Getting Real: Technoscientific Practices and the Materialization of Reality

[T]he body is . . directly involved in a political field; power relations have an immediate hold upon it; they invest it, mark it, train it, torture it, force it to carry out tasks, to perform ceremonies, to emit signs . . power is not exercised simply as an obligation or prohibition on those who "do not have it"; it invests them, is transmitted by them and through them, it exerts pressure upon them, just as they themselves, in their struggle against it, resist the grip it has on them (Foucault, Discipline *25–27*)

Power is transmitted through the repeated application of pressure on the body. The body reacts to the forces, manifest as shifting material alignments and changes in potential, and becomes not simply the receiver but also the transmitter or local source of the signal or sign that operates through it. It is this responsiveness of the body that makes it the effect and instrument of visualizing technologies.

While Foucault's comments refer to the human body, my subject matter is a piezoelectric crystal. When pressure is applied to opposite faces of a piezoelectric crystal, it emits an electric signal that can be amplified and displayed visually (see Figure 1a). Conversely, piezoelectric crystals undergo deformation in the presence of an electric field. More specifically, if an electric signal is applied to the crystal, it will expand or contract depending upon the polarity of the signal (see Figure 1b). High frequency oscillating signals cause the crystal to vibrate, resulting in the propagation of ultrasonic waves. The piezoelectric effect was first observed by Pierre and Jacques Curie in 1880. Today, the dual

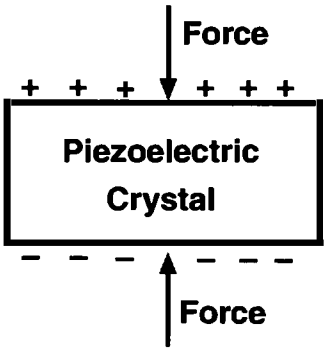

Fig. 1a The piezoelectric effect. A force applied to the opposite faces of the crystal (e.g., from an impinging ultrasonic wave) results in an electrical signal. The signal can be displayed visually. In this capacity, the crystal serves as a receiver.

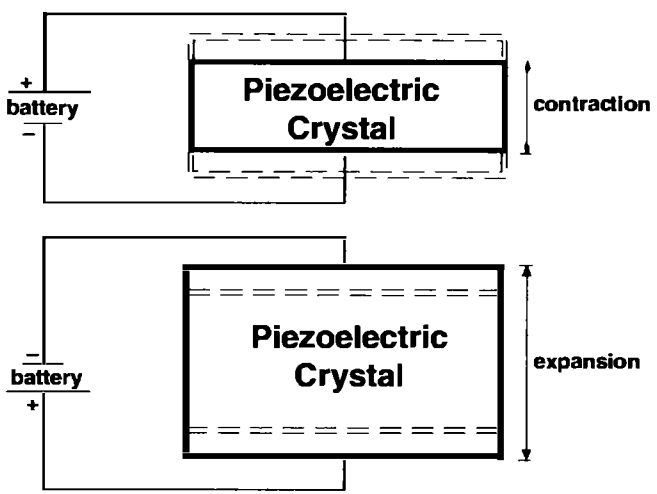

Fig. 1b The reverse piezoelectric effect. Application of an electric signal causes the crystal to contract or expand. High frequency oscillating signals cause the crystal to vibrate at high frequencies, resulting in the propagation of ultrasonic waves. In this capacity, the crystal serves as a transmitter.

functionality of the piezoelectric crystal as both transmitter and receiver make it the key element for a particularly poignant apparatus of observation–that of the transducer for ultrasonography.

In this essay, I will argue that the piezoelectric crystal is a material instrument, the "soul" of an observing apparatus, through which, not simply signals, but discourses (in a Foucaultian sense) operate. Examining the coupling of this instrument to an array of apparatuses, I use the piezoelectric transducer as a tool to examine the question of the relationship between the material and the discursive more generally. This relationship is at the center of a feminist framework I call "agential realism" (Barad "Meeting"). Agential realism is inspired by Niels Bohr's epistemological innovations, which he saw as deriving from his seminal contributions to the development of the field of quantum physics. Bohr's epistemology calls into question several foundationalist assumptions that Western epistemology generally takes as essential to its project; among these are an inherent subject/object distinction and the representational status of language. Agential realism is an epistemological and ontological framework that extends Bohr's insights and takes as its central concerns the nature of materiality, the relationship between the material and the discursive, the nature of "nature" and of "culture" and the relationship between them, the nature of agency, and the effects of boundary, including the nature of exclusions that accompany boundary projects.[1] Agential realism entails a reformulation of both of its terms–"agency" and "realism"–and provides an understanding of the role of human *and* nonhuman factors in the production of knowledge, thereby moving considerations of epistemic practices beyond the traditional realism versus social constructivism debates. Significantly, a more robust understanding of materiality follows from this framework, one that enables feminists and other liberatory theorists to take account of the ways in which "matter comes to matter," including the active role of material constraints and conditions within a theoretical framework that acknowledges poststructuralist and Marxist insights exposing matter's multiple modes of "mediation." My approach in this paper is to read Judith Butler's theory of performativity and the framework of agential realism through one another to provide an expanded understanding of the relationship between the material and the discursive and a richer account of materiality, agency, and the nature of social practices, including technoscientific ones.

The Materialization of Bodies

A text that has become canonical for its engagement with issues of subjectivity and the materiality of the body is Judith Butler's provocative book, *Bodies That Matter: On the Discursive Limits of "Sex."* In this text, Butler offers an account of the subject that acknowledges the important constituting effects of discourse and power, without falling prey to social determinism. And she gives an account of the material nature of the human body without reinstalling the body's materiality as foundational or self-evident. These accounts of the subject and of the body's materiality are brilliantly linked together through her notion of gender performativity.

Butler opens the book with a critique of the notions of construction that circulate in feminist theory and challenges feminists to "return to the notion of matter, not as a site or surface, but as a process" (9):

> *To claim that sex is already gendered, already constructed, is not yet to explain in which way the "materiality" of sex is forcibly produced. What are the constraints by which bodies are materialized as "sexed," and how are we to understand the "matter" of sex, and of bodies more generally, as the repeated and violent circumscription of cultural intelligibility? Which bodies come to matter–and why? (xi–xii)*

Butler's contention that matter should be understood as "a process of materialization that stabilizes over time to produce the effect of boundary, fixity, and surface" (9) is important in its reconsideration of what it could mean to claim that bodies are "socially constructed." However, Butler's notion of materialization is limited in several important ways. In this paper, I examine some of these limitations and suggest an alternative understanding.

A question that goes to the heart of the matter is whether Butler's account of materialization is sufficient to take us beyond the passive/active dualism that her displacement of construction is in part meant to counter. For as the subtitle "On the Discursive Limits of 'Sex'" already hints, while Butler's temporal account of materialization displaces matter as a fixed and permanently bounded entity, its temporality is analyzed only in terms of how *discourse* comes to matter. It fails to

analyze how *matter* comes to matter. What about the "material limits": the material constraints and exclusions, the material dimensions of agency, and the material dimensions of regulatory practices? Doesn't an account of materialization that is attentive only to discursive limits reinscribe this very dualism by implicitly reinstalling materiality in a passive role?

Since the questions I want to raise concern the way matter is incorporated into Butler's account of materialization, I want to carefully distinguish my critique from a host of accusations against Butler that incorrectly accuse her of idealism, linguistic monism, or a neglect or even erasure of "real flesh and blood bodies." It would be a gross misunderstanding of Butler's work to accuse her of collapsing the complex issue of materiality to one of mere discourse, of arguing that bodies are formed from words, or of asserting that the only way to make the world a better place is through resignification. On the contrary, Butler *does* provide us with an insightful and powerful analysis of the *discursive* dimensions of the materialization of real flesh and blood bodies. My charge is that the analysis of materialization that Butler offers leaves out critical components.

The fact that Butler's analysis enacts its own exclusions is not in and of itself a fatal flaw. On the contrary, according to Butler's own treatment of the nature of exclusions, they are not only necessary but productive, particularly in their instability and consequent availability for rearticulation. An obvious question, though, is whether the redrawing of lines, the enactment of new cuts, to counter the passivity of materiality, entails a necessary renunciation of Butler's theory of performativity, or whether an enlarged account of materiality can be offered that can enact a productive appropriation and elaboration of her theory. That is, is the exclusion of particular features of materiality a constitutive constraint of analyzing materiality performatively? It is far from obvious how to take account of material constraints, for example, if materiality itself is the "dissimulated effect of power." Isn't some *fixed* sense of the substantive character of materiality required to think about how materiality constrains processes? And, furthermore, if it has taken this much work to wake us from our ontological illusions, does any reference to material constraints threaten to undercut this achievement?

Technologies of Embodiment

> *Consider the medical interpellation which (the recent emergence of the sonogram notwithstanding) shifts an infant from an "it" to a "she" or a "he," and in that naming, the girl is "girled," brought into the domain of language and kinship through the interpellation of gender. But that "girling" of the girl does not end there; on the contrary, that founding interpellation is reiterated by various authorities and throughout various intervals of time to reinforce or contest this naturalized effect. The naming is at once the setting of a boundary, and also the repeated inculcation of a norm* (Butler, Bodies 7–8)

In the section of *Bodies That Matter* where Butler explains her conception of materialization, she offers this example of the medical interpellation of an infant at birth–or prior to birth of a fetus through the use of ultrasound technology–which initiates the reiterative process of becoming a gendered subject. But is the parenthetic inclusion of gender interpellation through ultrasound technologies really so unremarkable, so insignificant to considerations of (interpellation and ultimately of) materialization, that it requires no further analysis? Can this potential oversight, this off-handed dismissal of significant differences signaled by the phrase "notwithstanding," simply be rectified by adding the appropriate material constraints, or is it possible that the very accounting of discursive constraints may require revision once material constraints are brought into the analysis, that is, once there is a reworking of what is here excluded?

As feminist analyses have made clear, ultrasound technology is a historically and culturally specific practice, involving discursive and material elements, that has differential effects on different bodies and lives. As Alice Adams notes: "Representations of the mother-fetus relationship in medical illustrations must be read as channels of economic as well as informational and ideological exchange" (Adams 128). For example, beyond the obvious economic limitations of differential *access* to such technologies, is the question of differential *impact* for those who do have access, and ultimately for those who do not. Dion Farquhar writes:

> *Recent years have witnessed expanded attempts by some physicians, ethicists, and legal scholars to hold pregnant women liable for causing prenatal harm, to impose criminal or civil sanctions on them after the birth of a sick or disabled infant,*

> *to restrict the behaviors of pregnant women, and to impose medical or surgical procedures . . . forcibly on them, ostensibly in order to prevent fetal harm. These interventions treat the mother as a mere maternal environment relative to a rights-bearing fetus that is analogically compared to a pediatric case. The targeting of poor, relatively disenfranchised pregnant women of color who are drug abusers is clearly a wedge for moralist state regulation of all women's bodies in a symptomatic displacement of social amelioration from one of its principal sources-exacerbated conditions of racialized poverty. (170)*

The material and discursive dimensions of ultrasonography vary in time and in space. The sonogram does not simply map the terrain of the body; it maps geopolitical, economic, and historical factors as well. For example, Teresa Ebert warns that gender interpellation must be understood in terms of the relevant relations of production:

> *This truth is painfully clear if we move beyond the privileged boundaries of the upper-middle class in the industrialized West . . . and see what is happening to "girling" in the international division of labor–especially among the impoverished classes in India. Here the "medical interpellation" . . . of . . . fetuses, particularly through the use of the sonogram, immediately places "girled" fetuses not only in discourse but also in the gender division of labor and unequal access to social resources. About 60 percent of the "girled" fetuses are being immediately aborted or murdered upon birth . . . because the families cannot afford to keep them. The citational acts, rituals, and "performatives" by which individuals are repeatedly "girled" . . . are not simply acts of discourse but economic practices. (360)*

Feminist analyses of scientific and technological developments have made evident that there are material as well as discursive factors that are important to the process of materialization, and while Butler would surely not deny this, her analysis does not give us any insights into how to take account of the material constraints, the material dimensions of agency, and the material dimensions of regulatory practices that make the gender interpellation of the fetus through ultrasound technology different from a situation in which "girling" begins at birth.

Bohr's Epistemological Framework

Representationalism and Newtonian physics have roots in the seventeenth century. The assumption that language is a transparent medium that transmits a homologous picture of reality to the knowing mind finds its parallel in a scientific theory that takes observation to be the benign facilitator of discovery, a transparent and undistorting lens passively gazing at the world. Just as words provide descriptions–representations of reality–observations reveal preexisting properties of an observation-independent reality. In the twentieth century, both the representational or mimetic status of language and the inconsequentiality of the observational process have been called into question.

I turn to the work of physicist Niels Bohr as a place to begin articulating my notion of agential realism. Bohr's search for a coherent interpretation of quantum physics led him to more general epistemological considerations that challenged representationalist assumptions about the nature of scientific inquiry. His early-twentieth-century epistemological investigations focused on issues of contemporary significance: 1) the connections between descriptive concepts and material apparatuses, 2) the inseparability of the "objects of observation" and the "agencies of observation," 3) the emergence and co-constitution of the "objects of observation" and the "agencies of observation" within particular material and conceptual epistemic practices, 4) the interdependence of material and conceptual constraints and exclusions, 5) the material conditions for objective knowledge, and 6) the reformulation of the notion of causality. Reading Bohr's epistemological framework through a feminist lens provides useful insights into the questions at hand.[2]

Bohr's careful analysis of the process of observation led him to conclude that two implicit assumptions needed to support the Newtonian framework and its notion of the transparency of observations were flawed: 1) the assumption that observation-independent objects have well-defined intrinsic properties that are representable as abstract universal concepts, and 2) the assumption that the measurement interactions between the objects and the agencies of observation are continuous and determinable, ensuring that the values of the properties obtained reflect those of the observation-independent objects, as separate from the agencies of observation. In contrast to these Newtonian assumptions, Bohr argued that *theoretical concepts are defined by the circumstances required for their measurement.* It follows from this fact, and the fact that there is an empiri-

cally verifiable discontinuity in measurement interactions, that there is no unambiguous way to differentiate between the "object" and the "agencies of observation." As no inherent cut exists between "object" and "agencies of observation," measured values cannot be attributed to observation-independent objects. In fact, Bohr concluded that observation-independent objects do not possess well-defined inherent properties.[3]

Bohr constructs his post-Newtonian framework on the basis of "quantum wholeness," that is, the lack of an inherent distinction between the "object" and the "agencies of observation." He uses the term "phenomenon," in a very specific sense, to designate particular instances of wholeness: "While, within the scope of classical physics, the interaction between object and apparatus can be neglected or, if necessary, compensated for, in quantum physics *this interaction thus forms an inseparable part of the phenomenon.* Accordingly, the unambiguous account of proper quantum phenomena must, in principle, include a description of all relevant features of the experimental arrangement" (Bohr, *Philosophical Writings* III, 4, emphasis added).

Bohr's insight concerning the intertwining of the conceptual and physical dimensions of measurement processes is central to his epistemological framework. The physical apparatus marks the conceptual subject-object distinction: the physical and conceptual apparatuses form a non-dualistic whole. That is, descriptive concepts obtain their meaning by reference to a particular physical apparatus which in turn marks the placement of a constructed cut between the "object" and the "agencies of observation." For example, instruments with fixed parts are required to understand what we might mean by the concept "position." However, any such apparatus necessarily excludes other concepts, such as "momentum," from having meaning during this set of measurements, since these other variables require an instrument with movable parts for their definition. Physical and conceptual constraints and exclusions are co-constitutive.

Since there is no inherent cut delineating the "object" from the "agencies of observation," the following question emerges: what sense, if any, should we attribute to the notion of observation? Bohr suggests that "by an experiment we simply understand an event about which we are able in an unambiguous way to state the conditions necessary for the reproduction of the phenomena."[4] This is possible on the condition that the experimenter introduces a constructed cut between an "object" and the "agencies of observation."[5] That is, in contrast to the Newtonian world

view, Bohr argues that no inherent distinction preexists the measurement process, that every measurement involves a particular choice of apparatus, providing the conditions necessary to give definition to a particular set of classical variables, at the exclusion of other equally essential variables, and thereby embodying a particular constructed cut delineating the "object" from the "agencies of observation." This particular constructed cut resolves the ambiguities only for a given context; it marks off and is part of a particular instance of wholeness (i.e., the phenomenon).[b]

Especially in his later writings, Bohr insists that quantum mechanical measurements are "objective." Since he also emphasizes the inseparability of objects and agencies of observation, he cannot possibly mean by "objective" that measurements reveal inherent properties of independent objects. But Bohr does not reject objectivity out of hand; he reformulates it. For Bohr, "objectivity" is a matter of "permanent marks–such as a spot on a photographic plate, caused by the impact of an electron–left on the bodies which define the experimental conditions" (Bohr, *Philosophical Writings* III, 3). Objectivity is defined in reference to bodies and, as we have seen, reference must be made to bodies in order for concepts to have meaning. Clearly, Bohr's notion of "objectivity," which is not predicated on an inherent distinction between "objects" and "agencies of observation," stands in stark contrast to a Newtonian sense of "objectivity" as denoting observer-independence.

The question remains: what is the referent of any particular "objective" property? Since there is no inherent distinction between object and apparatus, the property in question cannot be meaningfully attributed to either an abstracted object *or* an abstracted measuring instrument. That is, the measured quantities in a given experiment are not values of properties that belong to an observation-independent object, nor are they purely artifactual values created by the act of measurement (which would belie any sensible meaning of the word "measurement"). My reading is that the measured properties refer to phenomena, remembering that phenomena are physical-conceptual "intra-actions" whose unambiguous account requires "a description of all relevant features of the experimental arrangement." I introduce the neologism *"intra-action"* to signify *the inseparability of "objects" and "agencies of observation"* (in contrast to "interaction," which reinscribes the contested dichotomy).

While Newtonian physics is well-known for its strict determinism, its widely acclaimed ability to predict and retrodict the full set of

physical states of a system for all times, based upon the simultaneous specification of two particular variables at any one instant, Bohr's general epistemological framework proposes a radical revision of such an understanding of causality.[7] He explains that the inseparability of the object from the apparatus "entails . . . the necessity of a final renunciation of the classical ideal of causality and a radical revision of our attitude towards the problem of physical reality" (Bohr, *Philosophical Writings* II, 59–60). While claiming that his analysis forces him to issue a final renunciation of the classical ideal of causality, that is, of strict determinism, Bohr does not presume that this entails overarching disorder, lawlessness, or an outright rejection of the cause and effect relationship. Rather, he suggests that our understanding of the terms of that relationship must be reworked: "the feeling of volition and the demand for causality are equally indispensable elements in the relation between subject and object which forms the core of the problem of knowledge" (Bohr, *Philosophical Writings* I, 117). In short, he rejects both poles of the usual dualist thinking about causality–freedom and determinism–and proposes a third possibility.

Bohr's epistemological framework deviates in an important fashion from classical correspondence or mirroring theories of scientific knowledge. For example, consider the wave-particle duality paradox originating from early-twentieth-century observations conducted by experimenters who reported seemingly contradictory evidence about the nature of light: under certain experimental circumstances, light manifests particle-like properties and under an experimentally incompatible set of circumstances, light manifests wave-like properties. This situation is paradoxical to the classical realist mind-set because the true ontological nature of light is in question: either light is a wave or it is particle, it cannot be both. Bohr resolved the wave-particle duality paradox as follows: "wave" and "particle" are classical descriptive concepts that refer to different mutually exclusive *phenomena*, and not to independent physical objects. He emphasized that this saved quantum theory from inconsistencies since it was impossible to observe particle and wave behaviors simultaneously because mutually exclusive experimental arrangements are required. To put the point in a more modern context, according to Bohr's general epistemological framework, referentiality must be reconceptualized: the referent is not an observation-independent object, but a phenomenon. This shift in referentiality is a

condition for the possibility of objective knowledge. That is, a condition for objective knowledge is that the referent is a phenomenon (and not an observation-independent object).

On Apparatuses

Discipline "makes" individuals; it is the specific technique of a power that regards individuals both as objects and as instruments of its exercise. . . . The exercise of discipline presupposes a mechanism that coerces by means of observation; an apparatus in which the techniques that make it possible to see induce effects of power, and in which, conversely, the means of coercion make those on whom they are applied clearly visible. (Foucault, Discipline *170–71)*

Apparatuses, in Bohr's sense, are not passive observing instruments. On the contrary, they are productive of (and part of) phenomena. However, Bohr leaves the meaning of "apparatus" somewhat ambiguous. He does insist that what constitutes an "apparatus" emerges within specific observational practices. But while focusing on the lack of an inherent distinction between the apparatus and the object, Bohr does not directly address the question of where the apparatus "ends." In a sense, he only establishes the "inside" boundary and not the "outside" one. For example, if a computer interface is hooked up to a given instrument, is the computer part of the apparatus? Is the printer attached to the computer part of the apparatus? Is the paper that is fed into the printer? Is the person who feeds in the paper? How about the person who reads the marks on the paper? How about the community of scientists who judge the significance of the experiment and indicate their support or lack of support for future funding? What precisely constitutes the limits of the apparatus that gives meaning to certain concepts at the exclusion of others?

A central focus in Bohr's discussion of objectivity is the possibility of "unambiguous communication," which can only take place in reference to "bodies which define the experimental conditions" and which embody particular concepts, to the exclusion of others. This seems to indicate Bohr's recognition of the social nature of scientific practices: making meanings involves the interrelationship of complex discursive and material practices. What is needed is an articulation of the notion of apparatuses that acknowledges this complexity.

Theorizing the social and political aspects of practices is a challenge that is taken up by Michel Foucault. Like Bohr, Foucault is interested in the conditions for intelligibility and the productive and

constraining dimension of practices embodied in "apparatuses." Reading Foucault's and Bohr's analyses of apparatuses through one another provides a richer overall account of apparatuses; it extends the domain of Bohr's analysis from the physical-conceptual to the material-discursive more generally; provides a further articulation of Foucault's theory, extending its domain to include the natural sciences and an account of the materialization of nonhuman bodies; and offers an explicit analysis of the inseparability of the apparatus from the objects and the subjects of knowledge practices, and of the co-constitution of material and discursive constraints and exclusions.[8]

In *Discipline and Punish*, Foucault explains that the proliferation of what he variously calls "apparatuses of observation," "apparatuses of production," and "disciplinary apparatuses" are related to the eighteenth-century development of new technologies; of particular noteworthiness is the panopticon as an observing instrument for the new human sciences and its role in the dispersion of power through the shaping and disciplining of docile bodies.[9] Through this technology of examination and individualization, this "political technology of the body," a new "microphysics of power" emerges: power evolves historically from acting as an external force upon the individual to its more contemporary form, in which power is exercised through individual bodies. Disciplinary power orders the body, fixes and constrains movement. Foucault explains that "this technology is diffuse, rarely formulated in continuous, systematic discourse; it is often made up of bits and pieces; it implements a disparate set of tools or methods. In spite of the coherence of its results, it is generally no more than a multiform instrumentation" (Foucault, *Discipline* 26). Disciplinary power is exercised through various apparatuses. It "link[s] them together, extending them and above all making it possible to bring the effects of power to the most minute and distant elements" (216).

Foucault's insights concerning disciplinary practices and the "microphysics of power" have profoundly altered the ways in which power and knowledge are currently theorized. However, a crucial feature of observing practices that seems not to have been appreciated by Foucault is the dynamics of intra-action and the inseparability of observing apparatus and observed. That is, although Foucault insists that the objects (subjects) of knowledge do not preexist but only emerge within discursive practices, he does not explicitly analyze the inseparability of apparatuses and the objects (subjects). In other words, Foucault does not propose an

analog to Bohr's notion of phenomenon or analyze its important consequences. Does this insight of Bohr's contribute anything important to our understanding of material-discursive practices and the "microphysics of power?" While the panopticon may be exemplary of observing technologies in the eighteenth century, ultrasound technology makes for a particularly poignant contemporary apparatus of observation, and it is from this vantage point that I want to examine some of these issues. Significantly, in obstetric ultrasonography, the piezoelectric transducer is a prosthetic device for making and bridging boundaries. And it serves here as well as the interface for the reading of Bohr's and Foucault's insights through one another.[10]

Ultrasonic waves were originally used for sound navigation and ranging (SONAR) in the detection of submarines during World War I. Further developments of SONAR technologies during World War II led to important progress that facilitated its use in the field of medicine. Obstetric applications of ultrasound technology occurred in the late-1950s. By the mid-1960s, obstetric ultrasound gained wide acceptance by the medical community. A decade later ultrasound was regarded as integral to the practice of obstetrics.

It is now common to find fetal ultrasound images immediately preceding pictures of newborns in family photo albums. But neither the production nor the interpretation of ultrasound images are simple matters: both involve highly specialized forms of knowledge. In fact, the frequency of misdiagnosis using ultrasound technology is significant even with physician use, and the medical community is currently debating the possibility of mandatory certification for those using the technology. A textbook in ultrasonography states:

> *Individuals admitted for training . . . should have post-secondary education in the following areas: medical ethics, medical terminology, clinical anatomy and physiology, medical orientations and administration, nursing procedures, general human anatomy, and elementary physics. . . . An ability to improvise the standard procedure when necessary is essential. . . . The ability to deviate from normal techniques when necessary and to develop new and better techniques to keep the department up to date is also the responsibility of the sonographer and the physician. (Hagen-Ansert 618)*

The piezoelectric transducer is, on one account, the machine interface to the body. The transducer is both the source and the receiver of ultrasound waves. When sound waves reflected from different body parts impinge on the transducer, they are converted into electric signals that are visually displayed. A multitude of factors influence the image produced on the screen. Different kinds of tissue have different acoustic impedances; the reflection of the beam varies with the interface geometry, and the differences in impedances between the materials making up an interface. Furthermore, the beam resolution is a function of the frequency and different applications require different transducers. Each piezoelectric transducer has a natural resonant frequency which depends upon the sample thickness and the mounting of the transducer element in the assembly, among other factors. Producing a "good" ultrasound image is not as simple as snapping a picture; neither is reading one.

Employing a Bohrian epistemology makes the limitations of a conception of the piezoelectric transducer as a component of an idealized observing instrument evident: the transducer does not allow us to peer innocently at the fetus, nor does it simply offer constraints on what we can see; rather, it helps produce and is "part of" the body it images. That is, the marks on the computer screen (the sonogram images) refer to a phenomenon that is constituted in the intra-action of the apparatus and the object (commonly referred to as the "fetus"). The objective referent for the properties that are observed is the phenomenon, *not* the object of this knowledge practice. (It could prove quite useful to contest and interrogate the common usage of the term "fetus" to refer to the object being imaged since this is not the objective referent. Which referent is assigned particular attributes matters for political and scientific reasons, for epistemology as well as ontology. Mistaking the object of observation for the objective referent can be used to certain political advantages which may then have consequences for how scientific practices, among others, are reiterated. What if the term "fetus" is resignified to refer to the phenomenon in question?)

However, to understand the complex nature of the phenomenon in question it is necessary to understand the nature of apparatuses and the processes by which they are produced. It would be wrong, for example, to equate the apparatus with the transducer and to conceive of the transducer as some preformed object that sits atop a shelf and is available to whomever whenever it is needed. Apparatuses are not preexisting or fixed entities; they are themselves constituted through

particular practices that are perpetually open to rearrangements, rearticulations, and other reworkings. This is part of the creativity and difficulty of doing science: getting the instrumentation to work in a particular way for a particular purpose (which is always open to the possibility of being changed during the experiment as different insights are gained).[11] Furthermore, any particular apparatus is always in the process of intra-acting with other apparatuses, and the enfolding of phenomena (which may be traded across space, time, and subcultures only to find themselves differently materializing) into subsequent iterations of particular situated practices constitute important shifts in the particular apparatus in question and therefore in the nature of the intra-actions that result in the production of new phenomena, and so on.[12] Which shifts actually occur matter for epistemological as well as ontological reasons. We are responsible for the world within which we live not because it is an arbitrary construction of our choosing, but because it is sedimented out of particular practices that we have a role in shaping (see "On Agency and Causality" below).[13] The materialization of an apparatus is an open (but non-arbitrary) temporal process: apparatuses do not simply change in time, they materialize through time. *Apparatuses are themselves material-discursive phenomena, materializing in intra-action with other material-discursive apparatuses.*[14]

For example, piezoelectric transducers materialize (and are iteratively rematerialized) in intra-action with a multitude of practices, including those that involve: medical needs; design constraints (including legal, economic, biomedical, physics and engineering ones); market factors; political issues; other R&D projects using similar materials; the educational background of the engineers and scientists designing the crystals and the workplace environment of the engineering firm or lab; particular hospital or clinic environments where the technology is used; receptivity of the medical community and the patient community to the technology; legal, economic, cultural, religious, political, and spatial constraints on its uses; positioning of patients during examination; and the nature of training of technicians and physicians who use the technology.[15] Hence, the production and reproduction of the technology involves particular disciplinary practices that Foucault specifically mentions such as those involving legal, educational, hospital, medical, architectural, military, industrial, and state apparatuses. The surveillance of technicians, physicians, engineers, and scientists in their formation as particular kinds of subjects is implicated in the surveillance of the fetus and vice

versa. In obstetric ultrasonography, the piezoelectric transducer is the interface between the objectification of the fetus and subjectivation of the technician/physician/engineer/scientist.[16]

Obstetric ultrasonography is not a singular practice, but a range of different local practices involving a myriad of material configurations and discursive formations. For Foucault, apparatuses of observation are material arrangements that instantiate particular discourses, where "discourses" are not merely "groups of signs" but "practices that systematically form the objects of which they speak" (*Archeology* 49). As we have seen, Bohr's insistence on the indissociability of materiality and intelligibility is central to his epistemological analysis.[17] Using Foucault's theoretically sophisticated notion of discursivity to further articulate Bohr's framework seems particularly apt.

On the other hand, Foucault's notion of materiality is not sufficiently developed to carry through this elaboration. While Foucault analyzes the materialization of human bodies, he seems to take nonhuman bodies as naturally given objects.[18] That is, Foucault does not treat the materiality of human bodies on an equal par with the materiality of nonhuman bodies (nor does he concern himself with boundary drawing practices through which the division between "human" and "nonhuman" is constituted). The mechanism of materialization offered by Foucault operates through the "soul," which he then reads as a "certain technology of power over the body" (*Discipline* 29). In the next section, I will offer a more general account of materiality and materialization, rounding out the extension of Bohr's analysis from the physical-conceptual to the material-discursive.

On Materiality and Ontology

While talk about the "real" on the precipice of the twenty-first century may be the source of such discomfort that it always needs to be toned-down, softened by the requisite quotation marks, I believe that "we" cannot afford to not talk about "it." Positivism's death warrant has many signatories, but its anti-metaphysics legacy lives on even in the heart of its detractors. However strong one's dislike of metaphysics, it cannot be banished, and so it is ignored at one's peril. How *reality* is understood matters. There are risks entailed in putting forward an ontology: making metaphysical assumptions explicit exposes the exclusions upon which any given conception of reality is based. Yet, the political

potential of deconstructive analysis lies not in the simple recognition of the inevitability of exclusions, but in insisting upon accountability for the particular exclusions that are enacted and in taking up the responsibility to perpetually contest and rework the boundaries. In this section, I propose an understanding of reality that takes account of both the exclusions upon which it depends and its openness to future reworkings. I call this ontology *agential reality*.

Bohr's attitude towards the relationship between language and reality is exemplified by the following remark:

> *Traditional philosophy has accustomed us to regard language as something secondary, and reality as something primary. Bohr considered this attitude toward the relation between language and reality inappropriate. When one said to him that it cannot be language which is fundamental, but that it must be reality which, so to speak, lies beneath language, and of which language is a picture, he would reply "We are suspended in language in such a way that we cannot say what is up and what is down. The word 'reality' is also a word, a word which we must learn to use correctly." (Petersen 302)*[19]

Unfortunately, Bohr is not explicit about how he thinks we should use the word "reality." I have argued elsewhere that a consistent Bohrian ontology takes phenomena to be constitutive of reality (Barad "Meeting"). Reality is not composed of things-in-themselves or things-behind-phenomena, but things-in-phenomena. Because phenomena constitute a non-dualistic whole, it makes no sense to talk about independently existing things as somehow behind or as the causes of phenomena.

The ontology I propose does not posit some fixed notion of being that is prior to signification (as the classical realist assumes), but neither is being completely inaccessible to language (as in Kantian transcendentalism), nor completely of language (as in linguistic monism). That reality within which we intra-act–what I term *agential reality*–is made up of material-discursive phenomena. Agential reality is not a fixed ontology that is independent of human practices, but is continually reconstituted through our material-discursive intra-actions.

Shifting our understanding of the ontologically real from that "which stands outside the sphere of cultural influence and historical change" (Fuss 3) to agential reality allows a new formulation of realism (and truth) that is not premised on the representational nature of knowl-

edge. If our descriptive characterizations do not refer to properties of abstract objects or observation-independent beings, but rather through their material instantiation in particular practices contribute to the production of agential reality, then what is being described by our theories is not nature itself, but our participation *within* nature. That is, realism is reformulated in terms of the goal of providing accurate descriptions of agential reality–that reality within which we intra-act and have our being–rather than some imagined and idealized human-independent reality. I use the label *agential realism* for both the new form of realism and the larger epistemological and ontological framework that I propose.[20]

According to agential realism, reality is sedimented out of the process of making the world intelligible through certain practices and not others. Therefore, we are not only responsible for the knowledge that we seek, but, in part, for what exists. Phenomena are produced through complex intra-actions of multiple material-discursive apparatuses of bodily production.[21] Material-discursive apparatuses are themselves phenomena made up of specific intra-actions of humans and nonhumans, where the differential constitution of "human" (or "nonhuman") itself designates a particular phenomenon, and what gets defined as a "subject" (or "object") and what gets defined as an "apparatus" is intra-actively constituted within specific practices.

If technoscientific practices play a role in producing the very phenomena they set out to describe, might not this process be understood in a performative sense? Does the framework of agential realism provide a way for us to understand the materialization of bodies in terms of the intra-active production of phenomena? And if so, doesn't this imply that material constraints and exclusions and the material dimension of regulatory practices are important to the process of materialization, that performativity must be understood as not simply an issue of how discourse comes to matter but also of how matter comes to matter?

Several challenges arise in exploring the possibility of understanding technoscientific practices in terms of Butler's theory of performativity. Perhaps the most immediate question is whether Butler's notion of materialization is robust enough to extend her theory to considerations beyond the realm of the human body. Questions have already been raised by feminists as to whether Butler's notion of materialization is robust enough for its own purposes: Does it adequately account for the processes by which human bodies materialize as sexed? What insights might be gained from science and science studies that could be produc-

tively appropriated in the further articulation of feminist theories? Could a physicist's understanding of matter and scientific practices usefully intervene in feminist reconceptualizations of materiality so that it becomes possible to understand not only how bodily contours are constituted through psychic processes, but how even the very atoms that make up the biological body come to matter, and more generally how matter makes itself felt? Is it possible that such a revised account of performativity could lead us to a realist understanding of the materialization of bodies, one that takes full account of materiality and yet does not reinstall it as a site, or a surface, or a natural uncontested ground or bedrock for feminist theory?

Reading agential realism and Butler's theory of performativity through one another is not about some proclaimed symmetry between subject and object, or social and scientific practices, but rather about the production of mutually informative insights that might be useful in producing an enriched understanding of materiality, agency, and the nature of technoscientific and other social processes.[22] Ultimately, I argue that the agential realist reconceptualizations of agency, causality, and materiality that I offer suggest a reworking of Butler's notion of performativity from iterative citationality to iterative intra-activity. I begin with a brief review of some key claims of agential realism.

In the previous section, I argued that apparatuses are temporally (re)produced in intra-action with other apparatuses–that apparatuses are themselves material-discursive phenomena. Since material-discursive apparatuses intra-actively produce material-discursive phenomena, the temporality of apparatuses is implicated (with)in an ever changing agential reality. Phenomena are the effects of power-knowledge systems, of boundary drawing projects that make some identities/attributes intelligible, to the exclusion of others. The identities or attributes that are measured as part of knowledge projects do not represent inherent properties of subjects or objects. "Subjects" and "objects" do not preexist as such, but are constituted through and within particular practices. The objective referents for identities or attributes are the phenomena constituted through the intra-action of multiple regulatory apparatuses. Phenomena are inseparable from their apparatuses of bodily production. Hence, according to agential realism, materialization is understood in terms of the dynamics of intra-activity.

Butler's statement that at stake in her reformulation of the materiality of bodies is "the recasting of the matter of bodies as the effect

of a dynamic of power, such that the matter of bodies will be indissociable from the regulatory norms that govern their materialization and the signification of those material effects" (*Bodies* 2) might be read as a statement that bodies are material-discursive phenomena that materialize in intra-action with, and are inseparable from, particular apparatuses of bodily production, that is, particular practices through which they become intelligible. However, although both Butler's theory of performativity and the framework of agential realism retheorize materiality as a process of materialization, Butler's account of materiality is limited in significant ways, raising a series of pressing questions. Granting, for the moment, an account of the nature of the human body such that, through the mechanism of psychic identification, it remains perpetually vulnerable to the workings of social norms, how can we account for the ability of these norms to materialize the human body? That is, what is it about the material nature of regulatory practices, and of human bodies, that enables discourse to work its productive material effects on bodies? If regulatory practices are understood to have a material dimension, how is that materiality theorized? Is the materiality of regulatory apparatuses different somehow from the materiality of the human body? What is the relationship between materiality and discourse such that regulatory apparatuses are susceptible to being reworked through resignifications as well as through material rearrangements? Can the framework of agential realism help to resolve some of these issues?[23]

Perhaps the most crucial limitation of Butler's theory of materiality is that it is limited to an account of the materialization of human bodies, or more accurately, to the construction of the surface of the human body (which most certainly is not all there is to human bodies). The importance of this contribution should not be underestimated. Understanding the psychic dimension of regulatory practices is a crucial component of understanding how bodies come to matter and how the process of their materialization enables critical interventions into that very process which reworks the terms of exclusion and production.

In contrast to Butler's more singular focus on the human body, the framework of agential realism does not limit its reassessment of the matter of bodies to the realm of the human. In fact, it calls for a critical examination of the practices by which the differential boundaries of the human and the nonhuman are drawn, for these very same practices are always already implicated in particular materializations.[24] If the retheoretization of matter as a process of materialization applies to bodies

in general (which in practice[s] are often constituted through a set of mutually exclusive categories as human bodies, nonhuman animate bodies, and inanimate material bodies [objects], significantly excluding cyborg bodies), then it becomes possible to provide a richer, more complete, and more complex understanding of the nature of regulatory (power/knowledge) practices and their participatory role in the production of bodies. To put it bluntly, if not crudely, the material dimension of regulatory apparatuses, which is indissociable from its discursive dimension, is to be understood in terms of the materiality of phenomena. Apparatuses have a physical presence or an ontological there-ness as phenomena in the process of becoming; there is no fixed metaphysical outside. This framework provides a way to understand both the temporality of regulatory practices and their effectiveness (and lack thereof) in intra-actively producing particular bodies, that also have a physical presence. In essence, agential realism theorizes the material dimension of regulatory apparatuses in terms of the materiality of phenomena; it thereby provides an account of regulatory practices and their causal (but nondeterministic) materializing effects in the intra-active production of material-discursive bodies. Hence, materialization is not only a matter of how discourse comes to matter but how matter comes to matter. Or to put it more precisely, *materialization is an iteratively intra-active process whereby material-discursive bodies are sedimented out of the intra-action of multiple material-discursive apparatuses through which these phenomena (bodies) become intelligible.*

Speech acts can be understood as a special case of this more general account. There is a difference between the material instantiation of language in bodily gestures, or in sound waves propagating through the air, or in measuring devices: matter matters and so the nature of the specific embodiment matters. But what is true in any case, as a result of the indeterminant nature of intra-actions, is that, the efficaciousness of particular actions, whether speech acts or acts of another kind, is not guaranteed. Saying something is so does not make it so.[25] Making and using particular instruments in a lab does not produce whatever results are desired. Agential realism circumvents the problem of different materialities: there is no need to postulate different materialities (i.e., materialities that are inherently of different kinds), and so there is no mystery about how the materiality of language could possibly affect (through whatever mechanism and to any degree whatsoever) the materiality of the body. According to agential realism, the causal linkage

between the materiality of language and the materiality of the body is theorized in terms of the intra-action of specific material-discursive apparatuses.

The power of refiguring materiality as materialization is diluted if we limit its role to be merely an effect of the reiterative power of discourses or as a mere support for language. The new ontology offered here also makes it possible to take account of the material dimensions of constraints and exclusions without presuming matter to be a fixed ground existing outside of time, history, or culture. For example, theorizing materiality in a way that does not presume a fixed *a priori* ontological difference between animate and inanimate matter provides a framework for understanding the co-constitution and intra-action of humans within their human and nonhuman environment, and the materialization of the volume of the body in relation to its surface.[26] *Reference to the material constraints and exclusions and the material dimensions of power is possible within the framework of agential realism because "materiality" refers to* agential reality, *which is explicitly not nature-outside-of-culture.* Any attempt to reinstate materiality as natural would be exposed as being quite bizarre, since this would be to assign materiality to a place outside of the real (i.e., it would be to lose track of the objective referent).

Agential realism offers an expanded understanding of the matter of bodies, showing how it is possible to incorporate material constraints and exclusions in a way that simultaneously recognizes matter as a process of materialization. Taking full account of the nature of constraints and exclusions is important for understanding the materialization of bodies as well as the nature of abjection. Since the material and the discursive are intertwined in apparatuses of bodily production, material and discursive constraints operate through one another (the same is true for exclusions), and hence a full consideration of the limits to materialization needs to include an analysis of both dimensions in their relationship to one another, that is, as material-discursive constraints (exclusions).

For example, according to agential realism, in spite of its origins in SONAR technology developed during WWI, ultrasonography is not an idealized surveillance technology, a merely physical instrument that provides a view of the fetus as it exists independently of observational apparatuses. Rather, ultrasound technology designates specific material-discursive practices, limiting what is seen and produced in accordance with its own iteratively intra-active technoscientific, medical, economic, political, biological, and cultural, etc. development as an ever changing

phenomenon, and by its related and particular usages as a material-discursive apparatus of bodily production in intra-action with other historically and culturally specific apparatuses. So, for example, technological improvements in fetal imaging, particularly increased resolution, magnification, and real-time images encourage the patient and the practitioner to focus exclusively on the fetus whose moving image fills the entire screen. Such material rearrangements both facilitate and are in part conditioned by political discourses insisting on the autonomy and subjectivity of the fetus.[27] This has been accompanied by the objectification of the pregnant woman and the exclusion of her subjectivity. Material-discursive constraints and exclusions are inseparable–a fact that we cannot afford to ignore.

On Agency and Causality

As soon as I got hooked up to the monitor, all everyone did was stare at it. The nurses didn't even look at me any more when they came into the room–they went straight to the monitor. I got the weirdest feeling that it was having the baby, not me. (qtd. in Layne 38, emphasis added)

Situated knowledges require that the object of knowledge be pictured as an actor and agent, not a screen or a ground or a resource, never finally as slave to the master that closes off the dialectic in his unique agency and authorship of "objective" knowledge. The point is paradigmatically clear in critical approaches to the social and human sciences, where the agency of people studied itself transforms the entire project of producing social theory. Indeed, coming to terms with the agency of the "objects" studied is the only way to avoid gross error and false knowledge of many kinds in these sciences. But the same point must apply to the other knowledge projects called sciences. . . . The world neither speaks itself nor disappears in favour of a master decoder. The codes of the world are not still, waiting only to be read. . . . Acknowledging the agency of the world in knowledge makes room for some unsettling possibilities, including a sense of the world's independent sense of humour. Such a sense of humour is not comfortable for humanists and others committed to the world as a resource. (Haraway, Simians *198–99)*

. . . nonhuman agency deflects attention from human accountability to other entities, whether human, nonhuman, cyborg, or what/whomever. (Casper 853)

Foucault's theory of power is not deterministic. The subject is not determined by power relations; rather, subject formation may involve conflict, struggles, and local act of resistance. How are such resistances possible? Butler takes up this question by examining how causality figures in Foucault's microphysics of power and she then offers her own account

of agency based on her theory of performativity. I begin this section with a review of Butler's analysis of Foucault's notion of causality and her account of agency. I then address the question of causality from the perspective of agential realism and examine the implications for an enlarged account of agency (including nonhuman, cyborgian forms, and material rearrangements).

If, according to Foucault, power is not simply constraining but also productive, if it does not act as an external force on a subject but rather operates through the very constitution of the subject, then how is to possible to even begin to address the issue of determinism? And yet this issue is of great significance, for what is at stake in the notion of causality is both the question of agency and the meaning of construction.[28]

Butler understands materialization "in relation to the productive and . . . materializing effects of regulatory power in the Foucaultian sense" (*Bodies* 9–10). In fact, she takes the materialization of the body to be coextensive with the body's investiture with power relations. Butler sees this understanding of the materialization of the body, through the productive workings of power, as an occasion for rethinking causality. Hence, when she writes that "'[m]ateriality' designates a certain effect of power" (*Bodies* 34), she cautions that:

> *[t]his is not to make "materiality" into the effect of a "discourse" which is its cause; rather, it is to displace the causal relation through a reworking of the notion of "effect." . . . The production of material effects is the formative or constitutive workings of power, a production that cannot be construed as a unilateral movement from cause to effect.* (Bodies *251*)

In a performative context, the subject cannot be presumed to be the site of agency since the subject does not have "some stable existence prior to the cultural field that it negotiates" (Butler, *Gender* 142). Rather, it is the reiterative character of performativity that opens up the possibility of agency: "That this reiteration is necessary is a sign that materialization is never quite complete, that bodies never quite comply with the norms by which their materialization is impelled" (Butler, *Bodies* 2). Butler explains that the juncture of contradictory discursive demands on the subject prevents the subject from following them in strict obedience. "It is the space of this ambivalence which opens up the possibility of a reworking of the very terms by which subjectivation proceeds–and fails

to proceed" (*Bodies* 124). Hence, although norms are compulsory, this does not make them entirely efficacious, and the fact that the norm is never finally embodied, but is always part of a citational chain, presents an opportunity for a subversive resignification of the norm.

How are the issues of causality and agency formulated in the context of agential realism? Bohr insists that his analysis shows that causality is neither a matter of strict determinism nor unconstrained freedom. The exclusions that are necessarily associated with the enactment of any particular boundaries between "subject" and "object" foreclose the possibility of determinism. In a sense then, these exclusions provide the conditions for the possibilities of opening up the future. Material-discursive apparatuses offer constraints on what is produced, but they also always produce particular exclusions. Therefore, intra-actions are constraining but not determining. The notion of intra-actions reformulates the traditional notion of causality and opens up a space for material-discursive forms of agency. Hence, according to agential realism, the possibility of agency does not require a "clash" of apparatuses (i.e., a set of contradictory cultural demands); even when apparatuses are primarily reinforcing, agency is not foreclosed.

Agency is a matter of intra-acting; it is an enactment, not something that someone or something has. Agency cannot be designated as an attribute of "subjects" or "objects" (as they do not pre-exist as such). Agency is a matter of making iterative changes to particular practices through the dynamics of intra-activity and the mechanism of enfolding. Agency is about the possibilities and accountability entailed in refiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices.[29]

What about the possibility of nonhuman forms of agency?[30] From a humanist perspective the question of nonhuman agency may seem a bit queer, since agency is generally associated with issues of subjectivity and intentionality. However, if agency is understood as an enactment and not something someone has, then it seems not only appropriate but important to consider nonhuman and cyborgian forms of agency as well as human ones. This is perhaps most evident in consideration of fields such as science, where the "subject" matter is often "nonhuman." For as surely as social factors play a role in scientific knowledge construction (they are not the sole determinant–things don't just come out any way we'd like them to be) there is a sense in which "the world kicks back."

In a special issue of the journal *American Behavioral Scientist*, devoted to the "Humans and Others: The Concept of 'Agency' and Its Attribution," Monica Casper offers a politically astute critique of the debates on nonhuman agency within science studies.[31] She argues, for example, that they have failed to consider how the very notion of nonhuman agency is premised on "a dichotomous ontological positioning in which [nonhuman] is opposed to human" (840). She points out that these approaches to nonhuman agency exclude a crucial factor from analysis since "the *attribution* of human and nonhuman to heterogeneous entities" is always already the consequence of particular political practices. Casper demonstrates the kinds of political assumptions that can lie hidden in accounts that begin with a pre-formed human/nonhuman dichotomy by using her research on experimental fetal surgery to examine the construction of the "human" through particular technoscientific practices.

Casper argues that "a major way in which fetal personhood is accomplished . . . is via constructions of the fetus as a patient":

> *Through a range of practices within the domain of experimental fetal surgery, the fetus is constructed as a potential person with human qualities. In weekly fetal-treatment meetings, for example, fetuses are routinely referred to as "the kid," "the baby," and "he" - all quite human (and gendered) attributions. This process is aided by the use of diagnostic ultrasound which provides "baby pictures of fetuses still in their mothers' wombs" (Petchesky 1987; Stabile 1992). These images are used in fetal treatment meetings during case presentations and are referred to in humanistic terms. (843)*

She warns that "constructions of active fetal agency may render pregnant women invisible as human actors and reduce them to technomaternal environments for fetal patients" (844). Ultimately, Casper draws the line in a seemingly ad hoc fashion: "I want historically 'nonhuman' people and animals to have agency (and I must admit I worry less about machines in this regard), but I do not necessarily want fetuses to have agency" (852). She justifies this move as follows: "My refusal to grant agency to fetuses, while simultaneously recognizing it in pregnant women and in my cats, is about taking sides. My politics . . . are about figuring out to whom and what in the world I am accountable" (853).

I strongly agree with Casper that it would be a mistake to foreclose the drawing of boundaries between the "human" and the "nonhuman" from critical analysis. But I am not so sanguine about the implicit universality of the boundary that she draws in her articulation of who/what gets to be an agent. Furthermore, Casper seems to imply that one is only accountable to that which one takes to be an agent. In light of this particular association of agency and accountability, what does it mean to forever exclude the consideration of fetal agency? Isn't it possible that in certain circumstances there may be a need to strategically invoke fetal agency to counter the material effects of sexism or other forms of oppression? For example, what are the implications of this exclusion in the case where "girled" fetuses in India are "aborted or murdered upon birth . . . because the families cannot afford to keep them" (Ebert 360)? The intensification of global neocolonialism, and the asymmetrical exclusions and constraints (such as those governed by asymmetrical labor, fiscal, technological, and information flows) that accompany it, require ever more vigilance concerning questions of accountability, not less. The advanced foreclosure of agency may impair, or even completely occlude, the analysis of accountability that is so vitally important. The attribution and exclusion of agency–like the attributions and exclusions involved in the construction of the human–is a political issue.

Is the attribution of agency to the fetus a universal culprit? Where would particular kinds of feminist interventions, such as midwifery as an alternative to (over)medicalized birthing practices, be without acknowledging the fact that the fetus "kicks back?" I suggest that the critical issue lies not in the attribution of agency to the fetus in and of itself, but in the framing of the referent of the attribution (and ultimately in the framing of agency as a localizable attribution). As a starting point I consider the following question: who or what is this "fetus" to which agency is being attributed?

The construction of the "fetus" as a self-contained free-floating object under the watchful eye of scientific and medical surveillance is tied to its construction as a subject under the law and the myth of objectivism whereby the scientist is conceptualized as "authorized ventriloquist for the object world" (Haraway, *Modest Witness* 24). Absent from this picture is the pregnant woman and accountability for the intra-actions of particular medical, scientific, and legal practices (including the construction of the "object of investigation," its connection to the legal construction of the fetus as a "subject," the exclusions enacted by the construction, and the

epistemological, ontological, and ethical consequences). That is, while Casper argues that the reduction of pregnant women to technomaternal environments for fetal patients is a consequence of constructing the fetus as an active agent, I am arguing that this reduction is tied to the specific constitution of "objects" and "subjects" in the intra-action of specific apparatuses of bodily production and not to fetal agency *per se*. In other words, I am calling into question the presumed alignment of agency and subjectivity and insisting that it is the latter and not the former that has played such a crucial role in abortion debates in this country since the 1980s. The "fetus" ought to be positioned in relation to its objective referent, that is, in relation to agential reality.

From the perspective of agential realism, the fetus is not a pre existing object of investigation with inherent properties. Rather, "fetus" designates an element of agential reality, a phenomenon that is constituted and reconstituted out of the historically and culturally situated iterative intra-actions of material-discursive apparatuses of bodily production. The fetus as a phenomenon "includes" those apparatuses/phenomena out of which it is constituted: in particular, it includes the pregnant woman (her uterus, placenta, amniotic fluid, hormones, blood supply, nutrients, emotions, sounds, etc. and her surroundings, and intra-actions within it).[34] The "object of investigation" is constructed through particular boundary articulations involving particular material-discursive constraints in the construction of the apparatuses themselves. Hence, it is not a given that the "object" is a self-contained, free-floating body located inside a technomaternal environment; rather, this identification is the result of particular historically and culturally specific intra-actions of material-discursive apparatuses. For example, the racialized and classed construction of an "epidemic of infertility," which "contrary to its popular presentation as a problem that overwhelmingly afflicts white, affluent, highly educated women, is actually [a problem that is] higher among the nonwhite and poorly educated," has served as justification for the expanded development of a range of new reproductive technologies for the production of white babies. Simultaneously, it has deflected attention from accountability for environmental racism, which is thought to be responsible for the existing racial asymmetry in the actual statistics (Hartouni 45). In this instance, the new reproductive technologies work to reproduce the fetus and particular race relations marking more women's bodies than just the particular ones that serve as "maternal environments."

Recall how agency and accountability are tied together. According to agential realism, agency cannot be designated as an attribute of "subjects" or "objects," but rather are constituted within specific practices. Furthermore, apparatuses are not mere physical instruments that are separable from the objects of observation. Rather, apparatuses must be understood as phenomena made up of specific intra-actions of humans and nonhumans, where the differential constitution of "human" (as with other forms) itself designates an emergent and ever-changing phenomenon. Agency is about the possibilities and accountability entailed in refiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices.

The fact that the fetus "kicks back," that there are fetal enactments, does not entail the concession of fetal subjectivity. Recall that the fetus is a complex material-discursive phenomenon that includes the pregnant woman in particular, in intra-action with other "apparatuses." And fetal enactments include the iterative intra-activity between the pregnant woman and her fetus. This formulation exposes the recently intensified discourse of hyper-maternal responsibility as a displacement of the real questions of accountability onto the pregnant woman who is actively constructed as a "mother" bearing full responsibility, and the full burden of accountability, for fetal well-being, including biological and social factors that may be beyond her control.[33] The real questions of accountability include: accountability for the consequences of the construction of fetal subjectivity which emerges out of particular material-discursive practices, accountability for the consequences of inadequate health care and nutrition apparatuses in their differential affect on particular pregnant women, accountability for the consequences of global neocolonialism including the uneven distribution of wealth and poverty, etc.

There are different possibilities for reworking the material-discursive apparatuses of bodily production including acts of subversion, resistance, opposition, and revolution. These reworkings will depend upon human, nonhuman, and cyborgian forms of agency. Learning how to intra-act responsibly within the world means understanding that we are not the only active beings–though this is never justification for deflecting that responsibility onto other entities. The acknowledgment of nonhuman agency does not lessen human accountability; on the contrary,

it means that accountability requires that much more attentiveness to existing power asymmetries.

Acts of subversion, for example, include, but are not limited to, changes in practices enacted by enfolding the material instantiation of subversive resignifications. Other possibilities include direct changes in the material conditions of people's lives. In all cases, we must of course be attentive to the intertwining of material and discursive constraints. In an article entitled, "Gynogenesis: A Lesbian Appropriation of Reproductive Technologies," Elizabeth Sourbut explores the subversive potential of new reproductive technologies. The subversive potential of gynogenesis, in which the genetic material from one egg is added to a second egg to create an embryo from two female parents, exploits "the contradiction between the 'unnaturalness' of test-tube conception, and the supposed 'naturalness' of the [patriarchal, heteronormative] institutions these techniques are meant to perpetuate" (Franklin 226). To date, none of the (mouse) gynogenones have developed to term. It appears that this is due to some "gene imprinting" mechanism which is not yet understood: that is, all the necessary genes are there, they just have to be "turned on and off" at appropriate times. Gene imprinting is the name that geneticists have assigned to this form of nonhuman agency. This is not to suggest that this naming and this assignment are simply descriptive; on the contrary, they must be understood performatively. Future technoscientific intra-actions leading to the successful development of gynogenones will depend upon understanding the nature of this form of nonhuman agency and how it changes in intra-action with agential shifts in the material-discursive apparatuses of bodily production; intra-acting responsibly in the world will require thinking critically about the boundaries, constraints, and exclusions that operate through particular material-discursive apparatuses intra-acting with other important apparatuses.

While gynogenesis has not yet been realized, the new reproductive technologies have already been enlisted for purposes other than those to which they were intended. "There are lesbian couples in the United States where one partner is implanted with an embryo created by her lover's ovum and donor sperm. That partner, technically a surrogate, then gets to give birth to her lover's baby" (Martin 358).[34]

Needless to say, while subversive acts play on the instability of hegemonic apparatuses, they–like the hegemonic attempts to contain contradictions and add stability to the apparatuses–include reinforcing

and destabilizing elements. In this case, the destabilizing effects of (mis)appropriations of new reproductive technologies, including challenges to the patriarchal and heteronormative structure, are accompanied by the reinforcement of class asymmetries and the cultural overvaluation of raising children that are genetic offsprings. Accountability and responsibility must be thought in terms of what matters and what is excluded from mattering.

Conclusion

As I write the conclusion to this paper, the piezoelectric transducer is being enfolded into a new and very powerful technoscientific practice. Going most commonly by the name of "3D ultrasonography," it is also known as "volumic echography," "volume sonography," and "ultrasound holography." The idea behind this new technology is close to half a century old, but it has only started to materialize within the past decade, now that the computer technology has become sufficiently developed, and it is only within the past couple of years that a concerted effort has begun to integrate it into medical practice in this country and abroad.[35]

If the standard fare two-dimensional ultrasonographic technology takes great advantage of the high status accorded to the visual in our epistemological economy, then the new three-dimensional technology raises the stakes by orders of magnitude, inducing a kind of manic exhilaration over the epistemic earnings potential of this virtual reality tour of the body that makes real-time two-dimensional ultrasonography seem downright rudimentary. Unlike the two-dimensional images which have this "unnatural" "x-ray" quality to them, the new three-dimensional images have an all too familiar quality: the images are so "lifelike" that they seduce the viewer into thinking that the representation of the object is isomorphic with the object itself; the image seems to be just like what would be seen with our own eyes, but even better (if only our visual capacities had a zoom feature, the ability to rotate images without physically moving around an object, and the ability to slice away with a "virtual scalpel" any opaque section of the object that was visually obstructing our view)![36]

How does this new technology work? Recall that the ultrasound images that are most familiar to us are created by imagining a single two-dimensional cross section of the object. Hence, when a fetus is

imaged, the sonogram has that "x-ray" look to it: the body is rendered "transparent" because a cross sectional view does not privilege surfaces; in a sense, it has no respect for surfaces whatsoever. The new three-dimensional technology works by scanning successive close planes of the object and storing the information in a computer until the entire object is scanned. The computer integrates the two-dimensional images, producing a three-dimensional mapping of the entire volume of the object. The different surfaces of the body can then be rendered from the information obtained about the volume. Hence, the images viewed on the computer screen can restore that feel of opacity that we are visually accustomed to: the surface materializes derivatively from the volume information, hence enabling this technology to render the image of the body intelligible to us in a way that matters–constituting this material-discursive practice as a particularly poignant instrument and vector of power.

Of course, this apparatus of bodily production is materializing in intra-action with other practices, like those that help constitute the abortion debate in this country, and this technology will no doubt be enjoined to help stabilize the materialization of those apparatuses in particular directions. There are many other possible uses, including nonobstetrical ones, for this technology: it has, for example, the potential to drastically increase our understanding of human biology and to significantly change surgical practices.

Understanding the nature of the phenomena produced by this powerful technology will require a more complex understanding of bodies than we currently have. A theory of the biological body alone will not do, a theory of the constitution of the body's surface is not sufficient. Three-dimensional ultrasonography is both a symbol and a practice pointing to the necessity of knowing how to read the relationship between surface and volume. Might this powerful technology produce important insights concerning the nature of this relationship or the consequences of using different mappings? Might the "virtual scalpel" provide some insight into the nature of boundary drawing practices? Might feminist theory provide crucial insights into the practice of three-dimensional ultrasonography, such as: locating the objective referent, understanding the epistemic and psychic seductiveness of visual representations, understanding the epistemological and ontological consequences of making particular virtual cuts, and getting practitioners to reflect on the ways in which this technology has the potential to both erase and initiate the patient's subjectivity?[37] There is a need for feminists to be involved in

the practices of science, technology, and medicine, the theorization of technoscientific practices, and the theorization of the social, the cultural, and the political. There is a need to understand the laws of nature as well as the law of the father.[38] But understanding and reworking different disciplinary apparatuses in isolation won't suffice. Intra-actions matter.

This paper derives from the keynote address that I gave at the Institute for Research on Women "Gender, Technology, Place" Conference at Rutgers University in March of 1996. I was fortunate to have the opportunity to explore these ideas further during two other talks at Rutgers: a Distinguished Lecture for the Center for the Critical Analysis of Contemporary Culture in December of 1996, and the Laurie New Jersey Chair Inaugural Address in February of 1998. I want to thank my colleagues at Rutgers for their encouragement and hospitality during my visits. I also want to especially thank my colleagues in the NW "Women in the Public Sphere: Power, Practice, and Agency" seminar for their questions and comments on an earlier draft. I am grateful to audiences at other institutions who graciously engaged with these ideas. I am indebted to Alice Adams, Linda Alcoff, Judith Butler, Lorraine Code, Leela Fernandes, Michael Flower, Ruth Wilson Gilmore, Laura Liu, Rupal Oza, Joseph Rouse, Jennifer Rycenga, Louisa Schein, and Caridad Souza for generously taking the time to discuss these issues with me and to Ellen Rooney for her editorial assistance.

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Notes

1 As will become clear later in this paper, the framework of agential realism challenges the disciplinary divide between epistemology and ontology and suggests a new approach which I label *epistem-onto-logy*, referring to the study of the inseparability of being and knowing (Barad, "Meeting the Universe Halfway," "Agential Realism," and "Getting Real"). Properly speaking, agential realism is an epistem-onto-logical framework.

2 It is Bohr's general epistemological framework, and *not* his interpretation of quantum mechanics, that is of interest here. It is important to note that Bohr did not see the epistemological issues with which he was concerned as being circumscribed by Planck's constant. That is, he did not see them as being applicable solely to the microscopic realm. In fact, Bohr insisted that if Planck's constant had been larger the epistemological issues that concerned him would have been more evident and we would not have been as inclined to being fooled into representationalism. In this regard, I want to emphasize that my approach does *not* rest on mere analogies between the microscopic and macroscopic domains. Rather, my approach is to examine and further elaborate Bohr's insights concerning widely applicable philosophical issues such as the conditions for objectivity, the appropriate referent for empirical attributes, the role of natural as well as cultural factors in scientific knowledge production, and the efficacy of science

(especially in the face of increasingly numerous and sophisticated demonstrations of its contingent nature).

3 For more details see Barad, "A Feminist Approach," and Barad, *Meeting the Universe Halfway*. Note: "Agencies of observation" is Bohr's term, which he seems to use interchangeably with "apparatus." Because of the usual association of agency with subjectivity, "agencies of observation" hints at an ambiguity in what precisely constitutes an apparatus for Bohr. For further discussion see the section of this paper titled "On Apparatuses."

4 Bohr quoted in Folse (124).

5 Bohr called this cut "arbitrary" to distinguish it from an "inherent" cut. But the cut is not completely arbitrary (see Barad, *Meeting*) and so I use "constructed" as a contrast to "inherent."

6 Since "wholeness" takes on a particular set of connotations within feminist theory, it is probably worth mentioning some of the ways in which "wholeness" is being reconceptualized here:

> Wholeness, according to agential realism, does not signify the dissolution of boundaries. On the contrary, boundaries are necessary for making meanings. Theoretical concepts are only defined within a given context, as specified by constructed boundaries. Wholeness is not about the prioritizing of the innocent whole over the sum of the parts; wholeness signifies the inseparability of the material and the [discursive]. Wholeness requires that delineations, differentiations, distinctions be drawn; differentness is required of wholeness. Utopian dreams of dissolving boundaries are pure illusion since by definition there is no agential reality without constructed boundaries." (Barad, "Meeting" 182)

Note: See the section of this paper titled "On Materiality and Ontology" for a definition of "agential reality."

7 According to Newtonian physics, the two variables that need to be specified simultaneously are position and momentum. According to Bohr, our understanding of causality as Newtonian determinism must be revised because mutually exclusive apparatuses are required to define "position" and "momentum."

8 The extension of Bohr's analysis from the physical-conceptual to the material-discursive also depends upon a fuller account of materiality than that offered by Foucault (see below). Not that Foucault limited his account of discursive practices in any way to exclude the natural sciences, but his analysis of the productive effects of power/knowledge systems on bodies seems to be confined to human bodies (see note 18). See Rouse's *Knowledge and Power* for a detailed philosophical analysis of the extension of Foucault's notion of power/knowledge to the domain of the natural sciences.

9 "[W]hat was new, in the eighteenth century, was that . . . the disciplines crossed a 'technological' threshold . . . [whereby hospitals, schools, and workplaces] became . . . apparatuses such that any mechanism of objectification could be used in them as an instrument of subjection, any growth of power could give rise in them to possible branches of knowledge; it was this link, proper to the technological systems, that made

possible within the disciplinary element the formation of clinical medicine, psychiatry, child psychology, educational psychology, and the rationalization of labour." (Foucault, *Discipline* 224)

10 In a sense, while Foucault's account is being appropriated to help articulate an "outside boundary" for Bohr's account of apparatuses, Bohr's account provides crucial insights about the "inside boundary," providing a significant corrective to Foucault's account of the dynamics of power/knowledge.

11 Bohr is completely inattentive to the temporal nature of apparatuses and practices. Bohr's analysis starts with the possibilities for selection of instrumentation, for example, devices with movable parts or devices with fixed parts; he does not say anything about the practices that produce the instrumentation or acknowledge the fact that instrumentation is constantly reworked as part of the practices that produce phenomena.

12 Because of the nature of intra-activity, phenomena that are in the process of materializing are always already implicated in other practices that are in the process of materializing other phenomena. This is not to say that intra-activity is a deterministic dynamics. On the contrary, as has already been alluded to and will be discussed more thoroughly below, intra-actions entail a reworking of the notion of causality. Intra-actions are constraining but not determining. Materialization is an open (but non-arbitrary) process.

13 See Barad ("Reconceiving") for a discussion on doing responsible science and its connection to an agential realist reworking of the issue of (scientific) literacy. See Barad (*Meeting*) for a post-structuralist reformulation of accountability.

14 Materialization is taken up in detail in the next section. The notion of materialization that is suggested here shares certain features in common with Butler's notion (e.g., materialization in both cases is a temporal and open process) and yet it differs in other ways discussed below.

15 Piezoelectric materials are used for many nonmedical applications as well. One company has used piezoelectric materials to develop "smart skis," skis which "know" how to damp different vibrations in order to maximize contact between the ski and the snow. "Smart technologies" were developed in conjunction with other aerospace and military applications of piezoelectrics that address vibration problems. Boeing, Rockwell, Lockheed Martin, Honeywell, McDonnell Douglas, Northrop Grumman, General Electric, Bobcox & Wilcox, Westinghouse, Racor, TRW, and Raytheon are some of the main customers.

16 In the current political climate in the U.S., the objectification of the fetus is related to its subjectivation as the patient and the "desubjectivation" of the pregnant woman as a "container" or "maternal environment" for the fetus. See below.

17 For Bohr, not only is what is produced dependent on what gets excluded, but the "constitutive outside" is a matter of material-discursive exclusions (not simply discursive ones). That is, intelligibility and material conditions of exclusion are indissociable.

18 Butler cites a particular passage in *Discipline and Punish* (30) as

evidence that Foucault *theorizes* the materialization of the prison as well as the prisoner (Butler, *Bodies* 34). I disagree with her on this point. Concerning the passage in question, I read Foucault's point as insisting on the *importance* of the material arrangements that constitute the prison (and sustain particular discourses) and are the basis for its efficacy as an instrument of power. I do not take this to mean that the materiality of the prison is constituted through being taken up in power relations. In any case, Foucault clearly does not give a developed account of the materialization of nonhuman (including inanimate) bodies. (The account of materialization that he *does* give depends upon the fact that ultimately "the soul is the prison of the body" [*Discipline* 30].) I do think that Butler's impulse to theorize the materialization of nonhuman bodies as part of a theory of the materialization of human bodies is absolutely correct, but she does not follow this impulse through to an actual account of materialization that is general enough. Indeed, what is ultimately needed is an account of materiality that seeks to understand the practices by which materialization is implicated in the very drawing of the boundaries between the human and the nonhuman. I take up this question specifically below.

19 It is interesting to note the parallel between Bohr's and Butler's challenges to representationalism. In *Bodies That Matter*, Butler writes:

> The body posited as prior to the sign, is always posited or signified as prior. This signification produces as an effect of its own procedure the very body that it nevertheless and simultaneously claims to discover as that which precedes its own action. If the body signified as prior to signification is an effect of signification, then the mimetic or representational status of language, which claims that signs follow bodies as their necessary *mirrors*, is not mimetic at all. On the contrary, it is productive, constitutive, one might even argue performative, inasmuch as this signifying act delimits and contours the body that it then claims to find prior to any and all signification. (30)

20 Like Bohr, who intended his framework to have epistemological relevance beyond the sphere of science, I do not see any reason to limit the framework of agential realism to the domain of science, though this is not to presume its universal applicability. My stake in reconsidering concepts like realism and truth is related to my suspicion towards the feeling of comfort that antirealism seems to engender. It is worth remembering that many of the physicists working on the Manhattan Project at Los Alamos did not see themselves as involved in the search for truth, but immersed in the pleasure, satisfaction, and joy of making something new, making it work. The association of antirealism with play permeates the postwar culture of physics, especially in the classroom (see Barad, "Feminist"). Could it be that in other realms as well the facile rejection of realism is yet another symptom of late capitalism and the accompanying epidemic of abnegation of responsibility and accountability? Like our consumer culture's exaggeration of the plasticity of bodies, or its fascination with morphing, antirealism can be used to make differential relations of power invisible without removing them. Perhaps at this historical juncture, the weight of

realism–the serious business and related responsibilities involved in truth-hunting–can provide a ballast against current tendencies that confuse theorizing with unconstrained play.

21 I have appropriated the wonderfully rich descriptive phrase "apparatuses of bodily production" from Donna Haraway's article "Situated Knowledges" for my own purposes here.

22 The mutually informative methodology of reading texts through one another is particularly appropriate from the perspective of agential realism. In contrast, reading one text against another involves reifying or fixing of the text against which the other is viewed. In a related fashion, agential realism suggests the notion of *intra-action* as a nondeterministic, alternative dynamics to the limiting notions of *influence/impact/embedding* of one factor upon/in another. To assume a dynamics of influence is often to wrongly attribute agency to reified notions called Culture, Power, Discourse, etc. See Barad, "Reconceiving" and *Meeting*.

23 These questions are addressed at greater length and in more detail in Barad, *Meeting*.

24 Ironically, although one of Butler's primary concerns is the nature of abjection and the processes through which "human" is differentially constituted, Butler's account of materialization privileges human bodies from the start.

25 This particular point about the performative nature of speech acts has been emphasized from Austin to Derrida to Butler. See Butler's *Excitable Speech* for a thorough discussion of the political importance of the indeterminant, open nature of performativity.

26 Might Butler's suggestion that there are different kinds of materiality ("It must be possible to concede and affirm an array of 'materialities' that pertain to the body, that which is signified by the domains of biology, anatomy, physiology, hormonal and chemical composition, illness, age, weight, metabolism, life and death. None of this can be denied." [*Bodies* 66]) be read as symptomatic of the limitations of her account of materialization? Does the array of discourses that exist about the body mean that there must be different materialities? Or rather, is it the case that the intra-action of these different disciplinary apparatuses contributes to the materialization of the body?

27 Monica Casper has criticized actor network theory's account of material agency for its troubling implications concerning the status of the fetus as a subject. Recognition of material agency within the context of agential realism is not problematic in this sense both because the emergence and constitution of the "subject" is part of what is at issue and because agency is not aligned with subjectivity. For details see below.

28 Butler goes so far as to suggest that "[t]he controversy over the meaning of *construction* appears to founder on the conventional philosophical polarity between free will and determinism." She points out that the free will/determinism duality limits our thinking so that "the body" gets conceived of either as

> a passive medium on which cultural meanings are inscribed or as the instrument through which an appropriative and interpretive will determines a cultural meaning for itself. In either case, the body is figured as mere *instrument* or *medium* for

which a set of cultural meanings are only externally related. But "the body" is itself a construction . . . the question then emerges . . . How do we reconceive the body no longer as a passive medium or instrument awaiting the enlivening capacity of a distinctly immaterial will? (*Gender* 8)

29 Agency and its connection to issues of responsibility and accountability is an important element of agential realism (see Barad, "Meeting") For further elaborations, see Barad, *Meeting the Universe Halfway*.

30 In the science studies literature, this issue is often posed as the question of "material agency." This is due to an unfortunate tendency in the science studies literature to conflate "material" with "nature" or "nonhuman," counterposing the material world with the human one (as if humans are not material?), sequestering what is human in the purely cultural domain (a reinscription of precisely what is being contested here). So, for example, some science studies scholars use the term "material agency" (meaning "acts of nature"). I will speak of "nonhuman agency" and "cyborgian agency" since humans, nonhumans, and cyborgs are all material-discursive. As I will argue, this is not to presume that humans, nonhumans, and cyborgs are prediscursive entities that are fixed in advance (on the contrary). Other accounts of "material," "nonhuman," or "cyborgian" forms of agency include the actor network theory of Callon, Latour, and Law; and other alternatives by Haraway (*Simians*), Pickering (*Mangle*), and Rouse (*Engaging*). Pickering identifies his account of the "mangle of practice" as specifically posthumanist; ironically however, the liberal humanist actor that makes choices in the context of scientific practices is everywhere evident in his theory. My account of agency has more in common with Rouse and Haraway.

31 The issue of agency is bantered about in the infamous "epistemological chicken" debates in science studies (see Pickering, *Science*). The central figures in the debates include Harry Collins, Steven Yearley, Steve Woolgar, Michel Callon, and Bruno Latour.

32 The fact that pregnant women are referred to here as "apparatuses" should not be taken to mean that women are mere instruments or technologies for the development of the fetus. The notion of "apparatus" developed here differs significantly from more common uses of the term. As remarked earlier, material-discursive apparatuses are themselves phenomena made up of specific intra-actions of humans and nonhumans, where the differential constitution of "human" (or "nonhuman") itself designates a particular phenomenon, and what gets defined as a "subject" (or "object") and what gets defined as an "apparatus" is intra-actively constituted through specific practices.

33 See Caridad Souza's (forthcoming) important ethnographic research on and analysis of the racialized nature of the public discourse on personal responsibility and its displacement of state accountability.

34 While this can be seen as a disruption of the presumed equivalence of the biological and genetic mothers, Sarah Blaffer Hrdy makes the point that mothers raising nongenetically related children are properly biological mothers since biology is much more than genetics (private communication).

35 Information about three-dimensional ultrasonography is available on the World Wide Web (e.g., http://tanya.ucsd.edu/ and http://www.cs.uwa.edu.au/~bernard/us3d.html and http://www.worldnet.net/~henrib/3D_ultra.html).

36 The technical name for what I am calling a "virtual scalpel" is a "volume interactive electronic scalpel" (Nelson and Pretorius).

37 The subjectivation of the fetus through ultrasound technology was discussed above. Additionally, three-dimensional ultrasonography has the potential to obscure the patient's subjectivity: "Acquisition of volume patient data also affords the possibility of review after the patient has left the medical facility or communication of the entire volume via an interactive communications link to a specialist at a tertiary care center. This could reduce the need to refer a patient to a specialized center by permitting the primary physician and the specialist to consult and interactively review the study from both sites thus improving patient care and reducing costs" (Nelson and Pretorius). While this feature has some obvious benefits it also has the potential to remove the patient from the decision-making circuit.

38 I would like to thank Laura Liu for some wonderful discussions concerning the great untapped potential of engaging in mutually informative conversations amongst feminist scientists, feminist science studies scholars, and feminist theorists, and for giving me this way of putting the point so succinctly.

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