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Social science and a post-genomic future: alternative readings of genomic agency

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ABSTRACT *This paper explores competing discourses that envision different socio-technical landscapes opened up by the completion of the map of the human genome in 2003. It examines the ways in which the map, and its organising principle and very rationale—the gene as the sole or prime agent through which to understand the body and its disordering (as disease)—has been interpreted in quite distinct ways. It suggests how the sequences of a genomic map have post-genomic con-sequences that depend on a social rather than simply biological reading of genomic agency. Various accounts of the map and genetic agency or described, within science, science policy and social science, especially across science and technology studies (STS). The paper concludes with a comparative summary of these positions and asks whether a deconstructive reading of genomic agency by STS analysts might be the basis for a critical re-constructive engagement with post-genomic policy discourse that avoids the over-determination of agency one often finds in the latter.*

Introduction: a single map but multiple landscapes

> People often talk about the post-genomic era. Wrong. It's merely the post-hype era.
>
> (Sulston and Ferry, 2002, p. 211)

On 26 June 2000, the publicly funded Human Genome Project (HGP) and the private corporation Celera Genomics (CG) announced the first full 'draft' of the human genome (ref). This first template of the genomic map was regarded as a major scientific achievement that was seen to play an important navigational role, providing both anchorage and best routes for future genetics research. The announcement of the final version—the 'complete' genome—was made in February 2003. The HGP and CG had used different techniques to produce their respective maps, such that, as Bostanci (2003) has argued, the two versions of the genome do not completely converge. As a result, 'the' genome is best seen as an abstraction, a useful analytical device, a starting point, through which different interpretations of where and how to look for genes can be entertained. Indeed,

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over a year later one finds commentaries, such as this below, that bear witness to the unfinished task of genomic mapping:

> What should be sequenced next? For the human genome, the debate is divided between those who advocate the sequencing of genomes from more individuals—to learn more about genomic variation—and those who would like to see the human genome finally completed, by sequencing the heterochromatic regions. (Skipper, 2004)

Despite the broad agreement in genomics research today that the genome is best seen primarily as a heuristic reference map through which continuing exploration and filling out can occur, rather than a DNA 'blueprint' (Paabo, 2001), the very valuable methodological indeterminacy to which this speaks is rarely reflected in the discourse of other commentaries. Rather one finds accounts—both positive and negative—that, in reifying the genome and its agency, assume an over-determination of 'the genomics revolution' and the impact of the map on a future science and the socio-economic landscape. This is not helped by the simplifications found within the media hype (see Nerlich, Dingwall & Clark, 2002) that still surrounds genetics. As Hyman (2000, p. 2) observed shortly after the draft of the genome had been published:

> . . .it's very hard to write an interesting article that you have found a gene that is responsible for perhaps four percent of the variants, given certain assumptions. So instead, on the front page of a great New York paper. . . I woke up one morning, on an obviously news-poor day to see that the gene for worry had been discovered. And I had funded it.

It would be a nice irony to conclude that the very uncertainty associated with genetics is caused by the gene for uncertainty ('worry') itself. Irony is not the intent here, of course, and the fault-line that Hyman's observation points up within the genetics discourse—of provisionality on the one hand and determinacy on the other—stretches across much of the 'post-genomic' landscape. In part this is to be expected and as MacKenzie's (1999) trough of certainty tells us, divides those closest to the science [akin to the messy world of Latour's (1987) 'science-in-the-making'] and thereby most *un*certain, from those farthest away, and most certain. This notion of relative distance from science is useful for it is also a feature of a landscape: the closer up to the natural we are, the more its complication and complexity is revealed, while a panorama invokes a synoptic stability and ordering derived precisely through its breadth and distance, masking the turmoil on 'the ground'. Moreover, compared with a map, landscapes gain their meaning depending on one's relative position, or perspective on them. Landscapes differ then from maps in that they might have differing degrees of resolution and material complexity and change relative to the viewing point one occupies, rather than according to the particular metric one adopts.

Much of those who find themselves at what Glasner (2000) has called the 'epicentre' of science policy making [Jasanoff's (1990) 'fifth branch'] tend to be creators of panoramic rather than detailed renditions of the genomics map,

perhaps precisely because of the panoptic position they occupy. The landscape they envision is an anticipation of the application of science, translating the biological promise of the HGP map into a socio-technical future. This typically involves a recasting of the genomics map as a genomics 'roadmap' that establishes the direction to be taken and milestones to be passed that will mark out future research and development. In doing so it paints the broadest of canvasses: a recent example (EC, 2001) declares:

> The new knowledge base has enabled technical innovations such as genetic engineering, cloning. . .biocatalysis, gene testing, gene therapy and monoclonal antibodies, collectively known as biotechnology. . . [that] will be the basis for the next wave of knowledge-based economies with huge potential for improving the quality of life through the creation of highly skilled jobs, improved competitiveness and economic growth in Europe, better healthcare and new tools to address the different challenges such as protection of the environment.

The role of such visioning is not merely to chart the future but to do so such that the future can be made stable, can be secured for science: as Jasanoff (2004) notes elsewhere, this articulation between science and policy has always been with us and acts to stabilize (the picture of) a field, and set out the tasks ahead. However, as I shall explore below, there is no single panorama, no single future for genomics science, but one that is and will be contested and has to be crafted through the play of competing interests and agendas, within the epicenter and beyond.

This notion of futures-in-the-making has been developed through recent work by Brown, Rappert, and Webster (2000), Adam (1998; 2003), and others working within social science who have shown how futures must be mobilized if their hopes are to be realized. While the HGP map may tell science *where* to look it does not say *how* we should look and therefore what we might find or believe might happen. We can see this diversity of views not only within science policy debate but also within the critical analysis of genomics that is found within science and technology studies itself. I want to look at these two perspectives however in slightly different ways, as discourses about the making of science futures through representational landscapes, and as discourses about the reading of science futures.

Making genomics futures

There are three, very different, socio-technical landscapes that we can find within and circling around the epi-centre of science policy making: each sketches out quite different genomics futures. I suggest that the stories they tell offer different accounts of the ordering of the future through the 'genomics revolution' (see Collins, Morgan & Patrinos, 2003).

The first of these, illustrated in Figure 1 below is based on a UK policy document that tries to capture and organise the various components of genomics in-the-making. It paints a portrait of the genomics landscape and in doing so

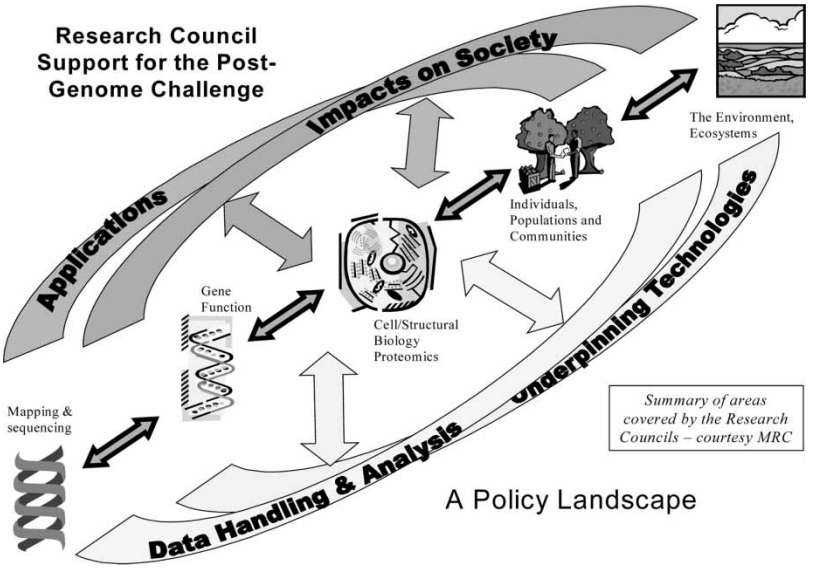

FIGURE 1. A UK policy landscape for genomics.

identifies not only the links between its component parts but also orchestrates areas of responsibility for the different UK science research councils. Tasks include meeting technology platform needs, responding to health or environmental 'challenges', or meeting the core bioscience needs in regard to DNA sequencing and cell biology.

What are the main features of this policy landscape? Clearly, the central feature is the cell and the role of proteomics to which all seems to refer, and through which the genomics information derived from DNA and sequencing will be made to 'work'. The post-genomic challenge is to mobilise genomics across a landscape for scientific activity and application. The technical infrastructure (such as coping with the huge data handling requirements of bioinformatics) is seen as a condition for the possibility of the field. The application of genomics is not, however, presented as linear, but two-way. Crucially however, this seems to be only the case along the central spine since here we see that genomics has an 'impact *on* society', while the technologies are also presented as *a*social. This portrait of genomics is broad and evokes integration, a systemic account of all the key components of the picture.

I want to suggest that this first version of the post-genomic world is one that offers a *social reordering of the landscape through science*. The scale and scope of the rendition and its cutting up into discrete areas acts as a sort of *purification* process, reflecting Latour's (1993, p. 36) critique of modernist claims:

> . . .the analysts, thinkers, journalists and decision-makers will slice the delicate network. . . into tidy compartments where you will find only science, only economy, only social phenomena. . ..

This purified landscape hides the uncertainties of post-genomic science, and relegates the messy business of society to a particular part of the schema rather than seeing this as intrinsic to all parts. Genomic agency itself is only suggested rather than articulated, posed as a 'challenge' that needs support. But in securing the same through major research council investments acts to mobilise the field and policy maker. Close up genomics—where we see the turmoil and lose the certainty—produces a rather different picture. For example, Bentley, a senior UK genomics researcher based at the Sanger Centre has recently observed in regards to genomics applications within medicine:

> Effective cures are not necessarily guaranteed, of course: the defective protein might be inaccessible or impossible to replace, the defect might be lethal too early in life for the administration of treatment, or there might be unexpected complication with the therapy. Despite early success in the treatment of severe combined immunodeficiency by replacement of the defective adenosine deaminase gene, it is proving a challenge to continue translation into clinical practice. (Bentley, 2004, p. 441)

The arrows of translation and linkage seen in Figure 1 could be fractured by such accounts of uncertainty from within the lab, but they are not precisely because the landscape provides a rhetorical vision that expects 'us' to rise to such genomics challenges. Things can remain in place.

Things are very much *out of place* in the second post-genomic landscape we see in other visions of the future. This is one that draws a dystopic picture of genomics agency in a future post-genomics landscape made up of monstrous images, chimeras and hybrids. Those who are critical of the modifications of 'the natural' wrought by a (human, animal, and plant) post-genomic world, argue that the developments in bioscience manufacture not only creatures that are artificial and grotesque but also life forms that disrupt our relation to nature, whether as human cells, nature or food. Alexis Rockman's (2000) now classic picture *The Farm* is perhaps one of the best-known examples of this dystopic vision. Not only are typical farm animals—a cow, a chicken, a pig—and crops distorted, they are seen to lose their identities: as Rockman (2004) says:

> In *The Farm* I am interested in how the present and the future look of things are influenced by a broad range of pressures—human consumption, aesthetics, domestication, and medical applications among them. The flora and fauna of the farm are easily recognizable; they are, at the same time, in danger of losing their ancestral identities.

The natural landscape and the human/animal place in it is now occupied by alien technology: this is tantamount to another form of purification, an *im-purification*—and here a *social disordering by science* of nature and our relationship to it, including to ourselves (Lewontin, 1993; Turney, 1998). The challenge here is how to bring a halt to this postgenomics future, driven along by a genomic agency that seems to have no limits. Those within the 'epi-centre' of science

discount such a view, and believe it is based on misunderstanding as well as an 'anti-technology' perspective. As Collins and McKusick (2001, p. 543) argued shortly after the draft of the genome were completed:

> Anti-technology movements, already active in the United States and elsewhere, are likely to gather momentum as the focus of genetics turns even more intensely on ourselves. Though the benefits of genetic medicine will be profound, there will be those who consider this advancement unnatural and dangerous. Efforts at public education need to start now to explain the potential benefits and to be honest about the risks.

It is, to some extent, a concern with potential risks that leads to the third representation of the postgenomics landscape I want to discuss, one that might be called a 'Foresight landscape'. Not unlike the policy landscape above, this maps out the future for a postgenomics society but does so by acknowledging that futures are always provisional and carry different risks, potentiality, and promise. Postgenomic science is shaped by various 'drivers' but these confront barriers that mean implementation is a more complex process. The landscape itself is seen as something yet to be built, though one that will be fashioned around some core building blocks. This landscape is one made by policy analysts for policy-makers, and *complication* is the characteristic marking the contours of this particular map. Figure 2 below is a typical example of a Foresight landscape for genomics.

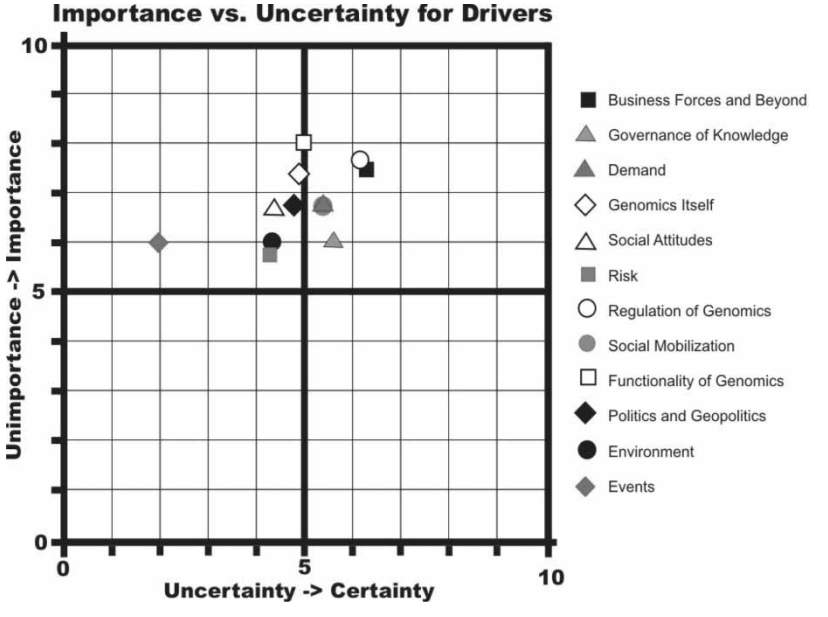

FIGURE 2. A genomics foresight landscape. *Source*: ESRC Genomics Scenario Exercise, 2002.

According to this representation, those seeking to foster a postgenomic future need to be aware of range of factors that can create difficulties, some of which are more, some less, certain to play a role. Existing aspects of the landscape need to be considered in developing things further since these are likely to cause a range of complications. Here the emphasis is on the building of an agenda around the *social ordering of science* through a consensus over how genomics agency is best prioritised and channelled. Foresight is an interesting area in science policy that combines Mode 1 and Mode 2 (Gibbons *et al.*, 1994) elements inasmuch as it marshals current scientific evidence and a range of stakeholder views on which to build a picture of the potential technological paths that could be followed (and through which a 'roadmap' might be built) in a particular field. The 'risks' identified along the way are best seen as ways of ordering reality and rendering it into a calculable form (see Gottweis, this issue).

A common foundation on which all three landscapes are built is the belief in a radically novel scientific development, the 'completion' of the human genome map. Genomics then becomes the main driver that reorders—in very different ways—the socio-technical world not only of bioscience itself but society at large.

In practice, of course, the 'epi-centre's' ability to differentiate the political from the non-political (Barry, 2001) in regard genomics and its governance will shape how these three agendas are worked through, and this in turn is likely to depend on wider political cultures, such as the contrast between the US and Europe over 'red' and 'green' biotechnology (Jasanoff, 2002).

These representations of postgenomic futures have been the focus of social science critique. I want now to examine alternative readings of the postgenomic future that, to a greater or lesser extent, link to the three accounts sketched out above.

Reading genomics futures

As the above discussion shows there are various landscapes in the making, indicating that the postgenomic future is highly contested, multiple and always unstable. The boundaries, risks and barriers each of the landscape invokes reflect quite distinct socio-technical discourses. This triptych of landscapes is, respectively, akin to a modernist version of Hieronymous Bosch's visions of the ordered *Garden of Eden*, the dangers of the *Garden of Earthly Delights* and the dystopia of *Hell.* Indeed some of the inventive distortions of the latter would not be out of place in Rockman's work noted above.

Bosch's work is an allegorical representation of a medieval world driven by religion. The postgenomic landscapes described above are representations of a contemporary world driven by science. Social science analysis of genomics produces its own triptych, three readings of genomics, driven by a hermeneutic critique of the field, each of which offers quite different accounts of genomic agency, that, like Bosch's pictures and the landscapes-in-the-making cannot easily be overlain or combined.

The first reading, found most commonly in science and technology studies, deconstructs the notion of genomic agency common to the three accounts

above, and emphasises the ontological and epistemic instability of the field, and thereby its future place and role in society. Ontologically, the genome is itself a highly unstable object, an instability hidden, as Glasner (2002; 1998) says, by being 'black-boxed', such that the HGP becomes '...an obligatory rite of passage through which all now pass not only without questioning its contents, but also without even looking inside' (Glasner, 2002, p. 269). Similarly, as noted above, Bostanci (2003) shows how the biological relationship between the genome and genes may be much more precarious than first thought: is the genome wrong if it fails to predict newly found genes? Even if this ontic instability where to be resolved, its epistemological gains in regard to knowledge that can be usefully applied may be much more limited because of the disconnect between biological and experiential definitions of the body, disease, and illness. Genetics, as Franklin and Roberts (2002) and Hallowell *et al.* (1997) have shown, appears to be able to provide greater *precision* in regard to identifying the locus of a (genetic) disorder, yet less *accuracy* in determining the extent of that disorder or its phenotypic expression and experience. This under-determination of genomics challenges the reductionism of most postgenomic futures, while at the same time opening up opportunities for the re-engaging of genomics with the social, as a hybrid (Latour, 1987) figure on the landscape.

The second reading, represented by a number of contributions from within medical sociology, the sociology of science, and philosophy, also takes up the theme of genomics as agency or driver of change. However, notwithstanding the force of the deconstructivists' critique, here the emphasis is on the ways in which the presumption of agency is, or will have an effect on society (Barnes, 2002). Finkler (2000) and Richards (1996) argue that the 'new' genetics' is likely to bring a new meaning to personal identity through the geneticisation of family and kinship relations. Such geneticisation is also likely to lead to both the confirmation and creation of patterns of inequality, through marginalisation, stigmatisation and greater surveillance (Nelkin & Tancredi, 1994). As such, a new form of social eugenics (Kerr & Cunningham-Burley, 2000) is said to arise that needs to be resisted (though how far this particular dystopia might actually be realised has been questioned; see Levitas, 2000).

Beyond the putative effect of a reductionist genomics in reordering or re-confirming social relations and social structures, others have suggested that genomics agency can be felt at the heart of social science itself, inasmuch as it redefines the boundaries between nature, species and culture (see Delanty, 1999, 2001). The very object of social science analysis—the social—is no longer clearly defined. Here the deconstructionism of our first reading is turned against social science itself, in a move that gives genomics considerable agency indeed.

The final reading we can sketch out relates to more recent attempts from within social science to help build a re-constructed genomics that is more 'socially robust' (a term first used by Nowotny *et al.*, 2001). This reads genomics has having agency to reshape natural and social boundaries, and thereby their inter-linkage, but demands of genomics a respect for contexts of both application

and implication. In doing so, it argues that genomics has to be fully located within a socio-technical domain that is marked out by competing political, economic and ultimately value-driven claims. As such, genomics should not—as our first postgenomic landscape described—be regarded as the science through which a reconfiguring of all else might occur, but a more modest endeavour that attends to existing interests. A recent example of this position can be found in the work of Tait (2004) in a review of the UK's 'GM Nation' debate: the government's focus on genomic science as the driver of agriculture simply partitioned the technology off from the wider system and so exposed it to attack from different sides. Much better, this argument goes, to have located genetics within the farming economy as a whole, thereby offering a more realistic and socially-informed assessment of its role, influence and likely utility.

This third position manoeuvres between the deconstructionist and determinist readings of the two other narratives on genomics and strives for some sort of negotiated determinism, inasmuch as it acknowledges a future agency to genomics yet one it seeks to anchor in wider societal priorities and processes. Not surprisingly, this work is closely linked to the genre of the Foresight landscape we painted above.

Discussion

We have summarised above three different post-genomic futures one can find as landscapes-in-the-making both to illustrate the contested nature of this future, and to provide a basis through which we can explore accounts of genomic agency. This theme has then been explored through the various 'readings' of the genomic 'revolution' by those working within social science. Again, there are some key areas of difference and debate around the notion of agency, which do not look like being easily combined through some process of 'theoretical triangulation', precisely because the ontic and epistemic status of genomics is 'read' differently.

Figure 3 below summarises the principal differences between the making and reading accounts of the postgenomic future.

The alternative accounts cut across each other in different ways: for example, the dystopic landscape is in some senses supported by the critique of genomic determinism but rather weakened by the deconstructionist line about the underdetermination of genomics. On the other hand, the complicated landscape of Foresight seems must comfortable with a reconstructive, socially robust genomics. These competing futures and narratives, are sometimes overlapping, sometimes in powerful discord with each other. In their different ways they either stress or challenge the degree to which genomics is *novel* and ushers in radical change. How can we try to make some headway in such circumstances?

It may well be best to abandon any notion of trying to define some *inherent* radicalism to the genomics map and the contours of the land and the road it will take us down. As Barry (2001) has argued elsewhere about innovation and 'inventiveness', '. . .inventiveness should not be equated with the development

Making genomics futures	**Effects of genomics agency**	**Postgenomic future**
Policy Landscape	Purification	Social ordering through science
Dystopic landscape	Im-purification	Social dis-ordering through science
Foresight Landscape	Complication	Social ordering of science
Reading genomics futures	**Challenging the notion of genomics agency**	**Postgenomic future**
Under-determination of genomics	Epistemic/ontic deconstruction	Hybridised socio-natural ordering
Genomic determinism	Reduction	Social dis-ordering through science
Negotiated determinism	Socio-technical reconstruction	Socially robust genomics

FIGURE 3. Competing accounts of a postgenomic future.

of novel artefacts, or indeed with novelty and innovation in general. Rather, inventiveness can be viewed as an index of the degree to which an object or practice is associated with *opening up possibilities…What is inventive is not the novelty of artefacts and devices in themselves, but the novelty of the arrangements with other objects and activities within which artefacts and instruments are situated, and might be situated in the future*' (Barry, 2001, p. 211–12, original emphasis). This position has also been developed elsewhere (Brown & Webster, 2004; Webster, 2004).

In light of this we should ask what defines the 'when' and 'where' of the 'new': most analyses see the relation between technology, culture and the material as instrinsically processual, 'unfinished' or 'in-the-making' (Latour, 1987). This makes any claim to some sort of novelty that can be marked off temporally and spatially problematic, both epistemologically and methodologically—even the human genomics map. Secondly, many authors in science and technology studies argue that technologies always build on existing ones, so where, one might ask are we to identify some significant break or shift heralding a distinctly new technology (here we are reminded of the old Greek story about the Ship of Theseus replacing all its timbers over 100 days: are they part of the original or a new (developing) boat?. Finally, it might also be difficult to identify novelty *in-itself*, since there is much evidence that shows how the *same* technoscience can be positioned and repositioned as old *and* new, depending on the networks and audiences it seeks to embrace or mobilise (Brown *et al.*, 2000; Webster, 2002). Technologies can be repositioned to have different functionality if they 'fail' as 'new' or 'path-breaking' in one context, and in being so may succeed precisely because they are framed as more-of-the-same, cashing in on familiarity (see Morlacchi, 2004).

Yet novelty in the form of disruptive change does seem to occur, or is at least perceived to do so, especially in areas such as cloning, genetic modification, bioinformatic databases, biobanks, biometrics, and so on. And these developments pose major legitimatory problems for the social ordering of science through formal regulation by the state.

So, in light of this, what analytical perspective can be adopted? We can usefully draw on Bauman's (2000) view of the modernity/'liquid modernity' relation: for him, liquid modernity does not connote a radical break from modernity but is simply part of modernity, a part that is (using a term we can borrow from genomics itself) 'over-expressed' in contemporary society. In other words we might want to argue that novelty is itself 'over-expressed' in the now, in what we have, in our technocultures, and the register of discontinuity more keenly felt and vigorously pursued.

Indeed, that this may be so may in part derive from Bauman's very characterisation of our liquid society, wherein embedded *relationships* are increasingly displaced by disembedded *relating*. In such circumstances boundaries are more friable, plastic and thereby novel configurations perhaps more possible.

It is this wider social phenomena that we should situate genomics novelty itself, rather than see genomics as intrinsically and necessarily transformative. This then allows us to turn our attention to the ways in which genomics research is or could be articulated in society to close off or open up 'possibilities' for different landscapes-in-the-making.

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