fields, even possibly “uniquely”—the latter is stated, not shown—does not provide a good reason why a set of criteria for a field of ethics to be distinctive “no longer apply,” here to nanotechnology. Hence, the arguably amalgam-like nature of the nanotechnology field does not *by itself* warrant treating nanoethics as a field or area in its own right, or as a distinctive subfield of applied ethics.

Fourth, Allhoff and Lin argue that

“nanoethics does seem to raise new ethical issues insofar as it adds a new dimension or ‘flavor’ to current ethical debates. For instance, though privacy may be a relatively old debate, the possibility of creating near-invisible and undetectable devices did not meaningfully exist prior to nanotechnology; so nanotechnology may help shift the privacy debate in an entirely new direction: whereas worries about unauthorized or unwanted surveillance have traditionally focused on a few agencies, notably governmental organizations, the possibility of cheap, ubiquitous tracking devices—emerging now with radio frequency identity chips (RFID) technology...and later to a greater extent with nanotechnology—‘decentralizes’ surveillance and changes the terms of the debate.” (Allhoff and Lin [11]: 184)

This argument too is invalid. That nanotechnology R&D may eventually enable “cheap, ubiquitous tracking devices” could result in concerns over privacy violation becoming more *salient* and *urgent*, hence could give ethical debates over privacy in relation to nanotechnology a more urgent “flavor.” However, that is not to be confused with that prospective development’s raising a qualitatively new kind of ethical issue. This is not the case any more than the fact that certain technologies enabled portable, affordable, and widely diffused glucose test devices entitles one to say that this phenomenon raises one or more qualitatively new ethical issues not present before such devices existed, a time when comparative access to medical treatment was already widely recognized as an ethical issue.

The present writer’s view about the criteriological question is that nanoethics would deserve to be regarded as a distinctive sub-field of applied ethics or a field in its own right, one on a par with bioethics and environmental ethics, only if (1) there exist at least some qualitatively new ethical issues raised by nanotechnology activity and its products, and (2) these qualitatively new ethical issues are due solely or predominantly to the nature of the nanotechnology field.⁹ Having argued that to date no qualitatively new kinds of nanotechnology-related ethical issues have been identified, let us consider their genesis.

⁹ The expression ‘nanotechnology field’ is intended to encompass elemental nanotechnology phenomena and products.

Are Ethical Issues Related to Nanotechnology Engendered by Features of Nanotechnology?

Some of the (non-unique kinds of) ethical issues related to nanotechnology identified to date *are* partly attributable to characteristic features or aspects of nanotechnology phenomena and products, e.g., the fact that nano-materials and nano-products are extraordinarily small in physical scale, and the fact that, due to quantum effects, elemental materials often exhibit quite different physical properties at the nano-scale than they do at larger scales.

However, all of the currently identified or projected ethical issues related to nanotechnology are no less attributable to *contingent features of the existing societal contexts in which nanotechnology R&D work is done and in which its fruits are exploited*. Consider the following features of the societal context of contemporary nanotechnological activity:

- to date, U.S. federal regulations designed specifically for nanotechnology materials, processes, and products are virtually non-existent;
- many national governments have made huge investments in nanotechnology R&D activity;
- national governments that have made such investments have earmarked relatively very small amounts of money or safety research;
- many companies active in commercial nanotechnology work believe the potential financial gains are substantial;
- nanotechnology researchers believe they have a chance to make significant contributions to the development of a new and exciting field and that the rewards for doing so could be substantial;
- some nanotechnology laboratories, staffed with research personnel drawn from countries around the world, have lab cultures that are substantially *laissez-faire* in character;
- in contemporary society, much or most new scientific knowledge can be turned into technological products and introduced into the market place with unprecedented rapidity;
- nanotechnology R&D is being pursued by many nations with a clear eye to enhancing their international economic and military competitiveness.

Thus, for example, the ethical issue of nanotechnology-related risk to privacy is attributable not only to the extremely small scale of nanotechnology phenomena and

products, an aspect clearly conducive to surreptitious monitoring. It is also due to the contingent politics, priorities, and preferences of the governmental institutions and organizations that will shape the outcomes of nanotechnology R&D into products with certain specifications and deploy and use them for certain purposes, all that occurring under particular legislative, regulatory, legal, political-economic, and cultural conditions that also help set the stage for such ethical issues to emerge.

Similarly, the nanotechnology-related ethical issue of researcher behavior vis-à-vis a material newly available at the nano-scale is engendered not just by the cardinal fact that elemental materials often exhibit radically different properties at the nano-scale. It also arises from extrinsic contingent factors, such as the specific social conditions that prevail in particular nanotechnology laboratories (e.g., their respective cultures), the time-dependent natures of the job markets in which nanotechnology researchers shape their research and seek jobs, the amounts, directions, and priorities of government funding for nanotechnology research, and the natures of the reward and punishment systems that prevail in nanotechnology research communities. Such considerations show that ethical issues related to nanotechnology are engendered *not* solely or predominantly by the nature of nanotechnology phenomena and products. The factors that engender nanotechnology-related ethical issues are *socio-technical*, not purely technical, in nature.¹⁰ Therefore, in light of the two necessary conditions, stipulated above, for a new area of ethics inquiry to be regarded as a distinctive field in its own right, the conclusion here is that ‘nano-ethics’ does *not* deserve to be so regarded.

Are There Any Ways in Which Nanotechnology is Different, Ethically, than Other Fields of Technical Inquiry?

In spite of the deflationary character of some of the answers given thus far, nanotechnology *is* different, ethically, from other fields of contemporary technical inquiry, in at least two ways. However, both depend on viewing nanotechnology not as an isolated domain or

field of technical inquiry, but as a total sociotechnical R&D, manufacturing, and regulatory enterprise.

The history of public resistance in the U.S. to biotechnology R&D and some of its fruits, from contested genetic engineering experiments in the mid 1970’s to the continuing controversy over embryonic stem cell research, is well known. Mindful of that history, the nanotechnology community is anxious over the possibility that widespread public resistance to continued major funding for nanotechnology research might emerge in the future. These (and perhaps other) characteristics of the historical and contemporary social contexts of nanotechnology have engendered an unprecedented situation. Some of nanotechnology’s key institutional promoters, e.g., NSF, have supported the *upstream* exploration of nanotechnology’s “social and ethical implications” in parallel with pursuit of basic nanotechnology research. The rationale appears to be to protect the field against the possibility of strong negative public reaction downstream if nanotechnology were to be implicated in serious social harm through negligent or irresponsible practitioner action, regulatory oversight, or manufacturing practices. Put differently, upstream study of ethical (and social) issues related to nanotechnology is viewed by some forces that support it as an *investment* in stable public funding support for nanotechnology R&D work in the future.¹¹

A second way in which nanotechnology is different, ethically, than other existing technical fields of inquiry has to do with the apparent emergence in the nanotechnology community of a challenge to a long-dominant paradigmatic belief in the scientific research community regarding the ethical responsibilities of researchers. A central tenet of the scientific community’s dominant belief

¹⁰ The degrees to which a given nanotechnology-related ethical issue is attributable to intrinsic features of the nanotechnology field and to contingent extrinsic features of the societal contexts involved will typically vary from issue to issue.

¹¹ In the 1990s, the U.S. Department of Energy and the National Institutes of Health devoted 3–5% of their annual Human Genome Project (HGP) budgets to supporting study of the ethical, legal, and social issues raised by the availability of new human genetic information. This came to be known as the ELSI program. It might seem, therefore, that NSF’s stipulation regarding study of “social and ethical implications” (SEI) is not unprecedented, hence that this is not a respect in which nanotechnology differs, ethically, from all other technologies. But the difference is that in the case of nanotechnology, study of its “social and ethical implications” is to be done as a constituent part of the mission of the consortium doing the research, not outsourced to scholars outside the enterprise, as with the HGP.

system has been that the only ethical responsibilities of *researchers* revolve around the Holy Trinity of Research Ethics: lab safety, data integrity, and respect for intellectual property (e.g., not plagiarizing the ideas or words of others and giving all contributors credit in publications in proportion to their respective contributions to the achievements in question). An important complementary dual tenet has been that society alone is responsible for whatever is done with the fruits of basic research and that researchers cannot be held responsible for that which they do not control, viz., end-use applications of their work. In the words of Nobel physics laureate, Leon Lederman,

“Our lame but perhaps time-honored response is that scientific knowledge is not good or evil; it is enabling. Modern science, however abstract, is never safe. It can be used to raise mankind to new heights or literally to destroy the planet. As democratic government spreads, it is the people and their representatives who must use the power provided by science. We give you a powerful engine. You steer the ship.” (Lederman [13])

One finding from the NNIN ethics survey shows unambiguously that the great majority of responding NNIN researchers reject this conventional position. When asked about their degree of agreement with the following claim,

“If a nanotech researcher has reason to believe that her/his work will be applied in society so as to pose a significant risk of harming human beings, s/he has an ethical responsibility to alert appropriate parties to the potential dangers.” (McGinn [6]: 126)

While 4.0% of respondents *strongly disagreed*, 0.8% *somewhat disagreed*, and 13.4% *somewhat agreed*, a remarkable 76.3% of the respondents *strongly agreed* with the claim (McGinn [6]: 115).

This response profile suggests that in the nanotechnology community a new paradigm of ethical responsibility in technoscientific research may be emerging to challenge the one reflected in Lederman’s conventional views. Nanotechnology appears to be one of the first fields, if not the very first field, of contemporary technoscientific inquiry in which this challenge is being posed and played out. What is reasonably clear is that most NNIN respondents do not exclude nanotechnology

researchers from the list of groups whose members they believe have ethical responsibilities toward society at large.¹²

In short, nanotechnology as a research enterprise is being required by its institutional patrons to address upstream the ethical (and social) implications of work in the field, and many if not most nanotechnology practitioners seem to be departing from the established paradigm of researchers’ ethical responsibilities by acknowledging that even researchers can have ethical responsibilities to society at large, not just to other researchers in their labs, those with whom they publish, and those working in their fields. These are two ways that NT is different, ethically, than other fields of contemporary technical inquiry. However, neither is due to any *intrinsic* technical features of the field; rather both stem from *contingent aspects of its (historical and contemporary) social contexts*, such as those sketched above.

Is It Desirable to Think, Write, and Speak of ‘Nanoethics’?

In spite of the apparent absence of any qualitatively new ethical issues related to nanotechnology, and the absence of any compelling rationale for regarding ‘nanoethics’ as a distinctive field of applied ethics or a field in its own right, the fact that there are ways in which nanotechnology differs, ethically, from other fields of technology might make it seem desirable or even valid to continue to think, write, and speak about ‘nanoethics.’

However, rather than continuing to refer to ‘nanoethics,’ the present writer’s position is that, all things considered, it is preferable to refer to ‘ethical issues related to nanotechnology.’¹³ If it were clear that use of the term ‘nanoethics’ was intended only to focus attention on the nanotechnology field so that it does not escape ethical scrutiny, then one could have no quarrel with such usage. But casual talk of ‘nanoethics’ may

¹² Asked about their degree of agreement with the proposition that “Academic researchers in nanotechnology have an ethical responsibility for the effects that new nanomaterials and nanodevices have on society,” 65.3% of respondents *somewhat* or *strongly* agreed, 18% *somewhat* or *strongly* disagreed, and 5% agreed *as much as* disagreed.

¹³ Examination of ethical issues related to nanotechnology falls within the scope of the cross-cutting subfield of applied ethics that John Harris calls “the ethics of science and technology.” See John Harris [14]. Interestingly, Grunwald uses the identical expression. (Grunwald [8]: 192).

leave listeners and readers with the impression that it is a distinctive subfield of ethics, on a par with bioethics and environmental ethics, and this could backfire. How so?

Suppose that qualitatively new ethical issues related to nanotechnology developments are *not* identified and that it is *not* shown that at least some ethical issues related to nanotechnology are solely or predominantly attributable to intrinsic features of the nanotechnology field. In that case, expectations, fueled by use of the term ‘nanoethics,’ that there *are* such distinctive issues and intrinsic grounds for attribution will go unmet and nanotechnology practice and products might come to be regarded as ethically unimportant or irrelevant and become the object of benign neglect. For those who care about protecting and enhancing societal well-being and environmental quality in contexts of rapid socio-technical innovation, involving nanotechnology or other emerging technologies, that would be an unfortunate and counterproductive outcome.¹⁴

The term ‘nanoethics’ invites those who encounter and use it to think that the ethical issues involved are attributable solely or predominantly to the nature of the nanotechnology field, rather than, as argued above, to variable combinations of the nanotechnology field’s intrinsic features and contingent extrinsic aspects of the

societal contexts in which nanotechnology activities are carried out. Although less compact and elegant, the expression *ethical issues related to nanotechnology in society* is less likely to be interpreted so narrowly, hence more conducive to analysts’ giving more accurate genetic accounts of these issues. Use of that expression would help counter rather than reinforce the tendency to attribute potential ethical issues and societal problems to nanotechnology per se, rather than to the dynamic interaction of nanotechnology and its contingent social situation and related socially shaped practices (e.g., re funding, public understanding, and regulation). It has taken major intellectual effort to discredit the seductive notions of autonomous technology and technological determinism; care should be taken to avoid inadvertently rehabilitating them.

Should Nanotechnology Practitioners Study the Ethical Dimension of Their Work?

Notwithstanding the absence of compelling arguments that qualitatively new nanotechnology-in-society-related ethical issues exist, or that ‘nanoethics’ should be treated as a distinctive field of applied ethics, pressure to familiarize nanotechnology practitioners with the ethical dimension of their work is increasing. In 2004, after extensive study, the United Kingdom’s Royal Society and Royal Academy of Engineering published a joint report on nanotechnology. The document recommended that “consideration of ethical and social implications of advanced technologies (such as nanotechnologies) should form part of the formal training of all research students and staff working in these areas and, specifically, that this type of formal training should be listed in the Joint Statement of the Research Councils’/AHRD’s Skills Training Requirements for Research Students.”¹⁵

More recently, the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act—the America COMPETES Act—became law. Section 7009 of this law stipulates that “The Director [of NSF] shall require that each

¹⁴ As seen in the section ‘Should Nanoethics Be Designated a Distinctive Subfield of Applied Ethics?’, in their 2006 article Allhoff and Lin defended the view that nanoethics is a distinctive field in its own right (Allhoff and Lin [11]). However, a year later, in “On the Autonomy and Justification of Nanoethics,” Allhoff espoused a different position. Having identified a number of ethical issues related to nanotechnology, he concluded that, “none of them is new or novel in any substantial way” (Allhoff [7]: 193). Moreover, he argued *against* the notion that although “the issues themselves might not be unique, they nevertheless are instantiated to such a degree that extant moral frameworks will be ill-equipped to handle them” (Allhoff [7]: 185). Instead, he concluded that while there is no “metaphysical” justification for regarding nanoethics as a distinctive field, viewing nanoethics as such *can* be justified “pragmatically” (Allhoff [7]: 206). For Allhoff, this means that in light of “the impacts that nanotechnology will have on society,” “nanotechnology deserves ethical *attention*” and nanotechnologies “must be evaluated along whatever ethical dimensions they manifest effects, whether well-being, rights and liberties, fairness, or whatever” (Allhoff [7]: 207). Although the present writer’s views are considerably closer to Allhoff’s 2007 position than to his (and Lin’s) 2006 position, I submit that, as argued in this section, the goal of coming seriously to grips with ethical issues engendered jointly by nanotechnology and its societal contexts is best served by jettisoning talk of ‘nanoethics’ in favor of talk about ‘ethical issues related to nanotechnology in society.’

¹⁵ See the Royal Society and the Royal Academy of Engineering, “Nanoscience and Nanotechnologies: Opportunities and Uncertainties,” RS Policy Document 19/04, July 2004, p. 87, Recommendation 17. See also <http://www.royalsoc.ac.uk> and <http://www.raeng.org.uk>.

institution that applies for financial assistance from the Foundation for science and engineering research or education describe in its grant proposal a plan to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduate students, graduate students, and postdoctoral researchers participating in the proposed research project.”¹⁶

The increasing pressure to do so aside, there are several reasons why providing for such study makes excellent sense in the case of nanotechnology. First, only 36% of 933 researcher respondents in the NNIN ethics survey indicated that they had taken “a course in which ethical issues closely related to science, technology and engineering were discussed.” Indeed, only 16.7% had taken “an *ethics* course focused on ethical issues closely related to science, technology, or engineering.” Not surprisingly, the majority of respondents rated themselves not at all, slightly, or moderately well informed about ethical issues related to nanotechnology.¹⁷ Happily, most respondents supported the idea of making study of ethical issues related to science and engineering—not just to nanotechnology—“a standard part of the education of future engineers and scientists.”¹⁸ In short, many nanotechnology researchers recognize a tension between their thin educational backgrounds and modest levels of understanding about nanotechnology-related ethical issues on the one hand, and their belief that such issues are important, likely to be encountered in their careers, and worth considering on the other. This situation suggests that it makes sense to provide such education to nanotechnology (and other) researchers, just as it has proven useful to provide intending researchers with opportunities to improve other underdeveloped work-related skills, e.g., technical communications skills.

¹⁶ 42 U.S.C. 18620–1. See, for example, http://www.nist.gov/mep/upload/PL110-69_8907.pdf. Pursuant to Section 7009, in January 2010 NSF began requiring that applications for research funding include research-ethics training plans. See <http://edocket.access.gpo.gov/2009/E9-19930.htm>.

¹⁷ Only about a fifth of the respondents believed themselves to be *quite* (15.9%) or *very well* (5.6%) informed about ethical issues related to nanotechnology, whereas almost four fifths rated themselves *not at all* (10.5%), *slightly* (31.8%), or *moderately* (34.6%) well informed about these issues (McGinn [6]: 115).

¹⁸ Almost two thirds (63.1%) of the NNIN ethics survey respondents agreed *quite a bit* or *very much* that study of such issues should become a standard part of future engineering and science education, while only 14.9% indicated that they supported this change *slightly* or *not at all* (McGinn [6]: 117).

Second, such study is likely to lead to greater attentiveness to the presence of such issues in the practice of nanoscale science and engineering. In turn, to the extent that the NNIN nanotechnology community is typical, that will probably mean less indifference to such issues,¹⁹ something that should contribute to diminishing the chances of harmful outcomes through a lack of awareness or negligence.

Third, the workforce in nanotechnology labs in more developed countries is becoming increasingly global in character, with researchers in such labs originating from many countries around the world, including China, Russia, India, and Turkey. Consequently, it would be naïve to assume that all researchers in a given nanotechnology facility have the same understanding of the basic ethical responsibilities of laboratory researchers. Requiring suitable ethics study for nanotechnology researchers could help ensure that they have a shared notion of the most basic such responsibilities, something that should promote more responsible professional behavior in settings in which pressures to engage or acquiesce in one or another form of misconduct, such as shortcutting that violates published lab safety procedures, can be intense.

Fourth, such education is worthwhile because if nanotechnology practitioners, acting ethically irresponsibly, do or fail to do something that results in significant harm to the public, the natural environment, or public welfare, the contemporary research enterprise of nanotechnology could suffer a funding backlash from the public. This could preclude or delay the realization of important individual and societal benefits and prevent the elimination or mitigation of existing harms.

But even if there are good reasons for providing such education, is it feasible? Some technical professionals deny or doubt that it is, others believe that even if it is, it is not an appropriate subject for researcher education. But such views often stem from the fact that

¹⁹ In the NNIN ethics survey, of the 516 respondents who *somewhat* or *strongly* agreed that significant ethical issues related to nanotechnology exist and who answered the ensuing ‘interest’ item, 61.5% were *quite* or *very* interested in such issues, whereas only 7.8% were *slightly* interested in them and 0.8% were *not at all* interested. Thus among respondents who agreed that significant ethical issues related to nanotechnology exist, there was little indifference to such issues (McGinn [6]: 104–105).

those holding them have deep misconceptions about the teaching of ethics. For example, some technical professionals believe that ‘teaching ethics’ is like teaching religion or engaging in political indoctrination. Others see ‘teaching ethics’ as having the misguided goal of trying to cultivate or create virtuous individuals, something they believe doomed to fail since, as they see it, virtuous behavior is at bottom a matter of character, will, and intent.

In refuting such misconceptions, it should be pointed out that the purpose of non-partisan education about ethical issues related to science and engineering in society is threefold: to alert present and future practitioners in these fields to the full range of harms that irresponsible technical practices, decisions, and actions can cause; to provide tools for thinking systematically, non-superficially, and critically-analytically about ethical issues related to science and engineering; and to eliminate the classic excuse of those previously denied such exposure: that they were unaware that there were important ethical issues in a particular domain of technical practice.

Conclusion

While significant ethical issues related to nanotechnology have been identified, none appears to be qualitatively new in kind. Having examined alleged examples of such issues and assessed arguments that there must be such issues, adoption of a defeasible presumption seems justified: *that the nanotechnology-related ethical issues claimed to be new or unique amount to old ethical wine in new technological bottles.* Moreover, the nanotechnology-related ethical issues identified to date have not been engendered solely or predominantly by intrinsic features of the nanotechnology field. Rather, their genesis is also due to contingent extrinsic features of nanotechnology’s micro-, meso-, and macro-social contexts.²⁰ All known ethical issues related to nano-

technology have roots that are *socio-technical*, not purely technical, in nature. Taken together, the qualitative non-novelty of nanotechnology-related ethical issues and the fact that such issues are engendered by combinations of intrinsically technical and extrinsically social-contextual factors strongly suggest that ‘nanoethics’ does not merit being regarded or treated as a distinctive subfield of applied ethics or as a field in its own right.

In spite of the qualitative non-novelty of ethical issues related to nanotechnology, there are ways in which the nanotechnology field is different, ethically, from other fields of technical inquiry. Two salient differences are institutional support for upstream study of nanotechnology-related ethical issues as part of the nanotechnology research mission, and the emergence in the nanotechnology community of a challenge to the long-established paradigmatic belief that researchers have no ethical responsibilities to society as a whole based on end-uses made of the results of their work. These differences too stem from contingent features of the nanotechnology enterprise’s historical and contemporary social contexts, not solely or predominantly from the field’s intrinsic nature or features.

All things considered, it is preferable to think, write, and speak about ‘ethical issues related to nanotechnology in society’ rather than about ‘nanoethics.’ An important reason why is to counter persistent temptations, posed by use of the expression ‘nanoethics,’ to believe that intrinsic features of nanotechnology phenomena and products alone engender nanotechnology-related ethical issues. Extrinsic contingent features of nanotechnology’s multiple societal contexts, features subject to alteration given sufficient social pressure and suitable educational initiatives, play at least as important a genetic role. Finally, for various reasons, not least to insure that nanotechnology practitioners of diverse national origins understand the general ethical responsibilities of scientists and engineers and the specific ethical responsibilities to which they give rise in contemporary nanotechnology workplaces, nanotechnology practitioners should be required to study the ethical dimension of their work as a part of their formal education.

To reiterate what was stated at the outset: hopefully the questions, arguments, and answers provided above will contribute, if only through identification, elaboration, and

²⁰ The micro-social domain is the everyday work world of the nanotechnology practitioners, *i.e.*, R&D laboratories and manufacturing facilities. The meso-social domain is the domain that encompasses interactions between nanotechnology practitioners from the micro-social domain and representatives of mediating societal institutions and organizations, such as funding and media organizations, and policy-making institutions (executive, legislative, regulatory, and legal). The macro-social domain is the domain of society at large, at either the local, regional, national, or global level.

rectification of their shortcomings, to putting subsequent discussion of specific nanotechnology-in-society-related ethical issues on a firmer footing.

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