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ABSTRACT This article examines some of the social and philosophical implications of stem cell technologies. Stem cell technologies promise to transform the way that healthy tissues for transplant are sourced and circulated; from a social economy in which citizens donate whole organs to others, to one in which embryos are a major source of therapeutic tissues. This article considers the transformations in concepts of health, bodily relationships and social indebtedness that such a shift might entail. Using the concept of biovalue, this article describes the ways embryos are biologically engineered to act as tissue sources, and considers the relationship between biovalue, health and capital value. It discusses the effects stem cell technologies may have on concepts of the healthy body, particularly on the temporality of ageing, and on understandings of the human more generally.

KEYWORDS *bioethics; cultural studies; embryos; health; organ donation; stem cells*

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> The gift is not inert. It is alive and often personified. (Mauss, 1967: 10)

Genes were among the most privileged biotechnical actors of the 20th century, attributed with qualities of biological causality and vital essence, the repositories of life itself (Keller, 2000). Certainly since the inauguration

of the Human Genome Projects genes have commanded centre stage in the theatres of popular science and big science alike. Nevertheless, commentators like Keller (2000) and Rose (2001) suggest that the gene is on the verge of displacement by new biological entities and models. In a post-genomic biology, genes will appear as simply one point in what Franklin describes as 'protein events in much longer sequential chains' (2001b: 19), components in complex networks of biological interaction rather than all-determining points of morphological origin.

Stem cells are one of these new biological actors, recently taking their place alongside genes as potent icons of promised control over our biology and health. The term 'stem cell' refers to any cell that can renew tissue in the body. The type most prominent in the media at present is 'pluripotent' stem cells, undifferentiated cells that have the capacity to develop into almost all of the body's tissue types. Some recent biomedical developments suggest that it may be possible to produce large numbers of undifferentiated stem cells that could then be induced to differentiate on demand, providing an unlimited supply of transplantable tissue. It is thought that stem cells may be very useful in treating currently intransigent medical conditions – Parkinson's disease, Alzheimer's disease, stroke, spinal cord injuries, arthritis – through the introduction of tissue into damaged or degenerated sites. Stem cells might also provide alternative therapies for common conditions like diabetes (NIH, 2000), promoting the growth of insulin producing tissue to replace pharmaceutical insulin regimes. Moreover, it may be possible to produce stem cell lines that are genetically and immunologically compatible with particular hosts, avoiding the problem of tissue typing found in whole organ transplants.

Stem cell research has been the subject of public controversy in the USA, Canada, Australia, the UK and Europe over the last couple of years, as various administrations try to work out regulatory frameworks for these promising, yet problematic, biological agents. They present certain kinds of political problems, for two reasons. First, the most viable source of stem cell lines is human embryos. Stem cells can be found in blood from the umbilical cord at the time of birth and from some adult tissues such as bone marrow, but these other sources do not appear to be as flexible or active as tissue derived from embryos. Hence stem cell technology brings with it all the familiar controversies that circulate around the embryo, the foetus, the right to life, and so forth.

Second, stem cell technologies are somewhat contaminated by their association with the new cloning technologies made famous by the birth of Dolly the sheep. If stem cell technologies succeed in engineering immunologically compatible tissues for human use they will do so by drawing on elements in the repertoire of techniques used for mammalian cloning, notably cell nuclear replacement (CNR).[1] Advocates of stem cell technologies make careful distinctions between therapeutic cloning for stem cell production and reproductive cloning for the production of whole new

creatures. Nevertheless, as Franklin (2001c) notes, the distinction is highly volatile and potentially controversial, and the association with the pejorative term 'cloning'[2] has generated further political heat in some cases.[3]

At time of writing these controversies are taking up the time and attention of the policy makers and politicians. A fairly pragmatic position has been struck in the UK, although not without some, muted, controversy. An existing piece of legislation, the Human Fertilization and Embryology Act (1990) that governs research on human embryos for reproductive health has been extended, after public and parliamentary debate, to allow for embryonic stem cell research as well.[4] Currently this research is limited to applications for neurological conditions like Parkinson's and Alzheimer's disease, although it seems likely that other conditions, like diabetes, will be added in the future. Medical researchers may now apply to the Human Fertilization and Embryology Authority (HFEA) for a licence to conduct stem cell research, using 'spare' embryos, left over from IVF procedures. The embryos must be no more than 14 days old, a limit set by the original legislation in order to mollify objections that research on embryos is unwarranted interference in fully human life (Mulkay, 1993). The Authority has stated that it will consider applications using CNR, and the recent (December 2001) production of a CNR embryo by the US biotechnology company Advanced Cell Technology suggests that applications may be forthcoming in the near future.

By contrast, President Bush has declared that US federal funding for stem cell research will be made available only where existing stem cell lines are used, 'where life and death decisions have already been made' (Bush, 2001: 10), rather than lines established by harvesting spare embryos.[5] Other administrations, like Canada and Germany, are exploring various compromises between biotechnological development and bioethical conservatism. The Canadian Federal House of Commons committee on health, for example, has just (December 2001) recommended a regulatory system similar to that now accepted in Britain, using 'spare' IVF embryos and licensed through a specific regulatory body. Unlike Britain, the report recommends that it be illegal to create embryos solely for research.

With these various regulatory frameworks in place, it seems likely that stem cell technologies will continue to garner considerable public interest, and to be objects of hope for the medical charities and advocacy groups, like the Parkinson's Disease Society, that form the natural constituency for these technologies. In the UK at least one biotechnology company, ReNeuron, has announced that it is gearing up for a clinical trial of stem cell transplantation for stroke victims. Many clinical researchers consider such plans premature, given equivocal results in related trials elsewhere (Meek, 2001). For example, a recent US clinical trial using foetal neural tissue to treat Parkinson's disease produced improvement in some patients, and exacerbated symptoms in others, pointing to the difficulty of calibrating and controlling a biotechnology that becomes fully internalized in the

body (Freed et al., 2001). Other research groups are focusing on animal model research, in the hope of more controllable clinical applications in five to 10 years time. Hence it seems possible that stem cell technologies could become an important component of biomedical therapeutics over the next decade or so.

Biotechnology and biovalue

My interest in these new stem cell technologies arises out of a more general interest in biotechnology, and its relations to sociality and subjectivity.[6] I am particularly interested in ways that developments in biotechnology frequently destabilize and reconstitute naturalized relations between bodies, bodily fragments, human identities and social systems. Biotechnological change effectively produces new material conditions of possibility for these relationships, challenging existing ethical, legal, ontological and sociological frameworks for their understanding and organization. So, for example, new reproductive technologies have exercised profound effects on structures of parenting and kinship, creating new relational categories like surrogate mother and sperm donor. New genetic tests, that identify a person's risk for contracting conditions like Huntington's disease, can reconstitute a tested person's identity, family and social world in complex ways. As Novas and Rose comment:

> When an illness or a pathology is thought of as genetic, it is no longer an individual matter. It has become familial, a matter both of family histories and potential family futures. In this way genetic thought induces 'genetic responsibility' – it reshapes prudence and obligation, in relation to getting married, having children, pursuing a career and organising one's financial affairs. Hence . . . these descriptions do not merely inform the judgements, calculations and actions of agencies of control – they shape the self-descriptions and possible forms of action of the genetically risky individual. (2000: 487)

Like new reproductive technologies and genetic tests, stem cell technologies involve a reorganization of the boundaries and elements of the human body, the development of new kinds of 'separable, exchangeable and reincorporable body parts' (Rabinow, 1999: 95). Rapid changes in the relationship between human bodies and bodily fragments have characterized developments in medical biotechnology over the last 40 years or so. Organ transplants have been succeeded by IVF, by genetic tissue sampling, by the creation of human cell lines and now by stem cell technologies. Each of these developments has created new possibilities for health, and produced new kinds of medical knowledge. They also involve often unpredictable implications for identity and embodiment. What does it mean when the human body can be disaggregated into fragments that are derived from a particular person, but are no longer constitutive of human identity (Rabinow, 1999)? What is the status of such fragments, and how is the status

of the individual (strictly speaking the in-dividual, he who cannot be sub-divided) altered to accommodate these possibilities for fragmentation?

At the level of social relations, how might the exchange of such fragments between persons, their donation or sale, their receipt and reincorporation, constitute relationships between them? Here I am working with the proposition that the circulation of biological 'gifts' create forms of social reciprocity and imagined community in much the same way as the circulation of others kinds of material goods in both traditional and market economies (Mauss, 1967; Frow, 1997). This proposition forms the basis for Titmuss' (1997) classic study of the social effects of tissue economies *The gift relationship: From blood to social policy*, which analyses the different social effects generated by different methods of tissue (blood) donation and management. For Titmuss, *giving* blood as an act of altruistic donation establishes social ties of indebtedness between fellow citizens, and creates the condition for the maintenance of community between strangers. *Selling* blood, on the other hand, creates instrumental, non-binding commodity relations between producers and consumers. The first economy creates social relationships based on generosity and indebtedness, an acknowledgement that the blood recipient's health is now owed to another. The second severs ties between the bodily fragment and the person from whom it is derived, so that it circulates as a commodity and is incorporated as an object of possession and consumption, without the creation of a tie between vendor and purchaser.

While Titmuss' work has been criticized for its idealism and its posing of an absolute and unsustainable opposition between gift and commodity (Frow, 1997) it nevertheless recognizes a constitutive relationship between the distribution of biological tissues and formation of social relationships more generally. On this model the exchange of biological substance is simultaneously a technical/material and a social act. Bodies that are materially implicated in each other through tissue donation and transplantation are also socially implicated, and medical systems that exchange and circulate tissues are also social systems.

Since Titmuss' study in the early 1970s, rapid developments in biotechnology have produced more and more kinds of bodily fragments, that can be alienated, altered, redistributed and reincorporated in increasingly complex economies. Nevertheless, if my analysis of the implications of Titmuss' model is correct, each such shift requires a reconsideration of the kind of social and corporal economy the new technology might imply, and what kinds of economies it might be situated within. In particular, the ideal gift economy set out by Titmuss is becoming more difficult to reconcile with the recent, ever-growing capital value of the biological fragment, and the ability of biotechnology to make cells, tissues, genes and the like ever more productive.

At this point I want to introduce the idea of 'biovalue', developed in some of my earlier work, (Waldby, 2000) to elucidate this biotechnical

trajectory. Biovalue refers to the yield of vitality produced by the biotechnical reformulation of living processes. Biotechnology tries to gain traction in living processes, to induce them to increase or change their productivity along specified lines, intensify their self-reproducing and self-maintaining capacities. This intensification or leveraging of living process typically takes place not at the level of the body as a macro-anatomical system but at the level of the cellular or molecular fragment, the mRNA, the bacterium, the oöcyte, the stem cell. Moreover it takes place not *in vivo* but *in vitro*, a vitality engineered in the laboratory, where, as Rabinow puts it, the biological fragment is constituted as a 'potentially discrete, knowable, and exploitable reservoir of molecular and biochemical products and events' (Rabinow, 1996b: 149). Here a repertoire of biotechnical procedures can be developed that induce the fragment to expand, to accelerate or slow down, to unfurl or recapacitate, to produce new substances or develop along new pathways, to recombine with other fragments and swap properties. In short biotechnology finds insertion points between living and nonliving systems (Mackenzie, 2002) where new and contingent forms of vitality can be created, capitalizing on life.

Cast in these terms, biotechnology produces a margin of biovalue, a surplus of fragmentary vitality. There are, generally speaking, two incentives for the production of biovalue. The public incentive, foregrounded by the technology's advocates, is the hope of creating a use value,[7] some viable contribution to human health. Scientists, funding bodies and patient groups hope that, one day, the vitality of the stem cell will be transformed into a lessening of debility, an improvement in functioning and well-being. As Rabinow notes, the legitimacy of biological research, its right to funding and experimentation, depend more and more on the claim to produce some therapeutic or clinical application, rather than simply the production of new biological knowledge. While the modernist biology of the cold war could legitimate itself with reference to the need to understand the basic organization of the natural world and living organisms,[8] contemporary life sciences are increasingly involved in the production of health.

> More than ever before, the legitimacy of the life sciences now rests on claims to produce health ... the bioscience community now runs the risk that merely producing truth will be insufficient to move the venture capitalists, patent offices, and science writers on whom the biosciences are increasingly dependent for their new found wealth. (Rabinow, 1996: 137)

The second incentive, as Rabinow's words clearly imply, is the production of exchange value, of biological commodities that can be bought and sold. The production of biovalue is caught up with the production of capital value. The process of producing biovalue is also the process of technical innovation that enables the patenting of cell lines, genes and transgenic organisms as inventions, securing their status as intellectual property and possible sources of profit for their inventors. However the process of

translating the activity of the biovaluable fragment into vitality at the level of the bodily system or profit at the level of the biotechnology company is highly uncertain. The end result may not at all resemble the scenario presented by the advocates for the technology, and science publics are increasingly critical of the rhetorics of hope (Mulkay, 1993) that are routinely deployed in the launching of a new biotechnology.

Currently, advocates for stem cell technology are producing optimistic promises of a new biology, a regenerative body that can repair and renew itself in the face of trauma, ageing and deficiency. This regenerative biology will, they claim, replace or substantially supplement current economies of tissue production and circulation, organized through anonymous blood and whole organ donation and characterized by risk and scarcity. Stem cell technologies promise to turn scarcity into plenty, and to develop new ways for the living body to utilize tissue resources in the production of a renewable health, less vulnerable to the predations of time and ageing.

In what follows, I want to consider the various tissue economies that are involved in stem cell technologies, and speculate about the implications they may have for biopolitics more generally. What kind of biovalue is being engineered from stem cells, and what health use values and exchange values are suggested by this engineering? What effects might stem cell technologies have on existing systems for the management and exchange of tissues, particularly on organ donation and transplantation? What idea of the healthy body is being projected by stem cell technologies? What modes of social relationship and imagined community will be constituted by the donation, engineering, distribution and transplantation of embryonic stem cells? To use John Frow's (1997) phrase, what kinds of indebtedness will be set in motion? Stem cell technologies are very new, and their sociotechnical consequences cannot be known at this stage. Here I want to raise questions and develop some theoretical approaches to these new entities, rather than provide definitive answers.

Tissue economies

Medical and political interest in stem cell research arises, it seems to me, at the intersection of two biopolitical problems. One of these is the ageing of the population in first world nations. With a decline in mortality, and increase in longevity, more and more people develop chronic and degenerative conditions associated with ageing – stroke, Parkinson's disease, Alzheimer's disease, heart disease and the like. Health systems devote an increasing proportion of their budgets to the long-term management of such conditions (CMOEG, 2000), as people live longer with more disease.

The second problem is the increasing difficulty of mobilizing tissues under current technical and social conditions, in the face of an ever-growing demand. Since the Second World War in the UK, Canada, Australia and

Europe blood donation has been nominally organized according to the principle of anonymous donation to strangers, the model celebrated by Titmuss. Organ transplantation first became viable in the 1950s, and whole organ donation has been largely modelled on blood donation. Organ donation is sometimes from a live donor, particularly in the case of kidneys, but more often from a legally dead body. These gift economies have been the primary source of living tissues for therapeutic transplantation and transfusion over the last 50 years.

As numerous commentators have observed (Frow, 1997; Rabinow, 1999; Franklin and Tutton, 2001) these gift economies have never worked without commercial supplementation, the illicit or official buying and selling of blood and organs.[9] A number of recent developments have further reduced the viability of donation economies for the production and circulation of living tissues. Blood transfusion systems have increasingly been associated with the spread of viral diseases like HIV and Hepatitis C, producing a growing mistrust of the public health management of such enterprises (Rabinow, 1999). Willingness to donate whole organs has been reduced in the face of hospital scandals like the recent discovery of organ banks, harvested from dead children without their parents' consent, at the Alder Hey Hospital and Bristol Infirmary in the UK (Legge, 2000). As Franklin and Tutton note, the decline in the legitimacy of organ donation suggests that 'the value given to body parts has grown as trust in the medical profession has possibly been eroded' (2001: 8). This suggests that the network of anonymous social trust and bodily indebtedness created by tissue donation economies are becoming less workable as declining medical legitimacy and increased commercialization take hold in first world health systems.

In contrast, Renée Fox (Stafford, 1999) locates the problem for organ donation not on the side of supply but on that of demand. She argues that, in addition to the recurrent problem of tissue typing, the difficulty of finding an immunologically compatible donor, the primary reason for organ shortages is a dramatic expansion in the constituency for organ transplantation. More and more conditions are defined as amenable to treatment through transplant, hence eligibility lists grow longer and longer. The practice of retransplantation also increases demand, as the immunological rejection that inevitably accompanies any organ transplant propels the organ recipient back onto the waiting list. Hence the organ shortage is not so much a problem with donation but more a problem, as Fox puts it, of 'aspiration to transplant' and 'to replace every worn out part of the human body' (Stafford, 1999: 243–4).

These recent refigurations of tissue economies, the expansion of demand alongside the problems of supply, means that, more than ever, healthy living tissue has the status of a scarce and precious substance, distributed according to carefully controlled systems of triage. In general, organs go to the sickest, the youngest and those in need of a second transplant (Stafford, 1999). The ever-growing constituencies for organ donation who are not

privileged by these hierarchies form a ready market and source of capital value for other sources of tissue.

Stem cell technologies identify a new and highly flexible source of tissue to augment the scarcity of existing tissue economies. Rather than living tissue donated by fellow-citizens, stem cell technologies source tissues from the very margins of (pre-) human life, the embryo. Stem cell research in the UK uses 'spare' embryos, those produced as part of the IVF process. IVF treatment routinely produces more embryos than can be used in actual reproduction, and couples may consent to their use for research. If spare embryos are not donated, they are usually disposed of. Hence stem cell technologies shift the source of tissue from a whole organ to a tiny collection of cells, and from an unarguably human person to an entity whose status regarding the human community is the subject of bitter contestation. For opponents of embryo research the embryo is not a biological fragment of another's body, but an autonomous being, a proto-child who cannot legitimately be given away.[10] For advocates, the embryo is a legitimate gift. The fact that the IVF couple can donate the embryo implies that it is a biological fragment of their two bodies, not unlike other bodily fragments that they may donate under other circumstances. It is not a member of the human community. Nevertheless its *potential* membership, its status as *human* embryo rather than the embryo of another species is the thing that makes it such a valuable source of transplantable tissue. Advocates of stem cell research generally portray the spare embryo as a precious substance. If it is not freely donated it will be simply wasted, a recklessly squandered resource. So, for example, the Chief Medical Officer's report into stem cell technologies argues:

> The vast majority of embryos used in research are embryos created in the course of infertility treatment and which, for whatever reason, are no longer required for treatment. The only options at this stage are to let the embryos perish or to use them, with the express consent of the individuals whose eggs or sperm have been used to create the embryo, in licensed and controlled research as part of the effort to enhance . . . human lives. (CMOEG, 2000: 38)

Stem cell technologies are, in these terms, particularly productive sources of biovalue precisely because they can rehabilitate what would otherwise be needless waste and transform it into a spectacularly active, flexible and manageable tissue resource. Here we can discern two conflicting ideas about the life of the embryo, and about the idea of 'life' more generally. For opponents of stem cell research, the life of the embryo is biographical, the beginning point of a human narrative that should be allowed to run its social course.[11] For advocates of stem cell research the life of the embryo is a form of raw biological vitality. From this point of view the embryo is not killed. Rather its vitality is technically diverted and reorganized. Embryonic stem cells have particular cell capacities and qualities that are quite different from those of adult, differentiated tissues and organs. The

hope of stem cell advocates is that these qualities can be isolated and made available for the augmentation of the adult body, the production of new forms of health. The healthy body proffered by stem cell research is not the immunocompromised, medicated and indebted[12] body of the organ recipient, but rather an immunocompetent, self-renewing body where stem cell biotechnology is fully incorporated as part of itself. In what follows I want to consider in some detail the ways that stem cell technologies engineer embryonic matter to mobilize and leverage these capacities and qualities, reorganizing them in ways that suggest this utopic, unencumbered health.

Capitalizing organism time

The biovalue produced by stem cell technologies depends on complex temporal reconfigurations, the engineering of cellular, embryonic and ultimately ontological time. I would argue that the manipulation of the time scales and trajectories of biological fragments is one of the major biotechnological strategies for the production of biovalue. As Rose (2001) comments, intervention in the temporality of biological pathways is a crucial part of the new biotechnological repertoire, across a number of different biological fields.

> All life processes now seem to consist of intelligible chains of events that can be reverse engineered and then reconstructed in the lab, and modified so that they unfold in different ways ... Life now appears to be open to shaping and reshaping ... by precisely calculated interventions that prevent something happening, alter the way something happens, make something new happen in the cellular processes themselves. (Rose, 2001: 15)

Stem cell technologies clearly alter the trajectory of biological development, at numerous points. As Franklin (2001c) notes, CNR and its cognates involve the reversal of *genetic* temporality. CNR involves the creating of an embryo not by the usual process of *in vivo* conception, fusion of egg and sperm, but through the *in vitro* insertion of the nucleus of a cell from an adult body's organs or tissues into an oöcyte, an unfertilized egg. The oöcyte has in turn been enucleated, that is, had its own nucleus removed to make way for the introduced nucleus. This creates an embryo with the genome of the adult from whom the nucleus was taken. Prior to the cloning of Dolly, it was assumed that the nuclei of adult cells had lost their totipotency. That is, once programmed to produce a particular kind of cell they lost their ability to produce different kinds of cells (Keller, 2000). Cloning based on CNR demonstrated that adult cell nuclei could, in fact, be induced to revert to or reactivate their embryonic potential.

> The version of cloning by nuclear transfer used for Dolly succeeded by reprogramming the nuclear DNA of an adult, differentiated, body cell to make it behave like an embryo: a cell that could produce every kind of tissue – that is,

> a cell that could become a viable offspring. It was the ability to *reprogram* the adult DNA to go back in time, which was the astounding accomplishment of Wilmut's team ... In sum, [they] have devised means of reversing cellular processes by resetting the cellular clock. (Franklin, 2001c: 345, original emphasis)

Stem cell therapies using CNR would involve the same kind of reprogramming, inducing the DNA in the adult cell of a patient to reactivate the potential it had at the point of conception. The embryonic tissue would be histocompatible with those of the donor, and could be used to repair organs or degenerate tissues. Such tissues would carry no risk of immunological rejection and the person would not need to take immunosuppressive drugs.

The establishment of immortalized stem cell lines[13] also reconfigures biological time, rerouting and reharnessing the temporal processes of ontogenesis. Pluripotent stem cells are embryonic cells at the first stage of differentiation, after the cells that form the placenta and supporting tissues for the foetus have divided off. They are pluripotent in the sense that they are capable of giving rise to most of the tissues that comprise an organism, although they cannot, at present, be induced to give rise to blood. In uninterrupted embryonic development in the uterus the stem cells that form the embryonic tissue cluster, the blastocyst, eventually divide and differentiate into the cells, tissues and organs that constitute the infant human body. To create a stem cell line the blastocyst is disaggregated into individual stem cells. These cells are then immortalized; that is they are induced continuously to clone themselves in their undifferentiated state. Cells that are immortalized will continue to divide and multiply indefinitely.

Hence immortalization involves not a reversal of biological temporality but its arrest; cells are maintained and expanded at a particular point in their developmental trajectory, the moment of pluripotency. In the Thomson (1998) study that established the first human embryonic stem cell lines, cells were cultured for four to five months without differentiation. That is, one stem cell multiplied to produce two stem cells, without differentiating into more specialized tissues. These cell lines were later induced to differentiate into the main groups of embryonic tissue layers. Subsequent experiments have induced stem cell lines to differentiate into the precursors of several mature tissue types, including neurons. Moreover, stem cell lines can be frozen, stored and grown again once thawed (CMOEG, 2000). So immortalization permits the arrest, immobilization and deployment of undifferentiated cells at specific points in their development, and the reactivation of differentiating activity on command. It also expands stem cell biomass to usable levels, so that the single 'spare' embryo, with its 200 cells and all its attendant political problems, forms the starting point for significant amounts of stem cells that can be produced and banked, the perfect self-renewing bio-commodity. As one medical article puts it, stem cells could act as, 'Universal donor cells ... "off the shelf" reagent, prepared and/or additionally engineered under good manufacturing practices readily

available in limitless quantities for the acute phases of an injury or disease' (Snyder and Vescovi, 2000: 828). This detailed control over the time of ontogenesis will, if it is achieved, present a unique and uncanny temporal resource for both health and subjectivity. It will, in effect, allow people to revisit specific moments of their own ontogenesis, activating a technobiological version of their own body's formation. If CNR technologies are used to produce therapeutic clones, with the same genome as the human donor, the embryonic tissue resource is also a kind of delayed twin, a repetition of the donor's first moments of biological emergence.[14] Certainly this is not a perfect iteration; at the level of genetics, the embryo will inherit mitochondrial DNA from the enucleated egg used in the replacement process, an inheritance with currently unknown consequences for the utility of the stem cells. Nevertheless CNR stem cell technologies suggest ways in which the extreme margins of human technogenesis can, as I have argued elsewhere (Waldby, 2000), form the most important kinds of material resources for the production of human health and the preservation of subjectivity against the predations of the body and illness.[15] Following Braidotti (1994), such biotechnological manipulations of organism time might also act as a kind of psychic resource for shoring up a position of biological autonomy or individualism. She argues, regarding reproductive technology, that it is driven by a fantasy of parthenogenesis, the desire to be,

> In total control of one's origins, that is of being the father/mother of one's self. . . . This implies the blurring of generational time, of one's position in time, in relation to others. . . . The fantasy of being at the origin of oneself, [is] of not having to recognise one's beginnings in others – one's parents. (Braidotti, 1994: 23)

This revisiting of ontogeny is pursued in order to intervene in the temporality of yet another biological process, the process of ageing. Not surprisingly, biology's changing control over the temporality of the bodily fragment has coincided with a shift in its understanding of the processes of ageing. According to Sinden (2000), biology has recently abandoned a model of the body as temporally homogeneous, involving a uniform growth, renewal and ageing. Instead it has adopted a model in which the body's times are heterogeneous, sites of self-renewing vitality interspersed with sites of irreversible loss and degeneration.

> [Until recently] it has been generally believed that a human body builds up most of its cells and tissues early in life, and then everything begins to fall apart, cell by cell; the whole degenerative process accelerating as we get older. In fact, the daughters of the same cells that were the totipotent originators within the first weeks of our life . . . busily work away through our lives . . . repairing [damage] . . . It is now believed that such rebuilding is going on constantly all over the body: stem cells are making new cells continuously for bone, liver, heart, muscle and even the brain . . . . While some cells and tissues seem to replenish themselves constantly throughout life, . . . other tissues such as brain and heart seem

> to decline inexorably with age and suffer major irreparable functional loss with damage or disease. (Sinden, 2000: 18–19)

Here we can see a rethinking of the human body as a complex 'sheaf of times' as Serres (1982: 75) puts it, the co-existence of cellular proliferation, mutation, growth and self-renewal with wearing, ageing, loss and decay. In this complex temporal bioscape the regenerative activity of the stem cell can reinvigorate ageing sites, and harmonize them with more vigorous kinds of tissue. Sites prone to degeneration like the brain can be augmented, and brought into line with self-renewing sites like the bone marrow. If ageing is now defined as a clash of heterogeneous tissue temporalities, it can presumably be adjusted so that tissues age in a homogeneous way.

Conclusion

The dream of stem cell technologies is then the dream of a regenerative biology, where every loss can be repaired, and where treatments currently available as pharmacology, like L-Dopa for Parkinson's disease, are replaced by the endogenous incorporation of tissues. The ageing body would partake of the embryonic tissue vitality of the very young body, able to reproduce itself indefinitely. This dream biology is, of course, unlikely to be realized as such. It is based on the hope that the vitality, self-renewal and immortality of the biovaluable fragment can be scaled up to become the qualities of the macro-scale body. It ignores the risks, dangers and uncertainties involved in translating biovalue into health. As some stem cell researchers comment, the plasticity and immortality of stem cells are qualities that present risks of inappropriate tissue development, as well as therapeutic possibilities. '[Researchers] must create safeguards such that cells with theoretical "totipotency" do not give rise to inappropriate cells (e.g. muscle in the brain), transform to teratocarcinomas, or create autonomous organs within the larger organ (e.g. neural tubes within the heart)' (Snyder and Vescovi, 2000: 828). At the same time dream biologies can be highly informative about the social relations involved in medical biotechnology. John Frow, commenting on whole organ transplantation, makes a crucial observation about such dream biologies. He writes:

> Transplantation constructs a culturally very powerful myth of the social body – that is, of the limits and powers of all our bodies. This is the myth of the restoration of wholeness and of the integrity of the body: a myth of resurrection. Yet this wholeness can be achieved only by the incorporation of the other. The restored body is prostheticised: no longer an organic unity but constructed out of a supplement, an alien part which is the condition of that originary wholeness. (Frow, 1997: 177)

Health involves supplementation, and in more and more biomedical technologies, this supplementation is not pharmaceutical or mechanical but biovaluable. It utilizes value added biological fragments whose vital qualities

have been processed and engineered. The sources of such fragments seem to be diversifying. While the ideal gift economy described by Titmuss involved the exchange of body parts between consenting citizens, tissues and bioactive substances are increasingly derived from 'abandoned' human tissue, as in the Mo[16] and HeLa cell lines; from animals, sometimes transgenic animals, like the sheep cloned by PPL pharmaceuticals to produce an enzyme in their milk useful for the treatment of Cystic Fibrosis (Franklin, 2001c); and now from embryos.

At the same time, as Frow's formulation implies, the production of this kind of health expresses social relations of (sometimes unacknowledged) indebtedness. The healthy *owe* their health to others, human and non-human, and incorporate fragments of these others as a condition of their well-being. Titmuss' gift economy was one way of managing this indebtedness, drawing on its productive effects in the creation of common interest and relations of equality between embodied citizens. However the complex, deferred temporalities involved in stem cell biovalue and the ambiguous ontological status of the donated fragment may not lend this form of tissue production and distribution to Titmuss' proposals for a humanist imagined community, for the following reasons.

First the ontological status of the stem cell and the embryo; part of the difficulty of incorporating a transplanted organ for whole organ recipients is their acute, often guilty sense that their renewed bodily vitality and sense of a viable future is owed to the interrupted biography of another, the posthumous organ donor (Fox and Swazey, 1992). In this current stage of stem cell technology it is impossible to know empirically how embryonic tissue recipients may experience their new-found health. Yet Fox and Swazey's study of organ recipients suggest that this will be strongly conditioned by the recipient's evaluation of the human sacrifice involved in the donation. If the embryo from which tissue is derived is valued as an interrupted human biography, then it seems possible that the recipients will experience their health through media of guilt, indebtedness and shame. If the embryo is evaluated as a precious, vital fragment given by the couple to the recipient, then the relationship will be closer to that described by Titmuss, a bond of generosity and gratitude between fellow citizens. It seems possible that the tissue may also be interpreted in non-personified ways, as, for example, something more akin to medicine, the product not of human donation but medical ingenuity. Moreover the relationship of embryos to human status will doubtless become more complex and fractured if embryos prove to be such productive sources of tissue, so that the humanist valuation of embryos as proto-human may intensify, weaken or both. It seems inevitable that stem cell technologies will induce some difficult to anticipate mutations in what the human means, if human health and embodiment is enhanced through the technological manipulation of human ontogeny.

Moreover, the biovaluable engineering of stem cell tissues complicates

the play of gratitude and indebtedness celebrated by Titmuss in quite unprecedented ways. In the case of whole blood and whole organ donation, the gift is transferred more or less intact, more or less in a one-to-one relationship between giver and receiver, although mediated by technical systems that ensure the safe transfer and storage of the gift. In the case of stem cell technologies the donation of a single embryo is simply the starting point for a process of biovaluable amplification. A single cell disaggregated from the embryo might form the basis for an incalculable amount of therapeutic tissue, transplanted into innumerable recipients, for a diversity of conditions, over an unspecified length of time. The tissue will perpetuate the genetic legacy of the donor couple, quite possibly well beyond their lifetimes. The biovaluable engineering of the stem cell multiplies its biomass exponentially, so that the original donation is simply the starting point for an infinitely branching and self-multiplying network of tissue relations. The extent to which any tissue circulating in such a system is invested with relations of identity is difficult to specify. However, the fact that the tissues will perpetuate the *genetic* legacy of the donors suggests that, for the donors at least, this may be the case, as the equation between genetic material and identity becomes stronger and stronger in the popular imagination (Keller, 2000).

These complex new tissue networks demand a rethinking of biopolitical frameworks for the social management of tissue economies. Given the incalculable provenance of donated embryonic tissue, donation may become more and more problematic for IVF couples unless some means of articulating relations between donor and recipient is developed. Attempts to extract excessive exchange value from stem cells may also act as a deterrent to donation, as couples feel uneasy about giving their embryos to private companies intent on patent and the maximization of profit. Tissue recipients may have difficulties living out a form of health indebted to embryonic tissue.

At the same time these problems cannot, it seems to me, be addressed simply through the reassertion of the categories and morality of a humanist bioethics. Stem cell technologies, like many other contemporary biotechnologies, make evident the fact that the human is not a natural, biological category but rather a status and being emerging from a complex network of technobiological production. Contemporary biotechnology demands a bioethics that can understand the complex reciprocities and technical mediations between human and non-human entities, and frame ways of living that acknowledge this. The kinds of social relationships that may develop around stem cell technologies must be understood as part of a broader social negotiation over this network of production, and the kinds of humans and non-humans, entities and hybrids, health and illness it should produce.

Notes

1. CNR is discussed at length below.
2. Franklin (2001a) argues that the term 'cloning' now has only pejorative connotations in popular discourse, and is used as a shorthand term for the dangers of modern biology.
3. The HGAC (1998) report found that a number of those it consulted found the distinction between therapeutic and reproductive cloning arbitrary and meaningless.
4. A UK religious group, the ProLife Alliance, managed briefly to wrestle the governance of embryonic stem cell research away from the HFEA during November 2001, when they secured a bizarre ruling from the British High Court. The Court declaring that embryos produced through CNR were not embryos, as the term only applied to entities created through 'natural' fertilization. The Government was then forced to rush emergency legislation through both houses of parliament to prevent an outbreak of unregulated research.
5. Predictably the response to this rather weak compromise has been scathing. As one Australian bioethical conservative puts it, 'it enshrines the principle that it is wrong to benefit from experiments on someone you have killed, but right if someone else has done it for you' (Cook, 2001: 13). American scientists are concerned that the existing lines are too few to offer adequate genetic diversity, while companies like Geron in the USA and ES Cell International, a Singaporean/Australian consortium, are poised to negotiate profitable commercial deals for the use of their product.
6. I am using the term 'subjectivity' in a broadly Foucauldian way, where the subject is understood to be constituted through particular networks of disciplinary and biopolitical power, materialized in historically specific modes of embodiment. At the same time the term is intended to evoke the experience of the self, identity and agency made available within these networks.
7. The terms 'use value' and 'exchange value' are taken directly from Marx, in his elaboration of his theory of value in *Capital* Vol. 1. Use value describes the usefulness of an object, its physical properties that allow it to be consumed or do useful work for human beings. Exchange value pertains to the standardization of value through which one kind of use value can be exchanged for another. Hence the establishment of exchange value is intrinsic to the formation of markets and money-based economies.
8. See Kay (2000) for an account of the post-war pure research effort in genetics, for example.
9. For example, as Rabinow (1999) states, while whole blood was generally donated through the voluntary gift system in France, blood products like Factor VIII, a bioengineered clotting agent used to treat haemophilia, were sourced from commercial, international suppliers.
10. For some examples of this view of the embryo see Mulkay's article on the Parliamentary debates around the introduction of the Human Fertilization and Embryology Act. One opponent of the bill states:

    > If passed, [the law] will allow the in vitro embryo to be frozen, discarded, donated, sold and used for destructive research . . . On that basis the embryonic human being is a . . . another example of the throwaway society

that says, if it is not useful or convenient, get rid of it. (Cited in Mulkay, 1993: 729)

11. Thanks to Simon Cohen for this point. This position, being one dictated by in principle opposition to embryo research of any kind, tends to ignore the fact that 'spare' IVF embryos have no possibility of a biography, as they are not introduced into a uterus where they can become viable pregnancies.
12. Fox and Swazey's (1992) work, and that of Rosengarten (2001) found that organ recipients generally experienced powerful feelings of indebtedness, gratitude, identification and often guilt towards the person whose organs they receive.
13. Stable, pluripotent stem cell lines were first produced from human embryos only in 1998 (Thomson, 1998), although they have been established for other animals for much longer.
14. One of the dystopian scenarios associated with CNR technology is the production of an anencephalic twin, an immunocompatible donor body genetically engineered to develop without a brain, which could serve as a source of whole organs for transplant. Such anencephalic donors are not strictly dystopian fantasies. In the USA anencephalic neonates have been used sporadically as sources of organs for infants in need of transplants, with generally poor success rates and considerable strain for staff and families (Fox and Swazey, 1992).
15. In *The visible human project* (Waldby, 2000) I argue that medicine's privileged place in humanism derived from the ability of medical biotechnology to preserve and engineer the body in the service of subjectivity, at least up to a point. That is, medicine protects the self from dealing with the waywardness of the body's materiality, and the impossibility of containing its life within the confines of culture. Of course this protection is only ever partial, precisely because illness and death cannot be escaped indefinitely, and because medicine's own practices involve subjective encounters with the body's limits and recalcitrance.
16. For discussion of human cell lines and their provenance, see Rabinow (1996) and Erin (1994).

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