In Vitro Anthropos: New Conception Models for a Recursive Anthropology?

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Drawing on fieldwork in U.K. stem cell labs, where early human development is modelled *in vitro* using cell culture systems, and cultured cell lines are used to make new diagnostic tools, this article explores a new meaning for the phrase 'conception model'. In the London labs where the author has conducted fieldwork since the 1990s are many examples of how human reproductive cells are being used to manufacture and 'road test' new diagnostic tools. This paper explores the recursion involved in modelling early development 'in man' (as opposed to mouse, axolotl or sea urchin), and develops anthropological analyses of living human cell systems grown in Petri dishes that are aimed at illuminating the causes of human pathology. It is argued that several different levels of recursive modelling occur via '*in vitro anthropos*', and that these cellular models introduce a useful perspective on the debate over 'reflexive' anthropology, and the more recent turn to a 'recursive' anthropology. However, different kinds of difference are at stake in these two projects. Using cell culture modelling practices, and the 'conception model' offered by dish life as an analytic vantage point, the paper offers a 'looped' view to illustrate what the 'recursive turn' might look like, or reveal, as an ethnographic project. In contrast to the 'loopy' view of much reflexive anthropology, fieldwork through the looking glass, including the explicit turn to a recursive anthropology, is argued to be both an empirically robust and a conceptually creative practice.

Keywords: conception model, stem cells, recursive anthropology, ethnography of science, biomedicine, *in vitro* fertilization.

Slipping out of my street clothes in the tiny cubicle, I fold them neatly in a pile above my shoes before wiggling into the sterile, blue bunny suit provided for me by the lab. We are in the entryway to the air-locked chambers that will lead us into the clean-room research facility on the eleventh floor of the Guy's Hospital tower in London, high above London Bridge railway station and just south of the Thames. Here, in a recently built suite of GMP (Good Manufacturing Practice) laboratories dedicated to cultivating human embryonic stem cells (hESCs), a new research tool is being perfected, namely a Petri dish model of a human genetic mutation. Superior to animal models because they can be more precisely controlled and monitored, and a potential pathway to the manufacture and testing of new drugs for both rare and common genetic diseases, these new hESC models comprise a key contemporary strand of the process Hannah

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Landecker describes as 'culturing life' (Landecker 2007). I have come to see, and to film, how these models are made.

Having worked with the members of the Guy's stem cell team for over a decade, I have observed many of the crucial breakthroughs they have achieved as one of the world's leading centres of hESC research. Initially working with Professor Peter Braude, Dr Stephen Minger and Dr Sue Pickering, I chronicled the birth of 'WT3', the U.K.'s first hESC line in 2003, while conducting an ethnographic project on pre-implantation genetic diagnosis (PGD) – the source of the embryos used for many of the Guy's, King's and St Thomas' cell lines (Franklin and Roberts 2006). With the Guy's team I visited the first hESC derivation lab annexed to an Assisted Conception Unit (ACU) in Sheffield in 2005, and contributed to the original funding application for a similar lab at Guy's (Franklin 2006). I wrote about the Guy's lines in *Dolly Mixtures* (Franklin 2007: 64–69) as a new form of 'life stock', building on earlier accounts of hESC lines as promissory forms of 'ethical biocapital' (Franklin 2001, 2003). Later, I worked with Guy's staff to devise the informed consent procedures for this type of embryo donation, as part of a national team of human embryonic stem cell research coordinators from the main hESC labs all over the U.K. (Franklin et al. 2008). As a result I know the culture of this stem cell lab in more than one sense of the term, and it is the cultivation of a successful cultivation culture that poses the recursive turn I seek to explore below.[1]

This article thus extends the continuing 'cross-fertilization', as Malinowski (1974: xxvi) described it, within anthropological debates over conception models by examining a specific kind of contemporary scientific tool, namely the *in vitro* models of human embryonic development that are now routinely produced in stem cell labs all over the world. While I want to put these models into dialogue with the history of anthropological debate about the causes of conception and pregnancy, and their relevance to wider cultural logics of personhood, kinship and identity, I also want to explore a specific dimension to this recursive relation, namely how the social and biological aspects of *in vitro* life are merged, coupled, or united in the formation of new human cellular tools. By doing so, I would also like to add to the debate about what a 'recursive' anthropology might mean, exactly, in the context of the long-standing anthropological concern with conception models – an anthropological recursion that has become highly developed in the context of debate over new reproductive technologies.[2] The classically recursive exercise of modelling and remodelling models in the context of debating debates over conception, need not, I suggest, be cast as 'sterile' (Shore 1992). Rather, the recursive turn in anthropology may help us to develop a more complex theory of technological cultures – including disciplinary ones. At the same time, they may also enable us to question what a 'recursive' anthropology would involve, and how it might be distinguished from a 'reflexive' one.[3]

U.K. Stem Cell Culture

The cultivation of a cultivation culture for human embryonic stem cell derivation is a major priority not only for the internationally renowned stem cell derivation team at Guy's, but for the British government, which has dedicated huge resources and time to this field of 'frontier' or 'horizon' bioscience (DoH 2011). The lab I am about to enter

in the Guy's tower is a manifestation of the effort to 'streamline' and 'translate' bio-innovation through new infrastructures such as derivation labs built directly adjacent to ACUs. By avoiding the 'bottleneck' in the research embryo supply chain created by the 'firewall' separating research from treatment, the wall of the lab I am about to enter has literally been punctured to allow fresh reproductive cells to be passed through a hatch from a 'dirty' surgical unit into a super clean laboratory. Here, on the other side of the wall from the ACU, gametes and embryos are carefully washed, housed, fed, labelled, characterized and stored. Some will return through the hole in the wall to be used for treatment, others will be cryo-preserved for future IVF cycles, and a small percentage will be donated to research. This lab is in turn part of a national network of stem cell derivation labs, which have the U.K. National Stem Cell Bank as their hub (see Figure 1).

The Code of Practice issued by the Steering Committee of the U.K. Stem Cell Bank (UKSCB) specifies the oversight mechanisms for research involving human embryonic stem cell lines and sets out the requisite procedures for their procurement, storage and distribution, as well as their use by clinical and research communities both within and outside of the U.K. All research on human embryos in the U.K. is under the statutory control of the Human Fertilization and Embryology Authority (HFEA), although hESC

Figure 1: The UK embryo supply functions as a coordinated network of embryo exchanges and transfers which have the national UK Stem Cell Bank as their hub.

lines are not, technically, considered to be embryos. Nonetheless, 'as the generation of embryonic cell lines involves the destruction of human embryos', the UKSCB Code of Practice is intended 'to ensure that research is conducted within an ethical framework that is transparent to the public' (UKSCB 2010: 2).

The complex relationalities that must be navigated, standardized and ethically overseen as part of the increasingly sophisticated and elaborate process of transferring embryos from a clinical context, such as fertility treatment or genetic diagnosis, into human embryonic stem cell donation raise unique questions concerning the donation of reproductive substance to research, as well as the need to document both the provenance of this substance and the mechanisms of its transfer into research (including research that may yield clinical products, research that occurs outside of the U.K., and research that may be commercialized; see Franklin et al. 2008). Human embryo transfer and exchange are well suited to traditional forms of anthropological analysis, combining kinship and exchange theory with models of gift prestation and commodity markets – and indeed suggesting that these domains are more intricately interwoven than may previously have been allowed.[4] There are well publicized scientific and political challenges faced by this sector, especially since an increased emphasis on public participation in, and dialogue with, emerging bioscientific initiatives such as stem cell banking is also a U.K. government priority (Davies 2008; Burchell et al. 2009; Franklin forthcoming (a)). As was the case for reproductive biomedicine, the U.K. government favours a strong regulatory and legal infrastructure to create a stable climate for bio-innovation as opposed to an essentially unregulated 'free market'. A major economic rationale thus underwrites the considerable U.K. investment in hESC derivation, which is at present largely a publicly and philanthropically funded enterprise.

The U.K. characteristically seeks to protect its distinct advantage in this field due to its long history of legislation in the area of human fertilization and embryology, although to some stem cell scientists this degree of regulatory apparatus is more burdensome than enabling (AMS 2011). Since 2003, the U.K. government has invested more than £200 million ($300 million) in the stem cell pathway in an effort to streamline both the donation of embryos and the derivation of new lines that will feed into the regenerative medicine pipeline. The new generation of labs, such as the GMP facility at Guy's, are a pump-priming investment explicitly intended to provide a more efficient pathway to translational biology and its potentially lucrative future markets. The IVF–stem cell interface is now pivotal to the development of new therapies and products intended to harness and capitalize the mass (re)production of regenerative cells for repair, which is seen as the next phase in health care, as well as a new source of wealth generation (Mason and Dunnill 2008). Described by the previous Blair and Brown governments as 'health and wealth deliverables', stem cell therapies and new regenerative medicine applications are being positioned by many governments around the world as the successor products to all of the Big Pharma 'blockbusters' that are facing a 'patent cliff'. Living cell technologies, or therapeutic bio-products, are described by the U.K. Department of Health in a recent report as 'a driver for the U.K. economy and future healthcare' with the 'potential to provide a step change reduction in health care costs' as well as generating new sectors of employment and new markets (DoH 2011: 45).

From Reproduction to Regeneration

Importantly, the U.K. drive to develop stem cell technology shares a genealogy with the development of new reproductive technologies for clinical use from the mid twentieth century onwards. By the late 1980s, assisted conception technology had already become a major medical service sector, and the focus of new medical specialisms as well as a rapid rise in the amount of basic scientific research undertaken in the fields of human fertilization and embryology (Clarke 1998). The rapid evolution of human IVF technology from infertility treatment into a source of human cells for stem cell research and regenerative medicine, in less than three decades, illustrates better than any other single example how profoundly human reproductive substance has been technologized from the late twentieth century onwards. The first major technology to enable the mass creation and handling of human embryo populations, *in vitro* fertilization is now a platform, or stem technology, supporting a wide variety of other applications which now extend beyond reproductive biomedicine to include hESC derivation and the potentially enormous field of regenerative medicine. In the beginning, IVF was envisioned as a means of bypassing blocked Fallopian tubes, later expanding into the treatment of male and undiagnosed infertility, and in the 1990s expanding into the prevention of serious genetic disease through its adaptation to preimplantation genetic diagnosis (PGD).[5] Since the first successful isolation of hESCs in 1996, and increasingly in the early twenty-first century, IVF and PGD have acquired a newly pivotal importance as sources of donated research embryos at the increasingly busy interface between assisted conception technology and regenerative medicine (Franklin 2012, and forthcoming (b)).

In sum, the new labs express the intention to rationalize the thousands of transfers of research embryos all over the U.K., to routinize and validate derivation procedures, to increase bio-security and ethical oversight, and eventually to remunerate the British population by delivering into U.K. GDP a larger share of the bio-economic pie. For this model of bio-economic growth to succeed, it is essential for new sources of 'live stock' to become more streamlined in order that they can be scaled up, banked and used for manufacturing new cell-based commodities on a commercially viable scale. Put simply, the significant appeal of human embryonic cell lines is their importance as the 'best' source of pluripotent cellular stock, and thus the most likely to repay capital investment. As the King's team describes this process: 'Pluripotent stem cells … can be provided in theoretically limitless quantities, and are therefore capable of providing more cells than from any other source, regardless of differentiation efficiency and stabilization. Thus they are the cell type likely to yield the most from invested capital' (Stephenson and Braude 2010: S678). Necessary to the realization of this yield are a number of banking issues including: 'legislation to allow use of human embryos for stem cell research', 'consensus for reporting the quality and type of embryos suitable for stem cell derivation', and 'a regulatory route map to facilitate clinical application' (ibid.: S678). These obstacles 'have largely been overcome, especially in the U.K'. (ibid), due to the collaboration of a large number of government agencies, again largely financed by the public sector. It is in this way that the U.K. is creating the equivalent of Greenwich Mean Time for stem cell banking, much as it earlier set the standards for the global financial

Figure 2: The Hole in the Wall.

sector – in which it continues to occupy a distinctly privileged location because of the global time that it standardized as the first global capitalist industrial economy.

At work propelling embryos through the holes in the walls of the new labs at the IVF–stem cell interface, then, are historically well-established goals of maximizing efficiency through scientific cooperation; promoting economic growth through government stimulus investment in infrastructure; coordinating the exchange of scientific knowledge and materials through the research councils, universities and National Health Service (NHS); and the standardization of regulatory codes and procedures in order to generate successful technological progress as well as 'paybacks' to the general public (who fund much of the research). At a more intimate level, the IVF–stem cell interface concretizes a new form of exchange, transfer or passaging, whereby the reproductive substances involved in a therapeutic quest, such as IVF or PGD, become entangled in the new frontiers of bioscience, bio-manufacturing, biological citizenship and the bio-economy. The cells that might be used to make much wanted offspring are also valuable as uniquely pluripotent reproductive substance. This precious, high-yield material is of prominent national importance, and distinctive scientific interest, while also being highly ethically charged, legally sensitive and politically volatile. Anthropologically familiar, the rapidly changing importance of reproductive substance is also an index of the 'reproductive revolution' that has occurred since 1978, and the difficulties of characterizing this form of bio-cultural change. A different species of 'looping effects' to those described by Hacking (1995) are at work in the national and international effort to establish appropriate codes of conduct governing the exchange, donation and handling of human reproductive substance, where both kinding and kinning matter to understandings of causality and knowledge that are being built into emerging classificatory systems for new biological entities, such as 'cybrids', cell lines and chimeras (Haraway 1997). A practical bioethics, mixed with a new kind of biological anthropology (or anthropology of biology), is

evident here at the juncture between human reproduction and regenerative medicine, looping between the production of human and natural kinds, as embryos conceived in the hope of a successful pregnancy are transferred into the search for new mechanisms of biological repair and economic re-growth. A new kind of biological reproduction is also forged in these contexts of remaking human life, where human reproductive substance is being shared in a complex web of biosocial ties. Copying conception *in vitro*, it turns out, both reproduces and changes it, not only by establishing a new ground state for sexual recombination, but a new coupling between biology and technology – or indeed even an identity between them. These 'looping effects' are also classically recursive mechanisms, in the sense that they generate change by reproducing their original conditions, or properties.

Reproductive Tools

While the sharing of reproductive substance across the IVF–stem cell interface is of anthropological interest because of the way in which it establishes new definitions of kinship, and new kinds of gift relationships, it is also of note as a novel context of tool evolution. Whereas much attention to new reproductive technologies and kinship has focussed on new kinship arrangements and the 'reconfiguration' of kinship (Franklin and McKinnon 2001) in the context of new understandings of what 'cultures of relatedness' might involve (Carsten 2000) once they are either 'after nature' (Strathern 1992a) or 'after kinship' (Carsten 2004), (or 'quantum'; Kirby 2011), another set of questions concerns the explicit transformation of reproductive cells into tools (Landecker 2007; Franklin 2012, forthcoming (a) and (b)). It is from the perspective of biology as technology that we encounter both a new relationship between reproductive substance and codes for conduct, and a useful synecdoche for emerging socio-political and bio-ethical challenges in 'the age of biological control' (Wilmut et al. 2000) more generally. Consequently we also encounter an interesting repeat of the Malinowskian premise that conception models recapitulate and consolidate fundamental principles of social order, as well as an opportunity to examine more recursively how the new biology of the stem call lab takes after, or models, social life.

The new tool I have come to see at the Guy's lab is a diagnostic human cell line. These bespoke lines are made from mutation-carrying embryos donated by couples undergoing PGD, whose 'affected' embryos cannot be used for treatment, since the purpose of PGD is to detect the presence of mutations that cause serious and often lethal genetic disease *in vitro* in order to ensure that embryos that are 'positive' for this mutation are not used to initiate a pregnancy. In turn, these embryos can be used to make cell lines that carry the genetic mutation and serve as test beds for new drugs, as well as for improving the ability to map, and interrupt, disease pathways. Successful lines of this kind have numerous advantages that are described to me by the head of the Guy's stem cell team in terms of better representing human pathophysiology, addressing disease mechanisms, and facilitating more effective drug discovery.

Describing the unique value of living human cell models of the mutations that cause genetic disease, Dr Dusko Ilic explains why a dish model made from such cells is not only a 'very, very useful tool' but 'the best tool you can get':

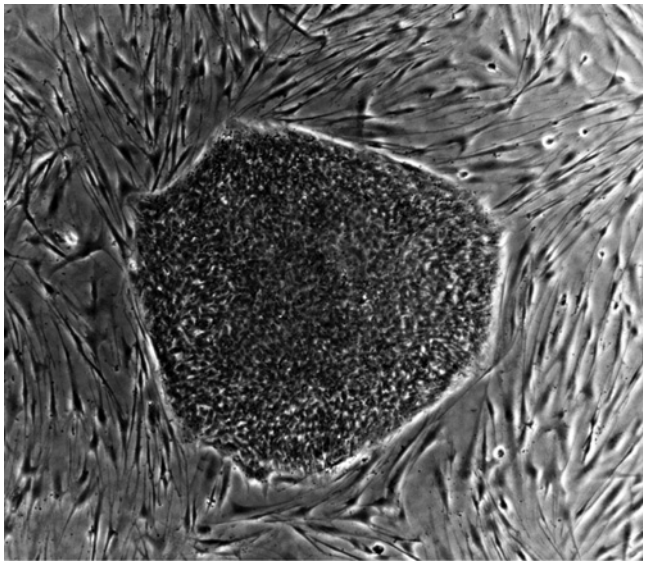

Figure 3: Human embryonic stem cell (hESC) line *in vitro*, showing central colony and surrounding 'stringy' feeder cells derived from mouse fibroblasts (MEF). Courtesy Guy's Stem Cell Team.

S.F.: So maybe if you could, um, just give an idea of what the advantages of a dish model would be, say compared to an animal model?

D.I.: So if you are talking about different monogenic diseases, they can be modelled the best with human embryonic stem cells or induced pluripotent cells. These cells can be differentiated into different cell types such as neurons, muscle cells or whatever is the cell type that carries the most pathology. With these cells we can then model disease *in vitro*, in the laboratory. The advantage of this system when compared with animal models is that by working in a human system you avoid species-specific differences. Although animal models are invaluable and irreplaceable for studying disease in the whole body context, they provide a limited representation of human pathophysiology. In addition, stem cells are an ideal tool to reduce the number of animals, complexity and costs associated with animal experiments in drug development and toxicology.

S.F.: So if you were looking at a particular mutation, would it be an advantage that the mutation was, as it were, a natural mutation as opposed to say a knock-in mutation in a mouse?

D.I.: Ah, it would from one point. I mean, there is no difference whether mutation occurs naturally or it is generated in the lab. As I mentioned, animal cannot replicate everything that is going in humans and obviously the best way that you can do lab work is with a human source of cells. It is still technically challenging to make specific mutations in human embryonic stem cells. This is easy to do in the mouse, because mouse embryonic stem cells are more prone to homologous recombination, et cetera, so you can do knock-in technologies or knock-out genes more easily. In human cells it

is almost impossible and very, very, very lower efficacy, so that is why we are aiming to get natural mutations.

S.F.: Right, right, right. So that is why you would be using PGD embryos.

D.I.: Absolutely. Absolutely. So those embryos, and cells from those embryos, they can be used. They are clinically unsuitable, and they are not used. And so the other option would be just discarding them. Like this they can be converted into very, very useful tools to address mechanisms of disease and also be a very good model for potential drug discovery. If you get a new drug, develop a new drug, you want to see how harmful or how beneficial the drug is, for this particular disease. Currently tests are done in animal cell lines, which are not the same as humans, as I mentioned before, or in human lines that are transformed that carry various mutations and that are more closer to malignant cells than to normal. Thus, the data may not be as clear and strong as one would wish. Therefore, cell lines derived from PGD embryos are actually the best tool that you can get.

The distinctive features of hESC models described by Dr Ilic are both practical and ethical. In part, these *in vitro*, or 'dish', models respond to the limits of existing technical expertise. For example, it is 'still technically challenging to make specific mutations in human embryonic stem cells' as opposed to the ease with which 'knock-in' mutation models can be made with mouse material. In turn, this contrast of technical complexity corresponds to 'species-specific differences' between murine and human cell lines, the former of which is 'more prone to homologous recombination, et cetera' making the introduction of mutations easier to achieve. The technical obstacle to the artificial induction of mutations of interest in the human consequently requires such mutations to be found rather than made. In contrast to the hand-made knock-in mouse models, human mutations must be 'naturally occurring'.[6]

While in many ways preferable to animal models, the dish models of human mutations are also limited in other respects. They are not 'whole body' models, for example. We can thus see in this passage that the multiple forms of modelling – natural, artificial, mouse, human, knock-in, knock-out, whole body and *in vitro* – together comprise a kind of modelling economy, or palimpsest. The information, or data, that is available through one particular modelling system can be filtered, interpreted and contextualized by the information or data from another model, in a kind of layered technical matrix. Where data from one model 'may not be as clear as one would wish', data from another model system can be supplied. The complexity of this multi-layered modelling work, in and of itself, is rightly the subject of much discussion in the science studies literature, and comprises an important parallel to debates about representation in anthropology. Similarly, there are several layers to the technology of modelling, and several different kinds of models, which work at different levels – from model organisms, or animal models, to dish models, model systems or test models.

Finally, there are ethical considerations that are not only important to, but constitutive of, the production of new cell models. The fact that PGD embryos are clinically unsuitable due to the presence of a pathological mutation means there is no possibility an embryo that has been donated for research because it is judged too 'poor quality' for treatment might in fact have been capable of producing healthy offspring (a risk that exists in the context of IVF, where the criteria for selecting the 'best' embryos

for transfer or storage are more uncertain). Similarly, the ability to produce human cell models that will reduce the need for animal experimentation also fulfils an ethical obligation. For all of these reasons, cell models can be seen to have ethical as well as practical value as new biological tools.

Biological Kinship

The use of biology as a technology, and reproductive substance as a 'tool kit', is not a new phenomenon: 'biotechnology' is another way to describe horticulture, agriculture or livestock breeding, not to mention vitriculture (cloning), fermentation (bio-processing) or beekeeping (biological control). However, the cultivation of human cellular tools and techniques, and in particular the use of shared reproductive substance to derive new tool pathways, represents both a new form of biological control and a new kind of biological kinship to technology. The inherently radical nature of the large-scale transfer of experimental reproductive technology 'into man' is epitomized by the rapid routinization of assisted conception technologies such as IVF – a technology that has become both a worldwide service industry and a new norm of family life. The closely related projects of culturing, handling and modifying human reproductive cells – also now in the process of being dramatically scaled-up for commercial manufacturing purposes – extend the traditional idea of 'biological relations' in new, and often unfamiliar, directions. As noted earlier, IVF is both a symbol and a vehicle for the rapid expansion of the technological means of controlling the earliest stages of human development, including conception, fertilization and cellular differentiation. The rapid expansion of IVF – a means of taking conception 'in hand' – has rightly been the subject of considerable anthropological inquiry that asks how this technology is implicated not only in changing conceptions of conception but in a newly recursive cultural logic, or grammar, of 'life itself' (Strathern 1992a, 1992b; Thompson 2005; Franklin 2007).

The increasing use of human reproductive substance as a tool is arguably one of the main sources of the classically recursive paradox IVF presents – in the form of a new conception model that both copies and changes its object. Importantly, this is also a very public process in the context of IVF, celebrated as it is as a form of family-making. Indeed, it is precisely because IVF is dedicated to that most 'obvious' of human activities (making babies) that it has become increasingly familiar and ordinary – indeed a new norm of twenty-first-century reproductive aspiration. But on the other hand, this new form of human reproduction has become increasingly complex and even surreal as IVF becomes the platform, or stem technology, for an increasingly wide and baroque array of biotechnical applications, from cloning to transgenesis. Similarly, as a clinical procedure, IVF has become 'routine' in the sense of having become more regular, widespread and unremarkable. But the experience of undergoing an IVF cycle has also become more complicated as the IVF platform has become the base, or launch pad, for many other, cognate therapies and applications – from PGD and intracytoplasmic sperm injection (ICSI) to human embryonic stem cell derivation and banking.

Even 'routine' IVF (which was never either 'just like' unassisted reproduction or very simple to begin with) has paradoxically become more complex and demanding as it has also become more familiar and 'normal'. Over the past thirty-five years, IVF has become

more elaborately technical in ways that continually generate new emotional, ethical and social challenges (egg donation, aneuploidy screening and vitrification being but a few examples). Hence, for example, in the past it was necessary for patients undergoing IVF to decide the fate of any unused embryos in advance of treatment, by choosing whether to freeze any viable extra embryos for their own later use, to donate them to another patient, to donate them to research, or to 'allow them to perish'. If they choose to freeze their embryos, patients in the U.K. must pay an annual storage charge, and legally have five years in which to use them, before they must make another decision: to keep them in storage for another five years, to donate them to another patient, or to allow them to perish. After ten years the process is repeated, but the option for further storage is eliminated. Many patients find the decision-making process about their embryos so difficult that it is a hugely time-consuming job for the IVF coordinator in each ACU to keep track of the consent trails attached to every embryo in cryo-storage. A couple that has split up, for example, may not want to make a 'final' decision about their embryos. Patients that have failed repeatedly to achieve a successful pregnancy may feel understandably ambivalent about continuing treatment. A different species of ambivalence may beset a couple who have succeeded in one or more IVF pregnancies, and who do not necessarily want more children, but are uncomfortable about the 'frozen siblings' in liquid nitrogen who will be either disposed of or given away if they are not 'given a chance' with another cycle of IVF (de Lacey 2007).

These dilemmas reflect the altered reproductive landscape that emerges in the wake of technologically assisted conception, which is structured by a combination of choice, luck, circumstance and procedure, as well as changing technological and bureaucratic norms. Never particularly straightforward to begin with, and despite having become more 'regular' and 'normal', IVF has become increasingly complex and challenging as it shares an increasing technological kinship with a wider range of not only reproductive, but now also regenerative, applications. For example, the new (post-2000) option to donate so-called 'spare' embryos to hESC research was deemed by the U.K. Parliament to be of sufficient complexity to require an entirely new consent infrastructure accompanying IVF and related procedures such as PGD. Hence, in an ACU which is part of a research facility, such as the one at Guy's, where the IVF surgery is next door to the GMP lab, where hESCs are being derived, patients are now routinely asked to consent to a new option, namely to donate their embryos to hESC research.

As a consequence of its increasing complexity, the threshold of the IVF unit has become a place of complicated kinships, ethical quandaries, government surveillance and economic speculation (as well as anthropological fieldwork). The 'moral pioneering' described by Rayna Rapp (1999) in the context of prenatal diagnosis equally characterizes the IVF clinic, and this term accurately describes the labour of clinicians, health professionals and scientists, as well as patients (Franklin and Roberts 2006). In order to consent to donate any extra IVF or PGD embryos to stem cell research, patients need to be made aware of, and to agree to, a number of conditions that are distinctive to reproductive biomedicine (Franklin and Kaufman 2009). Hence, for example, they have to be informed both orally and in writing that any lines derived from their embryos may exist in perpetuity, must be deposited in the UKSCB, and can then be licensed to approved researchers, including those from private companies, who, in theory, might

manufacture cellular products, or even patent new lines or applications. Patients who donate their extra embryos to stem cell research, which approximately 75 per cent of those who were asked in a national survey undertaken in 2007 agreed to do, must also be informed that they will not receive any information about their reproductive cells once they have been donated to research. Yet, they are also informed that, although the cells will be made anonymous, this anonymity must be coded in such a way that it is reversible in the event of a major public health event – for example the discovery of another rogue prion like BSE, or a new development in the evolution of BSE itself.

The clinicians and researchers at the Guy's ACU and hESC lab are, of course, aware of the extra burden placed on patients by the additional consent measures required for embryo donation to stem cell research. They are also conscious of the extra burden on themselves to produce appropriate guidelines and procedures for best consenting practice in this new field. For the same reasons, they are concerned with GMP (because it is the legally required as well as the most ethical way to conduct research that could lead to clinical applications); similarly, they are concerned with the best ethical practices for maintaining the supply of research embryos, and much time is devoted to working these out. As noted earlier, the reason the Guy's stem cell team prefers to use embryos from PGD is that there is no possibility for any conflict of interest to arise between the need for research embryos and the supply of clinical embryos, since PGD embryos that are diagnosed to be positive for a serious genetic disorder cannot be used for clinical purposes. PGD patients also often have a strong motivation to contribute to medical research on the genetic conditions affecting them and their offspring.

The *in vitro*, or 'dish', models of mutations made from PGD embryos are thus highly useful tools that also close both a kinship and an ethical loop of a particular kind. As I prepare to enter the clean-room research facility in my sterile blue suit, I will be following the same path as the eggs that travel from an IVF surgery through the hole in the wall into the derivation laboratory. Here, in this state-of-the-art facility, I will be able to observe, and to film, the basic propagation techniques used to derive hESC lines. Using hand-forged micro-tools made of tiny glass tubing, the lab staff will cut and re-plate tiny sections of hESC colonies, or 'lines', in order to amplify and stabilize them. Day after day they laboriously cultivate their cells in the noisy clean-room, banked with hooded worktops sucking air through a vast filtering system to maintain the very highest standards of air purity. Masked, gloved, capped, gowned and shod in standard issue plastic clogs, the team works long hours keeping the cells 'happy'. A well-performing line that has been passaged over 80 to 100 cellular generations will be considered 'well characterized' enough for potential deposit in the UKSCB. But most do not make it to the Bank, succumbing to contamination, failure to thrive or the many known and unknown causes of cellular 'unhappiness'.

A well-characterized, thoroughly passaged, and potentially useful cell line containing a human genetic mutation that is accepted for deposit in the UKSCB is thus a curious entity with a complex pedigree, or 'thick genealogy' (Franklin 2007). Originating from an embryo donated by a couple undergoing PGD – that is, from the context of reproductive biomedicine – this line would have started as a dissected inner cell mass (ICM) on a plate of feeder cells assembled by a highly skilled developmental biologist in a state-of-the-art derivation lab. It would have joined the carefully tended population of similar cell lines

in the warm, dark interior of the incubator, before being brought out, cut up, re-plated, evaluated, documented and fed at regular intervals. Eventually it would become part of an extended 'family' of lines, comprising an unusual form of lineage, or biological relatedness. This 'descent group' will have been the subject of intensive care for weeks, months or even years by a team of specialists before it can be divided up and parcelled out to new 'hosts' such as the UKSCB, other research labs or, eventually, commercial companies. Like all good models, Petri dish cell models both amplify and condense, as well as demonstrate, the foundational logics that enable them to come into being and to exist at all. The human cell lines at Guy's have built into them not only a complex history of hope and aspiration but also government endorsements, regulatory apparatus, professional skills and knowledges, and all of the other components that both activate and legitimate the promissory future of 'the age of biological control'.[7] A challenge for the anthropologist, and one that is both theoretical and practical, is thus not only how to characterize the social mechanics of biological culture but how to devise a means of engaging with the process of remaking *anthropos* that such a project necessarily foregrounds. In turning to this recursive question, then, it is helpful to revisit anthropology's own internal dialogue not only about conception models but the meaning of biological facts.

Conception Models

Anthropological uses of the term 'conception model' traditionally refer to indigenous beliefs about procreation, and take the form of descriptions of explanations of the causes of pregnancy, or 'coming into being', such as those collected by many twentieth-century ethnographers in the course of analysing kinship, religion and 'culture'. The meaning of 'model' in such accounts generally refers to explanations or theories as they are found in various societies, and thus corresponds to the dictionary definition of a model as 'a schematic description of a theory, system or phenomenon that accounts for its known or inferred properties' (*American Heritage Dictionary* 1998: s.v. 'model'). But the meaning of 'model' in this context has long been both complicated and doubled by the fact that anthropologists go on to produce more models of the models they find, using, for example, conception beliefs (or 'models') to model social organization or kinship. An additional complication results from the dual meaning of 'conception' to refer to both knowledge and procreation. For this and other good reasons, the interpretation of models and modelling has its own set of debates in anthropology, dating back to the very earliest efforts to define social structure, which, for some, was itself a term synonymous with 'model' in the sense of 'a form of' or 'based upon', while others emphasized how such models were analysed theoretically (another meaning of 'to model'). Much of the current attention to recursivity (a word derived from the Latin *recurrere*, 'to return, come back') derives from the relationship between framing devices, such as models, and their contents – as in the cases of remodelling models, or re-conceiving concepts.

Malinowski was concerned with both aspects of conception models – how they acted as frames, and how these frames could be used as models. He famously argued that what a culture believes about conception tells you what it believes about everything else: 'knowledge about kinship and social organization, religious beliefs, systems of

totemism, and magical ritual [are all] related to the ideas concerning paternity, maternity and descent' (Malinowski [1937]1974: xvii). His view of conception models was both mimetic and mechanical: the Trobriand model of conception served as a base for social structure, while also in itself manifesting the key linkages, or mechanics, out of which that structure was formed, thus serving to 'model' them for the native and the anthropologist alike. Indeed, for Malinowski the Trobriand conception model was at the heart of his effort to 'make possible a general science of anthropology' (ibid.: xxvii). Like the 'question of paternity' from which it is inseparable in the history of anthropology, the interpretation of conception models has been crucial to the evolution of anthropological thought, and anthropological debate concerning the wide variation to be found cross-culturally in causal accounts of both human and animal conception and pregnancy has been extensively studied as a means of reflecting upon the history of the discipline, perhaps most famously by Malinowski's student Ashley Montagu ([1937]1974) but also by many others both before and since. Imitating its content in its form, the famous anthropological debate about anthropological debates about conceptions of conception (the 'virgin birth' debate) became itself in turn the subject of an increasingly large literature dedicated to reconceptualizing conception in the context of increasing concern with how anthropology represented its 'others' (e.g., Jorgensen 1983; Delaney 1986; Shore 1992; Franklin 1997).

These questions have long been central to my own work on new reproductive technologies, and in particular to my interest in *in vitro* fertilization. My initial postgraduate work on IVF and the 'virgin birth' debates was initiated during the mid 1980s, at the height of the 'reflexive turn' in anthropology, and yet still at a point when the meaning of this term was highly uncertain.[8] The process of becoming more 'reflexive' could take many forms. On the one hand it might involve becoming more self-conscious of the cultural specificity of the anthropologists' own conceptuality, including its disciplinary history and regional origins, and thus its filtering effects. More powerfully, one might 'reflexively' consider how anthropology not only 'filtered' but actively constituted its objects, ultimately building an image of itself where an 'other' was imagined to be. While the goal appeared clear (to reduce the ethnocentrism of the anthropological project), the mechanisms for doing so remained both vague and diverse. Some corrective strategies looked outward – for example, to the greater involvement of anthropology's 'others' in the anthropological project. Others looked more critically inward, seeking new methodologies to divest anthropology of its solipsistic heritage.

The question of what 'anthropology at home' might add to the effort to counter the inevitable tendency for anthropology to reproduce its own inherited conceptual frames of reference remains an open question. We can be as reflexive as we want about the historical origins of the nature/culture dichotomy, for example, but in one version of this question no amount of discursive archaeology can help us to produce a 'symmetrical' anthropology, since such researches only confirm how culturally specific Western models of nature and culture are (MacCormack and Strathern 1980). Similarly, we can recognize the anthropological project itself as a 'peculiar' one, 'not unlike the Toda bow ceremony', to use Schneider's famous quip (Schneider 1984: 201), thus acknowledging the historical and cultural specificity of the very idea of a human science. And there are innumerable variations on these themes (Marcus and Fischer 1986).

Ultimately, the anthropological meanings of both recursivity and reflexivity – like relativism – turn on the question of comparison, and more specifically how comparison is used as a framing device. Traditionally, anthropological comparison has been cross- or inter- cultural. An alternative comparative grid to that used in cross-cultural comparison, however, is that opened up within the cultural apparatus of anthropology itself – what we might call the intra-cultural dimension. For example, Schneider (1984) emphasized the fixity of the 'genealogical grid' that he argued is used as a (Eurocentric) point of reference within anthropology, and which he claimed disguised a false universalism based on 'folk biology'. However, as Mary Bouquet (1993) showed in her fascinating ethnographic study of the pedigree concept as it was (not) understood by her Portuguese anthropology students, there may be a surprising amount of variation even within a term that would appear to have a relatively stable point of reference. As we now know from the myriad studies which have been undertaken on the new genetics by anthropologists and other scholars, both pedigree and genealogy are highly flexible 'basket categories' that contain many contradictory meanings.[9] Moreover, it turns out that 'genes' are no more stable in the lab than in 'lay' parlance: as Evelyn Fox Keller (2010) has recently argued, the question to be asked by both scientists and non-scientists is no longer what genes determine, but how the very idea of such a powerful hereditary substance ever came to be considered credible to begin with given how many variations of 'genetic action' have always co-existed in professions as diverse as livestock breeding, embryology and molecular biology.

The new emphasis, in both popular culture and professional science, on the plasticity of both genotypes and phenotypes foregrounds a comparative dimension within the very same conceptual frameworks that were formerly considered ethnocentric and Eurocentric because they were fixed and rigidly binary. But as Keller shows of the nature/nurture dichotomy, these terms were never quite so clearly defined, or dichotomous, even within the most technical scientific debates where they originated in the nineteenth century, never mind as they then travelled over the next century into various colloquial and often quasi-figurative uses. In my first ethnography of IVF, *Embodied Progress* (Franklin 1997), I argued that this 'additional comparative perspective' – meaning how terms like 'genealogy' or 'biology' varied within their technical scientific, or autochthonous, contexts – could be 'put into dialogue with more traditional forms of anthropological comparison', such as those that are conventionally used to identify and elucidate differences between cultures. Another approach, as the case of IVF makes clear, is 'the question of what kinds of difference these can be' (ibid.: 7). In an IVF unit, for example, biological facts, and models of biological causality, are frequently diverse, and 'normal' biological rules for making babies precisely do not apply.

There are also other differences that I had first noticed as a graduate student in a large U.S. anthropology programme (at NYU), particularly concerning the role of biological facts. The differences, for example, between cultural and biological anthropologists' understandings of concepts such as 'heredity', 'biology', 'genetics' or 'development' struck me as being just as great as the 'cultural differences' imagined to distinguish, for example, the scientific views on procreation in modern industrial societies from those alleged to characterize the preliterate societies that were the focus of the 'virgin birth' debates. If the animated debates I witnessed in the course of my postgraduate education over genes,

gender, race, kinship, sexuality and biological determinism were anything to go by, the differences between anthropologists' models of the human condition were not minor. It became additionally obvious during the 1980s that new reproductive and genetic technologies were unlikely to simplify matters. As the ethnographic study of both IVF and the new genetics has confirmed, modern consumers of biomedicine do indeed model both conception and heredity in highly variable ways that are functional because they are contradictory, and thus 'adjustable' – and so do professional scientists. As Duana Fullwiley shows in *The Enculturated Gene* (2011), both basic research in molecular biology and health-care programmes for populations affected by genetic disease are contexts in which multiple intersecting models of heredity, shared reproductive substance and biological relation co-exist and mix together – from model patients and model organisms to model populations and model frequencies. In addition to multiple local and national models of DNA and genetic inheritance, Fullwiley (ibid.) has also demonstrated how even within a single lab, in the context of a single scientific study, models of genetic substance, mechanism and effect are highly varied .

Models of Models

Debates about conception models, however, have never been limited to questions of fact. As the 'virgin birth' debates revealed, the issues at stake are not only about content but form – indeed, often including what Hayden White referred to as 'the content of the form' (White 1987). During the 1960s, John Barnes and David Schneider, among others, took on the problem of modelling as a core methodological and philosophical issue for anthropology. Hence, for example, Schneider pointed to 'some muddles in the models', arguing that the competition between descent and alliance theory had become a kind of rutting contest over models rather than a properly scientific debate: 'Too much time, effort and energy are spent in mending the model, in protecting it from new data, in insuring its survival against attacks', he wrote (Schneider [1965]1968:78). Echoing the claims of many others before them, both Barnes and Schneider noted the multiple modelling problems presented by conflicting interpretations of conception beliefs. Barnes, who strongly advocated a scientific sociology, argued that accurate interpretive modelling comprised an elementary component of the anthropological 'toolkit' (Barnes 1971: 263) that underwent continuous and progressive improvement through rigorous field testing followed by critical scholarly scrutiny. A keen model-builder himself, Barnes's ideal was the test-model familiar to engineers. Following a Kuhnian road map of intellectual development, Barnes located anthropology in a 'pre-paradigmatic stage' (ibid.: xxi) that awaited, among other things, better models.[10] His book-length case study of three leading kinship theorists (Murdock, Lévi-Strauss and Fortes) was designed to identify 'mature and developed logical structures that could be dissected and compared' (ibid.:268) in order to more powerfully consolidate anthropology as a social science.

Barnes proposed his own model (in the sense of exemplary) methodology in the closing pages of his monograph, which are worth quoting not only because they summarize a process that remains at the heart of anthropological research, but because they set out the basis for what Barnes elsewhere calls a 'single paradigm' or 'unified theory'

for anthropology. Having been extensively road-tested, as it were, Barnes identifies his colleague Meyer Fortes's fieldwork methods as the best tools for anthropological research, and their implementation through what he calls a 'helical' process:

> Fortes's work exemplifies [the beneficial] interaction between ethnography and comparative analysis. The ethnographer arrives in the field with a theory and an analytic toolkit which prove to be inadequate for coping with the ethnographic facts that crowd in upon him. He modifies his theory and develops new tools, or in the sometimes equally traumatic situation of wrestling with his data to produce an analysis that will stand up to the scrutiny of his colleagues. He then begins to apply the new form of analysis to other societies, and to teach his students to do likewise. The critical step in this helical process is insightful fieldwork imaginatively analysed, and Fortes shows just what is needed to take this step successfully. (ibid.: 264)

So far, so familiar – as this model of anthropological theory based on 'insightful fieldwork imaginatively analysed' remains at the core of how the discipline is taught and practised today. However, Barnes identifies some additional problems that could be described as somewhat less conventionally Kuhnian, and these are worth noting as they remain, if anything, even more prominent today as examples of the 'helical' or recursive tendency engendered by ethnography, thus modelling a very different set of implications for anthropology as a 'general science'. Indeed, the vision of science Barnes held for both sociology and anthropology has, if anything, receded further from reach rather than advanced toward a more consolidated set of paradigmatic principles or social laws. As we shall also see, the problems that have been encountered by social science have at the same time become more widely recognized by other sciences, indeed becoming ironically generic, and even paradigmatic, in this respect. Arguably this symmetrical uncertainty is both important and telling, although for reasons and principles that are in many ways the opposite of those employed by Barnes.

In his work on kinship theory, Barnes (1971, 1973) returns repeatedly to the problem that would, in more decontructionist terms, be described as 'the generative effects of recursion'. Whereas for Kuhn, the progress of science is essentially sociological – driven by changing definitions of 'normal science' that follow a more or less cyclical pattern – the more recent view from within science studies emphasizes the importance of non-human agency, for example in terms of how laboratory apparatus plays a generative role in the outcomes of experimental research. Like the problem of ethnocentrism, where the home conceptual model can 'get in the way', as it were, the problem of lab equipment is that it has an active presence that is itself neither always visible nor readily measurable (measurement itself being the classic demonstration of this recursion). We can see in the stem cell lab, therefore, another interesting 'intra-cultural' comparison, namely how both anthropology and developmental biology have become more 'recursively engaged' with their equipment, and the empirical problem of its role in shaping experimental outcomes.

This problem – the 'agentic' role of apparatus – is very familiar to any experimentalist. It is why scientific articles begin with lengthy descriptions of the precise materials and methods used in the experiment. These laundry lists of highly specialized kit are themselves lineages of technique, filled with items of standardized laboratory

equipment and tools named after their inventors such as Petri dishes, Spemann pipettes, Bunsen burners, and proprietary products such as Falcon Centre-well organ culture dishes (Becton, Dickinson and Company, Cell Cultureware Product Number: 353037). A prolific biotechnical kinship links Dulbecco's modified Eagle medium (DMEM; Invitrogen, USA) layered on a Ficoll-Hypaque gradient (density 1.077 g/cm; Sigma) and re-suspended in complete culture medium (DMEM with 10 percent fetal bovine serum, FBS; Hyclone, USA) to the successful propagation of viable hESC lines which can be directed to differentiate to order.

More often than not, experiments fail, and must be repeated – and the strict adherence to precise protocols is especially important when handling live materials. To begin with it is very difficult to isolate 'sterile' cultures in the context of propagating living entities. Whereas the clean-room labs at Intel are disinfected using radiation, such measures are obviously impossible for any laboratory working with cell cultures. Contamination is a constant problem, and not always one that can be easily detected. A second problem is that laboratory apparatus is intended to have determining effects on the substance with which it comes into contact. Hence, for example, the feeder cells that are used in stem cell labs are precisely designed to interact with – indeed to be metabolized by – the cell lines they support. Lastly, there is a degree of difficulty distinguishing between the tool and the object when it comes to an *in vitro* model system, since, technically speaking, a stem cell colony could not exist at all 'in nature' and is itself 'artificially produced' to begin with – that is, an 'artefact'. Indeed the entire *in vitro* culture system through which stem cells are propagated and maintained is a kind of tool – a model system designed to perform specific functions. To a certain extent, and because they are relatively new kinds of equipment, dish models are always models of themselves. As well as generating knowledge or information about a specific phenomena, such as mutation, for example, the scientists who work with dish models are also always learning more about the specialist craft of maintaining them – the same way a glassmaker is continually learning more about the properties of glass while making objects by working it into shape. Recursion, in this sense – attention to the properties of the equipment you are using to determine, or manage, the properties of something else – is itself an empirical, necessary and pragmatic art.

Recursive Effects

If we were to point to the uses of a recursive tool, such as an algorithm or a fractal, we would be looking at one version of how recursion is generative: it can be harnessed to productive effect, as in the branches of mathematics to which it is native. The question of how human societies will organize the production of new populations of human cells intended to be used for managing serious illnesses and injuries, for example, presents a different version of what we might call 'the uses of recursion' or 'recursive pragmatics'. This point is important because the process of technologizing human biology is both a pragmatic and a symbolic process. A living human *in vitro* model of genetic mutation, for example, illustrates why the problem of recursion, and the reproductive mechanism it relies upon, cannot simply be compared to relativism, for example in the Heisenbergian sense of how accounts of their objects are always influenced by

their relationship to their objects, or what Karen Barad has more radically theorized, in relation to the work of Niels Bohr, as 'intra-action' (Barad 2000). Nor is recursion the same thing as a dialectical relation, because it is differently generative. One way to consider the question of recursion, in other words, is to examine it as a question of reproduction. John Barnes met the problem of recursion, as had so many others, when he turned to conception models and the problem he described as '*depicting* biological facts' (Barnes 1973: 63, original emphasis). These conceptual models of conceptual models are recursive in the simple sense of 'folding back' on themselves terminologically: the same words are used for different things, both doubling and 'mirroring' each other (a dialectic is composed of opposites that are merged into a new synthesis). But like the dialectic, the recursive relationship is a generative one: like two mirrors facing each other (a classic image of recursion), the reflections are also ricochets. Normal speech is full of recursive elements – for example 'my house is my home' – as are many technological applications, which involve embedding subsets of instructions that refer back to each other (as in computer programming). Recursion is also a generative technique in mathematics, to produce series of numbers by using a formula that incorporates one or more of the preceding terms.

As Bruno Latour (2012) has recently argued, a recursive anthropology would be quite different from a reflexive one because it would not emphasize the production of difference (for example, in the context of cross cultural comparison) so much as the effects of sameness (how cultural comparisons parallel one another). Whereas the 'reflexive turn' in anthropology required greater critical awareness of anthropology's own shaping effects upon its objects (thus still privileging itself), a recursive anthropology would, according to Latour, require what he calls the 'symmetricisation' of anthropology in the form of an evening out of its study of itself with its study of 'others'. We will return to both the 'mirror' theory of recursion and its equivalent in Latour's 'recursive anthropology'. But to clearly elucidate the mechanisms of the problem that a recursive anthropology would address, it is helpful to return to the examples that confronted John Barnes, among others, in the study of conception models – for as we shall see, these can help us to imagine both a 'non-mirror theory' of recursion and a different kind of recursive anthropology .

As noted above, Barnes was not alone in the 1970s in identifying a crucial recursive problem for anthropology in the context of conception models. Like Schneider, Leach and Needham, he pointed out in his 1973 article 'Genetrix:Genitor::Nature:Culture' (part of a festschrift to Meyer Fortes edited by Jack Goody) that anthropology is inevitably recursive to the extent that it must reproduce its own conceptual models in order to understand those of others. 'Part of the basis for a comparison of ideas about kinship has to be our own cultural notions about the reproductive process, some of which are derived from formal science but which include others belonging solely to ethnoscience' (Barnes 1973: 65). Barnes suggested further that:

> Nowadays most educated people in the West have heard of genes and chromosomes and know the embryo draws its stock of chromosomes equally from its genetic father and mother. I guess that, in the sex-conscious culture of contemporary Britain, almost all adults believe that conception occurs when a spermatozoon penetrates an ovum. But what sort of knowledge is this? Surely most of us know as little about the physiology of

> human reproduction as Evans-Pritchard knows about meteorology. We believe these processes to occur because we believe also that at some point in the past long-forgotten scientists discovered that this is what happens. (ibid.: 65–66)

He goes on to point out that science itself has thrown into question the putatively natural basis of biological reproduction. 'In the laboratory', he notes,

> chimeric mice with even more complex constitutions have been bred and studied [Tarkowski 1961; see Wegmann 1970; Mullen and Whitten 1971, and references therein]. Indigenous assertions of human polypaternalism in nature have thus been vindicated for some mammals in the laboratory. Indeed there is evidence that double fertilization sometimes occurs naturally in humans [Benirschke 1970: 40–45]. Human polypaternalism seems therefore to be compatible with available scientific evidence. (ibid.: 67)

Barnes's point here is that we cannot simply distinguish between what Schneider (1972: 47–48) described as 'the scientific facts of biology' and 'biology as a natural process' any more than we can separate the cultural symbols that may be derived from these 'scientific facts' from their production to begin with (a point that is arguably particularly pertinent to the role of paternity in shaping conventions of scientific discovery while also being the subject of scientific study). All of these distinctions are shadowed and confounded by the question of representation, and the sticky materiality of the representational process, as the debate over ethnographic writing, or inscription, neatly encapsulates (Clifford and Marcus 1986).

That this debate (over conceptions of conception) has been so generative for so long is one matter. But by returning to the question of modelling, we may be able to get a more specific handle on what ethnography can offer as a means of demonstrating what a more 'recursive' or symmetrical anthropology of *anthropos* might involve. In the final section of this journey through modelling, let us finally go into the lab.

Handles

Inside the stem cell derivation lab at Guy's, where *in vitro* models of human cells are being cultivated by hand in a bespoke facility staffed by highly skilled biological scientists, an unusual form of representation is underway. I am here to film the feeding, re-plating and handling of the cells, and I have brought my video camera with me (it has been sterilized using small white pads). So I am going to watch Emma Stephenson, the post-doc who is my host, conduct some of these basic procedures, while describing to me what she is doing. While she begins to re-plate, or passage, a line, she explains to me the daily life of a 'happy' cell colony in her lab.

> E.S.: So every day we come in to inspect our cell lines, to see if they need any care or attention. We come in and check them daily. On the screen you can see the feeders all the way around the edge here. And then the colonies of stem cells growing on top of those feeder cells. The feeders are these long, thin cells, all around the outside, and then you can just about see there the defined edge of a colony. That's one colony, and that's another there [she points to lumpy, round islands of stem cells]. One here, and one there. So the dark bits

that you can see are cells that are beginning to die, and they curl up, lift off, and go into suspension. And that happens when the colonies get big enough to be cut up and moved onto fresh feeders. So I'm about to passage these, and what I will do is use a glass pipette, and I will score through the colonies like that [she traces a cross-hatch pattern with her index finger on the screen], and then each of those separate sections gets put into a fresh dish to re-grow again, exponentially, to give me, hopefully, six colonies out of each one.

S.F.: So how old is this line?

E.S.: This line was derived in about June last year. So it's only eight months old.

S.F.: And how come there are four colonies?

E.S.: We re-plate, so, once I chop this one up into maybe six, I'll move all of those into another well, so all six of those will grow and give me another colony.

S.F.: So, did this start out as six pieces and now it is four pieces? Or there were only four pieces to begin with?

E.S.: [Scans the well for other colonies.] I think in this one there were only four. So it was probably a smaller colony that we didn't cut up quite so much.

S.F.: I guess that's part of the art, you know how many pieces to cut it into.

E.S.: It does take time, yes, to see what they're doing, knowing when they're happy, knowing when there's something wrong, when to cut them, when to leave them, when to add a bit of extra something in the media.

S.F.: Is this a happy one?

E.S.: This is a happy one, yes.

The kind of care Emma is describing is less analogous to an anthropological encounter than a horticultural or, in Haraway's terms, 'companionate' one (Haraway 2008). Keeping the cells 'happy', however, is not simply a matter of good gardening, or sensible agriculture, since the relationship to the cells is conspecific: the cells are human, and the origin of their elaborate care lies in human suffering, as well as in embryos donated by would-be parents of children at risk of such affliction. The 'amity' or 'principle of prescriptive altruism' at stake here, to use Fortes's terminology, takes the form of a duty of care manifest as auto-cultivation, or quite literally as lineage extension, pursued in the name of greater biological control, achieved by artificially inducing a pluripotent cell line out of a human embryo in order to model human disease pathways. The resultant cell lines are both tools and models: they are literally handles enabling a better grip on a practical problem. Yet they are also lenses, looking glasses, and representational amplifiers through which it becomes possible to see, apprehend and extract workable meanings from active biological cultures. The 'paradox' Barnes attributes to David Schneider – that 'he appears to make natural science free of culture but to query the possibility of meta-categories for analysing cultures' because 'the comparative science of cultures has to be rooted in

a particular culture, the culture of the investigator' (Barnes 1973: 63) – here acquires a curious parallel, in the form of the culture media. Oddly, but tellingly, paralleling the question of ethnographic representation, and its artefactual legacy in shaping its objects, is the laboratory dilemma of routinizing culture methods, which determine cellular fate. Keeping cells 'happy' involves biological control – in the form of strict routines and norms so that the cells are not disturbed – as well as care and attention, to see if they might need 'a bit of extra something in the media.'

Cultivation requires 'seeding' a line from the inner cell mass of an embryo, which is placed on a feeder layer, and left to grow in the warm, dark interior of the incubator, supplied with graded air. In turn, successful lines are amplified by cutting them up and re-plating them, normally over several months or even years. These lineages of cells are 'characterized' once they have been shown to be stable through a battery of tests used to confirm their intergenerational uniformity. Stable and well-characterized cell lines can then be banked and made available to other researchers for a variety of applications. Eventually it is envisaged that clinical-grade hESC lines might become the source of new therapies, thus completing a loop from one human being to another, and possibly suggesting a new form of 'biological relation' manifest as an ethic of care.

In the meantime, a different kind of 'looping effect' between what Hacking refers to as 'natural' and 'human' kinds is evident in the context of human embryonic stem cell modelling, through which, using Hacking's language, people can be 'made up' (Hacking 1995). For Hacking, this process combines 'culture' ('ways of classifying that become possible only in industrial bureaucracies'), 'cognition' (culturally-specific classifications of human kinds) and 'causality' (bluntly, how classifications shape people – 'can change the kind of people that they are'; ibid.: 351). 'Kinding', Hacking asserts, is a form of causal action: it has effects, including changing the 'kind' into something else once it has been, as it were, kinded. In turn, 'because the kind changes, there is new knowledge to be had about the kind, [which] becomes part of what is to be known about members of the kind, who change again. This is what I call the looping effect for human kinds' (ibid.: 370).

Hacking's 'looping effects', first articulated in the mid 1990s, have many parallels in both anthropology and science studies. The work of Haraway offers a particularly

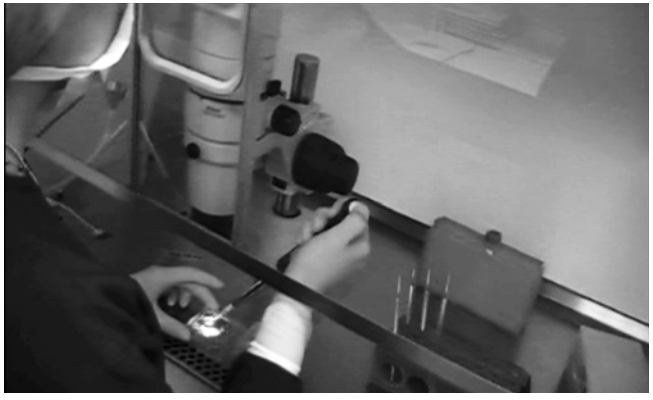

Figure 4: Re-plating cells under the hood.

elaborate account of the causal effects of kinding both within science – see her early work on embryology (Haraway 1976) and primatology (Haraway 1989) – and outside of it, in the way scientific categories travel to discipline their objects (Haraway 1985, 1997) with 'world-building' effects. Similarly, from the perspective of anthropology, as Strathern has shown, the negotiation of kinship ties in the post-Enlightenment 'industrial bureaucracies' is both 'effected' and 'affected' (to use Hacking's terms somewhat differently) by their scientific legacy – which allows kinship to be both 'dicovered' and 'invented' (Strathern 2005: 48). Combined with the vocubulary of 'concretization' introduced by Latour and Woolgar (1986) for the means by which *in vitro* substances emerge out of a vague early perception into definite and irrefutable ontologies (such as 'somatostatin'), we have equipped ourselves with an adequate conceptual toolkit to reach a final hypothesis: that at least one version of recursive anthropology is already modelled by the stem cell model of anthropos *in vitro*.

Conclusion

Working in the early period of experimental embryology, the famous biological technician and craftsman Hans Spemann conducted a now classic study using salamander embryos he partially bisected using fine hair loops tied around their centres at different planes of constriction. Thus he was able to influence the early development of organisms that later displayed, for example, two heads attached to distinct upper bodies united by a single lower trunk. Spemann's hair loops, made from the particularly fine and more elastic hair of his infant daughter, became, in turn, an eponymous tool in experimental embryology – a Spemann loop, used to roll and manipulate tiny experimental cells.

For Spemann, the technology to manipulate reproductive substance was inextricable from what Evelyn Fox Keller, following Ian Hacking, has called 'the biological gaze'. In her discussion of 'the biological gaze', such as that practised by clinical geneticists in the lab, Keller emphasizes its interdependence with touch, as well as its ethos of action, through which sight is allied to the handling of objects to investigate the causes of things, noting that 'the history of the biological gaze … has become increasingly and seemingly inevitably enmeshed in actual touching, in taking the object in hand, in trespassing on and transforming the very thing we look at' (Keller 1996: 108). The probing, imaginative eye, she argues, required the probing hand to enquire more fully into the mechanisms that make things 'work':

> The fact is that scientists have found a way to walk up to the object and touch it; no longer do they peer through the microscope with their hands behind their backs. This in fact was the great contribution the rise of an experimental ethos brought to nineteenth century biology: the desire – and increasingly the skill – to reach in and touch the object under the microscope, and thereby 'to make it real'. In other words, once the microscope was joined with the manual manipulations of experimental biology – marking, cutting and dissecting under the scope – … the microscope became a reliable tool for veridical knowledge. By the close of the nineteenth century, hand and eye had begun to converge. (ibid.: 112)

It was in experimental embryology, argues Keller, that the union of 'representing and intervening', as Ian Hacking (1983: 189–90) described it, became most prominent. Citing the classical experiments performed by Spemann, Keller notes that:

> At first with relatively crude instruments – perhaps a glass rod drawn very finely, or a hair from a baby's head – and later, in the twentieth century, with carefully machined microtomes and micromanipulators – researchers could not only represent but actually intervene in the choreography of the minute primal stages of life. They could isolate the fertilized egg, watch it divide, gently mark one of the cells with a dab of dye and follow it as it continued to divide … or they could carefully separate the cells … to see if the two halves of the young embryo could independently form whole bodies. (Keller 1996: 112)

It is by these means, she argues, that the biological gaze evolved from a practice not unlike astronomy into a 'hands-on' science seeking to identify the causes of development, by separating out and testing the very smallest units of life – that is, by manipulating them. In this way, the gaze became a probe, or eye, searching for the fulcrums of action, and aiming to identify the fundamental units, or handles, that would offer greater biological control. Linked to this change in the gaze was thus also a shift in what was being looked for; no longer mere 'classification' or 'natural kinds', as Foucault (1968) described the 'grid' mentality of pre-Darwinian natural science, but instead, as Keller notes, 'the means to alter – to induce a change in – the course of natural phenomena' (Keller 1996: 115). It was by this means, she claims, that scientists such as H.J. Muller, the classical geneticist trained in T.H. Morgan's lab in New York, were led to envisage a future in which control of genetic mutation would 'place the process of evolution in our hands' (Muller, cited by Keller 1996: 116). In the search for a recursive anthropology, a 'symmetrical' practice of auto-investigation, and an anthropology for the Anthropocene, as Bruno Latour (2012) sees it, the anthropology of anthropos *in vitro* offers not only a model of a model, a re-conception of conceptuality, or a new handle on the making of biological relations, but an anthropology of biology that would have allowed John Barnes to reach the symmetrical conclusion he lacked, namely that anthropos:model::model:anthropos.

A recursive anthropology of conception 'beliefs' enables us to take account of how beliefs make facts 'work', and how 'working up' new facts engenders new beliefs – which are in turn manifest as knowledge, such as the knowledge (initially only an imagined possibility) that a human egg could be fertilized *in vitro*. Fortunately this recursive process, by which conception beliefs and conception models influence how conception 'really' happens, is neither as difficult nor as 'loopy' a process as some critical accounts of reflexivity allege. No one can disagree that new facts of life are now routinely made in the lab – indeed it is expected, and believed, that the purpose of new human cellular technologies is precisely to facilitate greater biological control in the name of alleviating human suffering and improving human life.

The recursion, or return, which enables cellular tools to become new models for re-conceiving how human cellular action unfolds, and to gain the ability to redirect these biological pathways 'to order' in the name of literally remaking the human condition, is a process that is extremely familiar to anthropologists – in part because our methodologies are well suited to turning our own conceptual tools into new

models of social life. As in this article, in which the remodelling of anthropological models of conception is used as a frame through which to analyse the making of new conception models in the lab, the generative power of conceptual tools is a familiar trope in anthropology. That much of the liveliness of the discipline of anthropology derives from the ability to offer a 'looped view' of itself, as well as its objects, confirms a recursive principle at the heart of social life, namely that meanings are not only found but also made. In this way, anthropology, like IVF, both imitates and copies its objects, but also changes them by so doing. As we observe human biology becoming a more relative, contingent and manipulable condition, so too can we see it come to resemble sociality more explicitly. It will be important to keep this observation in mind as the project of taking human biology 'in hand' becomes an increasingly prominent part of social, ethical and political life.

Notes

1. The ethnography of stem cell science is a rapidly emerging subfield in the social sciences, particularly in the U.K. See, e.g., Franklin (2001, 2003, 2005, 2006), Waldby (2002), Franklin and Lock (2003), Kent et al. (2006), Wainwright et al. (2006, 2009), Eriksson et al. (2008), Geesink et al. (2008), Prainsack et al. (2008) and Stephens et al. (2008a, 2008b). For a review of anthropological approaches to stem cell research, see Bharadwaj (2012).
2. One of the reasons ethnographic study of new reproductive technologies has become part of the core anthropological curriculum is because of the ease with which they can be used to illustrate recursive effects and processes (Strathern 1992a, 1992b; Edwards et al. 1999; Franklin 1997). Similarly, it is the way in which the core anthropological concept of kinship is reconfigured in the context of new reproductive technologies that usefully models both reflexivity and recursion (Carsten 2000, 2004; Franklin and McKinnon 2001). A more explicit turn to recursion per se is evident in anthropological studies of the technology of the internet (Wilson and Peterson 2002; Kelty 2005).
3. Since it is beyond the scope of this article to provide a detailed review of the recursive turn in anthropology, or its many varieties – which arguably have key precedents in the works of Bateson (1972, 1979); see also Harries-Jones (1995), as well as Wagner (1981) and Strathern (1988, 2004) – I restrict myself to illustrating how recursivity is relevant in the context of the specific case study of human cellular models. In the conclusion I try to draw some more general principles from this case to distinguish between recursion, reflexivity and relativism in anthropology.
4. For a particularly powerful account of the interweaving of 'altruistic' gift and 'free' market economies, as well as the role of gender difference in shaping these markets, see Almeling (2011).
5. The history of IVF is complex and beyond the scope of this article. It should be noted, however, that although IVF is frequently described as having its origins in infertility treatment, its early practitioners had far more diverse goals in mind. Min Chueh Chang, who successfully fertilized the first mammalian egg *in vitro* in 1959, was working with Gregory Pincus to develop contraception, for example. Similarly, Robert Edwards began his research on mammalian egg maturation *in vivo* with a view to analysing chromosomal abnormalities, and he foresaw the relevance of human IVF for hESC derivation as early as the 1960s (Johnson et al. 2010).
6. For more detail on the work of Dr Ilic and his colleagues, see Ilic and Polak (2011, 2012), Ilic (2012) and Ilic et al. (2012); see also Stephenson and Braude (2010). Dr Ilic is head of the IPS cell Core Facility at Guy's campus and coordinator of the Cross-Divisional Postgraduate Programme in Stem Cells and Regenerative Medicine at King's College, London.
7. Paul Rabinow and Gaymon Bennett (2012) have used the idiom of 'practice' to describe and analyse many of the forces at work in the production of new biological tools, such as those pursued under the rubric of synthetic biology. One of their goals (see, e.g., Rabinow and Bennett 2008) has been to identify which practices are included in the large-scale scientific 'construction' projects characteristic of 'the biotech century' (and which are not). Their challenge 'to invent new sets of contemporary equipment'

and to 'put them into practice to remediate things as they unfold' (Rabinow and Bennett 2012: 43) prioritizes the role of 'practice-based enquiry' (ibid.: 150), such as the laboratory ethnography on which this article is also based.

8. I began my anthropological research as Annette Weiner's student at NYU in 1984 and moved to the Birmingham Centre for Contemporary Cultural Studies in 1986 to undertake a field study of early human IVF in the U.K. This work became the basis for my Ph.D., and later for the book *Embodied Progress* (Franklin 1997).
9. See Edwards and Salazar (2009) for a particularly vivid confirmation of this finding.
10. Interestingly, Barnes would have been based in the Cambridge New Museums site, and perhaps even in the Old Cavendish Building itself, where the Department of Sociology now stands, only a few feet away from the bicycle shed where Watson and Crick built their famous models of DNA in the 1950s.

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