INTRODUCTION Relatively Biological

Thirty-five years after its initial success as a form of technologically assisted human reproduction, and five million miracle babies later, in vitro fertilization (IVF) confronts us with a paradoxical legacy. Since its controversial clinical debut in 1978, IVF has rapidly become more routine and familiar, while at the same time also becoming, as Alice might have said, "curiouser and curiouser." Conception in vitro is now a normal fact of life, yet having passed through the looking glass of IVF, neither human reproduction nor reproductive biology look quite the same. Among other things, human conception can now be looked at—and not only through the microscope. The moment of conception can be viewed on the Internet; it is depicted in films and advertisements, and shown on the evening news. It can be downloaded in 3D from YouTube. This technologization of reproduction is both ordinary and curious. These images reflect the desire to know and understand that is conveyed in the normal meaning of "curious," but it is equally curious in the sense of surprising and unusual, that such images are ordinary at all. What does it mean that IVF has become a looking glass through which we see ourselves? What kind of view is on offer in the technological reproduction of human conception as a public spectacle? What species of technology is IVF? After all, it is not just a means of looking, or a spectacle—the point of IVF is to produce a new human being.

In reflecting upon the meaning of life after IVF, we must also consider the life of IVF—a technology that has had a complex evolution out of the study of natural history and the life sciences into clinical practice, and which is now intimately interrelated with the horizon industries of regenerative medicine and stem cell science. From an experimental research technique used in embryology, IVF has evolved into a global technological platform, used for a wide

variety of applications, from genetic diagnosis and livestock breeding to cloning and stem cell research. One way to view the history of IVF is as a basic technique that has circulated through science, medicine, and agriculture as part of an increasingly complex tool kit for the control of mammalian reproduction. From this point of view, the history of IVF is that of a stem technology that has become ever more thickly imbricated in the remaking of the biological that so distinctly characterized the twentieth century—a model technique for remaking life.

As such, IVF is also a lens or window onto the history of the process Evelyn Fox Keller (2002) describes as "making sense of life"—a process that, like IVF, has also become "curiouser and curiouser" over time. As Jane Maienschein (2003) argues, IVF has changed scientific understandings of what life is—a question that never had a particularly clear answer to begin with. Some of the earliest attempts to induce fertilization in glass, such as those carried out in the late nineteenth century by Jacques Loeb in sea urchins, were precisely designed not only to control life, but to redefine it. Loeb's discovery that eggs could be experimentally activated without sperm, by chemically inducing development in vitro, was explicitly intended to confirm a new definition of life as mechanical, and thus reengineerable. As Maienschein points out, for Loeb, his manipulations were life, and thus "called into question what we mean by a life" (2003: 79). And as Evelyn Fox Keller similarly observes, this process has continued to dissolve its object precisely through the attempt to clarify its particularity, to define its principles, and to characterize its specificity. As Keller notes, the effort to define what life is began only two centuries ago with Jean-Baptiste Lamarck's call for a "true definition of life" that did not rely upon classifying things that are alive, but could determine what life is, or its "essence." As Keller notes, "By far the most interesting feature of the quest for the defining essence of life, and surely its greatest peculiarity, is that even while focussing attention on the boundary between living and nonliving, emphasizing both the clarity and importance of that divide, this quest for life's essence simultaneously works toward its dissolution" (2002: 292). As Keller argues further, the "peculiar" process of defining life in the twenty-first century has cycled right back around to its pre-Lamarckian, late eighteenth-century form in the context of projects such as synthetic biology, which are aimed to demonstrate that the border between life and nonlife is entirely porous—and that life can be built from scratch from inorganic compounds. In a sense, this has already occurred in the form of synthetic chemistry, also known as organic synthesis, through which organic compounds are manufactured out of inorganic components. The meaning of the word "synthesize" to

describe "making" derives from chemistry, and has equally significant implications for the meaning of "organic" in biology today.

The "greatest peculiarity," as Keller (2002) describes it, in the history of defining life is precisely replicated by IVF, which has been one of the key research techniques involved in the characterization of life's defining properties in the past, and continues to shake them up in the present. Like Loeb in the nineteenth century, Shinya Yamanaka and his team in Kyoto discovered a means of chemically reactivating cellular potency using only four transcription factors to force differentiated mammalian cells back into their predifferentiated state—a process that is akin to making a viable developing embryo without either sperm or egg. They succeeded in mice in 2006 and in human cells in 2007, and this cell type—induced pluripotent stem (iPS) cells—has itself now become a new technological platform for basic research into the precise mechanisms of cellular development (Takahashi and Yamanaka 2006). This "going forward by going backward" biology is typical of the twentieth-century discoveries that employed in vitro models and techniques to explore the process of biological development only to "dissolve," as Keller puts it, the very concepts being explored (such as cellular differentiation).

Another peculiarity of this process involves the use of tools to remake biology—also a boundary that has been repeatedly breached in the attempt to define what life is, especially now that biology is itself increasingly understood as a technology—and thus as something that can be made. That biology has become a technology is not a metaphoric description: to make iPS cells, viruses are used to transport the required genes, and the genes, or factors, themselves become tools in the process of forcing a cell to reorganize itself. Indeed, the use of biological bits and pieces as tools to reengineer other biological systems is so ubiquitous in biology it is completely normal to think of biology as a technology in this sense.[1] But here too we come to another "curiouser and curiouser" moment, as this also means that technology is becoming more "biologized." And what might be considered particularly peculiar about IVF is that it not only models this process, and reproduces it, but makes new human beings too—and perfectly normal ones, at that. In vitro fertilization is at once a technique, a model, an imitation of a biological process, a synthetic process, a scientific research method, an agricultural tool, and a means of human reproduction—of making life. It is an experimental model system with more than one life of its own. Consequently, one way to think about IVF is that it is less easy to understand than it may seem—or that it makes a very curious kind of sense.

This thought is the basis for this book, which does not so much track the

history of IVF, or analyze its present, as attempt to make a different kind of sense of this technique both in and of itself and as part of a wider process through which the biological has become a more explicitly relative condition. I describe this as the emergence of biological relativity, which is explored in this book from the point of view of IVF, using this technique as a lens to consider what it means not only to understand biology as a technology, but technology as biological. I suggest that the dissolution of the biological and the technical has implications that go far beyond the questions raised by IVF itself, but that IVF offers a unique perspective from which some of these implications can be observed—a looking glass, of sorts (figure Intro.1). My aim in this book is to focus this looking glass not so much by following IVF around as by holding it still—using it as a dish model of itself, changing the filters, the depth of field, and the background light.

In vitro fertilization both recapitulates and personalizes a wider process through which biology is not only denaturalized but "cultured up." While continuing to function as an experimental tool, IVF technology is embedded in a naturalized and normalized logic of kinship, parenthood, and reproduction: it is pursued in the hope of alleviating childlessness. It has come to be viewed as normal and natural in the same way that most technologies that become highly popular and successful are quickly taken for granted (indeed, this is how revolutionary technologies are now defined).[2] But this too is a curious process—the way technology becomes, in Raymond Williams's terms, a cultural form—often associated with new social and institutional norms, and thus routinized. Williams urges us to read technological change neither as an inevitable process of historical invention nor as a response to human needs, but "in terms of its place in an existing social formation" (1990: 12)—taking into account both the intentions that produced it and its changing role as it evolves over time. In this way he challenges the "sterile" opposition between the view of technology as either determined by human intention, or determining it—as either a cause or an effect. Instead he urges us to understand both the causes and the effects of technologies as component parts of larger wholes, within which technology is not, in his words, "isolated" as a "self-acting force" (Williams 1990: 6) but belongs to a "complex" of a specific kind (25).

In this book, I try to read IVF in this way—as a complex or matrix of a particular kind. My concern is not only to read IVF as a technologization of biology, or as a biological technology, but as a case study that asks us to consider in more depth how this particular technology works, exactly. The first thesis of this book is that IVF constitutes a most unusual technology that works in a

FIGURE INTRO.1. Sir John Tenniel's illustration of Alice's looking glass, or speculum: "Then she began looking about, and noticed that what could be seen from the old room was quite common and uninteresting, but that all the rest was as different as possible. For instance, the pictures on the wall next to the fire seemed to be alive." Lewis Carroll, *Through the Looking Glass* (1871).

most unusual way—so much so that its own workings reveal a looking-glass view on both biology and technology in general, as well as the evolving relationship between them. The second thesis of this book is that it is the very obviousness of how IVF works that makes it a useful case study, because by looking through it differently, we can see what is not obvious about its workings at all. And in this way, we can perhaps arrive at a different set of starting points to ask questions about the evolving relationship between biology and technology—and more specifically between reproductive technology and the future of kinship.

Williams's point returns us to the question of how IVF has become more routine, more naturalized and normalized, more regular and even quotidian or ordinary. To begin with, IVF is a technique that replicates a well-known biological process, namely fertilization, and confirms the ability to simulate this process technologically. It is thus doubly reproductive: it successfully reproduces reproduction, and its reproductive success biologically is what confirms, or proves, that it works technologically. Representations of IVF typically reproduce, and condense, familiar narratives—from the naturalness of reproduction and the universal desire for parenthood to the value of scientific progress and the benefits of medical assistance—and the success of IVF is in turn offered as proof, or evidence, of how these logics fit together. As Foucault might have observed, IVF is normal because it already belongs to techniques of normalization—including, among others, those of marriage, kinship, gender, scientific progress, experimental embryology, livestock breeding, baby showers, consumer culture, and medical technology, not to mention Hollywood cinema, *Sex and the City*, Brangelina, and Mumsnet.com. But as Foucault also might have noted, this is what is useful about IVF as the condensed epistemic point of the many intersecting strands that make its logic seem so obvious and normal.

Primary among the norms IVF reproduces is a dominant kinship pattern, the logic of which IVF recapitulates exactly in its emphasis on the biological fertilization of two gametes in glass. However, this marriage of cells now exists in two forms as a result of IVF—the one occurring in vivo, and the other in glass. In vitro fertilization thus allows a new method of conception to be slotted in, as it were, to an older pattern by "marrying up" a biological model of sexual reproduction with a biologically based system of descent and family formation. The normalization of IVF, as Charis Thompson points out, is a "hybrid culturing" (2005: 115) that allows new technology to coevolve with existing sexual, gender, and kinship norms, adding a degree of flexibility to the reproduction of reproduction, while largely keeping the structure of bilateral,

biological kinship norms intact. Yet it is because this logic is recursive, in the sense of the "strange folding" of repetition, or the "turning back" of meanings onto themselves, that this reproduction is not exact, but rather, as I am calling it here, curious.

The manner in which IVF is embedded in, and is seemingly evidence for, the normalizing systems it both relies upon for its success and reproduces through its workings, is precisely where we encounter the curiouser side of IVF. Indeed, these two sides of IVF—how it is both normal and not—help to explain why the experience of undergoing it remains so paradoxical and ambivalent, despite the apparent obviousness of why IVF came into being to begin with. The more peculiar aspects of IVF very quickly become obvious to anyone commencing an IVF program, or entering what many women I interviewed for my first book on IVF described as the "intense" and "traumatic" world of IVF treatment (Franklin 1997: 11). Once inside this topsy-turvy world, a very different logic of IVF becomes visible, which is neither as normal nor as self-evident as that available from the other side of the door into the assisted conception clinic. Here, as for Alice, nothing is normal at all. In vitro fertilization is not a simple process of steps leading to potential success—it is a confusing and stressful world of disjointed temporalities, jangled emotions, difficult decisions, unfamiliar procedures, medical jargon, and metabolic chaos. You have to believe you will succeed even though you will probably fail, and the terms on which you reach either end point to treatment are constantly changing. As in the context of amniocentesis, another form of high-tech reproductive roulette, where negative results are positive, the experience of IVF is full of ironies. It is a complex and daunting medical procedure that requires a high level of compliance and commitment, as well as time and resources. Even people who succeed in the effort to achieve a take-home baby are often left disoriented and changed by their experience of undergoing IVF. Some will wish they never attempted it to begin with, and others will try again and again until they either succeed or give up (Throsby 2004). Few people go through IVF, in other words, without experiencing, either temporarily or permanently, and to a greater or lesser extent, a degree of ambivalence about this procedure—a view that is widely shared by IVF clinicians and nurses, who know better than anyone the potentially high costs of IVF. This ambivalence indexes the difference between the norms that IVF belongs to, and the extent to which it also challenges or contradicts these very same conventions.

The ambivalence that characterizes the IVF encounter, while specific in its form to IVF treatment, is also more generic, and I refer to it throughout

this book as "technological ambivalence," arguing that it is a constitutive component of biological relativity. As many social theorists have noted, such as Ulrich Beck (1992), ambivalence is one of the defining characteristics of the modern relationship to technology—be it television or e-mail, robotics or biotechnology, electric kettles or plastic bags. In vitro fertilization offers a useful perspective on this ambivalence because it is generated out of a context that, like IVF itself, is becoming much more routine—namely that of managing our biological relations to technology in the context of remaking life. This is why IVF provides a useful lens on the wider condition I am describing as biological relativity—because IVF is not only typical, but arguably prototypical of this condition and its corresponding ambivalences. The topsy-turvy world of IVF, in all its both obvious and not-so-obvious complexity, and precisely in its normality, thus offers us a looking glass into a looking-glass world, a model system of a model system, and a vivid picture of the retooling of reproductive substance. The very recursion that makes IVF confusing—that it both is and is not like what it imitates—is what makes it a useful hermeneutical apparatus for understanding "the age of biology."

However, I also argue that the ambivalence so profoundly associated with the technique of IVF, while derivative in part of its role as a modern, synthetic, high-tech procedure, also references older questions of sex, gender, and kinship—which IVF may help us to appreciate more explicitly. In other words, IVF not only offers a perspective on the ambivalence associated with modern technology, such as that described by Beck, but on older structures of sociality, including marriage and kinship. The fact that the normalization of IVF has not diminished the ambivalence felt by many who undergo it arguably tells us something about norms and norming themselves—namely that these too are reproductive technologies that engender deeply contradictory feelings. As Michael Peletz notes in his insightful discussion of ambivalence ("the simultaneous experience of powerful, contradictory emotions or attitudes toward a single phenomenon," as he defines it), anthropologists "have devoted scant attention not only to the myriad sources of ambivalence but also to their implications for an understanding of structure and agency as well as critically important processes of sociality, domination, and resistance" (2001: 414). This book takes up Peletz's challenge to examine "ambivalence as such" as a point of "frequently overlooked continuity between the old and new kinship studies" (2001: 414) in the context of being "after IVF."

This is also why this book attempts to integrate several different kinds of thinking about biology and technology into a conversation about IVF that may at times appear to stray rather far from its object. As noted above, to under-

stand the workings of IVF not only as a technology, but as a complex or cultural form—including its past, its coming into being, the history of its recent present, and its evolution and dissemination, as well as its future—requires an account of how it works in and through other systems. This includes other technologies—such as technologies of kinship as well as clinical equipment, and technologies of sex as well as the medium of the Internet. Similarly, such a conversation has to ask what "technology" means, as well as what it means to have become "biologically relative." There is obviously a limit to how far such a project can go in a single volume, so in truth this book only outlines one way to approach these questions. However, insofar as it successfully describes and illustrates the recognizable outlines of a problematic, it will have succeeded at the very least in its aim of opening a door to a different kind of conversation, not only about IVF but about "the question concerning technology" and its new kinship with "the question concerning biology." These questions centrally concern the embodiment of technology, and the ambivalence that accompanies its normalization.

This is a conversation that has already been very substantially developed in some areas of social theory, for example in the anthropological debate about technologies of kinship, and in the feminist debate about technologies of gender, as well as in the responses to Foucault's account of sex as a technology. I also draw attention to the extent to which Marx's and Engels's models of technology were suffused with analogies to organicism and biology, and to their account of the relation between hand and tool. This book is an attempt to retheorize reproduction, as well as reproductive technology, and I have given prominence to feminist debates on both of these topics, as well as to feminist science studies, drawing in particular on the work of Donna Haraway (1976, 1997). Returning to the idiom of the frontier that I explored in my previous book on cloning, *Dolly Mixtures* (Franklin 2007b), I attempt to examine the role of "pioneering" in the context of experimental embryology, and to contrast this to the model of "moral pioneering" developed by Rayna Rapp (1999) in the context of contemporary reproductive biomedicine. I explore the ambivalence of the frontier—a place of oscillation, fluctuation, and instability—toward the close of the book in relation to the artwork of a photographer in residence in the assisted conception unit (ACU) where I have worked for the past ten years, as a way of returning to the question of embodying technology that I argue IVF poses in a distinctly equivocal manner.

As in my previous work, this book relies on close collaboration with scientists and clinicians working in the fields of IVF, stem cell research, and regenerative medicine, as well as patients undergoing various procedures,

or active in patient support groups. Although this book is not traditionally ethnographic, it draws on fieldwork in clinics and labs, and the expertise of scientists who took the time to introduce me to their technical working methods. The analysis I offer of the visual cultures of IVF, human embryonic stem cell derivation methods, and micromanipulation of embryos has benefited from the enormous ease with which it is now possible to record fieldwork exchanges using a handheld video camera. In turn, this allows for a much richer analysis of biology in the making, some examples of which I have included in this book, particularly concerning the precise techniques of culturing and passaging human embryonic cell lines.[3]

As a result of its own somewhat eccentric "passaging techniques," this book is composed of a series of loosely interconnected chapters that attempt to make sense of the social, cultural, and technological legacies of IVF through a series of interpretive frames that both overlap and diverge. Throughout, I analyze IVF as a bridge to both new life and new kinds of life, and as a lens through which to depict changes in the meaning of biology, technology, and kinship. To do this I analyze reproductive substance as technology, but also technology as a reproductive substance, and more broadly the merging of the biological and the technical that are substantialized in, through, and as IVF. The mixing together of these perspectives in this book—a bit like the fusion of biology and technology it describes—is less a properly developed narrative analysis than a thought experiment in the form of a mosaic. The aim is to characterize the condition of being after IVF.

That mosaics are also embryonic tools ("fusion embryos"[4]) is apt because a major question this book asks is what it means that IVF has enabled a retooling of human reproductive substance. Ordinarily, technology might be imagined as something humans make in order to achieve desired ends: it is traditionally defined as the application of science. However, many of the most influential theorists of technology have argued that technological equipment and agency are a form of inheritance—indeed of inherited substance—as much as a means of altering the conditions of human existence in the present or the future. This is a similar, though inverted, form of the argument from kinship theory that institutions such as monarchies are technologies—indeed reproductive technologies—aimed at the controlled passaging of human substance over time and controlling the order of succession. The lineages of technology bequeathed from the past are far more numerous and formative than are the novel contemporary technologies most prominently associated with contemporary social change or impact—such as those associated with stem cell science, cloning, or reproductive biomedicine. If we consider the tech-

nologies of agriculture or domestication, for example, not to mention electricity or antibiotics (and this list could be rather long), we can see that they are already so much a part of who we are that we often do not even notice them, their pervasive structuring effects as invisible as grammar (language also being among the most important human technologies). Heidegger, for example, in *The Question Concerning Technology*, employed the Greek meaning of the word *techne* as a form of exposition or demonstration: "It is as revealing, and not as manufacturing, that *techne* is a bringing-forth" (1993: 319). Similarly, in "Building, Dwelling, Thinking," Heidegger argues that tools and technologies are the means by which the world becomes "enframed" for its inhabitants, shaping the "basic character" of Being or existence (1993: 350). This equipment, with and in which we live, is both inherited and formative, shaping both how we know and "do" the world. Jacques Derrida (1974), following the paleoethnologist André Leroi-Gourhan, more radically describes "man" or "anthropos" as rooted in an "originary technicity"—a position recently interpreted by Vicki Kirby (2011) as one that might also allow for a view of "life itself" as technics. Bruno Latour (1993) has described all identities as conjunctions, hybrids, and assemblages—as consubstantial "devices." Or, as Donna Haraway puts it more vividly, "chimeras of humans and nonhumans, machines and organisms, subjects and objects, are the obligatory passage points, the embodiments and articulations, through which travelers must pass to get much of anywhere in the world" (1997: 43). We do not need cellular technologies to evince for us that technology is cellular. How we have coevolved with technology is both an obvious and an unfolding question: as Williams (1990) so wisely noted, it is the very obviousness of this question that makes it so difficult to analyze.

As well as reframing technology, this book also seeks to reframe some of the arguments concerning "technological reproduction" from within the history of social theory. For example, with the benefit of hindsight, I argue it is possible to read Marx's accounts of machines and technology as more "morphogenetic" than perhaps even he intended. Marx repeatedly argued that the origins of modern technology are not to be found in the engineering genius of great inventors such as James Watt, whose name is now enshrined on every lightbulb for the eponymous energy source by which you may be reading this book. Although Marx's endorsement of the value of modern technology is often opposed to Heidegger's concern with its dehumanizing legacies, the chief argument of much of Marx's work is that technological innovation is the product of history, not its material progenitor. The equipment of the Industrial Revolution, he argues, comes into being as a result of political

and economic conditions, not the other way around. He situates the evolution of machines such as the self-acting mule jenny in the context of the social apparatus that provided the conditions of their production, or brought them into existence, such as the division of labor and the fetishization of commodities. In both Marx's and Engels's writings, the actual equipment used in industries such as agriculture is not only an inherited condition of human existence, but a crucial force in molding the human species being.

As Marx wrote in Volume 1 of *Capital*, the human body itself is a product as much as a means of the labor process: "Labour is, in the first place, a process in which both man and Nature participate, and in which man of his own accord starts, regulates, and controls the material re-actions between himself and Nature. He opposes himself to Nature as one of her own forces, setting in motion arms and leg, head and hands, the natural forces of his body, in order to appropriate Nature's productions in a form adapted to his own wants. By thus acting on the external world and changing it, he at the same time changes his own nature" (MECW, Vol. 35, *Capital*, Vol. 1, Book 1, C 7, section 1). Marx understood the history of both technology and the division of labor not only in terms of how people used their bodies to do things, but in how they adapted themselves to the physical conditions of production and were transformed by them. He also emphasized the sociality of bodies—their crucial interconnections with other bodies, and not only human ones. Both animals and tools were understood as crucial components of a systematic mode of production that was, in the case of industrial production, highly organized, and even to a certain extent symbiotic (e.g., clover = nitrogen = fodder = cattle = proletariat = surplus value = commodity = finance, etc.). As this book suggests, Marx's model of the human-tool-machine relation was vividly biological. His picture of human thought and action is of a process of *substantialization* through which the human is molded not only by the inherited, "given" (or "standing," as Heidegger would have it) conditions of equipment of any historical moment but by being continually reconditioned by the evolution of this equipment, much as, for example, the laborer must continually adapt to new mechanical conditions of production. His depiction of the evolution of machine technology is deeply infused with the conceptual apparatus of organicism and biological development that became increasingly prominent during his lifetime.

The evolution of technological equipment is complemented by Marx and Engels's view of the human as technological. This too presupposed a merging of biology and tool, and is described in Bernard Stiegler's (1998) reading of Marx as a new theory of life as much as of technology. The evolution of the

human hand into tools, and later into technological systems, such as factory production, is central to Marx's dialectical theory of machines and mechanization, often invoking Darwin's model of natural history (despite Marx's and Engels's critiques of Darwin as an apologist for industrial capitalism, they borrowed from his models of selection and adaptation to describe technology). Similarly, Marx and Engels depicted the natural and physical world as a tool kit made available for human use, and transformed by these uses into a "second nature" (Smith and O'Keefe 1980). To his tool kit, Marx added the legal, economic, and bureaucratic technologies through which the mode of production is organized and maintained. These too, he argued, provided the essential devices and mechanisms necessary for the machinery of industrial capitalism to develop, to grow, and to reproduce itself.

From this point of view, the traditional definition of a tool as a means, or device, that is given purpose by its user is not fully adequate—because, as both Marx and Engels argued, the significance of tools cannot be measured by their function alone. Tools, and the evolution of technology, must be understood as both inherited equipment and as the molding conditions of human existence, constantly reshaping what the human is by what it can do, in a dialectical process that extends beyond historical time into the mists of human species emergence. More than this, tools are never merely instrumental: as Heidegger insisted, they belong to the history of thought, and as Marx also argued, tools are the offspring of imagined worlds as much as actual ones. Tools are substantialized concepts.

As Donna Haraway (1997: 52) has argued, the context of contemporary biotechnological production is not only one that is defined by fusions of tools, concepts, and biological substances in the form of "living tools," but one in which biological relations are "corporealized" as both a conversion of nature into technique and an implosion of material and semiotic technologies as new kinships and kinds. The transgenic mouse model, she argues, is the product of a "recursive miming" that positions humans and nonhumans as biotechnological kin to one another—the materiality of their genomes "simultaneously semiotic, institutional, machinic, organic, and biochemical" (Haraway 1997: 99). The mouse model is an "instrument built to be engaged, inhabited, lived . . . and so building particular worlds rather than others" (135–136), and thus part of "the circulatory systems that constitute kinship—replete with all of its transhybridities" (134). To the extent that molecular biology is premised on the trope of rewriting biology, its genealogy simultaneously reconfigures the future of "biological" kinship as a set of relationships not only to, and through, but of, technology.

This brings us back to our central question, which is how to evaluate the significance of the fact that humans are now making tools out of reproductive substance, including our own. A question raised by the rapid evolution of IVF technology over the past half century, and in particular its new interface with stem cell research, is what it means to consider not only reproductive substance as a technology, but technology as a reproductive substance, as new biological relations and relativities are literally being made by hand, often using handmade tools. Arguably we are not particularly well prepared to address this question by either Marx or Heidegger, or many other theorists of technology, who have not provided many theoretical resources for analyzing either reproduction or reproductive substance. Indeed it could be said we need some new conceptual tools to describe the human conceptus as a tool.

Conventionally, reproduction has been understood in two distinct senses—as a process of social replacement (as in the reproduction of labor power), and as a biological process (as in sexual reproduction). Somewhat confusingly, reproduction is itself a term derived from manufacturing to refer to copying. This is the exact opposite of what it has meant in the context of biology, where sexual reproduction is precisely not the same thing as copying, or asexual reproduction, also known as cloning. This confusion is compounded by others, and also by a general neglect of the importance of what Marx called the "mode of reproduction" or the sexual division of labor. Indeed, throughout Marx's work the former is imagined to be largely explained by the latter. However, from the late twentieth century onward it has been increasingly evident that not only is sexual reproduction a process that can be dramatically reshaped by technology (which is what the phrase "artificial reproduction" means), but that it can be used as a technology (e.g., to produce new life forms, such as transgenic organisms). What IVF very publicly introduces is a form of technological transfer, or passaging, by which the technologization of biological substance becomes a mode of reproduction—including (and often uniting) not only sexual but also animal, human, digital, informatic, virtual, and mechanical reproduction. Put bluntly, the increasing control of biological reproduction "artificially" is one of the major technological advances of the twentieth century, and yet one that has only recently begun to be theorized (particularly in the work of Haraway). In vitro fertilization is the means by which this new form of technological control has been transferred into the human, thus confirming not only a new means of establishing a pregnancy but a new role for technology in making life.

One of the most helpful models for addressing the contemporary "engineering ideal" of biology (Pauly 1987), or the process of "culturing life" (Lan-

decker 2007), is that described in Adele Clarke's (1998) account of "disciplining reproduction." As Clarke notes, "the reproductive sciences have themselves been marginalized, and their centrality to the overall project of controlling life has thereby been comparatively ignored," despite the fact, as she was among the first to point out, that it is "the reproductive sciences that have to date facilitated not only control over reproduction but control over heredity, and hence over life itself" (1998: 276).[5] The control of reproductive substance through technologies of selective breeding is, after all, as old as agriculture while also more central than ever today to the production, for example, of new cell factories. During the nineteenth century, modern agricultural methods of selective breeding began to be introduced by figures such as Robert Bakewell, who carefully "disciplined" the reproductive substance of his livestock in order to increase their economic value, using methods such as in-and-in breeding among close biological relatives to "fix" desirable traits—a process that relied, as Harriet Ritvo (1987) has shown, on new forms of standardizing animals, as well as new means of calculating their fitness, documenting their reproductive performance, and devising new financial instruments to market their "genetic capital." Lineages of breed records, as well as still-existing Bakewell breeds (such as the Dishley Leicester sheep) continue this instrumental legacy (and have themselves now become valuable commodities). Selective breeding, which substantializes a concept in the form of a technique applied to animal reproduction (i.e., in-and-in mate selection to concentrate desirable traits), relies on a fusion of biology and technique to achieve the "disciplining" of reproduction (Clarke 1998). The same basic principle applies today at the most advanced levels of cellular reengineering, where both conceptualities and conceptions are being reconceived, remixed, and rewritten.

A different technology was invented in the nineteenth century to describe the organization of human reproductive substance—and the disciplining of reproductive outcomes—namely, the concept of kinship. In the work of Darwin, as both Gillian Beer (1983) and Marilyn Strathern (1992a) have shown, the idiom of kinship performed a function of translation—importing the aristocratic technology of pedigree into natural history to ground a new theory of the biological relatedness of all organic life through shared descent—that is, through shared reproductive substance. It was by this very means, Foucault argues, that a new definition of life, as a natural system, acquired an organic and conceptual unity and gave rise to the modern scientific discipline of biology (Foucault 1973). Once it became lawlike and systemic, Foucault argues, biology also came to be understood as a new apparatus of social and political

control, at both the individual and the species level—inaugurating what Foucault describes as biopower. This is the same "reproductive model" that gave birth to human IVF—just over a century after Darwin's reinvention of natural history (via kinship) as a system of interrelated, metamorphic, biological relations (evolution). Like Darwin's model of evolution, IVF models kin connections in a double sense: it introduces new kinds of biological relatives, as well as new models of biological relatedness.[6] This doubling effect of IVF is one of the main themes to which this book returns because it replicates a wider process I describe as "biological relativity," through which biology now exists as a more explicitly contingent, or relative, condition. One of the most striking features of IVF is how quickly and thoroughly the explicit technologization of reproductive substance it makes so graphically visible, and the radical new models of biological relativity it introduces, have been naturalized and commercialized.

One reason for the rapid adoption of IVF technology is, of course, that biological relativity is not so new. As Bruno Latour argues, the critical power of moderns is the ability to reverse their principles without acknowledging contradiction. How convenient it is, he notes, that "in spite of its transcendence, Nature remains mobilizable, humanizable, socializable" (Latour 1993: 37). The same is true of beliefs about biology, kinship, and shared reproductive substance—all of which are characterized by enormous flexibility in spite of often being tied to deterministic models. As Janet Carsten has argued, the term "substance" has an enormous and varied range of meanings, covering a full three pages in the *Oxford English Dictionary*. She reduces these to four broad categories: "vital part or essence; separate distinct thing; that which underlies phenomena; and corporeal matter" (Carsten 2001: 29). While on the one hand, Carsten surmises, the highly varied meanings of "substance" may be one of the reasons it is "good to think with," this breadth has also introduced analytic confusion. For example, a "blood tie" is imagined to be at once a physical and a symbolic connection. That blood is one of the only substances that does not perfuse through the placental membrane, and in that sense is never "shared," has not inhibited its widespread use as an idiom of consanguinity—or blood relatedness. But what are blood relations? Traditionally, and in a Euro-American context, these would be described as kinship relations that are defined not only in terms of what they "are" but what they "code for" in the form of conduct, obligations, and roles (Schneider 1968). As Carsten notes, however, such a definition both confuses and conflates two very different meanings of substance—as symbol and essence. This conflation is also evident in Mary Douglas's description of blood as a "natural sym-

bol," used in "social systems in which the image of the body is used in different ways to reflect and enhance each person's experience of society" (1970: 10). A very different perspective on blood is introduced by Annemarie Mol (2002), who argues it is instrumentally conceptualized in ways that give this substance different meanings in terms of how it is "done" through various techniques—for example, in the context of disease. In her view, blood does not "code" as a unified corporeal matter but as a multiple one: it is neither an essential substance nor an essentialized sign, but rather comes into existence as "a separate distinct thing" entirely in relation to its specific sociotechnical milieu.

For the purposes of this book, substantialization is used much the same way as it has been in psychoanalysis, science studies, or anthropology, where similar concepts such as "sedimentation," "concretization," "somatization," or "materialization" have been employed to describe the relationships between embodiment, sociality, identity, material objects, and technology. It is the inextricability of these interwoven forces that the breadth of definitions of the word "substance" usefully both expresses and confirms. At the same time, this term is also useful for this book because it has a much more specific meaning in the context of reproduction, where the term "reproductive substance" would normally refer to gametes and embryos. Arguably, one of the most important contemporary changes in this "specific" definition of reproductive substance is that it has been vastly widened by the development of methods to cultivate the regenerative potential of almost any living cell. As the iPS cell discussed earlier confirms, regenerativity and reproductivity are increasingly blurred in the context of stem cell science (which is also what the Dolly experiment confirmed). This returns us to IVF, which today must be seen as an evolving technological platform, serving as a base for an expanding variety of human cell cultivation methods, which are in turn linked to the prospect of improved human cellular replacement and repair. Human embryonic stem cell research is a direct offspring of the evolution of the IVF platform: it was derived from the same research on early mammalian development that enabled IVF to be used in humans, and is dependent on human IVF for the supply of research embryos necessary to the refinement of its clinical applications.[7]

Both the change in the meaning of "reproductive substance" brought about through stem cell research (so that even a skin cell can become a gamete) and the future translation of new cellular potentials into applications increasingly rely on IVF in complex ways. Much of my research preceding this book was conducted in a new generation of U.K. laboratories that have been designed,

built, and custom engineered to facilitate a more efficient interface between IVF and stem cell research. The axis of these labs, both architecturally and conceptually, is a hole in the wall, or hatch, connecting them to an adjacent ACU. The direct transfer of reproductive substance—gametes and embryos—can thus be more reliably, or "cleanly," facilitated from one context to another, that is, from an IVF unit to a stem cell lab (and back and forth; see Franklin 2010b). This book begins and ends in the leading U.K. lab dedicated to the facilitation of this novel transfer of reproductive substance, at Guy's Hospital in London, where the IVF–stem cell interface offers yet another window onto the question of what kinship futures are being engendered in the context of new reproductive technologies.

The new labs connecting IVF clinics to stem cell research substantialize what it means to be after IVF not only in their architecture but through the division of labor that occurs on both sides of the hole in the wall. On one side are patients attending ACUs for a variety of procedures, including IVF. These patients may be seeking a specific reproductive goal—namely, biological offspring—but their presence in an ACU is conditioned by many other factors, and will have additional outcomes, including a potential change in what they understand by "biological reproduction." In the same way the textile industry cannot be explained by a desire for clothing, IVF is not simply a response to a desire to have children. In vitro fertilization is indexical of its modern heritage, a combined apparatus of family and gender norms, scientific research programs, legal instruments, bureaucratic procedures, technical skills, and ethical codes (and so on). Now an expanding global service sector, the IVF industry has in turn become a generative matrix for new technologies, procedures, products, and markets.[8] This matrix is also the source of new biological relations and relativities that exceed the frame of existing concepts and understandings, much as they also both rely upon and extend familiar models of biology, technology, and kinship.

These new relations and products are what are being developed through the hole in the wall (figure Intro.2), linking the stem cell lab to the ACU, through a complex series of embryo transfers (Franklin 2006a, 2006b, 2006c, 2008, 2010b; Franklin and Kaftantzi 2008). In the lab, behind air-lock doors, the complex and delicate effort to take reproductive substance "in hand" is being laboriously pursued by dedicated research teams who are attempting to translate stem cell science into new applications, such as tissue engineering, regenerative medicine, and diagnostics. Here, the sophisticated handiwork of top-notch embryologists is not only yielding new life lines of cleanly cultivated cells for a wide variety of uses, but new templates for semiautomated

production of cellular products as this field scales up toward biomanufacturing. Similarly, at the UK Stem Cell Bank, which is the hub of a national network of stem cell researchers, the basic guidelines and standards for cultivation, storage, transport, handling, and banking of human embryonic stem cells are being refined, along with the code of practice governing their legal and ethical status (Franklin et al. 2008; Franklin and Kaufman 2009). These new standards comprise the most elaborate quality management protocols ever written for reproductive substance. They are the equivalent in the contemporary biological sciences of Greenwich Mean Time.

The hole in the wall thus offers a window onto a new mode of reproduction, or perhaps a two-way mirror (figure Intro.3). Through it, human reproductive substance is being "shared" in a way that enables an IVF embryo to become a tool that is embedded in a new set of codes for conduct. These codes of practice govern not only what happens to embryos, but the relationships that are established through them, thus establishing a novel system based on the exchange of reproductive substance. This new system of embryo transfer and human cell-based translation is an essential part of the equipment used to transform reproductive substance and to make it become differently productive—that is, to become pluripotent in order to be able to redirect cells to new commercial and therapeutic purposes. It is thus also here, in the interstices of codes and substance, that the meaning of "biological relations," and indeed of "biological relatives," is newly problematized, and it is this contemporary matrix that is the subject of this book.

Technologies of Sex

A crucial resource in the effort to understand the retooling of the human embryo is another twentieth-century invention, namely the analysis of sex as a technology. The phrase "technologies of sex" was introduced by Michel Foucault at more or less the same time human IVF was perfected in the 1970s.[9] Like Marx, however, Foucault used a relatively narrow model of reproduction in his highly influential work on both the history of the human sciences and the birth of biopower through the technologization of sex. His work provided crucial new understandings of what is meant by technology, primarily through his discussions of the relationship between knowledge and power as a technological one. As he pointed out, the discourses of sex with which he was concerned composed a "strangely muddled zone" with only a "fictitious" relation to reproductive physiology (Foucault 1990: 54–55).[10]

The significance of technologies of sex for understanding both reproduc-

FIGURE INTRO.2. The hole in the wall between the IVF clinic and the stem cell laboratory enables the passage, or transfer, of eggs and embryos back and forth between two contexts of "remaking life." Photo by the author, published with permission of the Guy's stem cell team.

tion and reproductive technology was pursued more directly within feminist scholarship in the 1980s. Building both on Marxist approaches and on the work of earlier feminists, such as Simone de Beauvoir, Ruth Herschberger, and Shulamith Firestone, the phrase "technologies of sex" took on new meanings, in particular through the work of Teresa de Lauretis (1987) and Judith Butler (1990). New models of sex, gender, and reproduction began to emerge from within feminist anthropology, elaborating Gayle Rubin's (1975) concept of "the sex/gender system" or what Shulamith Firestone (1972) before her had called "the political economy of sex." The critique of the categories "woman" and "female" repositioned the global biologism of a naturalized, a priori presumption of an automatic sexual "base" to human social arrangements as itself an artifact of the system it allegedly explained.

Anthropologists such as Marilyn Strathern were among the first to begin to apply these insights specifically to IVF. Somewhat ironically, Strathern (1992a, 1992b) pointed out, IVF explicitly artificialized the very facts of life that were formerly imagined to ground the natural origins of gender and sex: these facts

FIGURE INTRO.3. A view of the IVF interface where the director of the Assisted Conception Clinic, Professor Peter Braude, explains the way that eggs will travel from a "dirty" IVF surgery into a clean room. Photo by the author, published with permission of the Guy's stem cell team.

were rendered contingent, or relativized, by the very technology developed to "assist" them. By replicating "natural" conception, IVF itself became a new technology of sex—oddly and exactly paralleling the feminist argument that it is technologies of sex and gender that produce the effect of naturalized origins, rather than biology. For the same reason, the new assisted conception techniques "born" of the union of reproductive substance and technological innovation not only produced a new kind of biological relative but revealed a new condition of biological relativity, through which nature and artifice became interchangeable. Intended to enable a couple to reproduce biological offspring, IVF and its ilk paradoxically denaturalized biological reproduction by imitating it, or "taking it in hand." The fertilization these techniques substantialized in the form of new offspring was not only that between egg and sperm, but that between technology and biology. This fecund coupling has quickly been translated into the twenty-first-century ethos of biological engineering that now defines the fields of both genomics and synthetic biology. This is how IVF was transformed from "a bridge to new life" into a bridge to

new kinds of life. In sum, the bridge became a platform, a stage, and a launch pad by means of a translational imaginary that was animated by the prospect of future kinships not only between parent and child, but between technology and offspring. The evolving relationship between IVF and the wider context of biotechnological innovation of which it is a crucial part thus today poses new questions about the meanings of both biology and technology, as well as their relationships to both old and new technologies of gender, reproduction, and sex—all of which have become somewhat more curious.

The rapid expansion of IVF not only as a form of infertility treatment but as a technological platform, and now a vector to the biotechnology industry, is thus investigated in this book by means of the pair of related questions described at the outset of this introduction. First, how might we think about reproductive substance as a technology, and technology as a reproductive substance? And second, how can these related questions be analyzed together? As noted above, the animating technology of this book is experimental. *Biological Relatives* is organized as a series of close readings of texts and examples to offer a recursive perspective on the question of being after IVF. It is less a series of chapters than a mosaic, or complex of frames. Reading across several disciplines, I focus on the intersecting mechanics that enable the emergence of biology as a technology in the context of IVF, and I read IVF as both a model and a manifestation of this process. It is thus the role of IVF as both a working model and a model system that is at the heart of the thought experiment this book offers—which by definition is highly speculative rather than conclusive.

A result of this method and focus is that each chapter makes most sense in relation to the larger whole that emerges from their collective accumulation. While this is always true of any book, it is particularly true of this one. Much is left to the reader to infer across the chapters, which together attempt a serial reframing of a matrix that is still only barely sketched across all of them. Other books have provided much more coherent histories of IVF, including Robin Marantz Henig's (2004) *Pandora's Baby*, or Robert Edwards and Patrick Steptoe's (1980) *A Matter of Life*. Similarly, there are much better historical accounts of reproductive biology, including Adele Clarke's (1998) *Disciplining Reproduction* and Jane Maienschein's (2003) *Whose View of Life?* Neither is a contemporary portrait of IVF provided in these chapters, such as that on offer in Debora Spar's (2006) *The Baby Business*, and my aim is not to debate the ethical implications of new reproductive and genetic technologies, as has been done by Jürgen Habermas (2003), Francis Fukuyama (2002), and many others. In the long list of things this book does not do should also be mentioned that it takes a highly selective approach even to the topics it does

discuss in depth, such as the feminist debate over new reproductive technologies, the anthropology of new reproductive technologies, and the feminist literature on technologies of gender and sex. In sum, while drawing on a wide range of sources and many divergent avenues of scholarly debate, there are inevitably many obvious exclusions and oversights in the chapters that follow, and indeed within the book as a whole. It works best as an invitation to travel a particular journey in the effort to think through a particular problem, and to the extent that it achieves this aim in part by stimulating readers to identify significant resources or arguments that are inadequately presented here, I hope they will be motivated to contribute further to the general sociological problem *Biological Relatives* attempts to analyze.

This book also attempts to synthesize some of the ongoing themes in my own previous work, as I have sought to both document and theorize the emergence of new reproductive technologies including IVF (1997), embryo research (1999), preimplantation genetic diagnosis (Franklin and Roberts 2006), and cloning (2007b), as well as visual cultures of reproduction (1991, 1995, 2000). For example, it extends the analysis I developed with Celia Lury and Jackie Stacey (2000) in *Global Nature, Global Culture* of what we called "the traffic in nature," and it is a contribution to the "reconfiguration" of kinship (Franklin and McKinnon 2001) and the "remaking of life and death" (Franklin and Lock 2003b) in conference-based anthologies developed and coedited with Susan McKinnon and Margaret Lock. In places, I have returned to themes developed in these and other previous publications, such as the concept of "thick genealogies" introduced in *Dolly Mixtures* (2007) and the depiction of IVF as a "hope technology" in *Embodied Progress* (1997). Some of the ideas in this book first took shape in *Reproducing Reproduction* (Franklin and Ragoné 1999) and in *Technologies of Procreation* (Edwards et al. 1993), as well as *The Sociology of Gender* (1996). In the context of the contemporary attention to the development of IVF occasioning the award of the Nobel Prize in Physiology or Medicine to Robert Edwards in 2010, the question of how to understand its legacies has become more prominent, and *Biological Relatives* is also a contribution to that effort, organized in part as a reprise on my own long-standing interest in this technology since the mid-1980s, and more recently through collaborative work with Martin Johnson and Nick Hopwood on the British culture of mammalian developmental biology in the postwar period (Johnson et al. 2010).

To the extent that *Biological Relatives* revisits themes that were first introduced in these earlier, and ongoing, projects, some material will already be familiar to some readers, especially where certain problems have been re-

read and re-presented in order to develop the analysis further. The emphasis on close readings of key texts throughout this book is also a reproductive technology of sorts, manifesting the premise that reproduction is never an exact process, and that repetition is itself a generative mechanism. The pluricentric thought experiment that grounds this project is reflected in this book's format, which is more like a series of essays than a traditional (or even untraditional) ethnographic monograph. As noted in the afterword, a subtheme of the generative relations interconnecting practices of rereading and re-producing permeates much of the argument presented here, at the level of both substance and style.

Chapter 1, "Miracle Babies," examines IVF as a way of thinking and seeing reproduction, as well as of "taking reproductive substance in hand." It reviews, among other things, the emergence of the IVF–stem cell interface in the form of a new generation of purpose-built labs in the United Kingdom, and the public and parliamentary debate that has accompanied the introduction of a new generation of embryonic tools, most recently "human-admixed embryos," legalized in 2010. In addition, this chapter explores the condition of being after IVF and attempts to characterize how it has "become genealogical." The embeddedness of the logic of IVF in the pattern set by an earlier Industrial Revolution, also begun in the northwest of England, is combined with rereadings of both Marx and Foucault that build on those introduced above.

Chapter 2, "Living Tools," reframes the overall project of *Biological Relatives* by drawing on the work of Donna Haraway and Shulamith Firestone, as well as by visiting one of the new stem cell derivation labs that is annexed to an IVF clinic. Here we encounter stem cell science close up as it moves from being a still quasi-artisanal craft into a more mechanized and industrialized mode of reproduction. We also travel through the hole in the wall, following IVF eggs as they are "taken in hand" to become either potential offspring or living human tools. Drawing again on Marx's analysis of machines, this chapter both develops the theoretical models outlined in chapter 1 and introduces more empirical material to exemplify the general problems being examined in this book.

Chapter 3, "Embryo Pioneers," contains an episodic tour of some of the instructive scenes in the history of experimental embryology that I suggest are helpful in appreciating the long lineage of technique that is ancestral to human IVF—and to understanding the effort to "mechanize" reproductive substance, or "put it to work." In addition to extending the emphasis on technique that structures chapter 2, it provides some technical background to the birth of human IVF. The aim of this chapter is also to explore the combined

use of embryo transfer, artificial fertilization, and tissue culture in the making of what has come to be known as the "reproductive frontier" and to further explore this term. As a result, chapter 3 introduces a consideration of the work of the frontier idiom in the context of biology as technology (a theme that is developed further in chapter 7). Drawing on many of the historians who have addressed this topic far more cogently than I have, including Hannah Landecker, Scott Gilbert, and Nick Hopwood, I try to situate the history of human IVF in relation to the technological experiments and imaginaries that preceded it, conceiving of this exercise as a potted tour of various instrumental orientations that become relevant in different ways in various other places throughout this book.

Chapter 4, "Reproductive Technologies," contrasts the history of "making sex" in the context of experimental embryology and developmental biology with the "exact mechanisms" of sex and gender technologies as they began to be theorized within feminist debates in the 1980s, and in particular within feminist anthropology. This chapter offers close readings of the work of both Gayle Rubin and Marilyn Strathern, while also rereading the emergence of a model of gender as a technology. The goal of rehearsing such well-trodden ground is a "mechanical" comparison between the technologies of kinship, gender, and sex, and those discussed in chapter 3—an exercise that activates the mosaic, recursive, comparative structure of the book as a means to reflect on how IVF "works." Here, as elsewhere, the effort is not only to reread earlier work on kinship and gender in the light of being several decades after the birth of the first test-tube baby, but to emphasize how the logics of IVF both model and transform the structures of gender and kinship—thus potentially enabling us to think differently about their future manifestations.

Chapter 5, "Living IVF," also revisits a famous feminist history, namely the feminist debate over new reproductive technologies in the 1980s. Again, with the benefit of so many excellent and insightful accounts of this history available, this rereading brings a specific question into focus, namely the turn to understanding the experience of women undergoing IVF—arguably one of the earliest empirical investigations of human reproductive biology as technology, and of assisted conception as a means of "doing gender" as well as "making kinship." I argue that the early feminist analysis of women's experience of IVF deserves to be explored in greater depth—anticipating as it does many of the ways in which ambivalent relationships to biological technologies have been theorized since the 1980s. This chapter more explicitly engages with the ways in which the actual nuts and bolts of IVF parallel feminist accounts of gender and sex as "technologies"—and indeed as reproductive tech-

nologies. It revisits IVF not only as a technology of living substance, but as a biological technology that is lived as "a way of life," arguing that this pattern is now normative in ways that remain more curious than they may initially appear.

Importantly, this argument has already been made very elegantly by Charis Thompson (2005) in her pivotal study of IVF as a technology of gender, aptly titled *Making Parents*. Drawing on Thompson's work in chapter 6 ("IVF Live"), I explore the question of what IVF is reproducing in addition to, or at times in lieu of, biological offspring. This chapter poses another variation of the question of what IVF is "after." How has it become such a popular technological convention worldwide, and what kind of new norm is IVF? To explore these questions in a somewhat different way, I turn in the second half of chapter 6 to the role of IVF technology as a sign, an iconic technology that now not only remakes biological substance but makes visually explicit a new form of technological substance as biology. In order to understand not only the logic of IVF but its "call" and reach, a visual analysis is offered of the literal window IVF technology provides into the remaking of life, by enabling the translation of the retooling of reproductive substance into a circulating, public, interfaced, mainstream, and iconic image that is now widely and popularly legible as a primal (screen) scene of biological relativity.

This book closes in the ethnographic site where it began. Chapter 7, "Frontier Culture," returns to the hole in the wall, this time from within the ACU, opposite the lab, where the British artist Gina Glover has inhabited the "lens" of IVF as a photographer in residence. Looking through Glover's images enables the question of IVF as a "way of life" to be expanded into a broader question of how biotechnology is composed, domesticated, and familiarized. Here, the question of the future of biology is explored more explicitly as the future of kinship, and the future of kinship is explored from the point of view of how technology itself has become a form of shared reproductive substance. This question is once again reframed in this chapter through a consideration of technological progress as a frontier, and IVF as a site of both ambivalent and embodied progress. Looking back once again at the historical imaginaries that both preceded and engendered it, the question of being after IVF is explored both visually and experientially as a site of recrafted identity and women's work.

The overall themes of the book are briefly summarized in the afterword by rereading Derrida's understanding of the relationship between technics and life through the lens of IVF. Drawing also on the work of Hannah Arendt, the question concerning technology is here posed as one of dialogue: what

are the kinds of conversations we might have about the future of technology as biology, or the future of biology as technology—or the future of kinship in relation to both of these questions? By reviewing the main arguments of *Biological Relatives* in this final section, I make the case for why the history of reproduction—and in particular the retooling of reproductive substance in the context of IVF—provides an important window onto the ambivalent process of remaking life. What resources would we need for the remaking of life to become more dialogic in the future? Might IVF be a context in which this model of "originary technics" could be productively explored?

By combining an account of the various kinds of mechanisms that are the necessary preconditions for a human embryo to become a tool, my overall aim is to offer an account of IVF that extends our ability to engage more thoughtfully with the questions posed by the future of bioscience, biomedicine, and biotechnology. As set out in this introduction, the aim is to provide a different set of starting points for addressing the relation between the technological and the biological as one that is lived as the remaking of life. In particular, the aim is to challenge the isolating models of technological impact that presume what Habermas (1971: 58) has critically described as the automatic model of technological progress. By attempting to use models from kinship and gender theory to explore what it means to be after IVF, *Biological Relatives* provides an account of IVF and stem cell research that resists approaching these phenomena as embedded in a social context, or even as molded or shaped by social forces. As is so readily evident in the common phrases "science and society" or the "social consequences of technology," an implicit separation between the domain of the social and the scientific or technological is difficult to avoid. Yet this separation is fundamentally misleading: science and technology are never outside the social, just as IVF did not invent itself, and stem cell lines did not exist before they were cultivated or forced into existence.

Of the many reasons why it has proven difficult to integrate social and scientific, or cultural and material, visual and biological, or textual and physiological perspectives on IVF, one of the most prominent is the difficulty of integrating the models of technology that correspond to contexts as diverse as embryology, anthropology, historiography, feminist theory, continental philosophy, or biopolitics. This problem is compounded by the question of what is meant by "technological." Hence, for example, we might describe an automobile or the Internet as a technology, but be less likely to use this word to describe a newspaper, a child's imaginative game, a song, or a dinner party. However, on second thought, we can see how all of these cultural forms are thoroughly technological—they depend on prior technicity, and

we engage them through complex techniques that include not only know-how but understandings of who we are, what we can do, and how we want to live. Kinship, gaming, and cuisine, not to mention play, child rearing, and sharing meals are the outcome of an accumulation of highly skilled practices and technical systems, such as language, writing, and cooking, that have been developed and passed on for millennia. Indeed, these are some of the oldest human technologies, and are often imagined as the technologies that make us human.

It might be claimed from this point of view that everything is technological. And it is worth asking what our definition of humanity would be if it were denaturalized in this way. For one thing, such a thought experiment would require that we become both more and less precise in what we mean when we use the words "technology," "technique," and "tool"—in part by observing them close at hand, in specific contexts, and also over time, as they develop, change, fail, cease to exist, or expand. *Techne* is the Greek term for arts, whereas "technics" is often more narrowly used to describe methods or rules. "Technique" is used to describe skilled practices, whereas "technology" is often associated either with the application of science, or with systems of mechanical techniques, as in the context of industrialization. While we do not conventionally associate technology with gender identity or marriage, these too are, of course, highly organized activities that rely on prior art. Technology is derived from the Greek word *tekhnologia*—systematic knowledge of the arts, including both manual arts and skills and knowledge practices. From an anthropological point of view, all of human culture is composed of technics, techniques, and technologies—a marriage ceremony is no less technological than a windmill.

One reason, however, that it is not conventional to interpret marriage as a technology is that it is not seen as the application of science so much as an automatic reaction to the natural facts of reproductive biology, in essence merely socializing them as identity, ritual, and natural fact. In vitro fertilization is used as a case study in this book to explore not only what it means for an embryo to become a biological tool, or for our understanding of technology to become "more biological," but for these two perspectives to be combined in the form of a thought experiment through which our understandings of both biology and technology are both deepened and reconfigured. I argue that IVF reveals our biological relativity in the form of a technology employed to create biological relatives, thus changing how we understand the adjective "biological." Through IVF technology, reproduction becomes relatively biological—indeed, the contingency of biology achieved through the technique of

IVF is its raison d'être: "failed" biology can be made to work, or repaired, by being "taken in hand." The origin of IVF lies precisely in the effort to mechanize biological substance, while this impetus has also been described as the origin of kinship—commonly interpreted as the effort to organize, facilitate, and activate human reproductivity, and also commonly presumed to be one of the oldest and "elementary" human technologies. So in another sense, these two technologies—IVF and kinship—are already biologically related. They not only share the same form but serve the same purpose: they are kindred technologies in the making of kin and the kinding of life. The point of this book is to explore this connection—one that IVF makes highly explicit, but in such a densely compacted form as to appear at once miraculous and ordinary, recognizable and unfamiliar, routine and exceptional—a curious new norm of civilized existence. These paradoxes are among many that make IVF "good to think with" anthropologically. The project of this book is to do just that. If it is successful, neither biology nor technology will look quite the same again after we have reexamined them through the looking glass of IVF, and the curiouser and curiouser window its transfer "into man" has opened.