

# Embryo Watching

## How IVF Has Remade Biology

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**Abstract** In addition to being one of the most iconic of the new reproductive technologies introduced in the late twentieth century, in vitro fertilization is also a technology of representation – a looking glass into conception, a window onto early human development, and as such a new form of public spectacle. Still a rapidly expanding global biomedical service sector, IVF technology is also the source of new images of human origins, and thus offers a new visual grammar of coming into being. This lecture explores these connections, and argues that the micromanipulation imagery associated with IVF, and now a routine feature of news coverage and popular debate of NRTs, also introduces a new connection between cells and tools, thus returning us to one of the oldest sociological questions – the question concerning technology. Moving between IVF as a technology of reproduction, and a visual technology, enables us to revisit a series of broad sociological questions concerning technology, reproduction, genealogy and the future of biological control from the unique perspective offered by the conversion of the human embryo into both a tool and a lens.

**Keywords** IVF; micromanipulation; human embryo; biological control; visual culture.

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## I. Introduction

Although its first human offspring were not born until the 1970s, in vitro fertilization is now at least a century old, and is itself the product of many generations of accumulated scientific expertise. Early efforts to achieve fertilization in glass included the novel experiments on parthenogenesis undertaken by Jacques Loeb at the turn of the century, but his use of the sea urchin body as itself a kind of translucent container hints at an even longer history of embryo watching (Loeb 1913; Pauly 1987). A

key to understanding the eventual success of IVF in higher vertebrates in the post-war period is the shift that occurred in the study of embryology, from the late nineteenth century onwards, whereby the study of the earliest stages of biological development changed from being a largely descriptive project into one that involved forcing new kinds of life out of manipulated cells and organisms (Franklin 2013). This shift, described by both Philip Pauly (1987) and Hannah Landecker (2007) as a process of “taking life in hand”, cannot be separated from the evolution of technique in the context of embryology, for example the development of new culture media, micromanipulation methods, visualisation technologies, and new model organisms. It is also a shift that marks a turn from watching into more explicit forms of making, and the ultimate ‘designer baby’ to emerge out of this line of thought would be a fully synthetic embryo – a prospect toward which the functional iPS cell (named for the iPhone) gestures. The merging between what Ian Hacking (1983) describes as “representing and intervening” to produce what Evelyn Fox Keller has called “the biological gaze” (1996) are both central and indispensable to what we might call, after Sharon Traweek (1988), the culture of embryo culture. Like all scientific cultures, this project is at once local and international, personal as well as professional, and today it is increasingly orientated toward the development of new translational technologies such as stem cell research and regenerative medicine.

Notably, atypically, and for complex reasons that are beyond the scope of this lecture, the professional scientific culture of embryo research has increasingly become more prominent both within and outside of the scientific laboratory in the midst of biology’s ‘big bang’. As the Norwegian anthropologist Merete points out in her cultural analysis of contemporary cellular imagery, “cellular images have gained aesthetic as well as dramatic appeal, as they have moved out of the laboratory and become available for the public” (2012, 475). As she also notes, “images of (...) cells related to techniques of assisted reproduction” are central to this process. Indeed, there is no doubt that IVF is the primary technique through which the most famous of the newly mediagenic human cells, the human embryo, has become increasingly public visible, legible and even iconic. The unexpectedly dramatic and rapid expansion of IVF technology as a form of both reproductive biomedicine and basic scientific research is both exceptional and arguably under theorised in general, as well as in relation to the question concerning technology, or more specifically, the technics of visualisation. In addition to becoming both a platform technology and a way of life, IVF has been implanted into popular consciousness over the past three decades as a set of visual images and narratives depicting ‘live’ embryological procedures such as fertilization, micro-injection, embryo biopsy, genetic diagnosis, stem cell propagation, mitochondrial replacement therapy, and nuclear transfer, to name only the most recent and well established genres within what we might call the biooptical imaginary. The rapid routinization of IVF has been central to

the introduction of a new visual language of reproduction that is particularly striking in its vivid depiction of the merger between reproductive cells and hand held tools. Like the language of genes and DNA, the images and idioms through which IVF has come to be understood as a “helping hand” (Strathern 1992a; 1992b; Franklin 1997) have travelled far and wide, introducing a new version of ‘the facts of life’ as a union of cells and tools. Part of the way IVF has become more comfortable and familiar is through a kind of mass public education in reproductive biology so that the human gamete in a Petri dish now recognizably codes for a celebrated arena of medical scientific innovation and capacity as well as for a “miracle baby” and a “hope technology” (Franklin 1997). Indeed, these increasingly familiar visual images have arguably become the dominant visual signifier of the expansion of the IVF platform over the past half century, if not for ‘the age of biology’ in general. Like ultrasound imagery, with its ability to convey the live action of pregnancy as a screen image, IVF offers privileged visual access to the previously unseen events of early human life – and indeed is popularly associated with precisely this capacity.

This lecture explores the emergence of a new visual culture of manipulated reproductive cells, and their circulation as a highly public spectacle that refigures sex as something that is made. Visual imagery is essential to this process. In order to be taken in hand, the IVF embryo must first be made available to the eye, and once it has been transformed into an image, it can be circulated across the increasingly broad range of media that include newspapers, magazines, the internet and the scholarly literature. Unlike in the nineteenth or early twentieth century, the technological means of broadcasting high quality colour images, and their easy reproducibility, enables them to proliferate within the vast digital networks of contemporary culture, and thus to establish a new ground state for what I am calling the ‘global biological’. The interface between IVF technology and its worldwide audience, who are increasingly literate in its language of visual form, reveals how ‘live IVF’ circulates as a different kind of shared technological substance, and virtual life, as an iconic spectacle of artificial biology. IVF is thus a ‘culture media’ in more than one sense of the term. IVF is an example of a local biology that has become a global one, and this lecture explores this interface<sup>1</sup>.

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<sup>1</sup> I have used the term “global biological” elsewhere to describe stem cells, using ‘global’ in two interlinked senses. Stem cell science is both part of a global biological enterprise, and is dedicated, as was the human genome project, to the depiction of global aspects of the biological, as in their totality. The vast banks, registries and depositories of substances ranging from human blood and genes to stem cells and mouse models comprise global biological projects both in their reliance upon a high degree of global cooperation among scientific teams and their goal of better characterizing the global properties of phenomena such as cellular potency. See further in Franklin (2004, 60-62).

IVF is of course (and among other things) a very famous technology – perhaps even a technology that to a certain extent epitomizes what a technology is imagined to be and to do, and images of IVF are thus also a sign of the technological (especially where it meets the biological). The difference between conception via IVF and unassisted, natural, or ‘spontaneous’ conception is precisely what is celebrated by the adjectives ‘precious’ or ‘miracle’ commonly used to mark IVF babies as ‘special’. As Stewart Brand (2010) observes in his manifesto for synthetic biology, *Whole Earth Discipline*, what is also iconic about IVF babies is that despite their artificial or ‘test-tube’ origins, the viable offspring of IVF are indistinguishable from ‘regular’ children. This is another of the unifications IVF can be seen to perform, by linking the normal and the technological biologically. In this lecture, I explore the public face of IVF as a set of visual images to explore the question of how this technology of re-making sex has itself become conventional – a new reproductive norm that is based on taking biological reproduction ‘in hand’. The turn here, to IVF as a technology of representation as well as reproduction, adds another crucial layer to the question of why it is so popular despite the fact that it, still, usually fails in a majority of cycles.

## 2. The Baby in the Bottle

As Susan Squier points out in her analysis of the twentieth century history of the image of the baby in the bottle (1994), IVF technology has a powerful visual and literary genealogy which can be read, among other things, as a series of reflections on the reproductive politics of gender and sex filtered through the lens of artificial conception. Looking back to the nineteenth century, Squier points, for example, to feminist readings of Mary Shelley’s *Frankenstein* and its critique of “the new male birth of fraternal contractual democracy” with its “male monopoly on political creation” as well as her “powerful critique of the newly revised institution of mothering.” Together these themes have been argued to converge in Shelley’s creation of “a nightmare image of scientific procreation that anticipates IVF” (Squier 1994, 15). In the early twentieth century, she argues, these themes continued to proliferate in a host of tales, fables, novels, and children’s stories featuring technologies of embryology and reproduction, and the moral, scientific and political questions they raised. From Charles Kingsley Amis’s *The Water Babies*, to Julian Huxley’s *Tissue Culture Kings*, John Burdon Sanderson Haldane’s essay on *Daedalus, or the Science of the Future*, the prolific writings of his sister Naomi Mitchison, and their close friends and colleagues Aldous Huxley, Vera Brittain, John Desmond Bernal, and Herbert George Wells, in whose writings the figures of ectogenesis, cloning, and artificial reproduction conspicuously serve as the lens through which definitions of the future, and future technologies, are both imaged and imagined. As Squier notes,

these stories produced by a highly scientifically literate group of friends and kin (many of whom were closely biologically related as well as related through the study of biology) typically wove together elements from the history of embryology with science fiction, even sometimes very accurately predicting the future, as in Haldane's account of the young Cambridge undergraduate who successfully develops IVF (1924). As Squier (1994, 71) notes:

Haldane's story of the development of *in vitro* gestation parallels the actual story of the development of *in vitro* fertilization, as told in Dr Robert Edwards's autobiographical account. Both narratives move from successful animal embryology to advances in human embryology.

And yet, as she points out, Haldane's story – first delivered as a lecture in Cambridge to the Heretics Society – is also couched in the language of myth, narrating the victory of Daedalus over Prometheus as confirmation that biology has become the “pivotal” science for the twentieth century. Thus, “Daedalus looks cheerfully ahead to a future in which the invention of ectogenesis enables the control of human reproduction, the improvement of the human species, and finally the emancipation of mankind” (Squier 1994, 73).

In the same way that Squier argues the complex interwoven plots of Haldane's vision of ectogenesis united British biofuturists, humanists, and socialists with their detractors throughout the 1920s and 1930s in a debate over reproductive technology, so too can this period be understood in Foucauldian terms as an extension of the “entry of the phenomena peculiar to the life of the human species into the order of knowledge and power [and] the sphere of political techniques” (Foucault 1990, 141-2). Except that, to be precise, it is not merely sex, or even sexuality, in these debates that serves as the “pivot of the two axes along which developed the entire political technology of life”, as Foucault (1990, 145) suggests, but a more literal technologization of reproduction in the form of taking it ‘in hand’. It is artificial reproduction and ectogenesis that are pivotal in this debate about the future of the human – just as they have continued to be since.

Squier's account can help us to move more explicitly into the realm of IVF as a contemporary, twenty-first century representational field, or what I will describe as the visual logic of IVF, and in particular its role as a symbolic image coupling biology and artifice. What is notable in Squier's account is the sheer amount of imaginative reconstruction of sex, gender, kinship and reproduction that is occurring through the lens of ‘the baby in the bottle’ in this period. New possibilities of regeneration as well as recombination, in the form of chimeras, hybrids and mosaics, as well as cloning, transhumanism, and ectogenesis, are in free play amidst the questioning of traditional gender and kinship (and economic) orders



Crucial to the visual logic of IVF on screen is the fact that what we are looking at when we observe a fertilized egg, or embryo, in a Petri dish – or the manipulation of an egg or embryo in one of these handy chambers – is no ordinary sight. For many people, scientists, clinicians, and patients alike, witnessing a live human embryo is ‘special’. Images of early human life – be they of gametes, embryos, or foetuses – are distinctively media-genic in that they merge highly specialized scientific imaging apparatus with intimate human biological substance, condensed into a spectacle of shared origins. This makes of such images an especially suggestive primal scene of the new reproductive mechanics brought about by assisted conception, and it is not surprising much has been written about embryos as visual objects (Franklin 1999; Hopwood 1999, 2000, 2009; Dubow 2009; Morgan 2009)<sup>2</sup>. As many artists as well as news editors and lobbyists have recognized, contemporary embryological imagery is a potent contact-zone uniting scientific research, high tech laboratory apparatus, biological substance, and powerful visualizing techniques with the promissory future of ‘the age of biology’. These images at once sign the beginnings of human life, and shared human futures, while also depicting a shared, and uniquely human, technological legacy manifest as highly specialised craft (thus a second sign of being-ness as human technological agency). The images both reproduce and model a fusion of accumulated scientific knowledge, human reproductive substance, and technological artifice, multiply overdetermining the viewer position of witnessing ourselves, our technology, our future, and our obligations to one another. In this sense, and as the artist Suzanne Anker has poignantly suggested, the *in vitro* lens is also a mirror (Anker and Franklin 2010).

Importantly, and unlike other reproductive screening technologies, such as ultrasound, IVF imagery establishes a viewer position that is only made possible by the direct manipulation, or handling, of what is shown. In the very fact of these images’ existence is the structuring presence of the technologies that make them possible, the hands that hold the tools, the tools that manipulate the cells, the dishes that contain the materials, the knowledge of how to do all of these things, and the screens that display these scenes. All of this equipment depends upon the histories of technique that have been passed down as part of the still artisanal culture of laboratory labour, and the logics that make such scientific interventions both possible and desirable. The sense of being hands on is irrevocably part of what IVF imagery reveals, from a spectator position that reproduces the point of view of the manipulator. Thus the viewer of these images is always-already visually implicated in the substantive and con-

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<sup>2</sup>For a superb online resource on the visual culture of embryology, see Hopwood and Buklijas (2008) *Making Visible Embryos*, <http://www.hps.cam.ac.uk/-visibleembryos>. Bioartists have also made use of human embryos in projects such as Helen Chadwick’s *Unnatural Selections* (1996).

ceptual connections they establish: the double-grip of the hand-held tool securing the manipulated cell in place, and the screen that holds the image in focus within its frame, 'grip' the object the viewer is shown<sup>3</sup>. Hence, in addition to the practical or scientific questions posed by these primal scenes (how does life begin, what are its mechanisms, how do they work), and their "special" content (early human life, shared origins, potential offspring, cures for disease, etc.), there is an additional visual significance to the form of spectatorship Evelyn Keller (1996) describes as "the biological gaze", because the very ability to witness these objects references a prior series of interventions that has 'allowed us in' as viewers; looking, as we inevitably must, through the keyhole science has provided into a formerly hidden domain. It is impossible, in other words, to view an image of an in vitro embryo without inhabiting the position of its handler.

The popular version of the reproductive gaze inaugurated by the foetal photography of Lennart Nilsson in the 1960s, and now manifest as the contemporary imagery of IVF, stem cells, cloning, is derivative of IVF's history as a research tool, both in its logic and its logistics. In the same way that IVF was dependent upon earlier forms of embryo watching, so have later forms of this art come to depend on IVF. However an important shift has occurred since the 1960s, when both the images of the earth taken from outer space, and the images of inner space published in *Life* magazine, provided unprecedented visual access to aspects of the human condition that were previously unwitness-able. As noted in the extensive literature on the Nilsson images (Petchesky 1987; Franklin 1991, 1999; Hartouni 1992; Stabile 1992; Duden 1993; Kaplan 1994; Newman 1996; Michaels 1999; Franklin *et al.* 2000; Dubow 2009) and the 'blue planet' photographs (Kelley 1988; Duden 1993; Macnaghten and Urry 1998; Franklin *et al.* 2000; Cosgrove 2001; Poole 2008), part of the sense of awe generated by these now iconic twentieth century images derives from the absence of any visible technology within the photographic frame. The power of these photographs thus derives in part from the combination of their inferred technological potency and its absence from view. The only 'handle' these photographs offer is their frame.

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<sup>3</sup> Focusing the camera lens is essential to capturing a sharp image, and in the production of high quality cinematic images in the film industry the focus puller is assisted by the dolly grip, who moves the camera dolly to a preset mark while the focus puller adjusts the lens in tandem. A dolly grip will also assist a camera operator shooting through a hand-held device in order to guide him or her along a predetermined path. To make images of embryos, the camera operator in the laboratory (who would normally be working alone) captures a sharp image by moving the plane of focus up and down. The 'grip' that is provided by the focal plane is so narrow that is essential the equipment is bolted to the floor, often onto a heavy stone or metal surface, without the stability of which micromanipulation imagery is much more difficult to produce.



In contrast to such ‘portrait’ images, the relationship of technology to its objects in the visual culture of IVF is all about the explicit intimacy between tools and cells. Far from absent, the technological ‘handles’ through which cells are manipulated are not only often prominent in imagery of reproductive cells in glass: the tools are also often moving, as if alive, as in the signature image of micro-injection. Like ultrasound imagery, which gains in vividness what it loses through lack of focus through its ability to convey the live movement of the foetus in utero in real time, the newly iconic imagery of micromanipulation, like the popular short clips of beating stem cell colonies (the poster image for regenerative medicine), relies on a different visual vocabulary to the poignant still portraiture of the Nilsson foetus. The enlivening of tools, especially in contrast to the immobilisation of the cells with which they share the amber limelight, comprises a significant departure from earlier forms of reproductive imagery, as will be discussed in further detail below.

If the Nilsson imagery introduced a form of reproductive witnessing, or spectacle, which heralded the emergence of the public human embryo and foetus, the early twenty-first century equivalent of embryo watching can be found in images of micromanipulation. The ‘taking in hand’ of reproductive substance is now both familiar and quotidian in the form of publicly broadcast ‘live’ images, such as those used to illustrate news stories about cloning, stem cell research, and new reproductive technologies such as IVF. The now increasingly common flat-screen image of micromanipulation, for example, routinely displays a cell secured in place by a holding pipette on one side being penetrated by a micro-injection needle, a biopsy pipette, or some other micro-tool on the other.

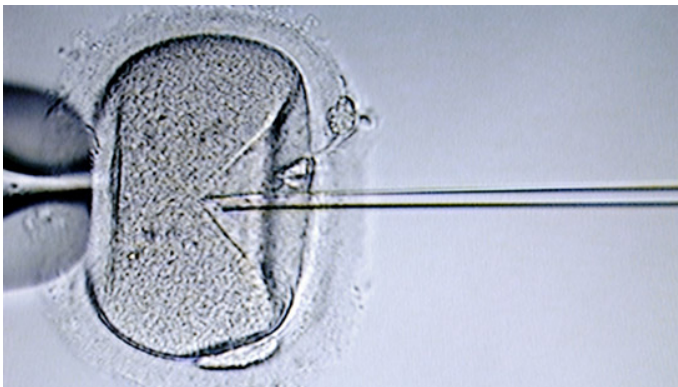


Fig. 2 – Micromanipulation. A Google image search of IVF quickly reveals dozens of micromanipulation images, such as this one, from a BBC website, where it is subtitled “IVF – in vitro fertilisation” (<http://www.bbc.co.uk/schools/gcsebitsize/science/aqa/nervesandhormones/controlinthehumanbodyrev5.shtml>, accessed 20 November 2012).

Such imagery has become a powerful and ubiquitous contemporary visual shorthand for union of technology and biology in the name of re-making life across a wide range of techniques from somatic cell nuclear transfer and transgenic animal production to preimplantation genetic diagnosis and aneuploidy screening.



Fig. 3 – Embryo biopsy. Image of embryo biopsy from 11 March 2011 coverage of mitochondrial disease testing from the Daily Telegraph subtitled: “A controversial IVF technique involving the DNA from three people is to be assessed by Government regulators”.

The familiar micromanipulation scene typically appears as a horizon, the pipette-cell-pipette fusion bisecting the frame in an assemblage that now codes for biotechnological investigation writ large. As Merete Lie (2012, 478) argues: “With a combination of new medical imaging technologies minuscule parts of the body, like cells and even the interior life of a cell, are materializing. Imaging technologies can transform human cells into astonishing and aesthetically appealing images.” It is these explicit images of cellular manipulation, greatly magnified and often shown in live motion, which have inaugurated the mass witnessing of new flows of reproductive and genetic substance in a spectacle of re-engineering at the ground zero of built biology. Already iconic, micromanipulation imagery is used in advertising, corporate logos, and on fashionable club wear and CD covers, as well as being featured on the evening news, in mainstream films, and documentary accounts of new reproductive technologies such as cloning.

Although, as noted above, it differs from earlier reproductive portraits in important and distinctive ways, the image of micro-manipulation shares a visual kinship with earlier iconic images uniting the logics of life and technology with the question of human obligations to the future, ethical horizons, and questions of “life itself” (Franklin *et al.* 2000). Like the foetus and the blue planet images, the cell at the center of the micromanipulation image glows with a radiant light – often blue or amber -- combining the ethereal beauty of life’s innate mystery with the power of the bioscientific gaze. Unlike such earlier images, however, the distinctly planetary cell becomes a window onto the ability to re-engineer biological interiority. With its faintly visible cumulus, or corona, the cell appears to emit vitality, or energy, as a kind of bio-luminescence, but it is not ‘floating in space’. The cell is at once bounded and permeable, ‘captive’ and already joined with the tools that hold it in place. Translucent, it is also somewhat opaque, with an obscure and grainy interior, lacking depth of field, while at the same time the tools convey a sense of reach ‘beyond’ the visible frame, or edge, of the image. Structuring the image is the shallow plane of focus, which, like the holding pipette, positions the cell securely in flat visual grip. Like a living Petri dish, the micromanipulation set-up handily presents a visually engaging biopic of tools that are the source of new life and poised to grasp, probe and penetrate the cell’s interior. In particular, the image of micro-injection, in which a needle is shown penetrating an egg cell, recapitulates the familiar ‘moment’ of conception, restaging the conventional denouement of the sexual union of egg and sperm, and thus life’s beginnings (Martin 1991). Instead of the agency of fertilization being carried by the substance ‘itself’, however, micromanipulation images of fertilization depict the helping hands of science as the active agents, which assume the activity formerly assumed to be merely biological, self-acting, or naturally automatic. Here, then, are the new mechanics of making sex – replacing and extending biological action in the form of hand-held tools.

In contrast to the still portraits of the foetus or the blue planet, the scene of micro-injection is cinematic, and the movement of the micromanipulation tools is the main ‘story’ these images convey, and emphasize<sup>4</sup>. Notably, these are more evidently ‘working’ screen scenes than the earlier images of inner and outer space, often linked in newsreel footage with scenes of white-coated scientists at work in their labs<sup>5</sup>. The cell in these

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<sup>4</sup> As both Lisa Cartwright (1995) and Hannah Landecker (2006) have documented, the history of the cinema has its origins in the effort to explore the mechanics of cell biology.

<sup>5</sup> The contrast is particularly evident in relation to Nilsson’s photos, the work of preparation for which is noticeably absent, as it is only the finished object in the form of a photograph he sought to produce, much as an earlier generation of specimen collectors artfully arranged their display objects in glass containers (another important lineage of *in vitro* imagery, see Anker and Franklin 2010).

images is tightly coupled to its tools, engaged in a process of itself being re-tooled, whereby its internal mechanics will be recomposed, reprogrammed, and remade. This is the bespoke wet life of the biotechnology lab in the making – no longer the pristine, untouched, ‘natural’ life of the planet or the foetus, part of whose grandeur lay in the autonomy of their inherent and ultimately mysterious life-giving properties, which exceed and predate even our most powerful means of technological creation.

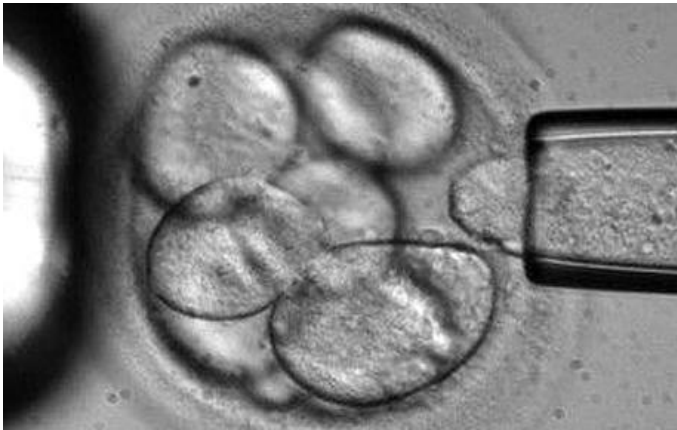


Fig. 4 – Stem cell research - The Telegraph 19 October 2010 ‘Stem cell research: a new age dawns in healthcare’<sup>6</sup>

The new animated digital embryological imagery also differs from earlier photographic reproductive portraiture in not being self-contained: this imagery does not remain within the frame. Whereas Nilsson’s foetal portraits employed the margins of the photograph to foreground the captured object alone, thus delivering visual set pieces which speak for themselves partly through the autonomy of the foetal body, the scene of micromanipulation always extends off-screen, breaking through the frame of the image along the trajectory of the handles of the micro-tools. These tools, and the camera, thus become the connections linking the cell to the modus operandi of the micromanipulation station, and the guiding hands and eyes of its live operator. The manipulation tools are scaled precisely to cellular dimensions to create a workable fit between the microscopic object and the prosthetic hands of the operator who will delicately reconstruct it, and so the tools are also magnified. So too are their movements, creating the slow, jerky, groping drama of connection between tools and

<sup>6</sup> <http://www.telegraph.co.uk/health/8072484/Stem-cell-research-a-new-age-dawns-in-healthcare.html>, accessed 20 November 2012.

cells depicted in the now-familiar genre of animated films that unite cells and tools against the blurry background and the flat light that is only barely gripped or visible within an almost impossibly thin plane of focus. These effects of scale, dimension, perspective, framing, and context reproduce the scientific gaze, its instruments, and its object – as well as its labour ‘exactly’ while at the same time rendering fragile and tentative the very connections they depict.

The confident-yet-ambivalent message these images communicate is particularly pronounced in the blurring of the tool and object they so vividly reveal. In the magnified image of micromanipulation, the aqueous environment of the cell is evident in the viscosity of its contents, which can be seen and sensed in the flows of substances within the hollow glass tools themselves. Like the cell, the instruments are transparent, enabling us to both see and see through this multi-layered scene of fertile coupling between tools and cells. In a kind of respiratory movement, the injection needle appears to inhale cellular contents for removal, and to exhale new material into the cell’s interior. In this sense, micromanipulation imagery mechanically imitates a metabolic symbiosis of parts. And indeed this is precisely what is occurring. Micromanipulation takes place on cells that are typically submerged in clear sterile oil, using tiny glass tools as thin as strands of hair. The micro-tools are secured with small clamps that attach them to hydraulically-driven ‘joy sticks’ that allow the manipulator to conduct various procedures, using touch as much as sight to guide his or her movements. The eyepieces are connected to a video lead that allows the manipulator to view the ‘bed’ of the machine on a monitor, and to record, transmit, or display and further enlarge these processes on screen. To view the contents of a cell takes a practiced eye, as there is little contrast, for example, between tiny semi-transparent organelles, such as the multiple pro-nuclei, and the rest of the cell contents, consisting largely of cytoplasm (Franklin 2003). It is for this reason that a colour filter is often used, to aid the manipulator in identifying the various parts of the cell by increasing resolution through contrast.

For both clinical and scientific procedures, there are five basic micro tools, which are used for manipulating eggs, embryos and sperm:

- 1) The holding pipette to fix and position the oocyte or embryo during a procedure;
- 2) The sharp microneedle to create an opening in the zona pellucida or shell of the egg;
- 3) The blunt-edged biopsy micropipette 15-16  $\mu\text{m}$  in diameter for polar body removal;
- 4) The angled micropipette 25-30  $\mu\text{m}$  in diameter for blastomere biopsy;
- 5) The finely pulled micropipette of 7-8  $\mu\text{m}$  inner diameter bevelled to a 30 degree angle with the tip pulled to form an ICSI insertion tool.

Additional varieties of micropipette for human embryonic cell line procedures are commonly forged by hand by softening a glass capillary tube over a burner and pulling it to form the desired width and tip to serve a particular purpose. Mechanical pipette pullers can also be used, and increasingly commercially prepared micropipettes are used in order to conform to industry standards. Two additional instruments, a microforge and a beveller, are used to fashion specialized features of these glass tools. In addition to controlling for the diameter of the end of the micropipette, and sharpening, bevelling, or flame-polishing (blunting) of the tip, micro-tools are bent at the attachment end to an angle commensurate with the bed of the micromanipulator, so that they can be positioned parallel with each other, and with the machine. As well as precision and pre-preparation, sterility is essential to the practice of micromanipulation techniques such as microinjection or embryo biopsy. For example, newly made tools may be exposed to ultra-violet radiation before use for up to 20 minutes to sterilize them, and cells are immersed in sterile equilibrated mineral oil during manipulation procedures. Purity has become more important to micromanipulation technology as the IVF platform has expanded various kinds of genetic testing, screening, and diagnosis, and the derivation of human ESC lines. The presence of male gametes adhering around the cumulus cells of the ova is potentially the cause of misdiagnosis when an embryo needs to be screened for molecular abnormalities, or contamination of a cell line<sup>7</sup>.

The most common micromanipulation procedure in the context of contemporary reproductive biomedicine is ICSI, intracytoplasmic sperm injection, now used both to enhance the purity of IVF embryos (by eliminating excess, potentially contaminating sperm), and to increase the fertilization rate of the limited egg supply by ensuring that the sperm penetrates the tough outer coat of the egg. Scenes of ICSI dominate the micromanipulation imagery made available to a wider audience, both because they are readily available, and perhaps because they replay a “familiar scene” of conception, involving penetration of the egg with the sperm-containing injection needle. This refiguration of the ‘moment of fertilization’, however, is, like IVF in general, both like and unlike its unassisted counterpart. As the following instructions for ICSI emphasize, the roles of the egg and sperm are significantly altered in this new, technologically assisted, version of the ‘drama’ of life’s beginnings:

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<sup>7</sup> The reliance on microinjection in the context of assisted conception has become more routine due to the increasingly standardised use of ICSI, intra-cytoplasmic sperm injection, in IVF in order to avoid contamination of the egg’s environment during fertilization. ICSI is also used in order to avoid sperm cell contamination when performing polar body removal or blastomere biopsy.

Under control of the stereomicroscope the washed sperm are added to the drop containing 10% PVP [polyvinylpyrrolidone], to slow down sperm movement, facilitating selection of morphologically normal sperm for injection. This also minimizes sperm adherence to the glass surface once it is inside the micropipette. .... A sperm is immobilised by gently rubbing its tail on the bottom of the dish and aspirated into the pipette, tail first... Once the oocyte is brought into focus, the ICSI micropipette containing the immobilized sperm is lowered and brought into focus; once again, the fluid control and sperm movement within the pipette are assessed. Should the sperm become stuck in the pipette, it is expelled and another sperm is retrieved, or if necessary the microtool is changed.

The holding pipette is lowered and the oocyte is rotated so that a slit opening in the zona pellucida is at the 3 o'clock position. The outer edge of the oocyte is brought into focus and the sperm is brought to the tip of the micropipette. The micropipette is guided through the slit opening in the zona pellucida into the center of the oocyte, and a small amount of ooplasm is aspirated into the micropipette to ensure breakage of the membrane by slow turning of the micrometer of the microinjector. Once the membrane has been broken, the contents of the micropipette, i.e. ooplasm and the immobilised sperm, are expelled slowly into the oocyte and the micropipette is slowly withdrawn. Complete control over aspiration and expulsion are needed to diminish the amount of medium deposited along with the sperm (Verlinsky and Kuliev 2005, 22).

As is evident from this technical description of ICSI, fertilization in the context of assisted conception is not narrated as a journey, an adventure-romance, or an epic quest, but as a difficult feat of manual control of tiny glass tools. Thus, although the ICSI penetration scene is legible as an analogy to 'normal' fertilization, the procedure is clearly quite different in terms of both form and content. Indeed, other than the fact that a sperm ends up inside an egg, almost nothing about the means of achieving this legendary union is analogous to the conventional narrative of the biological union of egg and sperm. Indeed, as in the case of IVF, for which artificial menopause is the counter-intuitive ground state required of the female patient, ICSI is in many respects the opposite of its unassisted corollary. Far from being an all but automatic natural process ensuring the flow of reproductive substance across the generations, ICSI imagery depicts a skilled manual feat of precision micro-engineering to achieve successful fertilization. Deliberately prevented from being either self-acting or automatic, the egg and sperm are forced into a microtooled union via manual assemblage. Formerly imagined as unstoppable, the sperm cell is firmly taken in hand by the micro-manipulator: first it is 'immobilized', then immersed in ooplasm, and 'expelled' into the egg – its tail having been cut off to make it more easily manageable and 'cleaner'. No longer a

heroic gamete-Olympian, the sperm must be brought under 'complete control'. The only active agent in this union is the handler.

What is just like 'normal' conception in the context of ICSI remains its purpose, namely the unification of egg and sperm – thus activating the process of fertilization leading to potential biological offspring. It is only from the point of view of ensuring the continuity of biological relations between parents and offspring that the logic of ICSI is identical to that of 'unassisted' conception. It is the aim of reproducing the familiar kinship pattern of bilateral descent, through which the offspring inherits an equal amount of shared substance from both parents, that drives this manual imitation of a biological union. And it is precisely the fact that this union did not occur naturally that makes the technological 'seconding' of this process appear commonsensical. Reversing the usual logic, according to which it is the biological facts of life that determine parenthood, ICSI is only isomorphic with the standard model of 'unassisted' conception if biological action is superseded by the very logic it is imagined to underpin. Consequently, it is a different union to that of the natural, biological merging of egg and sperm which defines the visual and technical logics of these images, namely the merging or fusion of substance and tool, or hand and cell. The ICSI coupling, it turns out, is comprised of several inter-related pairs: egg and sperm, camera and screen, tool and hand, viewer and manipulator, and substance and tool. The reproduction of this screen scene via the mainstream media adds yet another level to the distinctive visual logic of these images too, as it is the images themselves that come to comprise a kind of shared cultural frame of reference for witnessing the remaking of sex – or even a shared culture medium for understanding them. This layering of techno-logics – whereby ICSI might be viewed on television, for example, or downloaded onto an iPhone – in turn introduces a new convention of witnessing the 'exact mechanisms' of reproduction live on screen.

What is on display in such a spectacle is thus not only the logic of IVF, but the biological relativity implicit in making biological relatives. The relativity of the biological to the technical could hardly be made more explicitly visual than in the scene of microinjection, in which cells and tools engage in the complex intercourse of merging with a purpose. Beyond the frame, beyond the invisible hands, beyond the camera and its monitor, beyond the lab are all of the other important contextual elements through which this novel composition makes sense – such as the conventional understanding of what a parent should be, as well as the expectation of what technology can do, and the logic that puts these two forms of conventional thinking together to come up with ICSI as the obvious answer. But like IVF, the sense this equation makes may be superficially obvious in ways that obscure what is implicitly contradictory and even queer about its origins. For in addition to everything legible and ordinary about the logics of biology, kinship, reproduction, technology, progress, and hope (among others) are the counter-logics the ICSI primal



scene has the potential to suggest or imply – such as the fact that the difference between cells and tools has become irrelevant.

#### 4. Conclusions

It is in the convergence between the prevailing logics and conventions of biological kinship and those introduced by new reproductive technologies that IVF, ICSI and their ilk that confirm a new relativity of the biological that remains to be charted as the “age of biology” unfolds. There is no reason not to assume that the remaking of nature as technique will remain largely compatible with the logics of unassisted nature, or natural procreation, or of the ‘automatic’ flow of genealogy – nature has long been cultured up, after all, and biology has arguably always been a relative condition. Moreover, nature and biology are highly plastic categories, and as kinship theory confirms, biological parenthood has never been left to its own devices. To the contrary, the logic by which biological parenthood is understood to create a natural tie, or a biological relation, is highly dependent on specific forms of labour, including the crafting of substantial connections, family norms, kinship systems, inheritance patterns, marriage prohibitions, and other social technologies.

The way in which these new dimensions of reproductive experience stretch the frame of existing conventions is both paralleled and demonstrated in the imagery that has accompanied the rise of IVF over the past thirty years, and specifically the rise of micromanipulation imagery, in its very explicit staging of the mechanization of reproductive substance. If micromanipulation has become an increasingly recognizable visual shorthand for the fusion of tool and substance, and if ICSI introduces a new figuration of conception that is more strongly defined in visual terms than in narrative ones, what are the consequences of these shifts for understandings of ‘the facts of life’? Or with what we might call IVF? How do these new images interact with older, more established, representations of reproductive substance, such as the traditional egg and sperm narrative? How do they refigure the meanings of the biological, the technological, or the relationship of reproductive biology to new forms of digital representation? To understand the formation of an emergent global biological culture, and to interpret the ways in which IVF works not only as a technology of reproduction, but a culture medium, IVF is an excellent case study that will repay further investigation.

One defining feature of the imagery of retooled reproductive substance is its introduction of a new genealogical model, in which it is not only reproductive substance, but its directionality, orientation or ‘flow’ that is redesigned. In the familiar tree models of natural history, so favoured by Darwin, and still a basic tool of genetics today, reproductive flow is always one-way. It is also always brachiating, binary, and bilateral, but contained, and limited, in its irrevocable path. This arboreal pattern

of biological flow is superseded in micromanipulation images both by new conduits for the transmission, in the form of the tools, and the possibility of open-ended dissemination. These are the new coordinates of micromanipulated life. Extending beyond the frame, the micro-tools point not only to the genealogical terminus that is their object, but to the termination of the conventional genealogical model (so familiar to kinship studies) that was their predecessor. The rotation of its regenerative axis to a horizontal position re-orientates the genealogy of flat screen life, while detaching this scene from it from its genealogical 'trunk', and leaving it literally open-ended as a conduit. The new 'stem' of life in the flat screen world of cultivated human cells is the inner cell mass – the totipotent source of cells that can be amplified into regenerative lines. In the context of flat screen life, genealogy is an open-door.

The visual grammar that holds the micro-manipulation image in place, then, is not derived from the logic of sex or genealogy belonging to natural history, but rather to modern scientific technique. It might be difficult to find a more explicit visual representation of Rabinow's (1992) claim that life "will become technique" in a manner that reverses the order of Darwinian evolutionary time and *telos*, by making culture the origin of biology. The fact that the cells on the bed of the micro-manipulator are submerged in culture medium reminds us of the etymological roots of the term 'culture' in cultivation, that is, in the art of technique. What micromanipulation imagery provides is the kind of horizon-altering perspectival shift described by Barbara Duden (1993) in relation to fetal photography – offering an instrumental reframing of reproduction as technology. This is how micromanipulation imagery has become, in Duden's words, "part of the mental universe of our time" (1993, 1) in its depiction of the production of new life in ways that are detached from the orders and logics of living things that have structured far more than biological categories in the past.

It is the relativity of these former biological categories that IVF arguably makes more visible – both in its use as a clinical procedure, and as a research tool in science. To describe IVF as a technological platform has a literal meaning in relation to micromanipulation imagery that is both technically and metaphorically apt (as is the common description of the micromanipulation table as its 'bed'). The mental universe in which both IVF and flat screen life are legible – their grammar – is increasingly widely shared, and help to contextualize the question of why IVF is so popular in spite of all its difficulty, and why it is so curious despite having become more regular and normal. The same logic that makes IVF useful for clinical purposes – as a tool to aid in the overcoming of the obstacle of infertility – applies to the remaking of biology as technology more generally, and thus also to the newly conventional visual logic of micromanipulation, with its vivid depiction of taking living tools in hand. To the extent this logic also grounds a new understanding of technology as biology,

through the recomposition of reproductive substance, so too has it already reshaped the future of kinship.

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