Nanotechnology: The Visible and the Invisible

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Science and technology have become geologic phenomena: like grinding tectonic plates, subtle incremental movements over time add up to decisive transformations of our cultural topography. According to many pundits, nanotechnology will be the next manifestation of this process – subterranean changes that will burst upon society with little warning. Or so some believe, with varying degrees of hope and fear. The question is, what type of philosophic questions do we need to ask if we are to prepare ourselves for the next earthquake?

The portentous implications of nanotechnology are cast in high relief by the concerns of 19th and 20th century European or continental philosophy. Thinkers like Nietzsche, Husserl, Heidegger, and Merleau-Ponty comprise a rich and distinctive tradition of thought on nature, human nature, and the limits of our actions. Nonetheless, it is a tradition that is rarely applied to questions surrounding the relation of science and technology to society. While the reasons for this neglect include a willful abstention from policy on the part of such thinkers, the primary cause lies in the continuing societal love affair with positivism: thinking reduced to that which can be quantified, problems defined by what is amenable to the scientific method.

This has meant, generally, the marginalization of philosophy; and when the subject does come up, philosophy is usually limited to applied *ethics*, questions of risks,

responsibilities, rights, and informed consent. But ethics alone cannot capture the significance of scientific discoveries and technological inventions that remake our world. The re-creation of nature or society portended by nanotechnology promises to be a metaphysical and even theological event, touching upon our most basic questions concerning the nature of humanity and reality.

Policy-oriented philosophy has limited its attention to ethics; science, technology, and society studies (STS) has focused upon epistemology and politics. The motif of the laboratory has run through its debates: not only in the sense of asking what *really* happens in the lab (cf. Latour and Woolgar, 1986), but also that much of the work of STS scholars has turned upon the question of the extent to which scientific truth claims can be isolated, lab-like, from social matters (see the science wars). Moreover, STS is heir to a heritage that it itself positivist in orientation. The 19th century roots of the social sciences lie in the belief that the success of the scientific method in understanding the natural world can be duplicated by the application of the scientific method to questions of society. The prevalence of social constructivist attitudes within STS can be seen as the triumph of the 'value' side of the fact/value distinction: if science is not strictly objective, then it must be utterly a matter of personal interpretation.

Of course, one must wary of speaking as if continental philosophy is univocal. Continental philosophy comes in many forms: phenomenology, existentialism, hermeneutics, structuralism and post-structuralism, post-modernism and deconstruction, critical theory, as well as the work of Hegel, Marx, Kierkegaard, and Nietzsche. Indeed, Brian Leiter has claimed that there no is such thing as "continental philosophy"—although this does not stop him from later describing continental philosophy as having been improved by the greater logical rigor of analytic philosophy (see the Introduction to Leiter, 2004). For our purposes, the common message of many species of continental philosophy is the suspicion of the positivist claim that modern science has rendered traditional philosophical concerns otiose. Rather, we are still – and in the case of nanotechnology, again with greater force – condemned to questions of metaphysics

(what is the nature of the self?), aesthetics (what counts as a flourishing life?), and theology (are there more than prudential limits to what we should do?).

Nanotechnology challenges our ideas concerning the nature of the self, the reality of the sensuous world, and our norms concerning the proper limits of our behavior. Reflecting upon these larger and more traditional philosophic concerns in the context of the nanotechnology revolution must become an integral part of public policy.

The Philosophy of Science

Salesmen and consumers are familiar with the technique known as 'bait and switch' where customers are drawn into a store by the promise of a special price on an item, only to discover that the last one has just been sold. The customer is then directed to another, less palatable object for purchase. It is a technique that depends upon our short memory, as well as the inertia that accompanies our actions. Salesmen know that once a process is set in motion it can take on a momentum of its own.

In *The Crisis of the European Sciences*, Edmund Husserl (1970) explores the curious case of bait and switch that underlies the modern scientific project. Science began as an effort to explain the world that surrounds us: a richly imbricated mélange of sounds and colors and tactile experiences. Science has ended up, however, describing an invisible mathematical world disassociated from the one we inhabit. What started as a rigorous application of mathematics to the natural world has ended up substituting a mathematicized world for the one in which we live. As Nietzsche noted, the real world—the world of sun and shade and unrepeatable events—has became a fable, as our lived experience of things was relegated to the shadow realm of the "subjective" (Nietzsche, 1998; see also Foltz, 2000).

Of course, our probing of the invisible world of mathematics has led to very real and very visible consequences. The point of science's account of an underlying reality has not been primarily to describe, but also and preeminently to gain greater control over the

sensuous world in which we live. It has turned out that mathematics and the controlled experiment provide very good ways to control the natural world.

Philosophical examinations of science have never fully taken the measure of the role that control (in both epistemological and political senses) plays in the creation of scientific knowledge. This point has been hidden in part by the fact that the philosophy of science has been overwhelmingly a philosophy of *physics*. The typical scientific training of philosophers of science has been in physics, just as physics has supplied the majority of the problems, examples, and history that have been examined. The philosophy of science has thus been a philosophy of *laboratory* science: there have been next to no analyses of how a field-oriented philosophy of science would differ from accounts of science based upon bench science (Frodeman, 2004). Neither has there been much attention paid to the epistemological challenges of relating laboratory results, the controllable space par excellence, to the uncontrollable and non-repeatable world that they are representations of and that we actually live within. By definition lab results – or computer models, which are a cyber version of the same – exist in a utopian realm outside space and time: conditions controlled, circumstances repeatable.

Moreover, the control that has been gained has been dearly bought. In the process of embracing one invisible world, we have rejected another: the world of meaning, purpose, and *telos*. Aristotle thought that causality – that is, the process by which things are brought into being – necessarily involved purpose, something that was intrinsic to natural objects (*phusis*), and bestowed by humans in the case of artifacts (*techne*). Why, after all, would something exist unless it had a *reason* for existing? Modernity has worked from a different set of premises: for Newton and then Kant, the physical world consisted in blind forces, supplemented by a transcendent (Newton) or unknowable (Kant) deity. It was Darwin who dispensed with any need for a deity, by changing the parameters of the question. All of nature became the result of random variation and natural selection – relegating the question of why there is something rather than nothing to the dark corners of religious fundamentalism. It now became possible to imagine progress without purpose, order without orientation.

Making Nanotechnology Visible

For Husserl the crisis of science was a consequence of the gap between the visible and invisible realms of nature. If he is right about this, we should not be surprised at the suspicion with which the public treats science. The natural sciences, despite and even because of their spectacular results, have left the world of experience as a *terra incognito*, uncharted territory whose contours are now explored by poets, artists, and other culturally marginal figures.

So what of nanotechnology? How will nanotechnology affect this gulf? Nanotechnology represents a new type of invisibility – not mathematical, or electronic, but rather material in nature, the material invisibility of objects beneath the possibility of lived or phenomenal experience. Up to the present, it has been possible to hide cameras; but cameras were in principle visible, existing on the meso scale of human perception. With nanotechnology we will never know when we are under surveillance – or whether we have a GPS chip embedded in our skin or lungs. The possibilities for paranoia are endless. Of course, we have been moving in this direction for quite some time.

Rather than consisting of a particular material or process, the power of nanotechnology turns on smallness in general, and the characteristics and possibilities that result from diminished size. At the nano-scale the physical behavior of matter changes; new material possibilities become attainable, for instance, extraordinary strength and lightness. Our relationship to matter itself is changed as items can be built from the ground up, atom by atom and molecule by molecule. Lost is the brute givenness that had previously characterized our relationship with nature. Certainly, we have long been able to manipulate materials, fashioning carbon or gold into a variety of items. But we had not attempted to refashion carbon itself. Now the prospect exists of changing carbon into gold, or vice versa.

This radical miniaturization also raises possibilities of cyborg existence both more far-reaching and more subtle than any current technology. Biomolecular motors made of

inorganic nickel propellers and powered by an ATPase enzyme already exist, as do nanoparticle carriers able to cross the blood–brain barrier to deliver chemotherapy to treat tumors. It is one thing to wear eyeglasses, have cavities filled with ceramic, and walk with an artificial hip. The very clumsiness of these technologies preserves a discrete sense of what we might call 'natural' human life. But if and when our biochemical processes are constantly monitored for sickness by implants or an infinitesimal army of nanobots, detecting and eliminating ailments such heart disease or cancer before we even become aware of disease, have we not become a new type of entity susceptible to political or corporate manipulations? Under such circumstances the range of our will simultaneously expands and contracts, as do our ethical and social responsibilities. The ancient lottery of good genes and good health is replaced by a new type of arms race where the rich and the savvy enjoy a different type of (post-human?) existence from the rest of us (Fukuyama, 2002).

The larger political challenge of nanotechnology is to find ways to make invisibility visible – if not materially, at least politically, economically, and philosophically. Philosophers and humanists generally have a role to play in helping to enlarge the imagination of scientists, engineers, policy makers, and politicians, through thought experiments, literary productions, and works of art.

Nanotechnology, Metaphysics, and Theology

Not everyone sees nanotechnology as a revolutionary agent. Peter Binks of Nanotechnology Victoria believes that ‘Nanotechnology is just part of the general march of technology and we don't want to see it treated as anything different’ (Salleh, 2004). Many, however, sense that there is something new and uncanny about nanotechnology, a distinctive set of opportunities and dangers that represent something more than technoscientific business as usual.

This sense is grounded in two factors. First, there is an undeniably Promethean element to nanotechnology. Whether or not it eventually works out as advertised, nanotechnology gives us the exhilarating sense that we are seizing our own destiny and engaging in a

stunning new case of world-making. Technoscientific reason seeks to address our needs, wants, and aspirations even to the point of immortality – a point expressed in the title of futurist Ray Kurzweil and Grossman's (2004) screed, *Fantastic Voyage: Live Long Enough to Live Forever*. Second, and parallel to this, is a sense of foreboding. At least on a subconscious level, nanotechnology prompts the cautionary tales related to our pursuit of technology – Jekyll and Hyde, the Sorcerer's Apprentice, Shelley's Frankenstein, and the Tower of Babel – all the way back to the roots of Western culture, where Greek tragedy alerted us to the dangers of hubris.

This foreboding, moreover, has a post-modern spin to it, going beyond the sense that we may be goading the gods. Rather, as Nietzsche's Madman put it, we fear that God is dead – God as the marker of limit, of the proper, and the natural:

> Whither is God? I will tell you. *We have killed him* – you and I. All of us are his murderers. But how did we do this? How could we drink up the sea? Who gave us the sponge to wipe away the entire horizon? What festivals of atonement, what sacred games shall we have to invent? Is not the greatness of this deed too great for us? (Nietzsche 1974, section 125, p. 181)

Nietzsche believed that he had identified both the inescapable fate of humanity – to realize its meaningless, in the sense of any natural, pregiven purpose – and the solution to this conundrum – the Will to Power (or at least, the solution for him). Nietzsche was the first to clearly described the nihilism lying at the heart of the modern technoscientific enterprise: a growing and seemingly infinite range of power, with no discernable direction or purpose. His solution was to encourage us to embrace the radical freedom implied by this situation – to turn life into an aesthetic project where we look for the greatest possible opportunities to express our will.

But Nietzsche also had doubts whether we have the moral insight and constancy of will to match our scientific and technological prowess. He was honest enough to raise what remains one of the most fundamental challenges to his philosophy: that many cannot make sense of a world lacking in larger purpose, without a sense of the natural and pregiven. The 20th century growth of fundamentalist religions worldwide suggests that

for many people the modernist notion of reason that excludes a sense of meaning and purpose remains sorely inadequate. But what Nietzsche passes over is the fact that this response need not be read solely, or even primarily, as a point about human psychology – human weakness in facing up to the nothingness that lies at the heart of existence. Rather, the response can be seen as pointing up the crucial debility of all post-Darwinian accounts of the directionlessness of existence: they cannot account for the bare existence of anything at all.

It may be that Peter Binks is correct, although not in the way that he intended. Nanotechnology forms part of a general trend where our technoscientific prowess has become so great as to transcend science and technology. It is not that nanotechnology isn't potentially as far reaching as advertised; but rather that it is merely the latest example of what is occurring throughout science and technology. Originally posited as the opposite of and the repudiation of metaphysics, science and technology today have become metaphysical events in their own right, raising fundamental questions about what it means to be human and the nature of the good life. Science and technology has become real world experiments in metaphysics and theology.

Nanotechnology and Public Culture

At the October, 2005 meeting of the Society for the Social Studies of Science (4S) in Pasadena, Bruno Latour spoke of the need for a policy turn within the field of science, technology, and society studies. If the previous 25 years of work within STS had focused on fine grain analyses of laboratory life, Latour suggested that the next 25 years should be devoted to examining the policy implications of these insights into the relation of science to society.

Such a policy turn will involve much more than the straightforward application of scholarly insights to practical affairs. The so-called linear hypothesis, the belief that progress in (natural) science automatically equals progress in social good, may now be moribund, as is the old positivist dream that science is uniquely capable of answering political questions. But neither of these points have yet been replaced by a global account

of the relation between knowledge, scientific or otherwise, and decision-making. There is real theoretical work to be done on the relation of natural, social, and humanistic knowledge to decision-making, where we come to a better understanding of the relation between knowledge production and use in the Age of Google.

What tasks, then, lie before us? Given new scientific and technological developments such as nanotechnology, how do we proceed? I suggest the importance of uniting disparate threads that have been marginalized within both the philosophy of science and science studies. This would involve combining a stronger policy orientation to our research with a greater emphasis on the greater philosophic (not merely ethical) dimensions of science and technology. How, for instance, does the US Food and Drug Administration combine scientific findings with ethical, theological, and political views in the approval process concerning RU 486 – without being captured by any of these groups? Recent attempts at combining a policy orientation with traditional philosophic questions have been called humanities policy (Frodeman *et al.*, 2003), knowledge policy (Stehr, 2005), and philosophy of science policy (Frodeman and Mitcham, 2004). But by whatever name, our understanding of science policy stands to gain considerably if it is complemented by the development of a philosophy of knowledge policy.

Within the US, a narrow approach to humanities policy is already present within the National Nanotechnology Initiative. As before in the case of the Human Genome Project, the focus has been upon questions of ethics and epistemology: questions of equity concerning who benefits from advances, or worries about possible environmental damage from nanoparticles. Similarly, in genomics, questions have been raised about the reliability of genetic testing for susceptibilities to various medical conditions, and issues such as privacy, autonomy, and prior and informed consent. There is also a strong proceduralist dimension to questions of values, where it is emphasized that the right result is the one that comes from following the proper procedures: open deliberation, prior and informed consent, and opportunity for dialogue.

These brief remarks have advocated a turn toward a wider policy of knowledge that draws upon long-standing but currently unfashionable philosophic perspectives. Metaphysical and theological topics – by which I mean, again, questions of the nature of the self, our understanding of our place in the world, whether there are or should be any limits to our manipulations, and the like – have been treated as beyond the pale of reasonable discourse by both positivists and fundamentalists. Possible advances in bionanotechnology go to the heart of what it means to be human. What would be the consequences for our sense of self if our bodies become nodes in an information network, monitoring and reporting on our location and condition? How would our sense of personal responsibility and the boundaries between public and private be affected when exhaustive data about the status of our health and our caloric choices become part of a potentially public record?

The Visible and the Invisible

> What we call a visible is...a quality pregnant with a texture, the surface of a depth, a cross section of a massive being … (Merleau-Ponty, 1968, p. 136)

In his working notes to *The Visible and the Invisible*, Maurice Merleau-Ponty explores how what we do not see guides, relates to, or interacts with what we do see. In vision there is a relation between the surface of things and the depths hidden to us. In sketching a face, the artist tries to express what Merleau-Ponty calls 'the surface of a depth'—the inner nature of the individual that finds its expression at the surface (Merleau-Ponty, 1968, 1994). Similarly, a geologist learns to see into the rock, translating the two dimensional surface into three and four dimensions, and visualizing the landscape by rotating, unfolding, or completing it in mental space – geological vision structured or guided by what is not visible. It is then possible to learn to see the visible within the invisible.

Merleau-Ponty reminded us that we are embodied perceivers rather than the passive receptors of *quale*: we probe and palpate the world with our gaze. This probing does more than give us bare information about the world; it also helps us orient ourselves in space both natural and social, helping us to create an *axis mundi* or world axis to guide

our lives. Nanotechnology promises both to recreate our seen world from the bottom up, and to create new worlds of the unseen. In doing so, will it find ways to heal the breach Husserl described, or will it further strip the flesh from the world, attenuating or even breaking the relationship between visible and invisible?

These questions will take much more than a brief essay to address. And in fact, they are today in some fundamental sense unanswerable, in that such questions are dependent upon scientific and technological advances yet to take place. Nonetheless, it is crucial that we ask these questions now and recurrently across the process of developing new technologies. Ethics, values, and the largest philosophic concerns must become part of our conversation from the very conception of new technologies – upstream, rather than after most of the crucial decisions have been made. Otherwise, we simply ensure the continued irrelevance of our attempts at critical reflection upon technoscientific culture.

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