ASSISTED REPRODUCTIVE TECHNOLOGY: ETHICAL AND ECONOMIC INQUIRIES WITHIN THE LABORATORY

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THESIS INTRODUCTION

This senior thesis research project examined the ethical and economic dimensions of assisted reproductive technology research and knowledge from the perspective of laboratory scientists. This research asks how external factors, such as cultural discourses about the ethics of embryo usage; the profit-making potential of ART services, etc., make themselves relevant within the lab and the products that emerge out of the lab. This project was administered primarily at the Gordon Lab through participant observation of the lab and interviews with scientists and leaders of in vitro fertilization clinics. The purpose of this project was to investigate the moral and ethical frameworks of scientists, to examine the way market forces intervene in research, and to interpret the flow of embryos in a network.

Background and Literature Review

In the last 40 years, assisted reproductive technology (ART) has grown into a million-dollar baby-making industry. The introduction of in vitro fertilization (IVF) radically changed the reproductive process by taking conception outside of the body and into the laboratory, within a dish or test tube. Around the 1950s, more effective infertility treatment emerged as a new research focus, resulting in the world's first test-tube baby in 1978 through IVF [8]. From that point of departure, ART has increased in both variety and quantity ranging from intracytoplasmic sperm injection for male infertility to preimplantation genetic diagnosis for screening and selecting embryos [8]. As ART research
advances, two major innovations are on the horizon: gene editing and in vitro gametogenesis (IVG). Single gene editing when paired with preimplantation genetic diagnosis may eventually allow scientists to manipulate embryos to express certain desired human traits. IVG, on the other hand, could soon successfully create human gametes out of stem cells, supplanting even IVF in many ways (Cohen et al. 2017). Research in this field generally is financially supported by major IVF centers, pharmaceutical companies, and universities, not the government (Wymelenberg 1990). The presence of this gap in public versus private research funding has hindered the federal government’s ability to control and oversee ART research and technologies, leading to a flourishing, and largely unregulated, private industry (Roberts 2007, 194). At my field site, the Gordon Lab, the research goal is to improve IVF success rates for cases of infertility that may be the result of cellular metabolic malfunction (errors in chromosome segregation that are possibly tied to energy production). The scientists study embryo maturation from the single cell to blastocyst stage using microscope and imaging techniques in order to create noninvasive methods that best assess the viability of eggs and embryos from mitochondrial activity.

IVF costs an average of $12,500 per cycle, but the cost to achieve a live birth usually ranges from $66,000 to $114,000 (Falloon and Rosoff 2014, 63-69). Only about a third of states in the U.S. offer health insurance coverage for infertility treatment, meaning the majority of people pay out of pocket for this service. In particular, Medicaid (federal aid for the health care of low-income people) does not pay for ART at all (Falloon and Rosoff 2014, 63-69). Even when
coverage is present in the Western world, “all health care systems, public and private, set restrictive eligibility criteria that limit consumer access,” (Birenbaum-Carmeli 2009, 7). For example, some insurers dictate the sperm donor that can fertilize a woman’s eggs or the number of times a woman must first attempt a natural pregnancy depending on her age (Bernard 2014). Like any service that is paid for, ART becomes a market. Regardless of whether there is health insurance coverage or it is paid for out-of-pocket, the market varies in profitability and share based on the specific technology, procedure, end user, and location (Grand View Research 2018). In addition to the fertility clinics and hospitals where this technology is used, the manufacturer is also an important factor in the process. There are even start-ups that emerge from novel breakthroughs in research, feeding into the industry-wide push for new technology or machinery to drive up profits (Robbins 2017). The principal investigator and a post-postdoctoral fellow in the Gordon Lab created their own early stage start-up, based on their research into noninvasive tools, with the intention of using the technology for clinical applications. In fact, the lab has a relationship with IVF clinics in the area.

Fertility clinics, medical clinics where people go for specialized infertility treatment, operate as enterprises largely separate from hospitals. Private ART clinics have recently seen an increase in investment interest from private equity firms and venture capitalists (Front Line Genomics 2017). While this encourages the development of fertility clinic chains, the main concern is that investors may be pushing unnecessary treatments and services, especially for younger generations (Front Line Genomics 2017). Furthermore, the involvement of
investors does not make treatment more affordable. For some, fertility clinics wield their own power by choosing who to admit out of those who seek medical intervention for their infertility. In the situation where clinics offer a risk-sharing package deal (which a company helps them run) called the “baby-or-your-money-back program” and charge on the higher end of tens of thousands of dollars for a supply of multiple IVF procedures if necessary, they bank on couples who have a better chance of pregnancy on the first attempt which results in them keeping the rest of the money (Lieber 2017). Where does this leave those who arguably may need ART more, but are considered a higher risk monetarily? This demonstrates a negative relationship between money and access to life-enabling technologies that is ethically and economically problematic. The question of who has access raises the issue of how to gauge who needs reproductive technology. When weighing the argument for or against mandated insurance coverage, Falloon and Rosoff (2014) state that though ART users are most likely wealthier, ART is a lifestyle medicine akin to cosmetic surgery and, as an alternative that deserves mandatory insurance coverage, does not adequately rival adoption (63-69). Because they want genetically related children, those faced with infertility choose to use ART.

Though much has changed in the last decades in terms of societal acceptance, assisted reproductive technologies still are controversial. Scientists are major players in the forces at work. In my preliminary research, I found that when faced with concerns about the extension of their research to ethically questionable extremes, some of them appear dismissive. While there are scientists who consider the negative ethical implications of gene editing research leading to
“genetic upgrades for those who could afford them,” others contrastingly think it is unethical not to explore the possibilities of this line of research when they could help people. They believe this can be done in a “safe and reliable manner” with factors like laws of regulation in place (Belluck 2017). They think, though they do not speak for all, that because a “history of ethical overreach” with these technologies is lacking, these fears may be unfounded. My research project will investigate these ethical and economic tensions surrounding ART through an anthropological lens from the perspective of scientists working in a university bioengineering laboratory—inventing noninvasive techniques to better select viable embryos and ultimately improve the success of IVF. I hypothesize that because the scientific research and the scientists themselves are the fundamental source of this technology, this field site will be key in uncovering the dimensions of ART.

**Ethics**

Moral and ethical controversies are interwoven into the multiple facets of ART, and anthropologists in the past have approached these questions from various angles. A large ethical debate about ART pertains to its function as a medicine or medical technology. Thomas A. Shannon (1988) presents a challenge when he asks if medicine should “be used to cure disease or to respond to the desires of individuals and the values of the culture” (157). Furthermore, the classification of infertility as a disease then must be investigated. The question of ART as medicine is invoked when accounting for the lack of nationwide
insurance coverage and issues of accessibility (Shannon 1988, 161-162). If ART is not considered a medicine that saves lives from the disease of infertility, then why should it matter if those who utilize the technology are more likely to be rich and white rather than poor minorities or if the federal government authorizes health insurers to cover it? These entangled ethical and economic dimensions operate largely outside of the laboratory.

While infertility may not be considered a life-threatening disease, the suffering it causes cannot be discounted. This lends itself to a valid case for ART as a medical intervention. ART is in a category of biotechnological research that is “shaped by a pronounced sense of urgency to alleviate human suffering” (Sharp 2014, 8). Sarah Franklin and Celia Roberts go so far as to say that for some scientists this is a “primary moral obligation,” to not only eliminate as much suffering as possible but also to increase the technology’s efficiency (2006, 13-14). Furthermore, this research goal functions to convey the ethical world of ART within the scientific laboratory.

Science versus ethics and morality are areas that have long been portrayed at odds with each other. This emerges from the seeming contrast between the objective and subjective. Though scientists are undeniably the ones who speak for science, historically they have been discouraged from moral thinking due to the ideals of logical positivism that led to the scientific method. This philosophy set out to make science objective by eliminating the “scientists’ subjective perceptions, beliefs, and desires” (Rollin 2006, 21). Lesley A. Sharp argues that morality should be a consistent feature of certain scientific domains (2014). While
her argument concerns allotransplantation research, I feel its relevance applies to assisted reproductive technology research as well because, similarly, the issue of infertility legitimates constantly evolving research.

Sharp (2014) goes on to distinguish the conflation of ethics and morality within this field of biotech research. Ethics are denoted as the established set of codified rules such as the bioethical codes of conduct. Whereas, the moral regards the scientific interests and decisions that arise daily and influence the trajectory of research (Sharp 2014). Following Sharp’s example, I plan to focus on the quotidian research practices within the laboratory that may illuminate the moral imaginaries of scientists. However, I will also attend to the institutional ethical principles in place at the Gordon Lab in order to evaluate how they intersect and influence the personal moral frameworks of the researchers. Though the purely academic interest in the increase of scientific knowledge of ART has been attributed as a motivator of competition among scientists (Shannon 1988), my research project investigates whether and how the political economy of ART research and services influences or informs the moral and ethical domains of ART scientific laboratory research. The two forms through which I will interrogate this premise are the Gordon Lab’s relationship with a partnering IVF clinic and with the PI’s start-up company. By tracing how the actors and imperatives of these different domains influence and affect activity in the other domains, my findings will demonstrate the crucial stake scientists have in the ethics and economy of ART, in terms of what happens both inside and outside the laboratory.
Part C: Economics/Capitalism

Additionally, I hope to contribute to theories of political economy or capitalism, another body of work that is inextricably tied to ART and entrenched in the ethical issues explored above. Though capitalism is dynamic and mutable, and thus cannot be assumed to take a singular or predictable form or function (Sunder Rajan 2007, 7), an analysis of capitalism within the laboratory is one unique angle that must be examined. Biocapital is one particularly relevant type of capitalism that has been studied by anthropologists and hence further distinguished into distinct threads of discussion (Helmreich 2008). For example, there is a feminist focus that sets production against reproduction and yet another biocapitalist notion centers around questions of meaning, bringing ethical subjectivity in conversation with relations of production (Helmreich 2008, 471). While these multiple theories of biocapital do not completely fit an analysis of ART, I plan to fill in some of those gaps such as the lack of a discourse concerning ethical perspectives or questions of meaning specifically about biomaterial (embryos in this case). With my research, I will follow in the footsteps of substantivist economic anthropological work that scrutinizes the cultural values which motivate capitalistic exchange (Helmreich 2008, 471). However, I am more interested in specifying how these values that society holds filter into laboratory research.

According to Marx, a capitalist means of production functions to foster an impersonal relationship with products. Commodities are described as both a thing
and a social relation, but under conditions of advanced capitalist development, a commodity fetishism arises (Marx 1978, 319-329). The social relations necessary to produce the commodity are obscured, thus the commodity is viewed by both the worker and consumer as abstracted from human labor. While anthropologists have dealt heavily with capitalism and its influences on various biotechnologies, ART sets itself apart as a medical technology that helps create life—the result being an embryo, not just save or improve life. The embryo represents the ultimate commodity, wherein life itself is alienated from human relations. Therefore, my research project aims to substantiate this complete alienation of the embryo. This will require me to take on the question of the social and moral status of the embryo—at what stage can we attribute personhood to the object?

I hypothesize that, due to economic forces, the creation of life is not seen as the interrelations of persons (man and woman, maybe doctor too), but as a thing with intrinsic value devoid from human sentiment, which is the goal of innovative scientific research and can be exchanged for money. Because the embryo is the natural origin to a human being, it is troubling that its value is not based in human sentiment. For instance, the made-to-order embryo industry, in which “embryos are generated with a financial transaction in mind” is an apt example of the commercialization of ART with the commodification of the embryo as a tool (Cohen and Adashi 2013). In this way, the complete alienation of life takes place. According to Marx, commodity fetishism and alienation make it easier for capitalists to generate surplus value by extracting surplus labor (Marx 1978, 351-361). For that reason, I intend to explore how this dynamic plays out
within the laboratory and at the level of the labor of scientific researchers.

Kaushik Sunder Rajan refers to the 1980 Bayh-Dole act that led to the “rapid commercialization of research problems” as a reason for the new ease in technology transfer from academe to industry (2007, 6). This extraction could be represented by the drive for persistent technological advancement in ART to create life in new ways, which then may be associated with the demand for fertility clinics to offer more services and reach more patients. I hope my findings will contribute to an analysis of the contextual relationship between this scientific field and society (Sunder Rajan 2007, 6). I plan to investigate how the political economic structure influences or impacts the realm of ART research, by examining the nature of the relationship between capitalist market forces and the production of scientific knowledge about a valuable entity—the embryo.

**Part D: Anthropology of ART**

Lastly, my research will augment the anthropology of ART literature more broadly. The anthropology of science is a burgeoning area of academic discourse due to the significant push to situate science within larger social and cultural contexts (Sunder Rajan 2007, 4). Furthermore, this body of scholarship has shown that science and the social order mutually constitute one another (Jasanoff 2004). This coproduction has been theorized by anthropologists through the vantage points of kinship, the local vs. global, feminism, race, and nationalism not to mention ethics and political economy; however, my project is distinct from these
works in that it utilizes an approach devised from science and technology studies (STS): the actor-network theory.

STS is particularly relevant to an anthropology of ART because it is an academic area that engages the intersection of science and technology and the social. Technologies are sociotechnical products comprised of technical features as well as the social environments where they develop (Wajcman 2002, 351-356). Consequently, in attending to the importance of what ART means to whole communities, it poses the question of what our ideas about ART, in turn, say about us as a society (Dow 2016, 11-12). I will attempt to delve into ART using the laboratory as a mediator to bring the objectified embryo into the forefront. According to the actor-network theory, ART must be examined as a web of doctors, scientists, consumers, policymakers, and investors (Birenbaum-Carmeli 2009, 10). The network that I map in my project will flow from scientists in the laboratory who are close-up to embryos in a way that seems largely missing from literature. I will emphasize the embryo itself as an actor, and agency for the actor is defined through its relationships with others within a network (Shiga 2007, 43). While the theory allows us to equally view human and nonhuman entities in their interactions with the social world, embryos inhabit an interesting position as technically human but with a questionable level of agency. I am interested specifically in the circulation of the embryo and the various points of intersection that add to the dynamism of the scope of the ART network (Roberts 2007). My findings may reveal that social regard for the embryo is developed by but also reinforces the ethical, moral, and economic issues surrounding ART.
Methodology

This project will investigate the ethical and moral perceptions of scientists working on reproductive technology research. While scientists are central to the process of ART, primarily because the technologies that aim to nullify infertility are the product of their ingenuity and hard work, social science research on ART often leaves the personal considerations and motivations of these scientists out of the ethical debate. Yet, scientists must ethically and economically rationalize their research, as the result is scrutinized by IRBs, sought after by IVF clinics, and praised or criticized alike by the public. My research thus asks how the personal beliefs of scientists motivate their work and inform their personal engagement with questions of morality as they complete projects day-by-day. I examine their modes of thought and ethical encounters through interviews, participant observation and textual analysis of the academic conversation around the ethics of ART over time in order to assess how ethical and economic inquiries appear in the lab.

In order to determine the way in which scientists implement their personal ethical and moral frameworks to draw boundaries of acceptability, this aim will be elucidated through semi-structured and unstructured interviews with members of the Gordon lab. I interviewed the principal investigator, a postdoctoral fellow, and the graduate student that I work with directly.

The interviews centered around the scientist’s value or belief system so as to illuminate a) how they reconcile their motivations in their line of work with the
ethical and moral challenges that surround reproductive technology research and b) their perspective on the ideal relationship between the inner workings of the lab and the outside world (governmental authorities, ethicists, funding sources, and the general population) in the capacity of regulation or oversight.

I asked them why they became involved in this research, why they believe it is significant and what keeps them further engaged. I inquired about their own personal ethical values and daily moral reasoning and, additionally, their views on the established research ethics that facilitate laboratory practice. I hoped to gain a better grasp on the possible distinction between their own limits of acceptability and the general or institutionalized boundaries that have been set in place. I asked them what it is like to work directly with IVF clinics in the area, where the funding comes from and what they think about the controversy that at times surrounds ART research as portrayed in the media or by scholars in bioethics, STS, or anthropology. My objective here was to understand how they may rationally place their daily research assignments or even larger goals in conversation with outside factors as aforementioned—how do they consider the economic value of their work as well as the impact of the results of their research?

I observed as a means to scrutinize the regular practices of the lab, not only as the scientists do research but also when they discuss scientific papers in “journal club” and present their work in group meetings. As a biomedical engineering student, I also participated in research in the lab, particularly focusing on embryonic hatching. My goal is to comprehend how scientists engage with the ethical and moral realm in their interactions with the embryo, their colleagues,
and the outside world. When and where do scientists confront ethical issues in their daily work? How do they acknowledge and confront ethical conflicts? Aside from opinions, what happens when a scientist does not morally agree with a research project in the lab? Are there procedures and policies in place for managing these issues? What routine practices may be seen as rituals that contain an ethical basis? Many of the learned procedures that are deemed proper protocol for a successful experiment are completely accepted without challenge and disseminated to new researchers (like myself), but how did they come to be scientific method and why—what ethical implications may be uncovered here? Furthermore, how do the scientists’ own moral leanings align or conflict with the laboratory’s ethical policy and procedure?

Through the connection the lab has with IVF clinics in the area, I was able to interview doctors who were leaders in the field. My objective is to understand how the ethics and moral implications of the laboratory space align or conflict with that of the clinic. Do the personal moral frameworks of physicians agree with the bioethical codes of conduct that are in place within the clinical environment? What moral quandaries do clinicians face as they interact with patients that are the end users of reproductive technology on a daily basis? How might this differ from their views on the ethical and moral dimensions in the context of research the lab does on the human embryos that they donate to them?

This research will examine the way in which the market forces of alienation and commodity fetishism operate to advance scientific research in ART. In the endeavor to create life for those who desire it and are unable to attain
it by themselves, the embryo becomes a commodity and this fetishism feeds a commercial industry that continuously seeks to accumulate capital. Thus, ART research is not solely for knowledge production, but also the provision of a service with which comes various implications. Through participant-observation and interviews, I will evaluate the extent to which capitalistic influences drive the aims of scientific research within the lab.

Utilizing participant-observation once again, I will illuminate the ways in which capital and economic affairs intertwine with the daily activities of the lab. The lab receives what would have been discarded human embryos from IVF clinics, with which they share a mutually beneficial relationship. The outcomes of the experiments they perform with the goal of improving success rates of IVF directly impact these clinics. How do economic concerns influence the work of the lab and the production of knowledge? To study the forces of capitalism that may be at play, the research objective was addressed through interviews. These interviews will focus on the scientists’ notions of the economic interests within their line of work so as to uncover a) how they manage the relationship, if one exists, between their research aims and the lab’s funding sources as well as the opportunities for profit and b) their outlook on the way the high valuation of the reproductive technology they create limits those who may utilize it according to socioeconomic class.

This project aims to explicate how an embryo moves within a network, highlighting the boundary between the inside and outside of the laboratory. With
the embryo being the main nexus that brings scientists, doctors, and patients together, an inquiry into its movement between actors may reveal the changing dynamics of ART’s sociotechnical meaning. This STS approach will be a contribution to the larger field of the anthropology of ART. I intend to utilize participant observation and material culture analysis to interrogate the way we regard the embryo at different points of relation and what that says about society more broadly. I will be able to examine the contacts between the embryo and actors in the lab as different scientists train me on certain techniques and procedures such as thawing, staining, and working with embryos underneath a microscope. How are the embryos handled and what do those methods say about the embryo itself? My project along with other projects dealing with cellular metabolic processes that affect fertility fall underneath the same umbrella of research within the lab, so there is a link between my work and others in the lab. How are embryos shared among scientists and what does this bring to light about the positions of certain research projects? Most of the time I practice different procedures with dead embryos, but for experiments with live ones there is a regulatory process before they can be used. Why do such protocols exist to moderate embryo use?

I will trace the flow of an embryo with the lab as the focal point of the network. How does the network itself shrink and expand depending on different factors? I plan to explore further the company that makes these mouse embryo cell lines for purchase and their connection with scientific research labs like my site. Human embryos that are provided to the lab by partnering IVF clinics are
those that would have been discarded regardless. Where do these embryos come from and why were they deemed dispensable? The application of the results in the clinic is an extension of the work done on the human embryos in the lab. Within the lab, I will investigate all the different actors (including myself) that interact with the embryos. How do perceptions of the embryo change as they cross back and forth between company or clinic and laboratory? What common sentiments remain as the embryo bypasses borders? I hope to comprehend the shifts in frameworks regarding the embryo as it moves within a network that ties different actors together as well as how it is acted upon and what agency it may exercise.

Since its emergence 40 years ago, assisted reproductive technology has irrefutably changed the lives of many parents for the better. In its current state, the use of ART has become normalized, yet the fast-paced advancement of scientific research in the field continues to create controversy. This signifies an incoherence inside and outside of the laboratory, be it between scientists and the government or public. This senior thesis research project will serve to contribute to the field of anthropological work that is bridging the gap created by this negligence in better connecting the ART network. I aim for my work to be useful in combating the inequities surrounding ART and the general inattention of society concerning the activities within the confines of the laboratory.

**Positionality**

My freshman year, I took a seminar called “Medicine, Law, and Ethics.” I was drawn to it because of my deep rooted interest in both STEM and social
sciences. The co-instructors of the seminar, Shahram and Laura Khoshbin, were a married doctor and lawyer who were passionate about the significance of the intersection of their two fields. The seminar, as a result, surveyed different historical moments in medicine and the ethical questions that arose as well as the subsequent legal implications of some of the novel breakthroughs. We discussed topics such as cloning, abortion, mental illness, and eugenics. After introducing the topics with a lecture, our supplementary content consisted of movies with an assignment to write a short response paper following our two seminar meetings in the week.

I remember our weeks on cloning, assisted reproductive technology/in vitro fertilization and abortion seemed to follow right after each other, and I felt so unsettled. My brow remained furrowed, my mouth firm, and my facial expression perplexed throughout those classes. As a science student prior to college and somewhat conservative Christian girl, the only topics I had to contend with were evolution and abortion. Learning of these other moments in scientific research forced me to renegotiate my boundaries. What was it about the creation of life that attracted such contention?

What made me the most uncomfortable was how fast science was advancing. Scientists were assumed to have good intentions but why were they pushing the envelope forward into such uncharted territory? The question of what was natural and how science was upsetting the “natural order of things” plagued me. How could I be a science student if I was against furthering scientific research? I decided that scientific research wasn’t really the problem.
Advancements were rapid but, more importantly, out of control. I felt that society—lay people—were too trusting of scientists. People seemed so quick to praise and accept every novel development without any inner reflection or interrogation. Who was checking science? Should it be checked? My answer is yes.

The next year, I took an anthropology class taught by Professor Stephen Scott, Laboratory Lives: Scientific Spaces, Selves, Subjects. As a newly minted joint concentrator in Biomedical Engineering and Social Anthropology, I found this class highly relevant and timely. The class introduced me to the idea of a laboratory as a cultural site and consequently, laboratory ethnography. The year before I had realized that my problem was with science and the disconnect between the field and broader society. Now, I was learning to view the laboratory, arguably the home of scientific encounters, with a boundary that regulated communication, interaction, and influence between scientists and the outside world. As I did my research for my final paper in that class, I stumbled across articles about gene editing, preimplantation genetic diagnosis, and in vitro gametogenesis. The same feeling of being unsettled crept up again.

Moving into junior year as I began to choose a thesis research topic, I realized that I could not shake my interest in assisted reproductive technology and IVF, in particular. There was interesting scientific research being done in other areas for certain, but with a Christian belief that every life is ordained and then created by God, scientists tampering with the creation of human life bothered me. The idea of life is obviously very metaphysical, but I wanted to understand this
phenomenon through an anthropological lens. There has to be more to ART than simply giving those suffering from infertility the gift of children. If there ever was a topic “to make the strange familiar and the familiar strange,” for me, it is this one.

I like to think of anthropology as the study of not taking things for granted. Things include people, places, cultures, anything really. Anthropology looks deeper at everything. What informs the discipline is social theory because at its core, anthropologists study society. But the beautiful thing about anthropology is that in order to look deeper, one has to delve in, spend time, immerse oneself. The goal of anthropology is to explain, to make sense of, to bring us all together and make us better people by providing enlightenment and understanding of either what we do not know or what we thought we knew. Biomedical Engineering needs anthropology.

As an academic and professional discipline that is fundamental to our world and society, it has been taken for granted. Those who are not in the scientific or engineering world do not have a strong grasp on the knowledge being created there and most people in the world have a specific perspective on that knowledge. Anthropology can be helpful for everyone here. Because of this thesis research journey, I now question everything. I cannot take science or engineering at face value. I look for the moral and ethical everywhere. Thus, I study both STEM and social sciences because knowledge in both disciplines has led to my personal development and enlightenment.
CHAPTER ONE:
DNA DOUBLE-STRAND BREAKAGE INDUCED BY EMBRYO HATCHING

ABSTRACT

Hatching is an integral step in preimplantation embryo development, and issues during hatching may lower the chance of embryo implantation in the womb. The mechanics of the embryo hatching out of the restricting zona pellucida places physical stress on the embryo, leading to DNA double-strand breakage. While hatched embryos did not show signs of more DNA DSB compared to unhatched embryos, the highly concentrated regions were mainly found in the outer layer of the cell.

INTRODUCTION

In this thesis research, I used laser scanning confocal microscopy to detect DNA double-strand breakage (DSB) in hatching embryos. Cell migration has been shown to cause DNA double-strand breakage due to the mechanical stress caused by moving through constrained spaces [2]. Similarly, the hatching process by which the embryo squeezes out of the zona pellucida, an acellular shell made of glycoproteins, may also be damaging [3]. If impaired, hatching can negatively affect the probability of uterine implantation [4]. Preimplantation embryo development is a relevant area of study for the field of infertility. Therefore, this
research can further our understanding of preimplantation embryo development by elucidating the effects of hatching.

**BACKGROUND AND PREVIOUS RESEARCH**

Studies in preimplantation development have focused on the structure of the embryo in the different stages of development and improving aspects of in vitro culture that allow for a method of infertility treatment, in vitro fertilization services (IVF) [5]. Yet, even with the numerous advances in infertility treatment such as cryopreservation techniques, culture conditions for human embryos, and intracytoplasmic sperm injection [6]–[8], IVF success rates have remained low, impeded by the limitations in the understanding of preimplantation embryo development [5]. Even embryos that appear to be healthy may fail to implant in the womb, resulting in doctors at times transferring multiple embryos at a time during IVF treatment to improve the chances of pregnancy [5]. This can lead to various health complications such as low-birth weight and premature births [9]. Now, more research is focusing on the biochemical and molecular processes of the first stages of embryo development in order to gain an empirical understanding of any issues that could lead to poor pregnancy outcomes. My contribution to this research seeks to elucidate if the mechanical properties involved in hatching are leading to double-strand breakage.

While hatching is a both a biochemical and mechanical process, most studies only illuminate its biochemical properties [3]. Recent research contributing to the understanding of the fundamental mechanics of hatching has
shown that in cultured blastocysts, pressure increases linearly with intermittent drops [3]. Blastocyst formation occurs prior to the hatching process. The blastocyst contains the inner cell mass, a small group of inner cells [10], as well as the trophectoderm, the outer layer of cells surrounded by the zona pellucida [11].

![Cartoon of a labeled blastocyst](image)

*Cartoon of a labeled blastocyst [4]*

It was found that the embryo creates a pressurized cavity and eventually breaks out of the zona pellucida [3]. For cavity formation, pressure arises because of the constricting nature of external polysaccharide shell of the zona pellucida (3). The width of the zona pellucida layer decreases during embryo expansion because of degrading enzymes and stretching as the embryo increases volume [3]. Mechanical stretching of zona is essential for efficient hatching, but it also generates enough force that could result in DSB [3].

There are two speculated types of embryo hatching—pinhole and rupture [3]. Pinhole hatching, when the embryo starts hatching out of a small hole in the zona pellucida, can occur at relatively high zona pellucida thickness [3]. Rupture hatching, when the embryo bursts through and creates a wide opening, happens
after the shell thickness decreases below a certain point, partially through pinhole mechanism [3]. Because of the small opening, the pinhole mechanism appears to be the most potentially damaging to the DNA.

Double-strand breakage is the most dangerous type of DNA damage [12]. They are caused by environmental stress such as ionizing radiation and DNA-damaging agents [13]. However, it has been shown that mechanical stress can cause DNA damage as well [14]. When cells have to migrate through tight openings, it puts a physical strain on them which leads to DSB [2]. The nucleus specifically is relatively stiff, making it more susceptible to damage [15]. DSBs lead to the phosphorylation of H2Ax by kinases like ataxia telangiectasia mutated (ATM) [13]. H2Ax or histone H2A protein variant is a component of the histone octomer in nucleosomes [16]. Gamma H2Ax is the first step in recruiting and localizing DNA repair proteins [16]. Gamma H2Ax foci represent DSBs at a 1:1 ratio, so they serve as a biomarker for damage [16].

In order to detect the damage from hatching, fluorescence is an important tool. Fluorescence is when a chemical absorbs light at one wavelength and emits it at another [17]. The combined use of multiple dyes that tag different components inside the cell help to visualize both DNA nuclei and specifically DSB in my experiment [17]. The DNA fluorescence probe used in my experiment, SIR-DNA, is a far-red dye that allowed me to counterstain the nucleus without UV excitation [18]. With an emission wavelength on the higher end of the spectrum, it enables the use of low energy excitation [18]. The intensity of the SIR-DNA dye signals also lasts fairly long after multiple exposures to the
excitation laser [18]. For the double-strand breakage, the DNA staining kit came with two solutions. An antibody that binds to phosphorylated H2Ax at Serine 139, and a green fluorescin secondary antibody that binds to the first one in order to illuminate the DSB [19]. To see the two fluorescence stains indicating DNA DSB simultaneously, laser scanning confocal microscopy is useful. Confocal microscopy is an imaging technique characterized by its use of a focused beam of light while a second pinhole blocks out any light from the detector that is out of the plane of focus [20]. Confocal is especially advantageous in my research compared to epifluorescence because of the elimination of out-of-focus fluorescence flare, which improves the resolution [20]. This becomes an issue for thicker specimens when they are tagged with fluorescence labels [20]. Another advantage of confocal microscopy is the ability to capture the fluorescent dye stain throughout the multicellular, three-dimensional structure of the embryo [21]. The output of the microscope is a three dimensional reconstruction of optical sections of the specimen [21]. This is particularly useful for my experiment because I will be able to see the full extent of DNA double strand breakage in the embryo.

MATERIALS AND METHODS

Embryo Preparation

B1-05 or B1-10 straws of one-cell embryos were thawed in advanced K-SOM media. The embryos were placed in media, covered with oil, and cultured in an
incubator set at 37 degrees Celsius and 5% CO₂. Embryos, mid-hatching or completely hatched, were then fixed in PFA for a minimum of two hours.

Figures 1-2. Pictures display embryos at the very beginning of hatching and further along in the hatching process. The top arrow in Figure 1 points to the the embryo starting to hatch through a small hole. The middle arrow in Figure 1 indicates an expanded or enlarged blastocyst. The bottom arrow in Figure 1 points to an early stage blastocyst. The arrow in Figure 2 points to an embryo where a large majority has hatched through a much wider opening.

**DSB Staining**

For double strand breakage, we used the OxiSelect DNA Double Strand Break Staining Kit. The fixed embryos were washed three times in PBS before being incubated for at least two hours in the blocking buffer (1% BSA/PBS). Both the 100x Anti-Phospho-Histone Antibody Solution and the 100x Secondary Antibody, FITC Conjugate Solution were diluted to 1x with 1% BSA/PBS. The
embryos were incubated in Anti-Phospho-Histone Antibody solution followed by the Secondary Antibody for at least four hours. The embryos were washed five times with a wash buffer (PBS containing .05% Tween-20) after each incubation.

**DNA Staining**

Lastly, the embryos were placed in 50 nmol SIR-DNA staining solution that was diluted 1:40 with culture media. They were incubated for at least 4 hours.

**Imaging set-up**

The embryos were imaged with a Leica Confocal Microscope using the Argon and Helium-Neon lasers. In order to have adequate working distance, a 63x water immersion objective was used. The emission level spectrum ranged from 652 to 674 nm to view the SIR-DNA dye and 488 to 525 nm to view the DSB stain.

**RESULTS**
Figures 3-4. Of the three embryos pictured in the two figures, the left and middle embryos are partially hatched. The SIR-DNA dye appears red and indicates clusters of DNA in individual cell nuclei. The phosphorylated H2Ax foci appear green and indicates double-strand breakage. Figure 3 on the left is a Z projection at maximum intensity of a substack of the bottom half of the embryo, while Figure 4 on the right is the top half of the embryo.

Figures 5-6. Images display an optical section roughly about halfway through the depth of the embryo, where highly concentrated masses of double-strand breakage are located in the outer layer of cells.

DISCUSSION

To attend to the main research question, the part of the embryo that has hatched out does not contain significantly more DNA double-strand breakage than the embryo that remained in the zona pellucida. Instead, the highly concentrated areas of damage were more evident within the zona pellucida. The yellowish
areas of dye indicates the overlap between the DNA, stained red by the SIR-DNA dye, and the double-strand breakage stained green. Though the overlap between the red and green dye is found toward the center of the unhatched embryo, the clearly localized yellow regions pictured in Figures 5 and 6 were found in the outer layer. Finding more double-strand breakage in the trophectoderm rather than the inner cell mass is congruent with the mechanical stress it experiences prior to hatching. The blastocyst contracts and expands before enlarging and eventually hatching out of the zona pellucida. However, if more of the embryo hatched, then the cell migration of the denser inner cell mass out of the zona pellucida could lead to more double-strand breakage localized there than is pictured in the results.

There were aggregates of green dye, outside of the DNA and scattered throughout the compressed halves of the embryos in Figures 3 and 4, which suggests that the DSB staining may not be as effective. Phosphorylated H2Ax foci stained in green is normally found in nucleosomes (6) and has only appeared in the cytosol when induced (11). Additionally, comparing Figure 3 to Figure 4, there are far more stained H2Ax foci in the lower half of the embryo, which again points to the limitations of the staining.

In the next steps of this research, imaging a larger number of embryos can verify the findings. Additionally, a control experiment using DNA DSB inducer should be run to compare the results. It would be interesting to see if there is significantly more damage seen with the inducer or if it is comparable to the results of this experiment. Using a dye to stain for DNA DSB that is more specific to DNA could further strengthen this research.
CHAPTER TWO:
ENCOUNTERING ART IN THE LABORATORY

Introduction

In this chapter, I ethnographically describe the Gordon laboratory and the position of ART from the vantage point of the scientists at this site, which was illuminated through participant observation and interviews. I posit that the day-to-day practices of researchers in the laboratory systematically excludes morality.
The primary goal in their work is to learn and produce scientific knowledge about nature, specifically genetic biology. It is because of the use of mice as an animal model rather than performing experiments with human materials that allows scientist to circumvent the inevitable ethical dialogue born out of constant interaction with infertility patients. Nevertheless, the relationships and research collaboration the lab has with IVF clinics act as a bridge to the human services part of ART and its complementary ethics. All of this culminates in scientists’ belief that the positive results of ART research outweigh the possible negative consequences and ethical controversies.

A Night at the Lab

As I approach Northwest Labs at night, the tall, largely glass building looms in front of me. The 20-minute walk from my room in Leverett House was slow and steady, filled with silent prayers that I can get in and out of lab as quickly as possible without mistakes. I decided to take my time on my walk and was off with a sigh because I hate going into lab in the evenings or on weekends. The Mather Express Shuttle that usually takes me from right in front of my house to Northwest Labs does not run at those times. Despite the below freezing temperature, I’m sweating underneath my hat and scarf by the time I swipe my ID to gain entrance into the building. The warmth of the dimly lit lobby embraces me as I greet the security guard sitting on the left. Their presence reassures me that I’m not all alone in this 4 stories up, 4 stories down building. As I take the elevator up to the third floor, removing my hat and gloves along the way, I am
hyper-aware of my quiet surroundings. Swiping again to gain access to the line of
laboratories, offices, and meeting rooms on the left side of the third floor, I walk
past the rooms, some with lights still on though empty, almost to the end of the
hall to reach my lab’s office area. My PI’s office and the office where the
graduate student and postdoctoral fellow I work with usually sit are closed and
locked. I place my backpack on one of the waiting room chairs and drape my
jacket and scarf over it. Although I grab my phone and earphones, I don’t plan on
putting in my earphones while I’m here virtually alone. The Gordon Lab has two
entrances on the third floor. I pass the one right in front of the lab’s office area
and enter in on the left side. Walking in, the hum of multiple refrigerators and
freezers greet me and the motion-sensitive lights come on. The huge, white chest
freezer on the left reminds me of the two in my garage back home. It also contains
the frozen tubes of KSOM culture media and PFA that I use in my experiment.
KSOM is a liquid solution for embryo handling that cultivates the in vitro
environment that allows the embryo to develop. PFA is a fixative solution that I
use to freeze the embryo at the mid-hatching point. I pull off one tube of PFA
from a string of them and head upstairs, where the lab has another microscopy
room, my main working space. It is day four of embryo development, meaning it
has been four days since I thawed a straw of embryos and they are now hatching.
So, I’m here to fix them. After putting on some upbeat music to keep me
energized, I first turn the heated platform of the microscope on, so it can reach
37.5 degrees Celsius which is the same temperature that is maintained inside of
the incubator. Then, I pipette all of the PFA into a drop of about 70 or 80
microliters in a petri dish. I then choose a glass pipette with a thin, long-nose that the lab makes in house for embryo and oocyte handling. I attach it to my own personal plastic tubing to make my mouth pipetting instrument. Using some leftover KSOM media, I make a column separated by pockets of air in the nose of the glass pipette in order to control sucking up and transferring the embryos better. Then, I grab my culture dish with embryos from the incubator, place it on the warm microscope platform, take off the lid, turn on the lights of the microscope and peer in through the eyepiece.

After turning on the lamp of the microscope, I look through the eyepiece and adjust the magnification with my left hand using two knobs until the embryo becomes crisp and sharp in my vision. I use two hands, my left holding the right steady, as I place the tip of the glass pipette into the media droplet. I hold the pipette at an angle. The other end of the plastic tube attached to the pipette is held firmly between my lips. With a pull of pressure from my mouth, the fluid surrounding the embryo begins to wiggle. The embryo, a microscopic 3-dimensional body, puts up a little resistance. It is paramount that I get the pressure just right. If it is too light and only held for a short amount of time, nothing will move, and I will quickly grow tired. If the pressure is too hard, the embryo can be sucked up in a second but I lose control of where it is in the pipette. That can quickly end in disaster. But, if I apply just enough pressure and control the speed of airflow, I witness the embryo give way and move into the thin pipette as if following a streamline. When everything is going well, I can see clearly where the
embryo rests in the pipette. It remains in limbo there until I use air pressure from my mouth again to move it out into a new droplet.

An embryo is so small that you need a microscope to see it and it can easily get lost in a glass pipette. I have personally struggled enough with disappearing biomaterial under a microscope and in a glass pipette to have expert knowledge on this point. It has taken me months to become proficient at mouth pipetting, and proficiency is not mastery. I quickly got over the strangeness of using my mouth to transport embryos and oocytes, but I have not mastered the technique quite as fast. I knew being a scientist takes a certain amount of skill, but I am starting to think that I am really not good at this. The whole point of mastering mouth pipetting is that if I am not able to transport and clean the embryos quickly enough they will die, not to mention mouth pipetting is crucial to every step in my experiment. These are just mice embryos, but imagine handling human embryos that will be implanted in a woman’s womb in an IVF clinic. The level of skill and care that is required is enough to make me rethink working there.

Even as I practice different lab procedures, the banality of the number of embryos that I have killed strikes me as odd. While I recognize that I am still learning, a part of me feels bad because of the waste of something meaningfully precious in some regards. These embryos come from somewhere. While they are supplied by a company, they are the product of breeding mice. Over the course of my experiment, I watch the embryos grow and develop to the point where they would implant in a uterus and continue into full-blown pregnancy. I stain and
image their genetic makeup. So, when I discard them due to mistakes on my part, it feels like a meaningless loss because they did not fulfill their intended end. Any time I thaw a new straw of embryos, I must make note of it on an online inventory document in order to keep track of what has been used so the lab knows when to order more. It is not only an inventory of supplies used, but of the research process. Each straw of embryos has a story behind it. Some ended up in the trash, lost in glass pipettes and inevitably discarded. Others sit in a petri dish on a bench, after outliving their use. Then, there are the ones in action, actively going through the steps of my experiment. These embryos move from straw, to dish, to pipette, to dish, to incubator, to fridge, to microscope, and other places in between.

Making notes in the inventory is the easiest part of the entire protocol that makes up the first part of my experiment, which includes pulling out a straw of about five embryos that are submerged in a cryopreservation tank full of liquid nitrogen. The fluid that the embryos are frozen in is itself toxic, so after removing the embryos from the straw I have to wash them in droplets of media. Before I begin the thawing process, I wash my hands. Prior to grabbing the embryos from the tank, I pull out a small tube of KSOM culture media from a freezer and wait for it to thaw. Then, I prepare an incubation dish with a certain amount of media and put it in the incubator filled with carbon dioxide. This is where I will later store the embryos for days in order to allow them to culture and hopefully eventually hatch. After the incubation dish, I create the dish of media with one droplet in the middle and six around it in a hexagon formation. This is where I
will wash the embryos. I use the remaining media to create a column interrupted by pockets of air in the long tip of my glass pipette in order to control the movement of embryos when I use the pressure from my mouth to suck them up and transfer them.

Considering the highly detailed microsteps in just the first part of my experiment, it is easy to see how the moral and ethical status of the embryo slips the mind. As a new researcher learning the protocols, which requires repetition, I come into lab with a stepwise to-do list ordered in my head. I usually have my earphones plugged in and allow my mind to wander when I am waiting to complete the next step. It can be a mindless process, where I am not thinking too hard about anything. But even for veteran researchers deep into their experiment or analyzing resulting data, their focus is also on the tasks they need to complete—troubleshooting issues that arise, building or modifying tools for their experiments, and figuring out how they can get better data. The long hours they put in reflect this dedication.

Starting the fixing and staining steps of my experiment added an element of time into my research. Before, I could come in whenever and spend a few hours thawing embryos or practicing mouth pipetting and leave without a second thought. Now, fixing the embryos takes at least two hours and staining requires around four hours of incubation time, which means unless I overlay the droplet the embryos rest in with oil to preserve it, I will have to come back and move them. It requires me working around classes, section, work, meals, optimal study spaces, and social events to go back and forth from lab. This is when I started
coming into lab regularly on the weekends and in the evenings. Despite the odd hours I keep in the lab, I am likely to find a lab member there working on something. The lab sees activity at all hours. There are the members who stick to the traditional 9 to 5 on weekdays, including the PI and the graduate student that mentors me. But there are members who I find at a microscope or computer early in the morning on a holiday, after dinner time on a Saturday, or even in the early afternoon on a Sunday. Usually, timing overlaps in the lab are not an issue unless the same equipment or space is needed.

After my second run in with the postdoc in the upstairs microscopy room, he suggested we exchange cell phone numbers because it looked like we would have to “work around each other”. I think at first he was surprised to see me in the evening or on a weekend. The graduate student I work with religiously leaves by 5 p.m. But, my schedule as an undergraduate requires some flexibility. I can tell when he is using the room because he leaves his mouth pipette labeled with his name resting on the microscope, the lights in the room are on, and research supplies are left scattered. Being that he lives 30 minutes away, I cannot always tell if he is planning on coming back that same day or he has just left things until tomorrow. After a few instances where I wanted to use the microscopy room or was using it and he felt either rushed to finish what he was doing or had to wait for me to finish, he suggested I used the microscope downstairs. As the newbie undergraduate researcher in the lab, I try to be as amenable as possible. I agreed but with hesitation. The upstairs microscopy room, technically in another lab, is my preferred working space because it is familiar to me. It is a place of solace
within the lab for me because it sees little traffic compared to the microscopy room in our laboratory where I first started my training. As soon as I enter, the outside world falls quiet. I prefer the warm lights directly above the microscope table where I work rather than the main fluorescent light in the room because it provides a sense of intimacy. Once I’ve settled in with all of my supplies–KSOM, PFA, embryos, etc, I can easily lose track of time. The room bears witness to my most frustrating moments losing embryos to bubbles and glass pipettes, but it also has seen me in my most comfortable moments–dancing to music in between moving embryos from droplet to droplet, thoughtfully listening to podcasts as I wait for the microscope plate to heat up. On the other hand, the microscope downstairs that the postdoc wanted me to use sits on a bench in the lab out in the open. With lab members around and people walking and talking regularly, I feel naked and exposed. It is as if all eyes are on me, waiting for me to make a mistake. With multiple benches and shelves filled with supplies and equipment everywhere, it is uncharted territory that I must learn to navigate. The first time I used the microscope downstairs at the postdoc’s suggestion everything felt off. The lighting in the room wasn’t right. The microscope though similar to the one upstairs was different. I had trouble focusing it and finding the embryos through the lens. The chair wasn’t as comfortable. I lost all but two embryos by the end of it.

Thus, the actual day-to-day of work in the lab is disconnected from scientists’ moral imaginaries. Separating personal beliefs from professional tasks for other researchers as well as myself is not difficult to do. So then, when and
where do ethical and moral inquiries present themselves in the lab? Along with built-in institutional ethical principles largely regulated by institutional review boards (IRBs), the morality of research is established long before projects actually begin. At the genesis of a research project idea, it is properly vetted by peer scientists in the lab and superiors such as the P.I. When they all agree that the project is both appropriate and interesting, settling any challenging questions, this represents a moral consensus of sorts. The idea itself was likely informed by existing literature or previous projects that lends a sort of legitimacy and credibility. It can be assumed that, for the most part, the existing research was ethically acceptable as it was again likely peer-reviewed before being published in a journal. This weight carries over into the new idea. Once established, morality and ethics becomes a marked checkbox, dismissed as scientists move down their tasklist.

There we have the “local moral world” of scientists in the academic laboratory (Kleinman 2008). Arthur Kleinman speaks to the distinction of the meaning of moral in *What Really Matters* (2008). He emphasizes that the moral experience is a local one, which may be at odds with those on the outside of the local world (the morality of a person or group of people). Ethics then comprises of the values that transcend the local moral experience, providing something to align oneself with (Kleinman 2008). Thus, academic labs like the one I work in have its differences from private clinics, which may or may not participate in research, and academic hospital clinics, that also run laboratories, which are classified as non-profit. For the academic lab, their focus remains solely on basic
research. In order for them to move forward with their research, collaboration with IVF clinics/labs are crucial. These partnerships allow academic labs to work with human materials and facilitate translational research and clinical application because IVF clinics/labs have access to patients. At times, the work in academic labs can lead to a commercial venture such as my PI’s start-up, if they want to bring their work into a clinical setting. While their research aims to understand the biology behind infertility, their work is just as important as research with patients. However, their work may not be at the forefront of pushing the industry forward. Basic research in the academic lab is at the foundational level of ART. So within this local moral world, scientists value understanding the biology of infertility in order to contribute to work that alleviates infertility and provides people more choices. Because their core mission prioritizes the production of knowledge, the embryo is devoid of moral and ethical status and solely represents a research object.

**Setting Up The Site of Ethnography:**

The aesthetic of the Gordon Lab appears to be just as relaxed as the researchers that inhabit the space. Scientific equipment like glass beakers, petri dishes, and pipettes are out of place on the rows of shelves that start from the wall and extend all the way to the end of the room. The benches, black countertops that sit under the shelves in each row, are a little messy, often looking as if they haven’t been properly wiped down in weeks. A sign outside the microscopy room door alerts others to ongoing experiments. The rooms are almost always in use.
Most of the time, a few members of the lab can be found sitting quietly at their desk area, which is interspersed between benches, though people definitely come and go at all times of day. In a medium-sized lab with 10 to 12 permanent members, everyone gets to know each other fairly well, so it is not unusual to find people talking and joking. They talk about their ongoing experiments: their progress, their frustrations, and next steps. Sometimes, they ask each other questions about if they are using some space in the lab or some piece of equipment, or how to do something. One person might bring up a recent scientific research paper and ask if anyone else has read it, discussing their takes on the subject. They comment on what other researchers are doing and how other labs work. Sometimes, if you get two of the right people in the same room (usually newer members) with enough time and something bothering at least one of them, they express their frustrations about their work in the lab, how they are transitioning to the new environment, what it is like to work with other members.

The only place, and possibly the last you may think to look, to find assisted reproductive technology research in the Harvard Faculty of Arts and Sciences division is Robert Gordon’s lab. Up until my junior year when I began searching for a research laboratory, Gordon, the Professor of Applied Physics and Professor of Molecular and Cellular Biology, was just a name that I knew belonged to a well liked professor. After spending most of my junior fall struggling to find ART research that fell under the criteria of a biomedical engineering thesis, I took the advice of the Assistant Director of Undergraduate
Studies in Bioengineering Linsey Moyer to reach out to Gordon, who she knew did some work related to infertility.

Our first meeting took place in his office, a place I would soon begin to associate with our sit-down, face-to-face conversations. Natural light floods in from the entirely glass wall to our left. It contrasts with the mahogany furniture. Books line shelves along the remaining walls of the office. The area where his desk sits is roomy. The desk itself seems to surround his seat. I sit back comfortably in a seat across from him. The laptop he works on, unlike a personal computer, takes up little space. Stacks of books are scattered around elsewhere on the desk. The principal investigator (PI) himself is an over six foot man who manages not to appear imposing or intimidating. Although he almost exclusively wears long sleeve button down shirts rolled up to his elbows, he appears casual with a constantly relaxed posture. His shoulder-length light blonde-greyish hair is always pulled back in a low ponytail. He lends a kind, easy smile any time he greets people, which is whenever he sees them. In our meetings, I can see his thinking displayed on his face. Generally, my interview questions seem to befuddle him. In response to his facial expressions, I often rephrase my questions or ask him if they make sense, answering any clarifying questions he may have. This first meeting though, he takes my lack of independent research experience coupled with my obvious uncertainty about what ART research would look like in his lab in stride. He gives me an overview of his work and the published papers from his lab I had read beforehand came to life when he showed me imaging videos. When he finally asks about how anthropology would fit in, my jumbled
summary of my ethnographic questions and interests seems to both satisfy and intrigue him. I was accepted into his lab.

My second meeting with the PI featured introductions to a postdoctoral fellow and graduate student doing ART work. They proposed ideas for a research project I could work on. They sent me a few research papers to read and we set a plan in place for my training to begin. The goal as I understood it was to eventually be able to work independently. The postdoc is a good-humored Irish man. He keeps his reddish-brown hair cut short, maintains some stubble and wears glasses. His resting facial expression is always serious but he is quick to say something light-hearted. His Irish accent gives his voice a lilting tone. It makes it easy to tell when he is amused and when he is maybe a little annoyed. The graduate student, who works most closely with me and essentially came to be a mentor, is an Asian-American woman with long dark hair of average height. Coming from the South and being Christian, we had a few things in common. Her facial expression is usually blank, but her voice conveys all of her emotions. She speaks in exclamation points, question marks, or periods. It helps me determine her mood toward me in lab.

A Positivist Perspective

In general, when the PI is discussed, good things are almost always said about him. Since he was tenured fairly recently, there is not yet pressure on the lab to publish big papers as quickly as possible. The PI, while laid back, seems just engaged enough where each member of the lab feels like he cares about them.
and their work. While there are a few people with a background in biology, most of the lab members are trained physicists doing biology research. The PI himself is the magnet that attracts this certain brand of scholars as he told me he also was trained in physics, but has always been interested in the overlap between physics and biology, particularly biological self organization. The lab members are a mixture of theorists and experimentalists, and while everyone does experiments, there are those who have a background in theory. After training to think deeply about even the most basic assumptions in a structured manner, performing experiments is new territory to some members.

In such an environment, though the PI said any rules or principles that appear to govern his lab are never explicitly stated as we sit in his office, there are certain attitudes that stand out to a participant-observer. The first one being that perfection or, better yet, accuracy is the goal for experiment results. Even when results are “pretty good”, they can be better.

When I first started fixing embryos, the first two times were failures. My only instruction was to place the embryos in a PFA droplet and put the dish into the 4 degree fridge. The first time, the drop dried up over the weekend and the graduate student I work with was unable to rehydrate the embryos. The second time, someone knocked over my dish when they were grabbing something from the fridge. At that point, I asked the graduate student how I could ensure the droplet didn’t dry up and no one touched the dish. I felt as if my experiment was finally moving along only to be sidelined continuously. Every time I had to fix more embryos, it would take four days for the freshly thawed embryos to hatch.
Time felt like it was running out. The graduate student told me to relax because I couldn’t always make sure everything went perfectly. In reality, I would be doing steps and the experiment as a whole over and over again. I left lab feeling frustrated, but I began to understand that my experiment wasn’t going to be a perfect “one and done” situation. It required multiple iterations before results could really stand the test. The first time we successfully imaged embryos that I had stained for DNA was such an amazing moment for me personally. I had taken my time to carefully carry out the steps of the staining process and prepared the imaging dish. The microscopy room was cold and from the door to the walls to a curtain partitioning the room in half, everything was pitch black. I leaned against the wall and watched attentively as the graduate student prepared the Leica microscope, often calling in another lab member to help when she couldn’t figure something out. The most I did was position the imaging dish in place and find the two embryos under the microscope. When we turned on the fluorescence part of the microscope, the DNA in the embryos clearly shone neon blue through the lens. It was a beautiful sight that almost moved me to tears. I finally felt validated in my research efforts and deserving of the praise the graduate student gave me. But by that time I had learned, I turned to the graduate student as we were leaving the microscopy room on that successful day and asked “so, what’s next?”

Secondly, the lab members have a dominant “make it work” mentality which is very different from what I’m used to, coming from highly structured and regulated lab experiences in STEM or pre-med classes. Oftentimes to test new hypotheses and do an experiment that hasn’t been done before, members in the
lab must create or modify tools. As we sit in his office that he shares with the graduate student and another lab member, the postdoc in front of me looks very unperturbed when I mention this to him:

You are trying to do something that no one else has done before. If it’s interesting, it’s probably not so easy that you can just do it with things you can buy on Amazon because otherwise someone would have done it already. So there is some aspect of getting something to work that is nontrivial.

Lab members make the glass pipettes we use, lengthening and thinning the tip to be suitable for working with embryos, instead of buying them because of their expense. We do go through a number of pipettes during the research process, but this special pipette can just as easily be an added part of the grant budget. It seems there is something about tools being modified for our specific use. Given that they are highly intelligent graduate students or postdoctoral fellows; it makes sense that they may not need the structure that is more familiar to an undergraduate. The experiments I do in those classes have already been done before and, as a student, I follow detailed instructions to replicate them in order to empirically understand what I’ve learned theoretically. In addition, it seems that a general skill that comes naturally when working in the lab is the ability to troubleshoot.

With new inventions come a fair amount of failure and testing, and it is through this iterative process of trying different things to solve their problems
(troubleshooting) that much is learned. The postdoc offers his outlook into this experience:

*Often what your research question ends up being after you’ve done all this work is different from what you thought in the start. By the time you actually build something, it might be it was really hard to answer that question but you can answer a related question with the tools you’ve built. Once you’ve been working at something for six months with your hands, the question often changes for practical considerations. You work at it from both ends. You start off with some questions and then you adjust them on the fly. When you are picking experimental questions, they should be interesting scientifically and you should be able to answer them.*

According to the postdoc, the science happens when all of the set up is finished. In reality, “set up” may take a few years. The day of our interview, he tells me his task for the day is figuring out how to clean the glass pipettes rather than discarding them. The postdoc believes that the end—to find out something new about nature previously unknown—justifies the means—the time.

As I was sitting in the lab waiting room area one day in October, I witnessed a meeting of the minds. The postdoctoral fellow sat with another person in front of a conveniently placed white, dry erase board at the back of the room. It was covered with symbols and drawings, unintelligible to me. They gestured with their hands as they exchanged dialogue back and forth. Their resting position
consisted of a hand placed at the chin with the elbow belonging to that arm resting in the palm of the other hand attached to the arm crossing their torso. Sometimes, they used a dry erase marker to point at the board. They appeared as if they were speaking two different languages and trying to get each other to understand their own tongue. In reality, they were discussing their individual research and how it may be related to the other’s. While they started off sitting, they would occasionally rise up to use the board during their verbal descriptions. They asked questions of each other, they made comparisons and pointed out differences, and they seemed enthralled in each other’s work. This is how coming to understand “something new about nature” begins. The postdoc’s personal values represent the more “idealistic” end of the spectrum, where the opposite would be to pursue research that is more likely to launch a scientist’s career. The PI tells me every lab has a balance between the two ends of the spectrum, but he too, unsurprisingly, is more idealistic.

Hence, the embryo is seen as just another research object. The conception process is separated from sexual reproduction. It takes place in a distant lab away from nature. In my lab, embryo development takes place in a petri dish, under a microscope, and in an incubator. Disassociating an embryo from its origins becomes all too easy especially when we order our mouse embryos from a company and get our human biomaterials from an IVF clinic where they would otherwise be discarded. But if alienation requires a form of humanity to begin with, then how human are embryos? According to the postdoctoral fellow, he only needs consent to feel comfortable using human embryos and oocytes for research,
but the age of the embryo is also a factor. “I would be ethically totally fine with research on a day 5 embryo. Ethics kick in for me at the 10-16 week line,” he said. So it seems that when being utilized for research purposes, embryos are disconnected from their humanity, but as time passes and they are further along in the development process, they gain humanity. Lynn Morgan in *Icons of Life* argues that the rise of embryo collecting in the early 1900s can be attributed as the spark of a scientific and social transformation that made embryos a symbol of humanness in the Western world (2009). When embryos became material objects of scientific inquiry, the embryological view of human development was constructed (Morgan 2009). This gave embryos cultural importance; the science behind it crafted a perception of the embryo, now widely accepted, as time passes in each stage bringing it closer to the image of our natural, infant selves (Morgan 2009).

*Modes to Morals*

“I know you tried your best. Thank you for taking time to look for them. Thanks for all of your help today. I’ll come in tomorrow to thaw more embryos.” It was difficult to keep the disappointment out of my voice, but I had no one but myself to blame. I grabbed my stuff and walked out of lab feeling heavy with defeat. I had lost the last of my embryos just as we were about to image them for the first time to look for DNA staining. Even though the graduate student who I work with had said sorry and seemed to feel a little bad for me, I felt her frustration at my ineptitude. This was the first time I was staining for DNA and
looking at the embryos under a microscope, finally I was moving to the next major part of my experiment after months of practicing mouth pipetting. With each step though, there is a greater chance of something going wrong. I thawed a straw of five embryos, but as I washed them in droplets of media, I accidentally blew some bubbles and wasn’t able to find one of them. So, I ended up only fixing five embryos. After two previous fixing fails, where the solution dried up over a weekend and then someone knocked over my dish in the fridge, I waited the 2 to 4 hours it took for the embryos to be fixed before transferring the four into a media droplet. I lost one embryo in the process. It was my first time manipulating the embryos after fixing them and they moved differently. They felt more 2-dimensional. In the process of staining the DNA, which included washing the embryos in multiple droplets of PBS twice (PBS is a water-based salt buffer that maintains a constant pH), I lost two more embryos. PBS, which I used instead of media to make a column in my pipette the first time, was more fluid and not as easy to control when transferring the embryos. The embryos seemed to lie flat on the bottom of the dish and would not move with the PBS when I tried to suck them up. When I tried to see if I could lift up the embryo, I ended up tearing it to pieces. Once I finished the staining protocol, I transferred the one embryo left into a media droplet to keep it overnight. I notified the graduate student that there was only one left in case she didn’t want to go through the trouble of imaging a single embryo. She wanted us to still try. So, the next day I came into lab nervous that my streak of incompetence would continue, and then the graduate student told me I need to transfer the embryo into a 2 microliter droplet, a very tiny dot. She was a
bit nervous for me, but I assured her and myself I can do it. As I transferred the embryo into the droplet overlain with oil (so it wouldn’t dry up), I accidentally blew bubbles and lost the one embryo. The graduate student then spent 30 minutes looking for it in a mess of bubbles, media, and oil. It likely was stuck somewhere in my glass pipette, but alas, we couldn’t find it. A week of work wasted and I left lab with zero results.

In our lab, our research projects are done on different model systems. Particularly, doing work with the mouse as a model has various experimental advantages. I can make mistakes that result in discarded embryos without a concern for anything but the progress of my research and struggles in training. As the postdoc and I discussed what the transition from working with mouse to human oocytes would be like, he commended the benefits of the mouse model. “The mouse oocytes are more robust, identical, and you can buy them on the internet for like $5. It’s easier to do experiments with mouse oocytes especially if you are studying a generic phenomena. Mouse oocytes are a lot less precious when you make mistakes,” he said. Embryotech Laboratories, Inc, the company where we purchase mouse embryos, serves the industry primarily through toxicology testing of ART media and materials before they are utilized. This prevents embryos from being exposed to hazardous substances and conditions (Taft 2008). Quality systems are a significant factor in the success of IVF programs (Taft 2008). Early work using mouse embryos, which were the first to be cultured, set the groundwork for the development of culture media like KSOM used in my lab and in vitro culture procedure (Taft 2008). In addition,
Embryotech offers the cryopreserved mouse embryos and ova at different stages to be used as a research model. As my postdoc was alluding to, the mouse, with its small size, high fecundity rate, and ease of breeding, makes for a cheaper and easier resource for scientific work (Taft 2008). The mouse also shares similar genetic characteristics with humans: “99 percent of mouse genes have human homologs and gene order is conserved” (Taft 2008). However, the material advantages rather than the properties of the embryo itself determine the main reason mice are utilized as a research model (Taft 2008). Similar to what my postdoc refers to with generic phenomena, mouse models can help researchers finetune hypotheses to be later tested with human embryos or oocytes (Taft 2008). Nevertheless, the majority of the work in the lab utilizes the mouse model, circumventing the very human face of ART that naturally arises when doing research on human embryos and oocytes. This is significant because in quite a literal sense, philosopher Emmanuel Levinas said access or relation to the face of the other, which orders “thou shall not kill”, is straightaway ethical (1985).

Escaping the human face that one may see daily in a clinic, even in the form of discarded human embryos, allows researchers in a lab to avoid numerous ethical quandaries. Particularly within the environment of the lab, with all of its morally mindless research methodology, the daily practices, meetings, and behavior may differ.

With human research being such a hotbed of moral issues, there is some intentionality to focusing research efforts on mouse embryos and oocytes. This is reinforced by the government, which is a primary source of funding for the ART
research in the lab because we mainly work with animal models. After reaching out to the PI and requesting I take a look at the lab’s research grants, he suggests we meet because explaining how funding works would be best in person and hard to glean from documents. According to the PI, the university allocates a certain amount of money—aptly named, “a startup”—when one creates a lab. These funds are flexible, allowing PIs to conduct whatever research they desire. Additional funding will come from outside sources, such as the government. While there can be a variety of financiers, and the lab also has a private funder, governmental funding support provides legitimacy (Clarke 1998). Laws set by the National Institutes of Health (NIH), one of the main federal funders, are taken into consideration in non-NIH funded research (Adamson 2002). The NIH is the federal organization that set the ban on their funding of human embryo or gamete research. In addition, many regulations regarding human research projects apply no matter who funds it (Adamson 2002). Thus, we can see the powerful influence the government holds in its position.

Despite the financial influence of the federal government, private sources of funding allow for the little work on human embryos that my lab does. However, a specific research project may have multiple motivations behind it, my PI explained. The same set of experiments may help understand the fundamental biology of sexual reproduction just as well as improve IVF success rates. Oftentimes, it is through collaborations with heads of labs in IVF clinics that the more medically applicable research projects come to fruition. During our first interview, the PI explained to me how he became connected with an assistant
professor at IVF Center C’s Hospital doing basic science on cell division and mouse eggs and embryos, who worked in the same unit as one of his present research collaborators. “I learned that one of the main things that go wrong is errors in cell division in eggs and embryos. I became more interested in using medical issues to motivate basic science. I wanted to see if a quantitative understanding of biological processes could be useful in a clinical setting,” he said.

According to the PI, just as one project could answer different research questions, if multiple related projects use the same supplies, there is no issue with something funded by one project being used for the others. One of the postdoctoral fellows in the lab asked me the other day to borrow the oil in the microscopy room I work in for his experiment evaluating metabolism in mouse oocytes. I readily agreed. Now, if supplies funded by a federal grant were used on human embryo research, that would be a problem. My PI said this becomes difficult for labs doing stem cell research or even ART on a larger scale, where they would end up having two labs next to each other—one designated for human research, filled with privately funded supplies, and the other lab for non human research with supplies that can be federally funded. The supplies and experiments from each lab, although adjacent, never allowed to mix. At this stage, our lab does not have to worry about this. Even as the number of research projects with human embryos or oocytes grow, through collaboration with private clinics, we are able to outsource that work. One of our microscopes was just moved to IVF Center A.
The microscope was in the small microscopy room downstairs that I first began my training in. In the beginning of the 2018 school year, I learned that the room had been packed up entirely, forcing me to work in the microscopy room upstairs almost exclusively. Yet, the microscope seemed to have been sitting idly for a few months because it was only just moved recently. When I asked the PI about it, he said that research at IVF Center A has yet to begin. It will mainly be two of our lab members, the ones who did the few human research projects here, who will travel to Waltham to work with the microscope in the clinical environment. At an earlier point in the lab’s collaboration with the clinic, a medical student had come to essentially train in our lab, working on projects with a postdoctoral fellow here, before ending up at IVF Center A. In addition to the benefit of isolating human research in one location, so as not to accidentally use federal funds, the PI mentions the easier access to human materials as another advantage. For the projects that were carried out in the lab, the human oocytes and such were transferred from a clinic. This seemingly simple sharing of resources, both tools, researchers themselves and the knowledge they offer, not only efficiently cuts out many intermediate steps, but also blurs the boundaries between the “local, moral worlds” of the laboratory and the clinic.

*Seeing Research through a Clinical Lens*

Though the scientists in the lab primarily pursue their research to learn and gain a better understanding of nature, a byproduct of their work is that ART affects human livelihood in general society. In *Ethics on the Laboratory Floor,*
Burg and Swierstra posit that “reproductive technologies have changed the experience of having children to “choosing or deciding to have” children” (2013). At times, this is even the driving force of their research such as the larger goal in my lab to create noninvasive embryo selection tools in IVF. Then again, my PI notes that the lab’s relationship with IVF clinics is critical for basic science and medical application. “A lot of the research we couldn’t do without connection to the IVF clinic. Some of that is because of access to material (matured human oocytes or embryos), but some of that is knowledge and talking with them and learning about what goes on in clinics,” he said. Through collaboration with IVF clinics, scientists are brought out of the insulating world of their laboratory and obliged to face the human component that imposes an immediate and important significance to the outcome of their research. It also arms them with rhetoric and ethical postulates associated with doctors in a clinic to take up as fuel for their scientific research aims. In response to a question about the controversies that at times surrounds ART, the PI used phrases very similar to his collaborators, the doctors who run IVF clinics:

The goal is to alleviate human suffering. You could say having cancer is a lifestyle choice, but in an ideal world, just as people shouldn’t have to have lung cancer, people shouldn’t have to have infertility. It also relates to broader issues about control of reproduction with accessible birth control. People should not only have the freedom to decide when not to have kids, they should also have the freedom to decide when to have kids.
The purposed end here is two-fold: alleviate human suffering from infertility and provide choice in reproduction. Any concerns related to these objectives are of lesser importance. For my PI, the controversial issues surrounding ART make the field all the more attractive to him. “There are a lot of difficult questions related to this thing and reasonable people can have different opinions,” he said. While scientists recognize they are just one of many stakeholders with opinions and beliefs about ART, they strongly believe and trust in the process of scientific research on their side as an investigational tool. Though pursuing certain ethically questionable areas of research is actively discouraged by funding and ethics committees alike in the community, in the vein of the scientific method, performing experiments in order to test hypotheses is the only way to come to an evidence-based conclusion. Morgan questions this idea that “the moral status of embryos can be resolved by knowing scientific facts” in Icons of Life, where at the time of the embryo collection movement it had become a given (2009). But in actuality, scientists do believe further research can help settle ethical debate. The graduate student in my lab expressed a need for more understanding of biology before deciding if manipulations like gene editing are acceptable.

We don’t know if there are any repercussions because we don’t know enough about genetic editing. There is so much about genetic biology that we don’t understand. We have to understand every single bit of this
machine before we can start messing around with it. We only know the basic code but there are a bunch of add ons and modifiers that are in our biological system that we don’t understand. I think we need to learn more before we make a decision whether we should edit or not.

Additionally, we understand that scientists as actors view even the negative impacts of ART as private, not public, concerns that belong to the individual (Burg and Swierstra 2013). The graduate student echoed this point when I asked what her response would be to those who believe her research is ethically wrong. “That is their opinion. I don’t really try to change others’ opinions because they just don’t know the work I’m doing. I don’t feel the need to defend myself,” she said. Because the values involved in the field of ART are varying and fluid in society, there is no reason for scientists to bear responsibility for what some individuals decide to take issue with (Burg and Swierstra 2013). Furthermore, risk assessment in ART cannot be precisely quantified (Burg and Swierstra 2013). The qualitative discourse about the ethical issues in the field that does exist lacks the objectivity that is respected and regarded seriously by scientists (Burg and Swierstra 2013). Lastly, as you would expect from the creators of this technology, they are reluctant to believe the problems lie with reproductive technology itself, but rather those few scientists or doctors that misuse it (Burg and Swierstra 2013). So, controversial and negative aspects of ART are dismissed as quickly as they are acknowledged.
Conclusion

In conclusion, my main finding was that due to the research methodology, model, and funding, scientists do not consider the moral status of the embryo in the daily occurrences in the lab. The laboratory’s association with IVF clinics grounds ART research in something larger than the pursuit of knowledge, opening up a pathway to think about its effects on broader society and resulting ethical dilemmas.
CHAPTER THREE:
CLINICAL CONCEPTIONS OF ART

Introduction

In this chapter, I use semi-structured interviews with leaders of various IVF clinics to ethnographically describe the ART clinic. My findings at this site are juxtaposed with the laboratory ethnography that characterizes my last chapter. Here, I argue that thinking about morality is a part of the day-to-day clinic functions. The primary focus in the clinical environment is the welfare of the patients, which is underpinned by the great importance placed on the pregnancy success rates of a clinic. Private centers especially play a substantial role in translating research from collaborations with academic labs like my PI’s to tools that can be applied in a clinical setting. Furthermore, their funding and connections in the private sector allows them to be more proactively innovative in the field of ART. Their significance is highlighted by the ban on the use of federal funds for human embryo and oocyte research, which hinders research progress. Though it specifically affects academic-affiliated, nonprofit labs, the effects of the ban are felt across the field. In order to describe my findings, I launch you to the variety and complexity of ART with an account of my visit to the clinic and an introduction to my PI’s collaborators. Then, I will show you how daily occurrences in the clinic regularly lead to moral reasoning and, specifically, considering the ethical status of the embryo. Next, I will portray how patients are
centered in the clinic and success rates are of great significance. Lastly, I describe the power play at work in ART research with the private clinic and lab as well as the government.

Visible Values on my first Visit to IVF Clinic

Walking into the entrance of IVF Center A, there is a jumble of colorful words on a white wall. The words represent the beauty and positivity that must fill an infertility treatment center of this caliber. The Centers for Disease Control and Prevention 2016 clinical summary ART data reported IVF Center A had a 22 percent rate of singleton births out of the total number of IVF cycles [1]. The national average is 21 percent [1]. The waiting room of the clinic, though a bit sterile, infuses warmth in its open space with colors like red, orange, and pink. There is a counter against one wall with coffee and refreshments and popular magazines scattered on end tables. There seems to be two waiting areas. As I wait for my interlocutor, I sit at the one closer to the front desk, while the one further back is much bigger, containing more chairs and a TV. It seems to be designated for a longer wait. Dr. John Falk greets me in green surgical scrubs and a hair net. He walks me down a long corridor, passing patient visit rooms and we take a right turn into a section with offices and cubicles. After our interview in his office, he gives me an official tour. The cubicles are filled with people dressed in business casual, likely administrative roles. While there is one wall lined with offices like Dr. Falk’s, presumably claimed by other leaders at his level, the rest of the cubical space is surrounded by laboratories. Purified air is filtered into the rooms. In one
of them, a microscope from the Gordon Lab can be spotted. One of the lab technicians has been trained to use it. The two surgical operating rooms are close to the labs for easy transfer when the embryos are ready to be implanted in a woman’s womb or eggs are ready to be extracted. We pass the blood work room as we enter into the hallway with rooms designated for business purposes, exiting at the opposite side of the waiting room from where we entered in.

My visit to the center presented a real-world rendering of the complex network of factors that influence the operation of the ART clinic, both private institutions and academic-affiliated, nonprofit organizations. In its daily practice, I learned how regulations, ethics, research, and funding lies at the heart of the clinic. These values are centered around the patient and a successful outcome. My conversations with the leaders of ART clinics help me delve further into the above themes.

**The Laboratory’s Clinical Connections Portray ART Variety and Intricacy**

When I asked the PI of my lab to connect me with his collaborators in IVF clinics, he gave me the names of three doctors representing different areas in the breadth of the IVF clinic space. Though I emailed all of them in one sitting, Dr. Peter Turner was the first to respond to me, replying two hours later that same night. His prompt and willing response took me by surprise considering the multiple roles he fills.

Dr. Turner is a Professor of Obstetrics, Gynecology, and Reproductive Sciences at Yale School of Medicine. As a physician-scientist, he sees patients
and also does his own academic research, sometimes in collaboration with others such as my PI. In addition, he serves as the research director of IVF Center B, coordinating research for a huge consortium of IVF clinics in the United States, Europe, Asia, and South America. When we talk on the phone on a Thursday morning in early December, he tells me his general schedule is unique compared to his colleagues in different places. “Yesterday, I was doing research for an international group, mostly online meetings. Today, I am at Yale giving student lectures and tomorrow I will be seeing patients,” Dr. Turner said. In response to my follow up question about what it is like working with different IVF centers around the world, Dr. Turner said many private institutions doing infertility work have a commitment to move the field forward. IVF Center B is the world’s biggest company doing so, providing single model funding for reproductive research:

I’m trying to establish a system that can be used to make new discoveries. We want to improve the way we do research in the field by coordinating a number of centers through databases and protocols, providing them support - statistical design, analysis, nursing, technical–so they can be productive scientifically. The organization provides the means to do this. Because at the end of the day you need money also.

But long before he became the research director at IVF Center B, Dr. Turner describes a turning point in his career that became the focus of his research. After
doing reproductive endocrinology research for some time and completing his residency at Yale, he started another fellowship at the university when he happened to attend a lecture about oocytes and aneuploidy.

I thought it was fascinating because women are born with eggs and they don’t make new eggs, that is the belief at least. They are frozen in a meiotic cell division. At ovulation, that egg is activated and completes cell division. From age 25 to 40, as a woman gets older, the likelihood of making a mistake in cell division increases, so more and more eggs become abnormal as time goes by. In a very predictable manner, all women become infertile and menopausal.

In line with Dr. Turner’s belief that one of the key questions in the field of infertility is ovarian aging and decreased fertility in women of a certain age, his recently published research with the PI of my lab shows that fluorescence lifetime imaging microscopy could possibly be used to evaluate mitochondrial function in oocytes [2].

While I was not able to travel the four hours to Yale, the day after my interview with Dr. Turner, I took a thirty minute Lyft ride from campus to where I met with Dr. John Falk, the scientific director of IVF Center A. IVF Center A is one of the main centers, although there are twenty-five locations across New England, seventeen of them in Massachusetts alone. As we sit in his small office, he tells me that because the clinic is so large, there is a separate laboratory
director that runs the daily functions of the lab. Dr. Falk oversees if there are issues and helps with troubleshooting:

My role as scientific director is to look overarchingly at the laboratory function and new technologies we may use, to troubleshoot if there are problems, and to coordinate research that involves the laboratory whether that is through samples, where we are looking at new technologies, improving current technology or examining data to see how we can improve things to quality control or investigate new technology to see if they are improving things. Global oversight of the lab if you will.

With much room for innovation in the field, it seems they are constantly trying to improve the function of the lab with current technology while investigating new technology. The forward thinking mindset in IVF treatment is not new to Dr. Falk. Before becoming world renown, Dr. Falk completed his undergraduate degree and PhD in Australia. Monash University specifically, where he did his PhD, was one of the leading Reproductive Research Units in the world. According to him, the group had many of the world “firsts” in IVF, innovations such as hormonal stimulation, embryo freezing, and micromanipulation.

Though innovative, his current place of work, IVF Center A is a private organization. When I told him how my PI categorized it as “for-profit”, Dr. Falk gave me a polite but amused smile and responded in a matter-of-fact way:
Obviously, we are a business too even though we have academic affiliations and we try to give back to the community. Our ultimate goal is to improve IVF in terms of the success. Trying to make money out of it is a different thing though they may go hand in hand. We also do a lot of research into the social aspects of IVF like why patients leave treatment. We are trying to improve the whole IVF experience and not just the technical, lab aspects. Even though we are a for-profit organization and that drives us, we have other goals.

In regards to the technical aspect of IVF, he believes both the private industry and academic field works in tandem. He said, “you can argue that the academic labs are only interested in the basic understanding of things but somehow that can translate to a commercial venture. That model works.” In reality, his role more so acts to translate academic research into a product with a clinical application. His work with the Gordon lab, though ongoing, has so far resulted in a 2017 published review paper that shows the link between the metabolic function of embryos to their viability and points to the role of noninvasive technologies like microscopy as influential.

After a month of failed attempts and persistent follow up, I was able to speak to Dr. Charlotte Farris on the phone over winter break in the comfort of my home in Texas. As the Director of the ART Laboratory at IVF Center C, Professor of Obstetrics and Gynecology at Harvard Medical School, and a major leader in the American Society of Reproductive Medicine (ASRM), it was quite clear why
she was the most difficult of my PI’s collaborators to pin down. Speaking at length about the many hats she wears, she also manages to fit mentorship of students, residents, fellows, and junior faculty as well as serving on the boards of multiple publications in her day-to-day.

Her reasons for entering the field of assisted reproductive medicine were also refreshingly personal. Her journey began in 1980, she shares with me, when she started trying to have children. It took her two years to finally conceive, and then she had to terminate her pregnancy. Four more years went by as she again attempted to get pregnant, and she underwent an intrauterine insemination/ovarian stimulation cycle to conceive. Though she took low doses of hormones to stimulate her eggs, she ended up with three follicles which resulted in three embryos. Even though it was a one-billionth chance, she had triplets. Around her first trimester of pregnancy, Dr. Farris, who at that point was doing basic research, realized her new career calling. She made a decision to move into a clinical IVF lab directorship position by the time her triplets were four years old. A commitment that she successfully carried out. Her unique position has made her career all the more rewarding she tells me. “I can counsel patients because I’ve sat on both sides of the fence. I was a patient and I understand the agonies of infertility. But, I also from a professional standpoint understand the risks involved, and the limitations of the procedure,” Dr. Farris said. IVF Center C is considered an academic-affiliated, nonprofit organization. Dr. Farris, who is in charge of quality control and management of the IVF lab, understands the benefits
of working for a hospital-based ART center compared to her counterparts in private practice:

There is an intersection of profits being made with people wanting to do the right thing, to build healthy families for infertile couples. However, there is a huge competition among programs to get patients so they can increase their profit margins. It is easy for me to say because I’m in an academic institution and my salary is being paid for by the hospital. I can see the pressures that a private program might be under.

Her insight into the field of ART also may come from her time spent on the committees of ASRM. With around 8000 members, ASRM is one of the leading societies in reproductive medicine in the world, according to Dr. Farris. “I help to determine the way the field moves forward in an ethical framework appropriately, managing the press when things are put out in the public media whether inaccurate or accurate, setting down policies that make sense for the field of public medicine, etc,” she said. As for her relationship with the Gordon lab, she provides mature human oocytes and cumulus cells (the somatic cells surrounding oocytes) that the few members in our lab that work with human materials use. Dr. Farris and my PI just published an article in *Fertility and Sterility* in response to a study that ruled out the quality of cumulus cells as a predictor of successful live births [3]. They believe that cumulus cell gene expression could be a potential biomarker of oocyte quality and, subsequently, later embryo development.
Ultimately, while I was unable to engage in participant-observation in the clinical environment, my in-depth interviews with these three doctors helped me to comprehend the “local moral world” of the ART/IVF clinic.

**The Inescapable Ethics of Humans, their Embryos, Eggs, and Sperm**

Analogous to the IRBs that serve as the institutional standard of ethics for research in the laboratory, ASRM has a practice committee that draws up the guidelines for clinical practice in assisted reproductive medicine. Dr. Farris further explained the inner workings of the committee as a stakeholder. “The committee consists of experts in the field that can write and read the literature. We decide what guidelines should be written, and, after deciding on topics, we pull from the literature to make sure our guidelines are evidence based,” she said. Though I understood that the ASRM was highly respected and considered by doctors, I questioned why they set guidelines, which left room for loopholes, instead of firm laws. Dr. Farris said that in the United States guidelines are preferred to regulations:

There has been a hesitance to set down laws that firmly state you have to do things this way or that way. It is partly just the field of medicine itself. There is not much in medicine that is regulated by law. It is almost always set down by guidelines. The field has been very good at self regulating. It causes a heterogeneity in the patients we treat.
These guidelines set a norm where self-regulation is encouraged, which has led to a mixture of patients. Some who may not be served otherwise. Stern et al. sent out a survey of ethically complex situations to directors of IVF clinics in order to assess if they would provide treatment and under what conditions. Both private and nonprofit clinics were represented in their results. Also acknowledging the few federal laws but ASRM guidelines available, Stern et al. posited that decisions on difficult cases are often made by individual clinicians who must rely on their own best judgement about what is both ethical and legal [4]. Here, the clinic is set apart from the laboratory because there is need for a constant moral dialogue among the doctors and others involved in the operation of the clinic to decide if a service should be offered and who should receive treatment. According to Stern et al., ethical principles that are considered in these conversations may be patient autonomy, non-maleficence, beneficence, and justice [4]. More generally, they could also include philosophy of the use of medical technologies, concerns about legal liability and religious convictions [4]. These conversations, though they may be circumstantial, occur frequently in correlation to the unpredictable nature of the humans who come seeking help at the clinic.

At the end of our call, though our interview was running thirty minutes over the projected time, Dr. Farris had several stories that exemplify the continuous renegotiation of ethical perspectives in the clinic. Dr. Farris told me that her hospital has an Assisted Reproductive Technology Ethics Committee. "We convene the committee whenever an issue comes up that we feel deserves
There was a man who fell down an elevator shaft and died. His mother wanted us to freeze his sperm. He was not married, but he was engaged. His fiancé didn’t particularly want to have his sperm frozen. There was never any discussion between the couple that they wanted to have children.

So, the question was should they freeze the sperm or not? Immediately, the ethics committee was convened. The members, if available to attend, come from all walks of life—physicians, embryologists, nurses, judges, rabbi, and social workers. All of them have the opportunity to weigh in. In that particular scenario, it was decided to freeze the sperm because it all happened so quickly and they could not reach a decision. Dr. Farris told me the sperm still remains in her lab.

According to her, though they use the ASRM guidelines and take them very seriously, there may be situations where the guidelines do not necessarily apply. Continuing on, Dr. Farris said that she imagines the lab as a highly complex manufacturing plant in which the raw materials are eggs and sperm, and the end product being made is the embryo. Just like in the manufacturing industry, errors may occur. She gave me another example. When culturing human embryos in media, it is important to overlay the media with oil in order to inhibit the loss of water which will cause an ovulatory shift. While very few instances have
happened in the twenty-two years Dr. Farris has been at the IVF Center C, she told me that recently an embryologist in the clinic failed to remember this crucial step. So, the dish sat in the incubator overnight without an oil overlay and, as a result, the embryo degenerated. This mistake was not realized until it was time to transfer the embryo into a woman’s womb. The question was then, should this incident be shared with the patient? This decision was up to the four leaders in the division, including Dr. Farris. In the end, they were split down the middle. One side felt they should tell the patient. “I felt that we should so we can compensate the patients if they wanted to have a free cycle,” Dr. Farris said. The other half of the committee felt that since the damage had already been done, they should not subject the patient to the agony of knowing the clinic unintentionally did harm to the embryo. While the chair of the ASRM ethics committee advised them that clinics should always divulge information to the patient, in a situation that came out of an error never before faced by their clinic, Dr. Farris believed they had to come to a decision on their own. “As leaders of our division, we are going to come up with our own internal guidelines as to when we should or should not do so,” she said. In the end, the leaders told the patient-couple and initially they took it very well, but then became very angry. Dr. Farris and the team will be providing a free cycle to them.

Given the patient-facing nature of the IVF clinic, it is impossible to escape the consideration of the moral and ethical status of the embryo in the day-to-day work when inevitable mistakes can lead to a patient losing an opportunity to conceive a human life. A mother’s wish for her late son concerning his sperm
raises questions that demand answers which may not be institutionally established. Similar to a more developed embryo in lab that is closer to a would-be birth, embryos become more human in an IVF clinic where humans are involved. Dr. Falk expressed his continued amazement that he sees the “beginning of life” in his work.

“You see a sperm and an egg or a day 1 embryo and you know in nine months the information in that one cell is enough to get that to a small baby. The genetics and information in that cell and how that is contained to the right time and moment to ration into a human being. Even at a research level, understanding one-millionth of what goes on is quite intriguing.” - Dr. Falk

The embryo will be implanted in a woman’s womb with the intention of creating life. Hence, it is difficult to strip an embryo in that case of its humanity. Thinking about the potential birth of an embryo also affords it more humanity in a research context as was elucidated in my interview with a postdoc in my lab. In “Waiting: The Redemption of Frozen Embryos through Embryo Adoption and Stem Cell Research in the United States,” an essay in The Anthropology of the Fetus, Risa D. Cromer illuminates the ambiguity around frozen embryos. Her ethnographic findings highlight two forms of reproductive value [5]. Her research stems from the change at the end of the twentieth century, where unwanted or leftover frozen embryos could either become research material or adopted embryos to be born as children [5]. She shows us that the stages of the embryo correspond to either its utility for research or suitability for embryo adoption. A parallel can be drawn to the ethical status of the embryo as it moves throughout time and stages of
development. Morality and ethics become more apparent as the human entity that an embryo results in becomes more imminent. The patients that doctors constantly see serve as a reminder of this. Therefore, they become the focal point of clinics’ operations.

**Patients at the Center, Success Rates at the Top**

Taking into account the human patient may raise the stakes for clinics, but there remains a tension between soft factors like bedside manner and hard factors such as success rates. This is illuminated by an interlocutor’s story.

Kristina sat on the bus on her way to IVF Center C for the third day this week. Thankfully, she did not have another awkward run in with a coworker, inquiring why she was going in the opposite direction of her office at this time of morning. Two failed IVF cycles behind her had made her a little wiser. Sharing that she was going through the IVF process with others ended up only adding to her own disappointment if it failed. As she arrived at the hospital, she steeled herself to get her blood drawn again. At this point, the constant needles going into her body barely phased her. Each time she went through an IVF cycle had solidified her resolve. Even in the face of multiple failures, she knew she wanted a child. What actually attempted to shake her steadfastness every time she went in for bloodwork at the IVF Center C was the location of the IVF phlebotomy room. She had front row seating to the labor and delivery unit. As her blood was drawn to check if the IVF cycle was moving along successfully, she witnessed the very object of her desire—women in labor going in and with newborn babies going out.
“From a medical care perspective, there is a lack of sensitivity to address why this might not be the best place to send a bunch of infertile women. But, would I recommend that practice? I kind of have to because I have a daughter because of them,” Kristina said.

Kristina said that though she gave this feedback to the clinic, they were not surprised. According to her, IVF Center C is known for being one of the best in terms of results, so there is bound to be high volume. The 2016 CDC Report states that for women from the ages of 35 to 37, the IVF Center C had a 21.6 percent chance of a successful, healthy live birth using fresh embryos from non-donor eggs as opposed to the national average of a 15.8 percent chance [1].

Even when they may not receive the most “considerate” treatment, patients seeking fertility services tend to prize the clinics’ success in pregnancy outcomes. In Conceiving of Products and the Products of Conception: Reflections on Commodification, ART, and Abortion, Jody Lynee Madeira answers the conflict between ART as both a service for consumers and a medical treatment for patients with a shift in focus to the importance of the attributes behind both labels. She argues that since medicine has “long accommodated commodification” that we should simply seek to combine the best elements of both the patient and consumer roles [6]. Therefore, the ideal relationship prioritizes high communication, high empathy, high choice, and medium agency [6]. According to Madeira, while commodification affects how doctors define success and what medical organizations strive to achieve, the best in the field use commodification to their advantage to improve their services and maintain quality of care [6].
“Ideally, a health care consumer weighs medical costs against perceived benefits and obtains care from the “best value” provider. As market creatures, consumers are active in health care decision-making, armed with information, confidence, assertiveness, and the rights to demand treatment access, options, providers, and desires” [6].

When we consider Madeira’s words in the context of the ART clinic, we see ample evidence of this. Particularly for patients who pay for expensive infertility services out-of-pocket, careseekers want the best for their money. It is often these patients that Dr. Turner describes as very educated and full of intelligent questions—they have access to online resources and chat groups, among other sources. He further highlights the consumer identity of these patients by describing how much freedom they are allowed.

The way we practice at Yale is we give the patient information and we believe they will make the right decision. There are certain things we will not do like if any intervention is harmful, we will not do it. We will define to them the doable and acceptable things, and they choose in between. When we do egg donation or surrogacy, we don’t give them any ethical advice. We just ask them to see a social worker in those situations—the very, very complex cases. Even in those cases, the social worker does not tell our patient what to do. We just tell them the questions that may arise and what they should be thinking about. We don’t force any specific decision on them.
Madeira breaks commodification down as “the economic and cultural processes” that classifies commodities and its implications [6]. Throughout this chapter, the two distinct categories come alive in the operations of the clinic. So what do the critics of the commodification of ART say? They believe “women’s bodies and reproductive capacities, embryos, fetuses, and children should not be commodified, and warn that ART can coerce and exploit patients. They argue that it is impossible or unwise to monetarily value certain goods, that monetary valuation does not capture these goods’ significance, that valuation and exchange can warp those goods, and that transactions exchanging these goods for money are involuntary or accessed unequally” [6]. Though literature has much to say on the inappropriateness and unsuitability of commodification in the medical field, Madeira brings up the point that markets and culture are inevitably intertwined rather than commercialism dominating over the other [6]. The idea of choice in assisted reproduction which motivates doctors and scientists in the industry is largely associated with consumerism [6]. As she notes, “choice also connotes cultural decision-making norms” such as the fundamental rights doctors and scientists believe as a basis all people should be afforded—the right to procreate and be happy.

However, contrary to what Madeira believes to be an unavoidable “uncertainty through a generalized belief in the ability of the physician” on the part of the patient, my interviews in this chapter made it clear that the publicly accessible success rates of clinics’ services is a legitimate method for patients to
assess quality before making a choice. Despite how educated or involved the patients may be in the IVF process, Dr. Falk points out that it is the raw biological materials (sperm, eggs, and embryos) that drive the success of the reproductive technology or the lack thereof. “The saddest thing is the lack of education of women not understanding there is a biological clock. Some people will come here at 40 years old and they expect that IVF is the savior and they will get pregnant at the click of their fingers, they don’t realize it is the biological materials that drives the success or lack of success,” he said. Considering the term “assisted” reproduction, no matter how great the technology or services, the biological materials still determine success. They hold power, a sort of agency. While doctors and scientists desire to better understand how to assist women whose natural biological clock puts them at a disadvantage, the success rates are limited by these factors. Therefore, relatively high success rates are greatly valued. Though this data does not diminish the significance of the ideal relationship factors such as high communication and empathy, it does provide a certain sanctioned technical objectivity and legitimacy to the consideration of “best value”.

The pressure to maintain success rates has its negative consequences as highlighted by Dr. Farris; a compulsion on the part of IVF clinics to offer special services that may lack a community-wide stamp of ethical approval. “When patients pay out of pocket, patients absolutely want to go to the best program so there is intense competition. People go out and advertise and do things that aren’t
necessarily considered appropriate by the leaders in the field in order to increase the number of patients who come through the door,” he said.

Dr. Turner expresses how the desire to improve patient outcome, at times, also influences the application of ART research discoveries in clinical practice.

“Because of the pressure from patients who want to get pregnant as quickly as possible, the potential discoveries are applied to clinical settings very quickly. Quite quickly, if these technologies are not effective, it is realized and they are discarded,” he said. In an environment where humans will be directly affected by the outcome of research projects, it is crucial to understand how research in the IVF or ART clinic works.

**The Private Sector’s Pivotal Role and the Government’s Restrictive Hold in Research:**

Dr. Falk, as scientific director of his clinic, explained the difference between clinical research, where doctors and patients are involved, and technical research, which is mainly found in the laboratory. Furthermore, the research can be basic, following a very fundamental scientific question, or it can become more translational.

The work we are doing with Robert Gordon’s lab, trying to investigate the differences in the metabolism of human embryos in order to understand which embryos are more likely to cause a pregnancy versus not. That is something that would go from basic to translational research— if an embryo
has more energy will it have more of a chance of giving a pregnancy to
one of our patients?

He said he pursues projects that impact our understanding of the biology of
reproduction and ultimately will impact patient outcome. According to him, the
transition from translational research to clinical application is a slow, stepwise
process. Starting off with a basic understanding question, it needs to be
transferable as a technology to general laboratory staff.

“We have to show that it clinically impacts our patients for the good. It needs to
translate to a tool that can help our patients,” Dr. Falk said. He referred to the
collaboration between IVF clinics and academic labs as “historical.” Because
ART is still a relatively new medical field and the technology has a strong
research background, scientists and doctors alike are still interested in pursuing
research:

There are many private labs that don’t have that association. They just
treat patients and new technologies eventually trickle down to them. Other
labs like ourselves are interested in looking at new ways to help patients
and improve their outcomes, which is why we maintain an association
with academic labs but also start-up companies and other organizations
that have technologies that may help us.
Clinics like IVF Center A are not only instrumental in translating basic, technical research into technology that can help patients, but also are very well-positioned due to their placement in the private sector to be at the cutting edge of the field of ART.

As we discussed his work at IVF Center B, Dr. Turner emphasized that most of the real, human-applicable ART discoveries came from private institutions, who have a responsibility to advance the field:

If you look at these technologies that have changed the lives of millions of people, they have not come from institutions like Yale or Harvard, they come from these private institutions. All of these things are moving extremely fast. NIH and NICHD are the major funding sources for biological research. They don’t support research that may affect human embryos because of religious or whatever reasons. We rely on private institutions and funding to promote progress in our field.

He believes that the specific aims for the future of ART such as increasing implantation rates as well as decreasing multiple pregnancies and maternal complications will necessitate private institutions. “This requires a very organized research effort that has a large sample size,” Dr. Turner said. When I asked Dr. Turner the stipulations that came with the private funding offered through his company, he told me that IVF Center B under his research leadership created a scientific advisory board. The board of six individuals, who are extremely well
published in the field, were tasked with establishing priorities for the research sponsored by the institution. “The main priority is that the project should have a foreseeable aim in improving our patient outcome. The aim of the research that is done in this organization is not to compete with academic institutions or federal agencies. It is to do something that others don’t do or can’t do and apply this new information to practice and see whether it works or not,” Dr. Turner said.

Though he feels that his and my PI’s work is relevant and important for understanding the biology of infertility, Dr. Turner said that it may not necessarily affect patient care in the future.

“Let’s say Robert Gordon finds a microscope that can detect oocyte health. He can do proof of concept testing, but whether or not it works in a human setting, this organization (IVF Center B) is best equipped to check that. The emphasis is different. They are both needed,” he said.

In response to my inquiry into the scientific advisory board’s stance on research projects that may be ethically controversial, Dr. Turner pointed out that institutional review boards are an important limiting factor. “Even if a scientific advisory board finds a research project interesting, it has to go to a review board that is outside of this organization. They are quite strict actually,” he said. In fact, the doctors I spoke to seemed assured that their field was under sufficient control. Dr. Falk also told me that his lab has multiple channels of institutional oversight. “The laboratory has quite a few levers of control. For example, we have state regulations we have to follow. We have federal regulations we have to follow. We report to various bodies, etc,” he said. The oversight of clinic treatment practices
is also partly constructed by the ASRM guidelines. According to Dr. Falk, going against these guidelines is viewed very negatively in the ART community.

In our conversation about why the ASRM sets guidelines as opposed to laws in place, Dr. Farris expressed her personal disapproval of regulations, citing the federal moratorium that bans the use of funds on human embryo and oocyte research as an example. “I don’t think regulations or laws would be better. They would hamper progress in the field. The moratorium on research funds is an example of this. I’m an advocate of setting down frameworks by consensus building that ethically make sense and scientifically can advance knowledge,” she said. Dr. Falk also noted that the government loses an element of control by not sponsoring these research projects. “There is an argument that if the government did give funding they would have a better capability of regulating what goes on. The only way we can do any research is to have ethical approval, so that is the oversight,” he said. Dr. Farris referenced the November 2018 news of a Chinese scientist’s claim of creating the world’s first genetically edited babies. She pointed out that this was an individual misusing ART, when the safety checks had not been established. According to her, though guidelines state that gene-edited human embryos should not be transferred, research to further investigate this issue and eventually create a scientific norm should be encouraged:

In our country, because we are so hampered by embryo research funding the right work has not been done to establish whether it is safe or not. It absolutely affects my work in the context of not being able to do some of
the studies that I would like to do. I am not an advocate of willy nilly doing research on human embryos. I have a very active program for patients to donate their embryos for research. We can use those embryos if we have IRB approval. The sophisticated work that I would love to be able to do costs money, which is not even available to compete for from the NIH.

While the work she is currently doing with my PI circumvents the moratorium by focusing on cumulus cells, the somatic cells around human oocytes, Dr. Farris describes how the government may be influential even in the support from the private sector in funding research. “Private funding exists but it is just very difficult to get it, particularly for human embryo research because people feel very sensitive about it. But, if the government set a standard that it was appropriate under very strict guidelines, then the public in general may be more willing to accept the concept of doing work with human embryos,” she said.

Conclusion

The environment of the ART clinic presents a complex network of factors that is largely absent from the academic laboratory. The three doctors my PI collaborates with represent the breadth of the IVF medical field since they are leaders that span both private and nonprofit centers, a global consortium, and a highly-respected society of reproductive medicine. Due to the regulation of assisted reproductive medicine through guidelines and the patient-facing nature of
the clinic, doctors are forced to consider the morality and ethics of their work constantly.

Doctors in IVF clinics staunchly support their patients’ right to procreate and be happy. Though some centers are for-profit businesses, their main driver remains successful patient outcomes. However, making a profit margin fuels competition between clinics, which may encourage clinics to offer special services that are not widely accepted in the community. The field of ART is a unique medical field because the pregnancy rates of every clinic is publically available. This scrutiny serves as a check for clinics. These success rates added to the services they offer make up the metric for clinics as they strive to be the best. Patients, especially when paying out of pocket, with such high stakes will want the best.

Private organizations primarily push the ART industry forward. Some clinics solely treat and care for patients with infertility issues, while others also operate as labs. Because they are in the private sector, they are best positioned to collaborate with academic labs and other industry players. This allows them to move easily from basic to translational research then on to clinical application in order to assess if technologies directly impact patient outcome. Nonprofit clinics and labs that operate out of hospitals treat and care for patients and participate in research. However, they are more restricted due to the moratorium on federal funding used for human embryo and oocyte research. Both nonprofit and for-profit clinics are needed to provide services in the ART industry because there is an unmet burden for those who struggle with infertility.
After elucidating the diversity and complexity in the ART clinic, through the connections of the laboratory, I then addressed the moral and ethical aspects of the daily work. I further went on to highlight the patient and success rates as the main priorities of the clinic. Lastly, I presented my findings on the importance of the private sector of ART in research progress and conversely how the government’s influence over funding works to hinder research progression. Now that I have described the two worlds of ART and my subsequent conclusions, in the next chapter, I discuss the implications of all of this.
CHAPTER 4:
DISCUSSION AND CONCLUSION

The goals of my research were to attend to the ethical and economic questions in ART as they related to the embryo. I focused my research on the lab, but was able to also look at the clinic. In Chapter One, I find that the mechanics of embryo hatching lead to DNA double-strand breakage in the cells that make up the outer layer of the embryo. But, the brief sentence I offer to summarize my findings does not even a little justice to the realities of my research journey. I spent over a year staring at an embryo under a microscope. I transferred it with my mouth. I cultured it. I stained it. I lost it. I came to scientifically understand it in a new way. But ethnographically, I also scrutinized how I considered it in the most mundane, frustrating, and exciting moments in my experiment. I observed how it fit as a research object into the larger entity of the science laboratory. I learned how it connects the laboratory to the clinic, where it took on a form of humanity. It was a vehicle through which my field research precipitated.

My scientific research project is one, personal example of the quest to simply understand more about nature, or biology in this case, that primarily drives the scientific research endeavor. In Chapter Two, I find that this goal the scientists in my field site aspire toward works in tandem with the functions of the laboratory environment and the use of mouse embryos and oocytes to exclude moral reasoning from the daily practice of the lab. Even as an undergraduate researcher in the lab simultaneously carrying out ethnographic research by participant observation and interviews, I quickly fell into the systemic inattentiveness (a term
used by Professor Arthur Kleinman in an advising meeting) that characterizes scientific methodology.

Many of my claims about the ethical status of the embryo rest on the fact that the lab members including myself mainly work with mouse embryos and oocytes. The question then remains how would my findings change if we were working primarily with human biomaterial in the laboratory? Personally, the auto-ethnographic description of my experiences practicing methods, learning protocols and failing during the process of experimentation would take on a more serious tone. Given my moral qualms with research on human embryos, I may not be doing the experiment at all. Although for the scientists in my lab, the knowledge that these embryos and oocytes were donated for research validates working with them, this usually comes with an upper limit for the level of embryo development. However, the amount of lost embryos that I highlight in my research process would become an issue of waste. Buying mouse embryos and oocytes from a company and updating an inventory any time they are used is very different from human biomaterial shipped from an IVF clinic-lab of one of the PI’s collaborators. Then, there is the restriction of not using federal funds for work on human embryos or oocytes. The more complicated, and rightfully so, logistics that surround research with human biomaterial, it affords more value, but I argue that after all of that is squared away and as long as the embryos are not too far developed, the ethical status of the embryo reduces all the same to that of a research object and moral reasoning is not attended to regularly.
In Chapter Three, I find that, in contrast, the ethical status of the embryo is constantly brought into question in the IVF or ART clinic. Interacting with patients every day who express their desires, requests, and strong willingness to seek infertility help serves as an incessant reminder of the humanity of the embryo and affected patients. This imbues the day-to-day work of doctors in a clinic with moral consideration. Dialogue in response to situations that arise even take place within formal or informal ethics committees in the clinics. Policing within and throughout the clinic occurs because the strongest form of regulation in the field happens to be the practice guidelines established by the American Society of Reproductive Medicine.

After weighing my conclusions, one may further question if this field is adequately regulated. Given the institutional review boards (IRBs), publicly-accessible success rates and the ASRM guidelines, the scientists and doctors I spoke to seem to believe the claim that it is the most regulated medical field in the United States. The IRBs and the success rates required by the government amount to an established ethical oversight. In both the laboratory and clinic, this provides a false sense of security in their level of ethical control. The scientists, as my advisor Dr. Omar Sultan Haque pointed out in a meeting, outsource their ethical thinking to an extent, compounding their systemic inattentiveness. The doctors predominantly concern themselves with maintaining their success rates as they legitimize the standards of their clinic services. However, the ASRM guidelines, in place of federally enforceable laws, make room for the perpetual reevaluation of moral beliefs in the clinic environment. This compulsory flexibility and
rigorous ethical exercise I believe is crucial to working with human beings as is the case in a medical field. Laws set rigid boundaries that may hamper the evolution and advancement of ART. Without laws, doctors in assisted reproductive medicine freely adjust their values according to shifts in culture. One example is the growing diversity in patients being served. While the original demographic of IVF used to be wealthy, white, heterosexual, married women, now there is an increasing patient mix in regards to sexuality, relationship status, socioeconomic status, and age. Now, one question that plagued me during my research is if this is the job of a doctor? It is possible to argue that as gatekeepers of sorts in their field, it most definitely is. In actuality, I believe that this can be explained by viewing infertility treatment as a market and the patients that seek a clinic’s services as consumers. As the most basic concept of economics teaches us, more demand leads to a positive response in supply, and thus the result is an expanding of the consumer base. Concerning ART research, however, the NIH’s ban on work involving human embryos and oocytes is a double-edged sword. It affects the ability to make treatment more effective for human patients. Yet, it keeps controversial experimentation at bay like the recent case I refer to in chapter three where a Chinese scientist transferred genetically-edited embryos to a woman’s womb back in November of 2018. What then can we say about these situations we hear about where the field of ART seems wildly out of control? First, we must examine the pathway by which we receive these stories, the news media. Then, we must distinguish the one from the whole. The media may faithfully keeps a watchful eye over debated scientific research, ready to report
anything the public should know. But, their tendency to sensationalize stories influences our perception of ART though many of us do not actually understand what goes on in a lab or clinic. It is easy to take one story and paint a broad stroke over the entire field. After all, these stories are part of what drew me to my thesis topic. Yet, my time doing thesis research has shown me that these one-off reports do not accurately portray ART in its totality. We can acknowledge the people who cross society’s ethical boundaries and rightfully call for accountability and prevention. But, we almost must respect the people who have dedicated their careers to ART and have entrusted their hope among other things in it. Though we, the general public, have the right to opinion, we also must consider our stake in all of this as those largely unaffected.

My research methodology in chapter three may cast doubts on the soundness of my findings because my ethnography relies almost entirely on interviews. Taking this into consideration, the tone of this chapter is purposely quite distinct from the first ethnographic chapter. I tried to let the characters, the three doctors who lead different IVF clinics, tell the story. The incorporations of my voice and the ultimate arguments are grounded in their opinions and personal narratives of their life’s work. Nevertheless, I acknowledge that participant-observation would have only strengthened my claims or elucidated certain themes such as the tension between patient deference and the publicly accessible success rates that legitimize the clinic. My main end I believe, to describe how the clinic interacts with and juxtaposes my primary field site, the laboratory, was fulfilled.
My individual research project cannot be divorced from the larger area of research in the lab which focuses on creating noninvasive imaging tools or techniques to better select viable embryos in the IVF process and, as a result, increase pregnancy success rates. While my experiment represents more basic research, the strong collaborative relationships that my PI has made with leaders in clinics, displays the ease to which translational research may precipitate and lead to something that can affect patient outcome in the clinic. Both private and nonprofit clinics have the ability to bridge the gap between the academic laboratory and the clinic. However, private centers are pivotal in advancing progress in ART because they work with private funding and can form relationships in the private sector with startups and other biotech companies. They pursue research projects with the intention to innovate in the area of patient outcome, so experiments that contribute to a general understanding about reproductive biology, though also important, do not fall under this category. This example of the distinction in ART research reveals that in the field there is research to two ends, aligning with the perspectives from the two field sites I focus my ethnographic research on—ART as a field of science and ART as a field of medicine. The NIH moratorium on funding for research involving human embryos and oocytes also reinforces this divide and affords power to the private ART industry. Nonprofit clinics and academic labs that do not have the same level of access to private funding cannot pursue the same research projects that a private clinic and lab can run with. Instead, as I described in earlier chapters they may work mainly with animal models or with the cells around the oocyte. But, my
PI has taken advantage of his relationship with collaborators by moving a microscope to one of the private clinics in order for lab members to work on joint projects involving human embryos and oocytes more easily. In this regard, the easier path to innovation suits my PI’s research endeavors, which is under the umbrella of biomedical engineering. A field that is built on creating and inventing to help others in the field of biology and medicine. Lastly, I further argue that this relationship that the lab has with IVF clinics is vital for the moral imaginaries of scientists. Through conversations and joint collaboration, similar moral ideas about ART transfers to the consciousness of scientists, allowing them to situate their ethical beliefs about their research and defend the utility of their work, if need be. This approach in thinking about morality in ART, prioritizing the patient and their happiness and successful outcome, echoes the clinic. Yet, because of the construction of the lab environment and research process, a sort of settled moral objectivity dominates the daily functions of scientists. A mindset that could very well lead to a slippery slope as research in the field inevitably advances.

Returning back to the discussion on the clinic in chapter three, though I acknowledge the for-profit business angle of the private clinic, even mentioning how competition drives a demand for novel and innovative services that may be ethically questionable, I mainly portray the private clinic as a major player necessary for progress in the field of ART at least in the United States. So, what other issues stem from private IVF centers? While my initial hypothesis made strong postulates that the embryo was being abstracted from human sentiment, aligning with Marxist theory, I ultimately found that the commodification of ART
although present does not strip the embryo of its humanity in the clinic, but it has created an interesting balance between consumerism and medical treatment in patient care. Further research focused on private IVF centers would be crucial in elucidating how their business runs and the effect on the clinic and lab’s goals. Though I suspect that profit may be a larger issue than was found in my research, I am skeptical of that private clinics will lose their power anytime soon. Not only are the private organizations necessary in response to the federal moratorium, but our current healthcare system in the United States has encouraged the privatization of medicine in general. Thus, a booming private IVF industry with clinics and startups created by scientists like my PI is the norm.

My research into the everyday moral thinking of scientists truly was eye-opening in what it confirmed and challenged about those who develop ART. While I learned much about the internal occurrences in the laboratory, through the relationships with IVF clinics, I was able to also illuminate the morality of the medical perspective. Ultimately, I learned that in considering the ethical status of the embryo, factors such as funding, research methodology, and government as well as public oversight were quite powerful, structural forces on the individuals in this field.
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