Six Days in Plastic: Potentiality, Normalization, and In Vitro Embryos in the Postgenomic Age

Tessa Moll¹,²

Abstract
Part of the normalization of assisted reproductive technologies (ARTs) is the premise that the children born from in vitro fertilization (IVF) are no different from their counterparts conceived spontaneously. However, interest in peri-conception health and new epigenetic understandings of biological plasticity has led to some questioning the presumed irrelevance of conception in vitro, and when doing so, describing IVF children as “apparently healthy.” Taking “apparently” and “healthy” seriously, this article explores how modes of attention—ways of naming and framing embryo potentiality—shape understandings of health and normality. I contend that understanding the politics of potentiality, and how they may emerge in a postgenomic age, requires an unpacking of various modes of

¹Alfred Deakin Institute for Citizenship and Globalization, Deakin University, Melbourne, Australia
²School of Public Health, University of the Witwatersrand, Johannesburg, South Africa

Corresponding Author:
Tessa Moll, University of the Witwatersrand, Education Campus, 27 St. Andrews Road, Parktown 2193, Johannesburg, South Africa.
Email: tessamoll@gmail.com
attention and framing. Ethnographic findings from South Africa’s fertility clinics and emerging literature on epigenetic variation in IVF conception demonstrate how, under a genetic mode of attention, IVF clinics views “abnormality” as fated, unviable, and discardable. Exploring the possibility of answering the postgenomic questions to IVF reveals structural challenges to knowing long-term health implications. Incipient attempts within the fertility clinic at managing these questions shows various strategic techniques, such as leveraging epigenetics to marketable ends and shifts to individual responsibility.

**Keywords**
postgenomics, IVF, normalization, potentiality, attention, embryos

In an interview, eco-futurist Stewart Brand offered *in vitro* fertilization (IVF) as the quintessential example of how new technologies can acclimate into society. “I remember when that was an abomination in the face of God’s will,” he said, “As soon as people met a few of the children, they realized that they were just as good as the ‘regular’ ones” (Honigmann 2010). Parents of IVF children would say the same—their children are just like any other. Melissa was one patient I met during my fieldwork in South Africa’s fertility clinics. Just prior to the birth of her first born—conceived after four rounds of IVF—Melissa said IVF processes seemed like a far-gone “dream.” The injections, egg aspirations, and text message updates on her *in vitro* “embies”¹ were long gone. Just like any “normal” conception, Melissa was now worried about labor, breastfeeding, and sleep schedules. For anthropologist Sarah Franklin (2013), Brand’s words are indicative of the model that IVF instantiates: how “biology has become increasingly technologized” (p. 32), yet all the while grounded in scenes of normality and the everyday. IVF children prove that although the process itself is nothing like “natural conception,” it produces children just like the “real thing.”

But what if that isn’t the case? In an article in *The Lancet*, scholars calling attention to the significance of the peri-conception period to long-term adult health named assisted reproductive technologies (ARTs), including IVF, as a potential compromising factor (Fleming et al. 2018). Here, the children of IVF are described as “apparently healthy” (Fleming et al. 2018, 1848). The interest in peri-conception health is an extension of work related to the Developmental Origins of Health and Disease (DOHaD) hypothesis,
which positions fetal life as a “critical window” in which environments may shape long-term health outcomes (Gluckman, Hanson, and Buklijas 2010). Epigenetics, the science of gene expression, is theorized as the mechanism explaining the link between fetal exposure and adult health (Waterland and Michels 2007). The interest in peri-conception health, the DOHaD hypothesis, and new epigenetic understandings of biological plasticity call into question the presumed irrelevance of conception in vitro.

Describing this temporal framing as a window of potentiality, Pentecost (2018) argues that the DOHaD focus on the first 1,000 days of life compels intervention and investment in order to prevent “apocalyptic possibility” (p. 287). Taussig, Hoeyer, and Helmreich (2013, S4) define potentiality as a “hopeful idiom” oriented toward improved life produced by new biomedical interventions. In its orientation toward improvement, potentiality shapes the push toward ever more optimized health, driven forth under a new regime of prudence, individuality, and choice (Novas and Rose 2000). But, further to this, framing something as having or being “potential” kindles a moral claim to act. In this way, claims about potential operate “as vehicles for politics,” they argue (Taussig et al. 2013, S5). Bryant and Knight (2019, 109-16) alerts that what gets “framed” as potential is structured by perception and attentions. For something to become “named and framed,” it requires an apprehension of that potentiality, selective attentions in space and time. The notion that embryos, for instance, are a kind of proto-person has been shaped by the technologies of visualization, such as fetal ultrasounds and embryology staging (DiCaglio 2017; Morgan 2009; Duden 1993). In this way, potentiality, and its attendant politics, operates alongside technologies and techniques of attention, that is, biomedical technologies and knowledges that frame certain time periods and certain bodies as in need of intervention.

In what follows, I use Fleming et al.’s (2018, 1848) contention of IVF children as “apparently healthy” as a framework to explore the implications these new questions raise for ARTs in the postgenomic age. With the use of “apparently healthy” (my emphasis), these postgenomic questions to assisted reproduction qualify the normality and health of IVF children with the caveat, as far as one can know or see. I contend that understanding the politics of potentiality requires an unpacking of various modes of attention and framing. To understand what we can know or see, I lay out the “genetic mode” of attention to in vitro embryos. Then, I unpack why the questions about IVF children’s health are qualified and limited. Finally, the question of “apparently healthy” reasserts the normative value of “health.” In doing so, questions related to the health of ART children collapse distinctions
between notions of “health” and notion of “normality.” Here, I explore how IVF deals with “abnormality” under the current genetic mode of attention. Using ethnographic data, I point to several emergent articulations in the fertility clinic that are used to manage the questions of “abnormality” in the postgenomic context.

Throughout this article, I draw on observations in South African fertility clinics and interviews with patients, doctors, and various medical facilitators gathered during fieldwork in 2015-2016. During this time, I followed embryologists during their daily embryo monitoring, sat-in on conversations with patients and doctors on preimplantation embryo screening (PGS), and observed during clinic meetings where medical practitioners discussed scientific debates and innovations. The second half of the paper draws on scientific research and debates on the implications of IVF for the long-term health of children conceived from the technology. These include more than 50 scientific articles, reviews, and commentary representing the key journals and debates emerging in the field at present.

I explore how new scientific knowledge production shifts these questions, asking: how will we see or know this? While in many ways, epigenetics is the science of variation, it operates within a eugenic logic in that it “expands the realm of abnormality; things once normal, in a statistical sense, can become abnormal, in the sense of not-optimal” (Mansfield and Guthman 2015, 13, emphasis in original). Through this “abnormality creep,” the question of “apparently healthy” threatens to absorb the population of 8 million IVF children into a pathological grouping. Finally, postgenomic questions to IVF make visible the strategic backgrounding that assisted reproduction is in many ways always operating under logics of selective reproduction, filtering and screening “abnormalities.” The genetic mode of attention that I lay out here portends that the postgenomic questions to IVF children should not be left to the fertility industry or biomedicine alone.

A Science of Variation in the Normalizing Fertility Clinic

Social scientists have keenly followed the so-called biosocial turn, whereby the biological sciences have garnered a greater appreciation for the social environment and social scientists are finding inspiration in biology (Meloni et al. 2018). Much of this can be attributed to growing research in the postgenomics, a collection of various sciences—epigenetics, fetal programming, among others—that extend causal primacy of phenotypic outcomes
beyond the gene (Stevens and Richardson 2015). Epigenetics specifically refers to the mechanisms of gene expression, that is, how environmental factors ranging from nutrition, care, and stress can shape how genes become expressed phenotypically, without changing the underlying DNA. Epigenetics has spurred proliferating research from neuroscience to nutrition (Feinberg 2008). Social scientists have unpacked the shifting understandings in the postgenomic age of the relationship between nature and nurture, kinship and heredity, and the body and environments (Meloni and Testa 2014; Lock 2013, 2015; Landecker and Panofsky 2013; Stevens and Richardson 2015).

This paper contributes to a growing interest in how epigenetics and other biosocial sciences are shifting or reifying notions of normality and abnormality. As Mansfield and Guthman (2015) described, despite epigenetics’ potential as a dynamic and nondeterministic science of variation, the research remains tied to eugenic logics of diagnosing “abnormalities.” Other scholars note how biosocial sciences often reify binary conceptions of difference: the raced and classed representations of the “neurobiologically poor” (Pitts-Taylor 2019), the ephemerality of racial difference in microbiome research (Benezra 2020), and gendered and colonial dimensions of mestizo ancestry (Saldana-Tejeda 2017). Saulnier (2020, 51-52) argues that epigenetic sciences participate in a “medical model” that equates nearly all forms of difference as “deficits.”

ARTs and postgenomics have separately sparked growing scholarly interest, resulting in a vast and growing literature. Yet few authors address postgenomic questions in the context of assisted reproduction. This special issue is a major contribution to that gap (Keaney 2021; van Wichelen 2022). Sonja van Wichelen (2016) argues that postgenomics challenges the primacy of biogenetics that legitimate the ART and surrogacy industry. Jenny Gunnarson Payne (2016) describes “kinship grammars” that newly include epigenetics to knit biology and kinship in third-party reproduction. Keaney and van Wichelen’s contributions in this special issue continue to ask questions of identity, race, and belonging for children of ART.

Epigenetic sciences bring to light the IVF industry’s long-standing assertions of “normality” and the seemingly closed debate about risks. “Normality” and “normalization” is in many ways key to the global success of IVF, now the cornerstone technology of a multibillion-dollar fertility industry. Indeed, in the British press’s coverage of Louise Brown’s birth, the first “test tube baby” in 1978, the Brown’s family normality was a key tenant of the media framing, thus setting up a dominant narrative of IVF stepping in to assist in conceiving children to ordinary folks, albeit in an
extraordinary fashion (Dow 2019). Thompson (2005, 79-115) catalogues techniques of normalization in the fertility clinic, that is how “new material” is incorporated into preexisting grids of legibility. Naturalization, how ideas of the “natural” becomes a stabilizing “bedrock” for the “normal,” is a key technique of normalization and, in turn, domesticating and managing what could be seen as pathological or dangerous (Thompson 2005, 81). Anthropologists and sociologists have traced how ARTs normalize within cultural scripts to facilitate pregnancy and births in ways indistinguishable from “natural” conception (Bharadwaj 2016; Becker 2000). The sum of this work explains much of the global success of IVF, as a technology of normalization as much as it is a technology of conception (Thompson 2005; Franklin 2013).

This success and the seeming normalized acceptance of ART belie a longer history of controversy and anxiety. The Browns had agreed to abort the pregnancy if it turned out the fetus was “abnormal” (Challoner 1999, 41). Feminist critics in the 1980s raised questions as to the long-term safety for children of in vitro conception (Corea 1985; Overall 1987). Many cited diethylstilbestrol, or Diethylstilboestrol (DES), a synthetic estrogen prescribed to prevent miscarriages, as an example of reproductive medicine causing intergenerational harm. Research has monitored health outcomes (often only within the first year) for IVF children (Challoner 1999, 48); for instance, it has long been tracked that IVF children are at greater risk for low birth weight or preterm birth, though much of this has been attributed to the preponderance of multiple gestations (Tough et al. 2000).

The concern among feminist, bioethicists, and science studies scholars focused mainly on the risks to women or hormone-inducing participants. Researchers have documented the stress of treatment and the risks, such as ovarian hyperstimulation syndrome (OHSS), for egg donors in a global market for oocytes (Becker and Nachtigall 1994; Reddy and Patel 2015). Jain’s (2013, 128-50) chapter on the potential carcinogenic harms from oocyte donation describes the dearth of data on the long-term consequences of hormonal stimulation as a form of “structured ignorance” (p. 132), an impossibility of answering the question in the arrangement of private industry and barely present regulatory framework in the United States. With little evidence, practices continue unquestioned—a galling scenario as Jain points to the known connection between the hormones used in IVF and their carcinogenic effects in other medical treatments.

Shifting risk horizons of IVF—at the scale of pregnant persons and at the scale of national budgets—are driving the push to transfer only a single embryo also known as SET (ESHRE Task Force on Ethics and Law 2003;
Bergh 2005). The previously standard practice of transferring multiple embryos greatly increased multiple gestations, a risk for both pregnant persons and fetuses (Bergh 2005). Many regulating bodies and countries, including South Africa, have since limited the number of embryos that can be transferred (Saldeen and Sundström 2005; Moll 2019). With the push for SET came a greater need for criteria for selecting the best embryo (van Royen et al. 1999). Thus, changing risk horizons has shifted the ambitions of clinical reproduction medicine beyond accumulation—getting many embryos—to more narrow focus of getting “good quality” embryos.

And this shift has influenced technological innovations. The fertility lab has spawned several new technologies in recent years, supporting Franklin’s (2013) description of IVF as a “stem technology.” For one, time-lapse embryo technology has introduced new techniques of embryo visualization with large data sets and hopes for algorithmic embryo selection (Geampana and Perrotta 2021; van de Wiel 2019). As Thompson (2005, 260-63) argues, IVF, as a biomedical mode of reproduction, is troubled by a tension between its efficiency and its effectiveness: between attempts to improve IVF efficiency—reducing “excess” embryos and reducing multiple gestations—while not sacrificing effectiveness and ideally improving on its historically low success rates.

Success rates are a barometer for the effectiveness of new technologies, measured by pregnancy rates (marked by ultrasound or gestational sac) and/or live birth rates. Success rates stake out a “normative epistemology” (Thompson 2005, 104-9) in the clinic that shapes interventions and treatment trajectories, operate as a form of marketing and competitive gauge for differing clinics, and shape patient experiences (Moll 2019; Bharadwaj 2016). The balance between effectiveness (success rates) and efficacy (reducing multiples) has partially fueled the creation of new modes of technoscientific attention concerned with finding “the one:” the “good quality” embryo with the potential to become the sought-after child. Collard (2021, 108) argues that these new technologies monitoring and assessing embryos constitute a respatialization of reproduction into the interiority of the embryo.

This paper explores the intersection of the postgenomic concerns of “abnormality” within the norm-managed world of IVF. To do so, I first present an account of how clinics currently address “abnormality” in what I think of as a genetic mode of attention. Looking at the techniques, technologies, and logics within genetic modes of attention to embryo potentiality on IVF embryos provides a window for comparison with emerging postgenomic concerns.
Attention to Embryos in the “Genetic Mode”

There are many enumerations throughout the IVF treatment, but most reiterated was that, for IVF to work, “you just need one.” One refers to one embryo with the potential to be the sought-after, viable, and healthy child—an anticipatory logic that views embryos “through the lens of the already-human, its future always mapped out before it” (DiCaglio 2017, 19). Here, I describe the “genetic mode” of embryo potentiality in the screening and selection for “the one.” Firstly, this mode attributes embryo potential to its genetic components, linking viability with genetic normality. Secondly, this mode employs attrition to facilitate the filtering of “abnormal” embryos. As “mundane” embryo screening participates in the achievement of viability (Helosvuori 2018), it in turn also produces unviability. The genetic mode reflects that while ARTs foreground the desire for a child, it also backgrounds that certain kinds of children are desired; screening and selection serve both. The normalizing and routinizing of embryo selection is blurring the distinctions between arbitrating viable life and arbitrating “good quality” life (Wahlberg 2008). I set out this genetic mode of attention to understand how fertility clinics address “abnormality,” to thus understand the stakes of an emerging “postgenomic mode.”

Blurring the Lines of Viability and Normality

“There’s nothing that they [doctors] can do to increase the chances. It’s now all up to the chromosomes.” Liezl, a thirty-three-year old woman I met, was explaining her approach to her recent embryo transfer. Doctors transferred two embryos to her uterus an hour before we spoke, and now Liezl would have to endure the dreaded “two-week wait.”

Liezl was acknowledging that the embryo’s chromosomes contribute to IVF failures, through not implanting or miscarrying. Since the 1970s, research has noted embryo genetics as a factor in spontaneous miscarriage (Boué, Boué, and Lazar 1975). Dr. du Toit, a physician in South Africa, described the changing appreciation of embryo genetics. Asked about the early years of his research and clinical practice, he said, “We had very little knowledge or understanding of the embryo and the reason for non-implantation . . . . Today, we realize that the embryo, embryo’s chromosomes are the determining factor, and it’s out of our control. That’s determining life and pregnancy.” Here, embryo genetics are prefigured for their potential.
Embryologists have extensively debated methods of selecting “the best” embryo—framed as the embryo with the greatest probability to implant, and the least likely to have genetic abnormalities (Braude 2013), resulting in the increasing use of PGS.4 Alternatively known as chromosomal screening, PGS involves a biopsy of the embryo and the cells sent to a genetics lab. The resulting report details each embryo’s chromosomal composition, indicating if the embryo is euploid or aneuploid—that is, whether it has the “correct” number of chromosomes with no additions, duplicates, or missing pieces. Some aneuploidy embryos stop developing in vitro; others are unviable even if transferred. But many could result in viable children with certain genetic conditions, such as Down syndrome. While intended as a tool of “selective reproduction,” a technology to “prevent . . . or help bring specific kinds of children into the world” (Gammeltoft and Wahlberg 2013, 203), PGS in practice is articulated as a more precise method of embryo selection, an extension of embryo morphology grading, and framed in terms of improving the likeliness of “success.” And so, “success” comes to absorb not only a viable pregnancy, but a resulting “normal” and “healthy” child.

During my fieldwork, Lucy, an embryologist, explained PGS to a couple that had traveled to South Africa to have IVF with an egg donor. This clinic routinely offered PGS to overseas patients. Lucy told the couple that PGS increased chances for “success” and added that the embryos transferred would at least be genetically “normal.” She described PGS as screening to see “the potential of the embryo to form a pregnancy.” She explained why PGS was the preferred option for selecting embryos instead of only morphology grading: “We know that we can’t judge a book by its cover.” In other words, PGS can at least better “see” potentiality through the molecular depths of the embryo. But it is worth stressing that it is potentiality of a certain kind: The potential for a live child not to have genetic “abnormalities.”

Screening out aneuploidy embryos was framed to prevent miscarriages, which are viewed as “anomalies, misfires on the development path, failures and oddities” (DiCaglio 2017, 4), and thus shortening time from IVF to pregnancy and averting unnecessary grief. That is, PGS was articulated in its usefulness to ensure the increased effectiveness of IVF and producing a live birth, and one more quickly, while simultaneously backgrounding its role in producing the right kind of birth (although it decidedly does this as well). As argued by Collard (2021), “Although ostensibly about innate biological differences inscribed in the embryo’s genes, decisions about which embryos to implant and which to discard are steeped in sociocultural ideas of able-bodiedness, health, sexual dimorphism, neurotypicality, and
longevity—in short, of idealized form and function” (pp. 106-7). Medical practitioners articulated the viability of embryos in binary and genetic terms: the embryo was either “normal” (and therefore potentiated still toward a biographical life) or “abnormal” (and therefore unviable). In using aneuploidy as a mode to select which embryos to transfer, these techniques of apprehension are collapsing distinctions between the potentiality for biographical life and for what kinds of life are sought and desired.

**Harnessing Abnormality in Embryo “Self Selection”**

Upon egg aspiration—the retrieval of eggs and their movement to the embryology lab—each egg became recorded, a singular line in the chart, and, once fertilized with sperm, was potentiated toward biographical life (Waldby 2002). Despite this anticipation, while each embryo had a recorded history, not every embryo had a future. IVF embryos undergo what one patient described as, a “whittling” process: the number of eggs would reduce to the number of fertilized eggs, reducing further to day 3 embryos, and again reducing further to day 5 blastocysts.

The clinics I worked with debated whether to transfer embryos on day 3 or day 5 in vitro. Some embryologists favored day 3: a uterus is the “natural” environment for the embryos, they said. However, if day 3 came with many “good-looking” embryos, often the lab would suggest waiting to day 5 to allow for the “natural” dispersion between “good” and “bad” embryos to emerge more fully. A Cochrane review on this debate refers to this as “self selection” (Glujovsky et al. 2016, 6). This logic extended that while fewer embryos would make it to day 5 blastocyst stage, those embryos that did would be stronger, the better ones, the ones more likely to result in a pregnancy, and thus a child.5 In this way, the stress of in vitro environments facilitated “self selection” and screening of embryos.

In one case, a 44-year-old patient had been scheduled for a day 3 transfer. However, the lab team was surprised on day 3 to find seven viable embryos, so they called to reschedule to day 5. Debra, an embryologist, explained to the patient: “We don’t want to randomly select four embryos. We want to transfer the best. Over the next two days, they [the embryos] will show us which one is the best.” For Debra’s lab, it was preferable to allow the viability of the embryo to make itself known. This mode of embryo potentiality frames genetic composition as a predetermining factor for the fates of embryos. Rather than have the embryologists attempt to select the best embryo, it was better to have “nature” reveal its own selection via the emergence of aneuploidy embryos. Taussig, Hoeyer, and
Helmreich (2013) remind us that framing something through potentiality compels a moral claim to intervene and act. The above story reminds us that the inverse is also true: framing something as lacking in potential—unviable embryos—facilitates their transition to medical waste.

van de Wiel’s (2018) argues that egg freezing and visualization technologies rely on a reproductive necropolitics of the inevitability of ageing, fertility decline, and the fallibility of reproduction. Age-related reproductive decline and “ex vivo egg death” (p. 13) is a counterpoint to the usefulness of egg freezing’s extension of reproductive time, she argues. Here, in vivo embryo death is a different kind of embryo tool. Removed from both biographical potential and biological potential (Svendsen 2011; Waldby 2002), these dead embryos validate the biographical potential of their counterparts. In this genetic mode, their suspended embryogenesis reflects the connection between “abnormal” embryos and unviability. The genetic mode equates genetic “normality” with embryo viability, positioned along the “embryo-fetus-baby pathway” (Morgan 2009, 11).

**Postgenomic Questions to the Long, Long-Term Horizon**

Yet, epigenetics and DOHaD put forth a challenge to this genetic mode in IVF, where attentions are to screen the prefigured emergence of genetic “normality.” Epigenetics and DOHaD research led to many scholars asking in the early 2000s about the implications of IVF in relation to potential epigenetic alterations and health in the children born from the technique. Could the window of in vitro embryos be in fact shaping that potentiality? Could the in vivo culturing, which facilitates embryo self-selection, be causing epigenetic variations? Some 8 million IVF children spent some of the peri-conception period not within the uterus but within plastic petri dishes and culture media. What are the environments during in vitro development? And how is this particular peri-conception environment potentially shaping the health of not only the children of IVF, but their adult selves? In thinking through what and how we know or see, here I explore both what questions are being asked and the limitations and challenges to answering these questions.

Asking about IVF environments does not only include the embryonic environment but the environments of gametes—egg and sperm cells (see Lamoureux, this issue). Clinics often work with oocytes exposed to high levels of hormones, potentially affecting both oocytes and the uterine environment (Ramos-Ibeas et al. 2019). Some questioned specific techniques,
asking whether intracytoplasmic sperm injection (ICSI), the selection and manual injection of sperm into oocytes to fertilize, “bypassed almost all the natural selection mechanisms that operate in natural conception” (Maher, Afnan, and Barratt 2003, 2509), could be an issue. Others suggested that peri-natal issues or imprinting disorders with IVF children could be related to the reasons for using IVF in the first place—infertility, endometriosis, or advanced maternal age (Huntriss and Picton 2009).

But several (Huntriss and Picton 2009; Horsthemke and Ludwig 2005; Laprise 2009) pointed directly to IVF processes. The in vitro period—six days in plastic—might represent the very start of fetal exposure (Roy, Dupras, and Ravinky 2017). Fertilization and the first three days are critical periods for genetic and epigenetic reprogramming (Ramos-Ibeas et al. 2019) of the embryo. In vitro embryos not only reside in plastic petri dishes—also recently questioned for whether they leach endocrine disruptors (Swain 2019; Gatimel et al. 2016)—but also mass-produced culture media (Ménézo and Elder 2020; Morbeck et al. 2014). With growing concern over embryo environments, many questioned the lack of transparency (due to commercial trade secrecy) in the exact recipe in different culture media (Morbeck et al. 2014; Sunde et al. 2016; Simopoulou et al. 2018).

While the questions of the potential impact can be asked, numerous factors—such as trade secrets on culture media—makes it near impossible to find answers. For one, difficulties in parsing out harms and mechanisms are compounded by the impossibility of human embryo testing (Brison, Roberts, and Kimber 2013). This leaves animal studies and long-term cohort studies on IVF children. Animal studies do confirm that in vitro culturing does indeed affect the epigenome and development of offspring (Duranthon and Chavatte-Palmer 2018), but many acknowledge there are clear uncertainties when translating animal studies to questions in humans. The early articles on epigenetics and IVF children bemoaned the lack of long-term follow-up of IVF children (Laprise 2009; Niemitz and Feinberg 2004; Thompson et al. 2002). While cohorts exist that include and register IVF children, there is scant literature on the health effects beyond the first year (Bergh and Wennerholm 2020).

In South Africa, many clinics I worked with found themselves at a loss to even find live birth outcomes with patients, including many that traveled home to different countries or moved on to different doctors. As many as a third of clinical pregnancies in South Africa have no known birth outcome (South African Society for Reproductive Medicine and Gynaecological Endoscopy 2019 [SASREG]; Moll 2019). National and regional leaders
in the field have sought to rectify this by monitoring clinic outcomes (SASREG 2019, 7), yet these registries remain voluntary.

Finally, the challenges of understanding long-term effects are compounded by the fact that IVF children are largely still young. With the eldest IVF child aged just over forty, how can we know whether ART conception portends adult ill-health? Does the lacuna of an evidentiary basis, facilitated by a lack of long-term follow-up on ART children, mean that IVF remains, as one researcher argues, “a series of experiments-in-progress” (Thompson et al. 2002, 2786)?

**Epigenetics in the Fertility Clinic**

With uncertainty likely to remain, how are new postgenomic understandings taking root? I found fertility doctors excited to discuss epigenetics with their patients, but in decidedly different ways than the above-referenced work. In a staff meeting, a physician raised epigenetics as a way to shift discussions with patients wavering on IVF with egg donation. For him, epigenetics was changing the relationship of gestation and kinship (see Gunnarson Payne 2016; Keaney, this issue; van Wichelen, this issue, 2016). It’s not just genes that connect a parent to child, but the processes of being pregnant potentially instilled more of one’s biology into that child, he explained. He described kinship, “influence,” and biological links in mathematical terms: paraphrasing, he said, a child is 50 percent nature and 50 percent nurture, and of the nurture part, it is 50/50 each parent. Thus, a child from a donor egg is 75 percent yours. With epigenetics in mind, now a child conceived via a donor egg would be 80 percent or 90 percent yours. The doctor’s logic here extends Turkmendag’s (2018) notion of a “calculus of genes,” her term for describing the quantitative reasoning that simplifies links between DNA and identity. In each of the three clinics I observed, at least one physician spoke about the implication of epigenetics, but only in the context of its kinship possibilities. Here, epigenetic is curated to legitimize practices after sought-after grids of kinship and biology. But, as these grids of kinship and biology are deployed in efforts to market certain medical practices, it raises questions about how certain aspects of scientific knowledges gain traction (or don’t) when deployed in for-profit, private medical contexts.

Mosaic embryos provided another example of emerging postgenomic articulations. Mosaicism in embryology refers to embryos with two distinct cell lineages, described as both “normal” and “abnormal” cells. The implications for IVF, and in particular PGS, have only lately been discussed
A biopsy extracts about three to eight cells of a 300-500 cell blastocyst. Those handfuls of cells represent the whole embryo. If they find those handful of cells are “abnormal,” the clinical approach has been to discard the embryo under the paradigm of abnormality as equated with unviability. Yet with mosaics, the embryo may have both “normal” and “abnormal” cells; what if they have simply biopsied the few “abnormal” cells? “Healthy live births” have ensued from mosaic embryos (Greco, Minasi, and Fiorentino 2015; Gleicher et al. 2016).

At a weekly meeting, one embryologist asked whether mosaics precluded the validity of PGS. A doctor asked, “What ratio is compatible with life?” Meaning what percentage of “abnormal” cells within an otherwise “normal” embryo could produce a “viable” child? But the question could also have been phrased as the ratio compatible with the right kind of life. During the discussion, doctors put these questions differently, in terms of “risk.” If the embryo is too mosaic (too many “abnormal” cells), it will either fail to implant or miscarry. If less mosaic (mostly “normal” cells), it could potentially produce a “normal, viable” child, but it could also still result in the birth of a child with a genetic condition. In the discussion, the doctors kept reiterating that the best case scenario, if the ratio were incompatible with the right kind of birth, would be miscarriage. They preferred transferring embryos that have too many abnormal cells for viability (with an outcome of miscarriage) than risk the live birth of children born with genetic conditions. The potential for a live birth of a child with a genetic condition was framed as the worst outcome. They opted to maintain their current practices.

In a third example, a handful of news articles reflect another emerging articulation of the postgenomic problem to IVF. In the news stories regarding epigenetic variations in IVF children, the authors emphasize that this change represents tiny risks in real terms: “even if there was a slight increase in abnormalities, the rate was not much higher than in the general population” (Kolata 2009). In one emblematic example, reported in the UK’s Daily Mail, a researcher asserted that a study on the higher risk of cardiovascular disease among IVF children “should be no cause for concern for parents who had had IVF. ‘A healthy lifestyle—or not—will be far more deterministic of those risks than IVF conception’ he added” (Spencer 2018). Early within the article, it is mentioned that IVF children may employ preemptive measures—citing exercise, healthy eating, and pharmaceuticals—to prevent future cardiovascular risk.

The appeal to “a healthy lifestyle” as a way to “overcome” the risk of epigenetic alterations is telling. While DOHaD research often implicates
the social environment—social, political, and economic structures—in producing adult ill health, public health policy and remediation often recenters individual responsibility (Pentecost and Ross 2019; Richardson 2015). Epigenetics, described as the science of how “experience gets under the skin,” could be more accurately described as a science charting how bad experiences get under the skin (Meloni and Müller 2018, 4). Are epigenetics and DOHaD contributing to our ever-increasingly granular understanding of the harms of environments, parents, nutrition, and now variations of conception, as ways in which the mass of others differ from the norm? In other words, the idealization of unattainable and optimized health produces a growing spectrum of those not-quite adequate in health and ability. This creates an abnormality creep, with a growing number of populations, behaviors, bodies, and phenotypes that are “not optimized,” and therefore “not normal.” This abnormality creep is premised on a moral imperative to live up to—and ideally to exceed—so-called biological potentials. Absorbing IVF children into this spectrum of abnormality, optimization, and health extends neoliberal logics to petri dish embryos.

Conclusion

The implications of postgenomics to IVF are in many ways a fascinating question that reflects the web of entanglements between biology and technology (Franklin 2013). For one, as Thompson (2005) has described, the fertility clinics’ emphasis on normalization is often hinged on naturalization. Desires for children are natural; genetic links are natural; having children that resemble parents (and thus selecting donors by race) is viewed as natural. However, as Frost (2020) argues, epigenetics reminds us that “there is no prior moment in which a biological body could be said to be pure or unformed by social and political life” (p. 6). Epigenetics portends that there is no prefigured, pure, or unsocialized nature. The use of nature as a “bedrock” for the normal in IVF is on shaky ground. Furthermore, feminist critique of epigenetics and DOHaD has pointed to the gendered implications of these paradigms in practice. Wombs are seen as risky spaces for vulnerable, innocent fetuses (Mansfield 2017; Saldaña-Tejeda 2017), and mothers and pregnant persons are compelled to be responsible citizens in gestating future generations—or be blamed for failing to do so (Richardson 2015). But in vitro embryos are as yet womb-less, nurtured in climate-controlled incubators, metabolizing culture medium, and stressed by the penetration of pipettes siphoning a cell or two. Taking an embryological perspective (DiCaglio 2017), whereby a fetus-baby pathway (nor a
“healthy” one) is not anticipated, could offer ripe and rich theorizing for feminist technoscience and disability scholars.

As the question of the long-term effects of IVF cannot be fully answered, I have taken a different tack. Instead, I have sought to understand the implications of this question. In showing how “abnormality” is currently dealt with in the fertility lab, I argue that the “genetic mode” of embryo potentiality equates genetic abnormality with fated failure and attrition. Screening processes blur differing potentialities for IVF success. While foregrounding the potential for safely initiating a healthy pregnancy and live birth, routinized embryo selection also precludes certain kinds of birth. The cases of incipient management of postgenomic questions by the fertility industry and publics alike demonstrate the leveraging of epigenetics toward marketable ends, the continued genetic logics of screening out “abnormality,” and the abnormal creep of epigenetic variation with the appeal to individual self-management. In other words, if something like an “postgenomic mode” of IVF embryos and variation can be said to be emerging, the IVF industry and biomedical sciences cannot be left to determine its course. The bioethical question is how to move forward with uncertain information (Roy, Dupras, and Ravinky 2017). On one hand, potential harms must be identified, their mechanisms understood, and those must be communicated to have any semblance of informed consent in reproductive decision-making. Some fear that epigenetic variation information could be used as a form of “epigenetic discrimination” (Dupras et al. 2018), resulting in harmful forms of profiling. Could this include IVF children if they become equated with epigenetic “abnormality?”

The continued cataloguing of epigenetic alterations might require a different kind of politics, one that eschews the notions of normality and purity to which certain conditions create aberrations. A genetic vision of embryo potentiality views conception as the “start” and its fate already precoded; but epigenetics always points to the processional nature of viability, potentiality, and futures in the making. Mansfield (2017) describes this as a “folded futurity,” the enfolding of future and past into the figure of the vulnerable fetus. But, to echo DiCaglio (2017), paying attention to the temporal frames that bring embryos and fetuses into view can alert us to how those various fixings (six days in plastic, 1,000 days of life, embryo stages) that do not encapsulate the lively, sensorial, attentiveness of bodies (Frost 2020) that are untethered to futurity. Epigenetics may trace to certain exposures, but there is no prior to or return to so-called health or a norm. There is no “epigenetically normal” body; there is no normal body (Rose 2009). And hewing close to that replicates a medicalized logic that views
difference as pathology to be screened out or treated away. This article serves as a cautionary window into an incipient management of abnormality in IVF in the postgenomic age.

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**ORCID iD**

Tessa Moll [https://orcid.org/0000-0002-7230-7082](https://orcid.org/0000-0002-7230-7082)

**Notes**

1. Many patients referred to their *in vitro* “embies” (see also Becker 2000).
2. This is not intended as a systematic review. I targeted key journals in medicine, fetal programming, and reproductive medicine (including *The Lancet, New England Journal of Medicine, Human Reproduction, Fertility and Sterility,* and *The Journal of the Developmental Origins of Health and Disease*) and collected roughly fifty articles. All were read and reviewed. My objective is simply: (1) to point out that a growing number of scholars are raising and researching these questions and (2) to understand the limitations to answering them.
3. Thanks to the anonymous reviewer for this point.
4. A Cochrane review found little evidence to support its effectiveness (Cornelisse et al. 2020).
5. The Cochrane review (Glujovsky et al. 2016) found “low-quality” evidence for higher live birth rates among day 5 (blastocyst) transfers.

6. Scholars have traced the recirculation of “excess” and “abnormal” embryos (Collard 2021; Svendsen 2011). This was not the case in South Africa, where nonviable embryos become medical waste.

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**Author Biography**

**Tessa Moll** is a Postdoctoral Research Fellow in the School of Public Health at the University of the Witwatersrand and an Honorary Research Affiliate at Deakin University, working in the fields of medical anthropology and feminist technoscience studies. Her research interests concern the politics of reproduction, assisted conception technology, and postgenomics knowledge production, with a focus on postapartheid racialization in South Africa. Her recent work can be found in *Medical Anthropology, Reproductive BioMedicine & Society Online*, and the *Journal of Bioethical Inquiry* and in the edited volumes *Birthing Techno-Sapiens: Human-Technology Co-Evolution and the Future of Reproduction* (Routledge, 2021) and *Controlled Birth: Selective Reproduction and Neoliberal Eugenics* (Manchester University Press, in press for 2022). She is currently involved in an Australian Research Council-funded project Emerging Reproduction Markets in Southern Africa, based at Monash University, and working on a monograph on fertility care and race in South Africa.