The Cyborg Embryo : Our Path to Transbiology

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> I am making an argument for the cyborg as a fiction mapping our social and bodily reality and as an imaginative resource suggesting some very fruitful couplings. (Haraway, 1991: 150)

Part One: Old Words

As Donna Haraway noted of the embryological models described in her 1976 book on the metaphors of organicism that competed to organize 20th-century developmental biology, entitled *Crystals, Fabrics, and Fields*:

> The traditional mechanist sees similarities between the organism and actual machines such as the steam engine, hydraulic pump, or a system of levers and pulleys. The neomechanist builds a similarity set from codes, the molecular basis of genes, language, computers, and the organism. . . . The organicist tends to see similarities in the structure of molecular populations, the cell, the whole organisms, and the ecosystem. . . . Concrete analogies are drawn from models, gestalt phenomena, fields, liquid crystals, and also computers. These lists suggest that persons holding one of the three perspectives would be inclined to work on different experimental problems and to interpret the results in a different language. (1976: 205)

The scene Haraway describes is what has later come to be known as *science in action*, *laboratory life* or *sorting things out*.[1] Here too is Haraway's first cyborg – the cyborg embryo, not yet denominated as such, but as surely a product of 'worlds ambiguously natural and crafted' (1991: 149), 'couplings between organism and machine' (1991: 150) and a 'condensed image of both imagination and material reality, the two joined centres structuring any possibility of historical transformation' (1991: 150) as the chip, fetus, gene, seed, database, bomb, race, brain and ecosystem of her later work (1997).

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The love of irony that beats at the heart of the 'Cyborg Manifesto' may be diffracted here, but the urgent sense of competing worldviews, and their consequences, is fully sown.

Thirty years later Haraway's analysis speaks cogently to the embryo-strewn world of the 21st century. The anxious attention so often directed at 'the' embryo, as in the perennial debate over 'the moral status of the human embryo', forgets that human embryos are now a vast and diverse population, imaged, imagined and archived in media as diverse as liquid nitrogen, DVDs, virtual libraries, t-shirts, logos and brandnames.[2] Never very precise, the term 'embryo' is ever more a basket category, describing everything from a conceptus, a zygote or a blastocyst to a reconstructed cell, a fertilized egg or an embryoid body. We cannot map the complicated social, political, scientific, medical or ethical lives of human embryos, with all of their increasingly prominent civic and legal entanglements,[3] without the kind of material semiology, or grammar, of the biological that Haraway, uniquely, provides.

As Haraway reminded us in the 1970s, scientific experiments with embryos take place in laboratories, and the locatedness of knowledge production matters: it is real, factual, material, hands-on and in your face. It is also embodied: in the same way we are looking at biology when we see an embryo through the microscope, we are also using our own biological bodies to do this – to observe, to interpret, to move the focal plane up and down, coordinating our eyes with our hands, our hands with our brains, our brains with other people's brains to work out what we are seeing. If we are using a suction pipette to transfer the embryo, we may use our ability to breathe to do this, just as we may have been using our voice to talk to someone else in the lab about a problem with our equipment or what we plan to have for lunch.[4]

Famously two different words that have the same form, biology has always meant the thing itself and knowledge of what it is, and equally notoriously, these two biologies have not always been identical, as Haraway's prescient analytic genealogy of embryology confirms. But the extent to which biological knowledge, biotechniques and biology 'itself' reshape each other, and co-evolve, may never before have been made so explicit as today, through the redesign of the biological in the context of bioscience, biomedicine and biotechnology. The rebuilding of 'life itself' in the laboratory is redefining the future of the environment, food, wealth and health, and is consequently crucial to definitions of progress, social justice and power. This is not a context in which the social and the biological can meaningfully be separated: it is rather one in which 'we are all chimeras, theorised and fabricated hybrids of machine and organism' (1991: 150).

Re-reading Haraway amidst the current chorus of complaint about 'the cultural turn' and the rise of 'textualism', in which material reality is allegedly subordinated to the deconstructionist 'insistence' that everything is 'merely discursive', is to be reminded of the irony that postmodernist perspectives have become so demonized and misunderstood in a context that needs them so desperately. What is the motivation for insisting that there is, or must be, a real natural, material, factual or biological world that exists entirely independent of human action, and has its own separate and distinctive agencies and qualities, when the only conceivable means of knowing what such an 'external reality' might consist of is by interacting with it – which, by definition, means that the interaction must play a role in the constitution of what we know? Is this not what Einstein realized when he proposed the theory of relativity – now considered to be the closest approximation modern science is capable of providing for the 'real' nature of material reality?[5] Is it not basic laboratory practice to list all of your specific types of brand-named culture media in scientific publications, because it is assumed that the socially constructed environment in which we grow our own biological experiments cannot, in fact, be removed from the biology that is our object of study?

The gene is a typical example of this ontological *fort–da* – the familiar pantomime in which the really-real reappears as the no-there-there. When the draft sequence of the human genome was published in 2001 it was an event that quickly became a primer for a new era of post-molecular biology. But the lesson was not about what the genome 'told us': it was, and has been increasingly since, about what the genome didn't reveal (Keller, 2002). The silence of the genome has given way to the cacophony of the epigenetic – a theme, it might be added, that emerged out of embryology in the period immediately following that described in Haraway's accounts of the earlier part of the last century (R. Edwards, 1965, 2001, 2004, 2005; Graham, 2000; Horder et al., 1985; McLaren, 1981; Sapp, 1991; Willadsen, 1979, 1980).[6]

Thus, although the biotic and the informatic remain in the close cybernetic embrace Haraway described in the early 1980s, the coding or switching functions, the crossings-over and recombinant effects, have been de-geneticized. Coding is now a multi-functionality involving processes such as imprinting and entities such as the cytoplasm – famously dismissed by T.H. Morgan as a component of the cell that 'can be ignored genetically' (quoted in Sapp, 1991: 231). Consider, for example, the images that are combined in the model of 'biological control' derived from the context of cellular reconstruction, cell nuclear replacement or 'cloning'. Ian Wilmut's analogy of the egg cytoplasm as a powerful supercomputer which reprogrammes DNA (Wilmut et al., 2000) is crucial to the language of de-, trans- and re-differentiation that lie at the heart of the new field of embryonic stem cell research and the so-called 'Dolly technique' of somatic cell nuclear transfer. The reversal of the question 'What is the genetic message?' into its opposite of 'What is the DNA being told?' now counts as the bottom line in most biological discussions about the crucial pathways that determine one kind of biological form or another. The problem of expressivity – that genes can be given instructions – has now become an opportunity: the blueprint can be redesigned.[7]

In turn, this shift in perspective, toward what we might call the functional polarity of genetic direction, confirms what many mid-to late-20th-century embryologists, such as Anne McLaren (1981), had been claiming about the reversible segregation of the germplasm and soma throughout the 1970s: activation, de-activation and re-activation of germ line segregation, such as that which characterizes the digital switching back and forth of the X-chromosome, confirmed that an absolute distinction between germ cells and soma was untenable, that germ cells are influenced by their somatic context, and that DNA is thus a 'two-way', or reversible, messaging system.

It is thus not only the experiments of Jamie Thomson and John Gearhart with stem cells (Shamblott et al., 1998; Thomson et al., 1998), or Ian Wilmut and Keith Campbell's unlocking of the secrets of the cell cycle (Wilmut et al., 1997, 2000) which have brought us the great embryological revolution before us today: many of its roots lie in the crucial post-war period when the discipline enjoyed a flourishing climate of experimentation, particularly in the UK (Graham, 2000). This, in turn, and in keeping with Haraway's appreciation of 'the odd perspective' provided by her own history as a 'an Irish Catholic girl [whose PhD] was made possible by Sputnik's impact on US national-scientific education policy' (1991: 173), was the result of the post-nuclear turn, in both the US and the UK, toward the life sciences. Hence, the Medical Research Council's heavy funding of mutation research post-1945, in a kind of biological *mea culpa* for the atom bomb. It was 'radiation biology' that helped produce the Jackson labs in Maine, as well as the animal breeding experiments in Edinburgh and Cambridge, such as Robert Edwards' work on mouse ovulation (1965), and Steen Willadsen's manipulation of sheep blastocysts (1979, 1980), which, with fitting cyborg irony, were two of the key developments later transferred into *in vitro* fertilization (IVF), pre-implantation genetic diagnosis (PGD), somatic cell nuclear transfer (SCNT) and the derivation and banking of human embryonic cells.[8]

To understand the cyborg embryo, and its legacy of transbiology, we need an anthropology of the embryos around us, who are and who are not becoming part of our futures, and who are reshaping our understandings of life, death, health, kin, progress, hope, sex, capital and cure (Strathern, 1992a, 1992b, 1999, 2005). The over-determined coupling between embryonic bodies and technoscience, epitomized by the primal, and often animated, scene of micro-injection, is reshaping 'biological facts' and 'the facts of life' while also retelling us who we really are, much as genes did in a previous era, and before that evolution, heliocentrism and gravity (Konrad, 2003a, 2003b, 2005a, 2005b). If Haraway's cyborg lived perversely, and blasphemed ironically, what are today's cyborg embryos doing? If they are, as Charis Thompson suggests (2005), newly sacred and profane, what are the borders that secure their identities, and what else are they telling us?

Building on Haraway's concept of *trans-* to describe the shape-shifting categories by which new hybrid entities, such as transgenic mice, 'blast widely understood notions of natural limit' or kind (1997: 56), I want to add the *trans*-work of embryo transfer, and the translation of embryology into stem cell derivation and redirection. I want to suggest that, in the same way the cyborg was useful to learn to see an altered landscape of the biological, the technical and the informatic, similarly Haraway's 'kinding' semiotics of trans can help identify features of the postgenomic turn in the biosciences and biomedicine toward the idioms of immortalization, regeneration and totipotency. However, by reversing Haraway's introduction of *trans*- as the exception or rogue element (as in the *transuranic* elements), I suggest that *transbiology* – a biology that is not only born and bred, or born and made, but *made and born* – is indeed today more the norm than the exception. This observation, like other chimeras and hybrids, not only takes us back in time to the shared origins of cloning, stem cell research and what we might call the crucible of the genetics–embryology interface in post-war mammalian developmental biology, but forward to where these techniques are taking us, and the transbiology which is their means of reproduction.[9]

I want in addition to consider, as Haraway's cyborg manifesto invited us to do, what are the social contracts and exchanges, the handshakes and the exclusions, the gifts and the footpaths, that are part of how biology is literally being rebuilt today. Without being able to do justice – even in a very broad sense – to the entire scope of changes affecting the contemporary reorganization of living matter, and rather by taking a brief tour that is in many respects a purely anecdotal journey, I will look specifically at the role of assisted conception, or IVF, in the birth of the often startling embryology that surrounds us today.[10]

Part Two: New Worlds

Recently I visited the first of five UK human embryonic stem cell (hES) derivation laboratories to be built directly adjacent to an IVF surgery, or assisted conception unit (ACU). These facilities have been funded by the Medical Research Council (MRC) as part of the effort to move hES science as quickly as possible from the lab into clinical and commercial applications. These labs are where transbiology – regenerative medicine, stem cell science, tissue engineering – may begin to come to fruition in the form of new health and wealth products harnessing the pluripotent power of recombinant regenerativity (Ganchoff, 2004; Landecker, 2000, 2006; Lebacqz, 2001; Lock, 2001; Parry, 2004; Resnik, 2002; Squier, 2004; Thompson, 2005; Waldby and Mitchell, 2006). This translation of as-yet-ill-defined cellular potential into goods, markets and deliverables will, like agriculture, require a new operating system to achieve a change of scale (Franklin and Lock, 2003a, 2003b; Thompson, 2005; Tutton and Corrigan, 2004).

Although there is great uncertainty about many aspects of stem cell science, one principle on which there is widespread agreement in Europe, and to which the new UK facilities must be rigorously accountable, is that *its future must be quality controlled*. Quality assurance, not just technical assistance, is now the element that must be added to biology to make it as good as nature – as good as the real thing – so that new made-in-the-lab biologicals, such as pancreatic islets, heart valves or skin, will function normally. But quality control is not added *to biology itself*. Quality is about *taking away* the dirt, the noise, the pollution, the pathology and the 'junk' that detract from the reliability of biological function. Therefore, quality control, while not 'in' the biotic component, culture medium, embryonic cell line, etc., is everywhere all around it – like a protective seal against contamination. In sum, if biological control is the motor, quality control is the car, the road system, the traffic lights, the map, the sign-posting and the speed limit. Quality control covers everything from the petrol to the bitumen.

In the language of quality control, Good Manufacturing Practice (GMP), International Standards (ISO compliance), accreditation (by the Medical Health and Research Authority – the MHRA) and graded air (A, B, C or D), the new stem cell facilities involve annexing a 'dirty room' (an IVF surgery) to a 'clean room' (a derivation lab). Such an arrangement has never been undertaken before and the new unit I am visiting has been designed from scratch by a team headed by the senior embryologist. It has cost £1.5 million.

In the tiny dressing chamber we all put on 'bunny-suits' for our tour. These cover our clothes and we also need gloves and slippers. Everyone leaves their shoes by the door, and looks peculiar in their bright white hooded outfits. The grade of air where we are now is C – the third purest in terms of number of particles per unit. We will need to pass through the airlock to get into the B grade environment of the embryology laboratory, which has a higher air pressure, ensuring that the air-flow is from the higher grade into the lower grade area.

Inside the lab we are met by the roar of working stations known as hoods – they are sucking air out of the lab into a room full of ductwork that is larger than the one we are standing in. It's hard to hear and everyone agrees that one cost of quality control is ear strain. In theory, the quality of air under the hoods, which can be sealed, is A: the purest grade of air and the most quality controlled environment for manipulating cells.

All of the air is constantly being monitored. Tiny monitors on tripods measure the air quality inside the hoods, while above my head an alarm the size of a rolling pin offers three different levels of alert. Every piece of equipment connects back to a single computer in the consumables room, where it is backed up by reserve systems, with specific, approved and regularly tested protocols for everything from a major catastrophe to ordinary forgetfulness. All of these protocols and tests are documented and become part of the elaborate paper trail required for validation and accreditation of the facility.

At both ends of the lab, beside the hoods, small hatches are set into the wall. This compromises the clean room procedures, as one of the most elementary features of a clean room is that it is sealed. In fact this room has been fitted with a special high-heat linoleum application devised specifically to seal clean rooms. The hatches are essential, however, because embryos have to be transferred back and forth through them.

The hatch is the door to the crucial passage that connects the hES laboratory to the IVF surgery, where women come to have their eggs aspirated and prepared for fertilization, or their successfully fertilized embryos returned through the door for embryo transfer. Normally, what would happen would be that the eggs are passed through the hatch into the lab, checked under the microscope, transferred to the Petri dishes, labelled, fertilized and then, witnessed by two staff as required by law, and placed in the incubator. After 24–36 hours the fertilized eggs are evaluated by the embryologists and graded, and if they are considered suitable for transfer, the two 'best looking' and highest-grade embryos are selected to be returned to the surgery, where a physician will transfer them using a catheter into the uterus of the woman patient. Any remaining embryos can be frozen for later clinical use (which requires a consent form and a fee), donated to research (which requires a consent form but no fee) or 'left to perish' (which means they are in effect discarded).

This flow, or transit, of embryos in and out of the door between the clean room and the dirty room thus traces the contours of a complex interface between IVF and stem cell research that encapsulates some of the features of 'biosociality' (Rabinow, 1992) with which we have become familiar, while also posing new questions about what kinds of 'biological citizenship' (Rapp and Ginsburg, 2002; Rose and Novas, 2005) are occurring in the context of both IVF treatment and donation of embryos to embryo or stem cell research.

Without assisted conception there would be no human embryonic stem cell research. The supply of embryos for this prominent, competitive, global and fast-paced field of scientific research depends entirely on surplus, supernumerary, left-over, extra or spare embryos generated by assisted conception techniques, and specifically super-ovulation. The rationale behind this new facility, and indeed the UK programme of stem cell coordination of which it is part, is to enable more efficient transfer of donated embryos from IVF into stem cell research. This is the purpose of the hatch. It is through the hatch that fresh eggs will be transferred from IVF into the derivation process with minimal loss of quality: they will go directly into graded air.

The new facility makes this research transfer of embryos more compatible with the quality standards that are essential to the future viability of 'bench to bedside' and 'bench to market' models of the translation of hES derivation into viable clinical and commercial applications. Any level of successful product development, clinical validation, and market stabilization will require GMP and ISO quality control, graded air and clean room standards, as well as approved ethical protocols and full compliance with both UK law and EC regulations.

Specially designed, bespoke clean room facilities such as these are the natural home of the cyborg embryo that is as much a product of high-tech procedures, such as ovulation induction and cryopreservation, as it is of hope for a child and the desire for technological assistance to overcome infertility. In the same way, the *in vitro* embryo would not exist without earlier versions of such facilities, so too the new facilities never would have been imagined without the extracorporeal embryo: they are part of the same ecosystem, they are co-evolved. Transbiology, the remaking of biological functions, is the field of science most indebted to the cyborg embryo. As such, transbiology is also the progeny of its own popularity and success: it is the legitimate heir to the coupling of nature with the 'helping hands' of technoscience in the context of IVF – a handshake which turns out to have a return in the form of the vast population of stored human embryos that forms an unanticipated biological reserve, or archive, offering new possibilities of human repair (Mortimer, 2005).

Like Haraway's cyborg, who wanted to remind us about the social divisions engendered and reproduced in the 'frozen moment' (1991: 164) of any encounter with technology, the clean room is a place where 'tools embody and enforce new social relations' (1991: 164), and in the clean room these are defined by the necessity of reaching a compromise between a workable environment and quality control. In order to develop a viable system of performing their duties and protecting the lab against contamination, the embryology team carefully charted their footsteps and recorded their movements, in a kind of auto-Taylorization of their working environment. Taking their own dirty biologies into account, the team designed a strategic balance between the clean room requirements of GMP/ISO compliance, and the dirty work of transferring live, essentially contaminated, biological ingredients, including themselves, to and fro. Intel never had to deal with these kinds of 'live' transfers. To clean their rooms they irradiate them.

The footprints of the embryologists, then, remind us of another definition of trans-, the literal back and forth of the *labour* of creating new biologicals. Embryology crosses the clinical–scientific divide and, on both sides, is extremely laborious. Becoming a senior embryologist requires skills in craftwork (it is not uncommon for embryologists to make their own pipettes by hand, to their own specific preferences, with a Bunsen burner), emotional labour (IVF is a highly stressful form of treatment that usually fails), surgery (microsurgery on embryos requires immense skill and concentration), teamwork (the ACU relies on very precise teamwork to function at its optimum level) and managerial initiative (public sector hospitals and labs are continually under-staffed and under-funded).

The embryologists at the IVF–stem cell interface have additional duties of care because their work is unprecedented and consequently experimental, while the stakes on both sides of the hatch are literally life and death. Their duties require an intimate choreography, combining clinical care with scientific research, and the stakes are amplified on both sides of the very contiguity their facility has been designed to enable. Their own footprints, the paths of their own labour, define a workable definition of their space, in which they cohabit with lively and noisy machines, which breathe

the same air they do, and constantly communicate in a shared network. The blueprint of this facility reflects both professional scientific ambitions and a commitment to medical care: above all the facility is a testament to the hope that scientific progress will bring about new cures for chronic, terminal and degenerative diseases for which there is no cure, such as diabetes, Parkinson's and a range of single-gene disorders. This version of human improvement relies on an unusual exchange between reproductive hope and scientific progress. On one side of the hatch are the women who seek to benefit from IVF, while on the other are the scientists who hope to create new life not only for them, but for others as well.

Donors who claim, as most do,[11] that the desire to donate eggs and embryos to stem cell research reflects an obligation they feel to 'give something back' to scientific research in order to reciprocate the benefits they feel they have received by having had the opportunity to undergo IVF – itself a technique that required a pioneer generation of altruistic egg donors – are describing a new kind of kinship exchange: in exchange for their own personal reproductive hope to have a chance of being fulfilled (a shared parental aspiration which binds a couple through reproductive desire and intent) they will donate their own personal reproductive substance (the embryo that biologically embodies their sexual union) to science. In this complicated (but also simple) and potentially symbolic (but equally potentially not) act of donation, couples therefore *trans-substantiate* their embryo from being 'their own' to becoming an anonymous, publicly funded medical-scientific human embryonic cell line that, rather than being a specific entity, becomes part of a shared, collective commitment to scientific progress – a value that is almost inextricable from hope.[12]

The transfer of eggs and embryos through the hatch is thus at once literal, symbolic, political, practical, engineered, designed, controlled, risky, uncertain, hopeful, responsible, accredited, strategic and ambivalent. In terms of biological control it is semi-domesticated (most IVF and most derivative attempts end in failure), and in terms of quality standards it is at once compliant and non-compliant, compliant-near and compliant-far from what counts as clean room GMP. Like the cyborg embryo, transbiology is a mix of control and rogue, or trickster, elements. The hoods are noisy breathers, the eggs are dirty, and the door is queer: it does not belong, and the presence of so much biology in a clean room is matter out of place. The door between IVF and stem cell research – the hatch to transbiology – is beautifully simple but ethically complicated: it has lessons we can learn.

Part Three: Transbiology

When Haraway offered us her cyborg manifesto in the mid-1980s she sought a language in which she could both engage with the agendas of a critical biopolitics while resisting their purifying and puritanical tendencies, to make what she described as 'a slightly perverse shift' in the direction of thinking through some of the very conditions it might otherwise be imagined feminists and socialists needed to resist – such as technoscience. An example on her mind was the Lawrence Livermore nuclear laboratory at Berkeley, where she described the Livermore Action Group as a kind of cyborg society:

> . . . dedicated to realistically converting the laboratories that most fiercely embody and spill out the tools of technological apocalypse, and committed to building a political form that actually manages to hold together witches, engineers, elders, perverts, Christians, mothers, and Leninists long enough to disarm the state. (1991: 154–5)

In her manifesto, it was affinity groups, such as her own local 'Fission Impossible', which served as a new model of kinship-by-affiliation ('Affinity: related not by blood but by choice, the appeal of one chemical group for another, avidity', p. 155), and of resistance. What was important to her analysis, too, was the sense that some of the most fruitful couplings, such as that of her own PhD and Sputnik, might come from somewhat unexpected, and even apparently unsuitable, unions.

The hole in the seal, the embryologists' footsteps, the graded air, the hand-made pipettes and the donated embryos create another kind of laboratory affinity, oriented along the axis of a different kind of hope – or hope exchange. This affinity, like that of the Livermore labs, has a specificity and a politics that belongs to its time and place in the early 21st century. The transbiological, in which biology is made in order that it be born, like Dolly, whose viability was proof of the success of her making, is fully cyborg in its polymorphic panoply of elements: machine, organism, code, message, human, ovine, natural and re-engineered. Like the cyborg, transbiology is also made up out of the complex intersection of the pure and the impure, where quality and biological control are literally merged to create new kinds of organisms, but this purity is hedged about by pathology of various kinds (and see Latour, 1987, 1993). Like the cyborg, the transbiological is not just about new mixtures, playful recombinations of parts or new assemblages: it is fundamentally defined by the effort to differentiate these dirty descent lines into functional, safe and marketable human biology (Cooper, 2006; Landecker, 2006; Waldby and Mitchell, 2006). New parts made from regenerative technologies must be standardized, regulated, ethically sourced and validated before they can become part of our biology.

In sum, the domain of the transbiological, broadly including contemporary tissue engineering, regenerative medicine, cloning and stem cell science, is yet another heir to the legacies of agriculture, physics and reproductive biomedicine. This term describes the post-molecular genetics world, in which biology exists in multiple forms – digitally, virtually, synthetically, mimetically, algorithmically and so forth – that are endlessly combined (Parry, 2004; also, see Mol, 2003). It is a world of cyborgs, but also of mixtures in which it is the symmetry of parts that allows translation, so that the mouse, the sheep, the cow, the pig and the dog move together as animal models susceptible to re-engineering and improvement.

If the cyborg is the figurative offspring of corporate science in the age of military-industrial command communication control systems bearing the hallmarks of their Cold War designers, as Haraway claims, the turn to the bespoke biological in the 'age of biological control' post Dolly and immortalized stem cells has a closely related pedigree, but lives on a different frontier. To the extent that transbiology comes to us via the cyborg embryo, and in particular via assisted conception, it occupies a historically different context than that described by Haraway for an earlier era, and its ironic vocabulary remains particular to its time and place. For example, it is one of the ironies of IVF that its introduction to enable greater conformity to traditional family values has, in quite a short period of time, undermined the very basis of normative 'biological' parenting by introducing a seemingly endless, and inevitably somewhat parodic, *sequelae* of quasi-, semi- or pseudo-biological forms of parenting (Cussins, 1996, 1998; Franklin and McKinnon, 2001a, 2001b; Franklin and Ragone, 1998; Thompson, 2001, 2005). Also ironic is the way IVF emerges as a reproductive 'bridge to a new life' deriving from an earlier 'nuclear turn' away from atomic energy, and toward cellular totipotency in the post-war period. Importantly, then, the defining hallmark of the transbiological is the queer lineage it shares with IVF – which has proven not only a bridge to new life for desperately desired human offspring, but much else besides. Like Dolly, the first 'test-tube babies' were miraculous because they were 'impossible', and especially miraculous because they were normal. These precious and paradoxical children had to be protected against the stigma and potential shame of their technologically assisted origins. Now IVF itself is so normalized it accounts for as much as 5 percent of the birthrate in some countries, with more than 3 million IVF babies having been born world-wide in less than 30 years.

It is the normality, even the ordinariness, of IVF that in turn gives us the everyday cyborg embryo, which, previously having been perceived as something of an oddity, now feels at home in the living room. The extra-corporeal zygote or blastocyst is no longer confined to the clinic or the textbook but has been domesticated and is no longer strange. The embryo that is now crucial to the development of successful transbiology has become a familiar postmodern kinship entity – and, if anything, is becoming even more established as a member of the family (Franklin, 1995, 1999b). Not only a potential offspring whose existence is linked to us by ties of shared reproductive substance brought into being through the union of reproductive intent, bioscience and reproductive biology, the cyborg embryo is now also the gift that can create yet another kind of intimate connection to a technoscientifically enhanced future. As Marilyn Strathern has pointed out, this system of 'reproducing the future' is self-perpetuating (1992b).

What is interesting about these new reproductive connections, then, is the kinds of affinities, politics, 'frozen moments' and future possibilities that provide the grammar, or kinship structure, of their working order today, and thus their genealogical orientation in the future.[13] What is also significant, and cyborg-like, about post-Cold War reproductive and mammalian biology, with its odd turn away from nuclear power and towards nuclear replacement via the nuclear family, is that IVF, which seemed to be 'just imitating' the biological facts of sexual reproduction, has proven also to be so radically disruptive to this equation that it is no longer possible to refer to the so-called facts of life with anything like biological certainty at all any more. Indeed, the opposite situation now exists in just the same obvious but slightly counter-intuitive way that Haraway explicitly described for an earlier period of historical transformation when 'permanently partial identities and contradictory standpoints' (1997: 154) proved the most logical way to think about the question of how to take responsibility for science and technology.

Like many other chapters in the history of biological control,[14] the idiom of improvement – and specifically of merging nature with progress – has been central to the increasingly prominent role the extracorporeal embryo has played in the re-engineering of the facts of life. The cyborg embryo, itself the offspring of a union between reproductive failure and reproductive hope, has become, like 'natural conception' before it, something that is seen to be in need of careful management in order for it to be properly domesticated (Franklin, 1995, 1997a; Throsby, 2004). Couples who pursue the assisted conception route can, in a complicated act of affinity with scientific progress and potential communities of future beneficiaries, now also donate their surplus embryos to research to make colonies of immortalized, regenerative, anonymized and totipotent cells, which will be banked in the aid of an improved human future. This biological reserve, archive or master stock can be directed to transform into specific types of cell and, in theory, is the literal seed-bed for a previously untapped source of human repair. The improved biology of the future will be more reliable, then, both because control of biology is being built in to the biological itself, and because other forms of control are being introduced to stabilize the cultivation of new, rebuilt, biologies – such as quality control, standardization, accreditation, and risk management.[15]

Here, as with Haraway's cyborg, without whom we could not make sense of the cyborg embryo, its biological *sequelae*, its genealogy or its descent pattern, we see that transbiology carries its own politics and they are, as Haraway insisted so rightly, fundamentally sociological (Franklin, 2006a, 2006b). In writing of the turn-of-the-century embryo, Haraway demonstrated that we cannot even look at the embryo – objectively, scientifically, in the laboratory, under a microscope – without seeing it through the lens of our own, pre-fabricated, culturally inherited, ubiquitous, constitutive, real and inescapable frames of reference. Nor, as she demonstrated in her later work on primatology (1989), is it possible for scientific understandings to escape the interpretive devices, taxonomic conventions or situated and historically specific understandings of how we know anything at all. Transbiology is real, material, factual and consequential in all of the senses that Latour articulated so vividly in his account of the birth of new entities such as somatostatin, which become not only things, objects, stable functions, but part of a genealogy of other objects 'sedimented' through their increasingly routine use to become the taken-for-granted conditions of the world around us (1987: 88–93).

The idea that such a view is 'merely discursive', or that it represents a retreat from the 'real', is especially problematic in the context of our own biology being in the midst of a reconstruction it would be as irresponsible to ignore as it would be to define as 'textual' in origin.

Today, the transbiological offers similar lessons, not only about how socialized (and socializing) scientific understandings always are, but now, and ever more visibly, how social values, systems and aspirations are being engineered and constructed in such a manner that they too become part of human biology. The biologization of human values is in some ways as old as horticulture, when human preferences began to be nudged into seedlings, and mutated corn began to be selected for its ears, but that does not mean that transbiology does not have its own specificity. In showing us a new set of implications of the bioinformatic implosion that enabled the gene to become the master molecule and ultimate coding mechanism, Haraway also pointed to the impurity of just such mixtures, and their potential insubordinations. As we observe the rise of transbiology, in which it is a logic of parts and wholes, or engineering and assemblage – indeed of construction – that prevails, we are perhaps also observing a shift away from 'the translation of the world into a problem of coding' (1991: 165) and toward a translation of the problem of coding into one of context (a key point throughout all of Haraway's work, and one that could be described as thoroughly embryological). Nonetheless, it will remain the case that 'any objects or persons can be reasonably thought of in terms of disassembly and reassembly' (1991: 162) and that there are 'no "natural" architectures that constrain system design' (1991: 162) – which could easily be described as two of the core modelling systems for transbiology, which in no small part consists of reverse, and transverse, engineering.

One other thing also remains for certain, which is that whether increased biological control comes to be fulfilled as a promise or as a false hope in the context of transbiology is a question we will reckon better if we know our cyborg history.

Notes

1. Latour's *Science in Action* (1987), Latour and Woolgar's *Laboratory Life* (1986), and Bowker and Star's *Sorting Things Out* (2000) are but three of the many influential monographs documenting both the way in which science must be understood as material practice and why its conceptual legacies are never 'just descriptive'.

2. See 'Spheres of Life' in Franklin et al. (2000: 19–43) for a discussion of contemporary imagery of cells, embryos and fetuses in the context of globalization. See also a review of the work of artist Helen Chadwick depicting human embryos in Franklin (1999b). See Kitzinger et al. (2003) for an account of media representations of the embryo and see Morgan (2003: 269) for an engaging analysis of how 'embryos never speak for themselves'.

3. As Charis Thompson says of the embryo in the United States:

> The human embryo in the United States carries (in more legible form than most entities) active and latent meanings that are considerably more widespread and older than the technologies in question. The presence in the clinic of ex vivo human embryos raises in especially acute form enduring tensions between the sacred and the profane that characterize biomedicine. These characteristics make the embryo a good spokesperson. (2005: 247)

For European debates over embryos see Gottweis (2002), Kitzinger et al. (2003), Solter et al. (2003), Sperling (2004).

4. For an ethnographic account of learning to 'see' an embryo, see Franklin (2003c). See also IVF and PGD patients' accounts of learning to see embryos in Franklin and Roberts (2006). For public debate of embryos see Banchoff (2004), Becker (2000), J. Edwards (2000), Franklin (1995, 1997b, 1999a, 2003d), Kitzinger et al. (2003), Mulkay (1997), Spallone (1996), Strathern (1992a, 1992b), Waldby and Squier (2003) and note 3 above.

5. For a useful tour of critiques of 'the cultural turn', readers are directed to the Wikipedia definition of this phrase. Einstein proposed his theory of relativity in 1905. The principle of relativity was so-named by Max Planck in 1908. It contradicted Galileo's principle of relativity, according to which the constant laws of the universe must appear the same to any observer. Using electro-magnetism, Einstein established this could not be the case, as the presence of matter itself 'curves' space and time.

6. For useful accounts of the co-evolution of cloning, stem cells, IVF and PGD see R. Edwards (2001, 2004, 2005) and Graham (2000). See also Michael West's account of the emergence of stem cell science historically and in the US (2003). For overviews of stem cell research and cloning see Maienschein (2003), Parson (2004) and Wilmut et al. (2000).

7. On Dolly as an example of the redesign of biological function, or what I am calling here the transbiological, see Franklin (1997b, 2000, 2001a, 2001b, 2001c, 2003a, 2003b, 2005b, 2007, forthcoming).

8. In addition to providing a crucial link between nuclear physics and developmental biology ('radiation biology'), embryology provides important pathways between agriculture and medicine. Indeed, the cyborg embryo exemplifies and embodies linkages between the farm and the clinic, not only in the context of reproductive biomedicine, but more recently in relation to stem cell science, tissue engineering, cloning, and the field of regenerative medicine (Franklin, 2007, forthcoming).

9. For a superb description of being born and bred, see J. Edwards (2000). For an account of being born and made see Franklin and Roberts (2006), and for a fuller description of being made in order to be born, see Franklin (2007).

10. Without having the space here to do justice either to the considerable literature on reproductive biomedicine and stem cells, or what Squier (2000) calls the 'tissue culture point of view', I can only point the reader toward some of the many recent sociological accounts of 'the social life of stem cells' (Banchoff, 2004; Cooper, 2006; Ganchoff, 2004; Gottweis, 2002; Hogle, 2003; Landecker, 2000, 2003, 2006; Liddell and Wallace, 2005; Lock, 2001; Rapp, 2003; Resnik, 2002; Sperling, 2004; Squier, 2004; Waldby and Squier, 2003), the geneticization of

kinship (Konrad, 2005b; Nash, 2004) and some of the authors who have examined how these phenomena can be culturally analysed (Konrad, 2005a; Rose, 2001, 2006; Strathern, 1992a, 1992b, 1999, 2005; Thompson, 2005).

11. Research on motivations of couples donating embryos to research in general, and to stem cell research in particular, is somewhat sparse and often superficial. However it would be accurate to claim that Britain has a comparatively high rate of willingness to donate, more or less 70 percent (Franklin 2005a, 2006a, 2006b; Franklin et al., 2005; MORI, 2003).

12. To the extent that all reproductive technologies can also be considered 'hope technologies' (Franklin, 1997a), so they participate in what Mary-Jo and Byron Good and their colleagues denominate as 'the political economy of hope' that structures social relations within biomedicine (Good et al., 1990). The importance of hope to scientific progress, and experimental medicine, is not only an expanding field of cyborg politics, but also a significant source of new 'trans' relations – for example through xenotransplantation, allografts, or what Nik Brown and Alison Kraft denominate as 'new "blood ties"' and 'new future-orientated parental duties and responsibilities' (2006: 313).

13. See Ahmed (2006) for a useful discussion of the ways in which the orientations of objects determine their shape. This perspective can usefully be applied to bioscience and biomedicine, for example in terms of the work of hope to define desirable futures (Brown, 2003; Franklin 1997a, 2007; Thompson, 2005).

14. The term biological control is used in a variety of ways – from pest control, to cellular redesign, to biosecurity. All of these have as their opposite, however, biology out-of-control, which some theorists believe is as much a consequence of attempts at biological control as its opposite – for example in the way cane toads, introduced to control pests, became a problem in their own right, or the over-prescription of antibiotics produces resistance. For an evolutionary argument, which maintains, similarly, that domestication of animals is not a one-way form of biological control, but produces unanticipated effects, including on humans themselves, see both Leach (2003) and Haraway (2003). This is one of the main arguments of Haraway's *Companion Species Manifesto* (2003; see also Cassidy and Mullin, forthcoming).

15. Significantly, and in a divergence from the scene painted by Haraway of the informatics of domination that defined many versions of technological control in the 1980s, the idioms for stem cell propagation invoke the much older biological idioms of gardening, horticulture, botany and cultivation. One might even say that, in contrast to the clean, bright 'sunshine' fantasies of technological control in the earlier period, the cultivation of transbiology relies more on an idea of soil.

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