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Enacting Conservation and Biomedicine:
Cloning Animals of Endangered Species in the Borderlands of the United States

by

Carrie Friese

DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

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in the

GRADUATE DIVISION

of the

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[redacted]

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Dedication and Acknowledgements

This dissertation is dedicated to my partner Stephanie Miller, who made it fun and my father Walter Friese, who made it possible.

I am deeply indebted to all those who contributed to this project. I would like to thank all the people who took the time to speak with me, give me tours of their workplaces, and even invite me into their home so that I could travel around the country to conduct this research. Your kindness, generosity and openness has and continues to be greatly appreciated. In the process, I have become – as a medical sociologist - thoroughly enthralled with endangered and other human-animal worlds. I can only hope that this dissertation begins to do justice to the stories you collectively told and showed me.

I have benefited tremendously from a wonderful dissertation committee, whose scholarship made it possible for a medical sociologist to study the practices of cloning endangered wildlife. This dissertation would have been hard to find an intellectual home if it were not for Adele Clarke's research materials, Charis Thompson's tales of interspecies love and terror, and Donna Haraway's primates, cyborgs, and companion species. First and foremost, I would like to thank my dissertation committee Chair, Adele Clarke, for her mentorship and scholarly insights across my graduate studies. I consider myself tremendously lucky to have had such an exemplary advisor, mentor, and advocate while a graduate student. I would also like to thank Charis Thompson for constantly pushing me to think through the political economies of cloning across human-human and human-animal relations. Your kindness, generosity, and scholarship have been a constant source of inspiration. I would like to thank Janet Shim for stepping in during my time of need and always pushing my thoughts about medical sociology, science and technology studies, and biopower. You have been an exemplary professor. Thank you to Donna Haraway for acting as a reader on this dissertation. Your insights as I have conducted this research have pushed me in important directions and I can only hope that I have begun to take "the domestics" seriously enough in endangered animal cloning practices.

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Abstract

Since the birth of Dolly the sheep and in the context of the potential to create regenerative medicines using somatic cell nuclear transfer, over the past decade "cloning" has re-emerged as a "social problem" and more specifically an "ethical" problem. Somatic cell nuclear transfer has been configured as a technique for copying individuals, endangering the purportedly "natural" nuclear family and deterministically creating situations wherein excessive social control will be enacted and human life will be commodified. Drawing on both science and technology studies and symbolic interactionism, I contend that somatic cell nuclear transfer is not inherently meaningful, but rather becomes meaningful in and through its practice. I use qualitative field methods to enter some of the worlds wherein this technique has traveled and to consider the situated productivities of somatic cell nuclear transfer in action. In doing so, I reorient attention away from the *theoretical* practice of "human" cloning to the real, widespread, and understudied endeavors of cloning animals, focusing specifically on projects to clone animals of endangered species.

As somatic cell nuclear transfer has traveled, I contend that the technique has created relations across varying arenas, bodies, logics and systems of value. In other words, Dolly has been productive of new kinds of "assemblages". Such assemblages are likely to be constitutive of humans in the future precisely because most developments in biomedicine are first worked out by "modeling" with animal bodies and politics. I position cloning assemblages as modes of modeling bio-social-political-economic-ethical configurations for worlds premised upon transforming bodies and bodily relations for the purpose of enhancement in the operations of both conservation and biomedicine.

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CHAPTER 1

Toward a Sociology of Cloning: A Situational Analysis of Cloning Endangered Wildlife in the United States

[T]he persistent attempt to set human phenomena distinctly and widely apart from all other natural phenomena is a hang-over of theological teleology, an instance of organic ego-centrism, a type of wishful aggrandizement and self-glorification.
Read Bain (1928: 554)

People like to look at animals, even to learn from them about human beings and human society. . . . We find the themes of modern America reflected in detail in the bodies and lives of animals. We polish an animal mirror to look for ourselves
Donna J. Haraway (1991b: 21)

Since the birth of Dolly the sheep and in the context of the potential to create regenerative medicines using somatic cell nuclear transfer, over the past decade "cloning" has re-emerged as a "social problem" and more specifically an "ethical" problem. The relationships between somatic cell nuclear transfer and society have largely been defined by the field of bioethics, whose practioners have launched similar arguments against cloning since the 1960s when the field began to coalesce (Callahan, 1998; Hartouni, 1997). Cloning has been configured as a technique for copying individuals, deterministically creating situations wherein excessive social control will be enacted and human life will be commodified. In addition, cloning has been rendered as a technique that will endanger the purportedly "natural" nuclear family through artificial means of reproduction (Hartouni, 1997). Science fiction scenarios – such as *Frankenstein*, *Brave New World*, or *The Boys from Brazil* – are often used as stand-ins to represent these imagined futures.

Through these discourses, human "reproductive" cloning has largely been rejected across both scientific and nonscientific communities. At the same time, debates persist over the ethics and potentials of human "therapeutic" cloning, wherein somatic cell nuclear transfer would be used in conjunction with ongoing stem cell research programs with the goal of producing individually tailored stem cell therapies. Meanwhile, "animal cloning" has rather unproblematically continued, with the tacit presumption that these practices bear no relation to questions regarding the moral status of "the human". The central premise of this dissertation is that alternative frameworks are needed in order to begin to understand the productivities of somatic cell nuclear transfer across a full range of life forms (see also Franklin, 2007; D. J. Haraway, 2003a; Maienschein, 2002).

This dissertation project explores the meanings of somatic cell nuclear transfer (aka cloning) for humans and animals alike by studying this technique in action. To do so, I have used qualitative field methods to enter some of the worlds wherein this technique has traveled and consider the kinds of action and practices undertaken. I do not draw upon moral philosophy, as bioethicists generally do, to consider the worlds and bodies that this technique should not be allowed to travel to. In contrast, I am in accord with Donna Haraway's (2003a) argument that bioethics needs to "get real" (Barad, [1998] 1999), by which she means that it needs to attend to the matters and actions of technoscience in the making. Therefore, with this dissertation, I have entered some of the real worlds of somatic cell nuclear transfer to explore this set of techniques as constitutive and "situated" (Clarke, 2005) actions, which are (re)productive of forms, logics and meanings.

My approach to studying the meanings of somatic cell nuclear transfer is bound up in the traditions of science and technology studies (STS) and symbolic interactionism (SI). One of the core assumptions in the largely non-disciplinary field of STS is that science is social. There are no divisions between science and society, technical and cultural. If we want to understand what technocience is and what it means, we need to study it in action (Latour, 1987). The focus on action in STS is paralleled and informed by the focus on action in a Straussian SI. Such a symbolic interactionism rejects the notion of inherent meaning and instead positions meaning as emergent in and through action and interaction, and hence contingent. Whereas Strauss (1993) was centrally interested in the conditions and consequences of action and interaction in meaning-making processes, I focus on the situations in which action occurs and the productivities of these situated "intra-actions" (Barad, [1998] 1999).[1] Drawing on both science and technology studies and symbolic interactionism, I contend that somatic cell nuclear transfer is not inherently meaningful, but rather becomes meaningful in and through its practice. If we want to understand the productivities of this technique, we need to see how and where somatic cell nuclear transfer is actually being taken up as part of meaningful action and the effects produced.

By questioning cloning empirically and in a manner that emphasizes practices wherein somatic cell nuclear transfer is actually used, I reorient attention away from the *theoretical* practice of "human" cloning to the real, widespread, and understudied endeavors of cloning animals (see also Franklin, 1997; D. J. Haraway, 2003a). In predominant discourses regarding somatic cell nuclear transfer, animals are positioned as part of the material world that can legitimately be manipulated for human ends and betterment. Human and animal ontologies are here viewed as discrete, so that what humans do to animals does not shape what it means to be human. This logical apparatus is one that I seek to critique. I contend that somatic cell nuclear transfer brings humans and animals together in particular kinds of ways, enacting particular kinds of relations that are constitutive of both human and

[1] Thank you to Adele Clarke for making so clear this distinction.

animal identities and bodies. In other words, cloning endangered animals enacts a particular kind of human-animal relation that is constitutive of humans and animals alike.

While this dissertation studies "animal cloning", the human has always lurked nearby in my "sociological imagination" (Mills, 1959). Throughout this dissertation, I ask whether and how somatic cell nuclear transfer is part of emerging "assemblages" (Deleuze & Guattari, 1987; G. E. Marcus & Saka, 2006) that are likely to have consequences for humans and animals alike in the future, in ways that are unknown and unanticipated today. Dolly the Sheep can be understood as an "event" in Paul Rabinow's (1999; 2000) conceptualization of the word. Drawing on Michel Foucault's (1972) analysis of epistemic transformations, an event denotes a moment at which change and transformation becomes possible, offering a kind of fault line in the processes of social reproduction and allowing new forms and trajectories to emerge. Rabinow (1999: 180-81) defines an event as follows:

> From time to time, and always in time, new forms emerge that catalyze previously existing actors, things, temporalities, or spatialities into a new mode of existence, a new assemblage, one that makes things work in a different manner and produces and instantiates new capacities. A form/event makes many other things more or less suddenly conceivable. . . . Events problematize classifications, practices, things. The problematization of classifications, practices, things, is an event.

Within this frame, I am arguing that Dolly the sheep represented the *acceptance* of new knowledge about cellular development that allowed for somatic cells to circulate and garner value in new ways.

As somatic cell nuclear transfer has traveled, it has created relations across varying arenas, bodies, logics and systems of value. In other words, Dolly has been productive of new kinds of "assemblages" (Deleuze & Guattari, 1987). I contend that it is these assemblages that require analytic and political attention, rather than a single technique in isolation. Such assemblages are likely to be constitutive of humans in the future precisely because most developments in biomedicine (including reproductive science and technology) are first worked out by "modeling" with animal bodies and politics (see Clarke, 1987, 1998; Franklin, 2007; D. J. Haraway, 1989; 1991b). That is, I position these assemblages as modes of modeling bio-social-political-economic-ethical configurations for worlds premised upon controlling and changing bodies for the purpose of enhancement in the operations of biomedicine.

The practices of cloning animals are multiply situated, ranging from agricultural efforts to improve cattle herds for downstream consumption to cloning endangered species for conservation to cloning pets for pleasure and companionship to cloning laboratory animals as standardized research materials. I focus here specifically on the project to clone animals of endangered species. Cloning endangered wildlife has simultaneously been surprisingly unproblematic in public discussions, and yet a highly volatile topic in the social worlds of zoological parks and conservationism. As Dorothy Nelkin (1995a) has pointed out, sites of contestation are often particularly productive sites of analysis for social studies of science. Invariably, many of the people I spoke with who were involved in experiments using somatic cell nuclear transfer were also involved in developing this technique with species embedded in other human-animal relations, including livestock, companion animals, and laboratory animals. Focusing on endangered species allowed me to gain specificity in my analysis, while also the ability to compare the use of this technique across a range of human-animal relations.

I have also chosen to study practices in cloning endangered wildlife in order to begin to understand the connections and fissures between zoological parks and biomedicine. This represents an important area for future study in the field of medical sociology that explores knowledge production practices. As Elizabeth Hanson (2004), Adele Clarke (1987), and Donna Haraway (1989) have discussed, zoological parks provided critical knowledge and skills to life scientists at the beginning of the twentieth century to help develop and maintain animal colonies. Such colonies have been crucial to the implementation of the animal models approach to biomedical technoscience. As Donna Haraway (2006) has pointed out, biomedicine has literally been built on the backs of animals. While Haraway (1989; 1991b) has opened up the important ways in which animals model for not only human physiologies but also human politics, this central institution of animal modeling in biomedical knowledge production has been generally accepted rather than considered analytically in medical sociology. This dissertation represents an initial step in opening up for study the practices and logics involved in animal modeling within biomedical research, the critical juncture that I contend holds corners of biomedicine and species conservation together.

Across this dissertation, I juxtapose and differentiate my own analytic process with some of the predominate ways somatic cell nuclear transfer has been rendered meaningful to date. In doing so, I take cues from and draw upon Jane Maienschein's (2001; 2002; 2003) historical approach, Sarah Franklin's (1997; 1999b; 2007) genealogical approach, and Donna Haraway's (2003a) bio-ethics-politics-economics approach to cloning. Each of these scholars emphasizes the *matters* of somatic cell nuclear transfer. Such matters have largely been lost from focus in predominant cloning discourses, which generally focus on good/bad or right/wrong applications of this technique.

In sharp contrast to prevailing cloning discourses, I do not take a stand with regards to whether or not somatic cell nuclear transfer should or should not be used on the bodies of any species. Instead, one important rupture this dissertation makes is in the discourse of inevitability that has been a prominent feature of cloning discourses to date. That is, amidst calls for increased regulation to bar the possibility of cloning humans is the ever-present sentiment that cloning humans is, after all, inevitable. This discourse of inevitability is linked with the concept of progress, a linear notion of time that tends to represent the future as preordained rather than actively chosen and carved out. By studying the uptake of somatic cell nuclear transfer empirically, we quickly realize that there is nothing inevitable about cloning endangered wildlife or any other species for that matter. These projects require a tremendous amount of work. With empirical analyses, however, we can begin to point out troubling sites, sites that this dissertation points to but does not attempt to resolve. As Paul Rabinow (1999: 23) points out vis-à-vis genomics, we do still have time to carve out desired futures. With techniques like somatic cell nuclear transfer, the critical question becomes who gets to carve out whose futures and in what kinds of ways. To engage this question, I try to open up troubling sites in the assemblages wherein reproductive technologies are used with endangered wildlife, in the hopes of fostering dialogue among a wide range of actors.

In the remainder of this chapter, I next further explicate my interest in "animal cloning" by providing an overview to some of the ways in which somatic cell nuclear transfer has been addressed to date and the kinds of foreclosures these discourses make. I then turn to my own methodological approach to studying this technique and some of the theoretical approaches that I have engaged as useful in conducting this study. I conclude by providing an overview of the dissertation.

BACKGROUND: CLONING DISCOURSES

In order to think through somatic cell nuclear transfer and the kinds of meanings that this technique has, it is necessary to trace this word as a node through which varying historical, social, physical, technical and cultural practices and meanings are situated, which partially link up and diverge. As Donna Haraway (1989: 368-69) has aptly pointed out: "Cloning is simultaneously a literal, a natural and a cultural technology, a science fiction staple, and a mythic figure for the repetition of the same, for a stable identity and a safe route through time seemingly outside human reach." In this section, I provide a brief overview to cloning discourses with particular focus on the Dolly and post-Dolly moments. This section serves two purposes that may appear contradictory. First, this section is meant to show how my approach to somatic cell nuclear transfer differs from some of the more predominant ways in which this technique has been rendered to date. Second, the section provides an overview to some of the discourses that are important elements in the situations of cloning endangered wildlife in the United States. I resolve these tensions by positioning some of the discourses discussed below as "actors" (Latour, 1987; 1988; 1999c; 2005) in cloning situations, rather than explanatory devices.

I begin by briefly discussing bioethical discourses on somatic cell nuclear transfer and the epistemological assumptions that undergird these discourses. I show how bioethical and mass-mediated discourses on cloning intersect, given the prominence of bioethicists as news sources in discussions about "human cloning" that arose after the birth of Dolly the Sheep. Both of these discourses often rely upon science fiction scenarios, which I also discuss. This review is brief and admittedly risks overgeneralization. However, the goal here is not to unpack these discourses but to show how certain characterization have become actors in cloning situations. I then turn to the ways in which social scientists have used these discourses as sites of cultural analysis and criticism. These analyses help trouble and disrupt some of the taken-for-granted assumptions in prominent fears regarding human cloning, providing important critical wedges that I draw upon throughout this dissertation. I conclude by positioning this dissertation in a growing body of literature that seeks to carve out new ways of thinking and talking about somatic cell nuclear transfer.

Bioethics and cloning

The socialities of somatic cell nuclear transfer have largely been studied within the field of bioethics. While the label "bioethicist" classifies a diverse group of professionals with varying positions on somatic cell nuclear transfer, by and large this field has successfully argued against using somatic cell nuclear transfer to reproduce human beings (e.g., Callahan, 1998; Kass, 2002; McGee, 2002; The President's Council on Bioethics, 2002). The basis for such arguments lie largely in the notion that cloning people would result in legal and social disruptions to the status of the individual, the hetero-normative nuclear family, and the special status granted to humans as embedded in law and religion (e.g., The President's Council on Bioethics, 2002). The use of somatic cell nuclear transfer in the context of stem cell research has been the locus of greater debate among bioethicists, with questions largely focusing on the moral, and often metaphysical, status of the embryo. In sharp contrast, with a few exceptions (Twine, 2005, Forthcoming), bioethicists have labeled the use of somatic cell nuclear transfer with animals as unproblematic.

In the United States, bioethicists draw largely from the disciplinary apparatus of moral philosophy to analyze how and when somatic cell nuclear transfer as cloning troubles the normative features of social institutions. Here, cloning scenarios are often projected onto the normative structures and logics that undergird social institutions such as the family, the individual, or biomedicine. By asking how this technique may be congruent with or disruptive of the normative features of social institutions, the implications of somatic cell nuclear transfer are produced. In these discourses, the normative features of social institutions are the units of analysis.

In the division of labor, bioethicists have positioned themselves over the past few decades as bearing responsibility to contend with the "ethical, legal, and social implications" of scientific and biomedical techniques (Rose, 2007). This division of labor was institutionalized in the United States with the ELSI component of the Human Genome Project, which was formalized in 1990. Planners organized ELSI responsibilities to include: 1) anticipating the implications of mapping the human genome for individuals and society; 2) examining ethical, legal and social consequences of sequencing the human genome; 3) stimulating public discussion; and 4) developing policy to ensure that mapping the human genome would benefit individuals and society (National Human Genome Research Institute, 2007).

Since then, this bioethical/ELSI approach has been seriously critiqued among scholars in the field of science and technology studies for several reasons. First is the incorporation of presuppositions associated with the diffusion model and associated dualisms (D. J. Haraway, 2003a; Rabinow, 1999). According to this model, science and society are understood as discrete entities. Science is positioned as a privileged space that is value-neutral and thereby not in need of investigation. Instead, society becomes the site for investigation because it is in this space that value-neutral science is "socialized", or taken up in actual social practices, possibly in problematic ways. In many bioethical discourses, there is the assumption that somatic cell nuclear transfer becomes socialized when used on human bodies. This is an assumption that this dissertation seeks to critique, arguing that the actual practices of science are always already social. A second site of critique of bioethics has been its abstract, logico-deductive, philosophical approach. Even within bioethics, there are those who argue that an understanding of ethical behavior in a particular situation should be based on an empirical understanding of the actual practices (Barnes, Davis, Moran, Portillo, & Koenig, 1998; Koenig & Hogle, 1995; Koenig & Silverberg, 1999; Marshall & Koenig, 2001). This dissertation is such an empirical study.

Mass mediated visions: somatic cell nuclear transfer in the news media

A number of scholars have examined how cloning in the context of Dolly the Sheep and debates over human embryonic stem cell research has been represented in the mass media. Content analyses of coverage of the Dolly announcement in the mass media have found that reporting reactivated long-standing discourses regarding the transgressive potential of genetics and excessive forms of social control that science can bring about (Nelkin & Lindee, 1998; Nerlich, Clarke, & Dingwall, 1999; Petersen, 2002; Priest, 2001; Wilkie & Graham, 1998). Rhetoric used included such tropes as such "brave new world," "the ghosts of Hitler and eugenics," "master race," "the production of clones on an industrial scale," "the mass production of identical people," and "the making of armies of genetically identical slaves" (Petersen, 2002). Cloning was also often linked to the Frankenstein myth of the mad scientist driven by hubris (Lederer, 2002; Turney, 1998) and Aldous Huxley's (1950) *Brave New World* of excessive social control (Petersen, 2002). These images were in turn used to assert the need to control science through governmental bodies, although the viability of such regulations was also often doubted (Petersen, 2002). A significant area of social science and humanities research regarding cloning has been to deconstruct and trouble these discourses, discussed later.

Communications scholars have also analyzed mass-mediated images of cloning to explore how reporting links up with certain institutional interests. Scholars have noted that reporting on cloning has been very similar to other kinds of journalistic subjects,[2] but there are some important distinctions to the representations of cloning when compared to those of other biotechnologies (Nisbet & Lewenstein, 2002; Priest, 2001). Specifically, cloning has been framed as a "ethical" issue, whereas discussions of most other biotechnologies eclipse ethical concerns (Nisbet & Lewenstein, 2002; Priest, 1995, 2001). In addition, there was more diversity in the news sources and the media frames in reporting on cloning compared to other biotechnologies (Nisbet & Lewenstein, 2002; Priest, 2001). These trends are often linked to the fact that many scientists and commercial industrialists were "surprised" by the Dolly announcement, not believing it possible to reprogram differentiated cells (Petersen, 2002) (discussed in detail in Chapter Two). The ethical framing of cloning has also been linked to the prominence of bioethicists as news sources in stories about Dolly (Maienschein, 2003; Priest, 2001; Simonson, 2002). A number of scholars have found that journalists are "source dependent" (A. Anderson, 2002; Conrad, 1999; Karpf, 1988; Nelkin, 1995b; Nerlich, Dingwall, & Clarke, 2002; Priest, 1995; Smart, 2003) and that predominant media "frames" are outcomes of the relationships between reporters and their sources (Nelkin, 1995b). Scholars have also noted that certain scientists have become regular sources for journalists, or "visible" scientists, and speak for science on a regular basis (Goodell, 1977). In the case

[2] Cloning in the media is similar to other kinds of science reporting in that it has largely been discussed through an "awe-and-fear" and "shock-and-awe" frame and experts have been central in defining the issue (Priest, 2001).

of cloning, certain people became "visible" bioethicists in media representations of cloning (Priest, 2001). As such, there are some parallels between bioethical and mass media discourses on somatic cell nuclear transfer post-Dolly.

Susanna Hornig Priest (2001) has argued that the centrality of bioethicists in cloning news must take into account the lack of interest commercial industrialists had in human reproductive cloning (Priest, 2001). She contends that the prominence of bioethicists occurred because no other group with legitimacy and authority significantly challenged them. Somewhat differently, Alan Petersen (2002) contends that animal geneticists and embryologists were dismayed by the images of reproductive cloning in the press and worked in conjunction with bioethicists to downplay and discredit human reproductive cloning.

Cloning in science fiction

As shown, both bioethical and mass mediated discourses on cloning have drawn upon and refigured popular science fiction stories (Hartouni, 1997; Nerlich et al., 1999; Petersen, 2002). Both "Frankenstein" and "Brave New World" have become shorthand for the kinds of dangers that cloning represents (Petersen, 2002). These images are often "unpacked" and the meanings are presumed to be self-evident (Maienschein, 2003; Petersen, 2002). In this section, I briefly review how scholars have analyzed these stories vis-à-vis emergent biotechnologies generally and somatic cell nuclear transfer specifically.

In many cloning discourses, "brave new world" is often a stand-in for the notion that somatic cell nuclear transfer would be used as a technology of excessive social control by generating multiple copies of human in an industrialized production system. Sarah Franklin (2007: 204) states:

> The fear that attaches to the figure of the double, clone, or copy is thus not only of the loss of originality as identity. . . . It is also the fear of the

> asymmetry, or difference, between the original and its second, which is most often expressed as a fear of inequality, inferiority, and vulnerability to being used for another's purposes, or appropriated to another's ends."

Cloning as copying is here seen as a technique that can be used to mass-produce inferior people, constituting another axis along which humans will be divided for the purpose of pursuing unequal relations in the production systems of capitalism. "Brave new world" provides a cultural repertoire for expressing these fears.

Valerie Hartouni (1993) has critically examined Huxley's (1950) *Brave New World* in relationship to discourses on reproductive technologies generally. Hartouni (1993: 94) contends that Huxley's novel actually reinvents the individual of liberalism, despite his critiques of consumer capitalism and technological rationality. She argues that Huxley's tale is not about exploitation per se, but rather the ways in which totalitarianism breeds mediocrity. The Gammas, Deltas, and Epsilons are not tragic heroes of the novel. Rather, a few exceptional men whose capabilities are curtailed by the state represent the tragedies. Hartouni concludes that this novel does not provide an adequate medium for discussing the social ordering of inequality. This is in part because the story solely focuses on state power and fails to recognize other sites wherein power relations are enacted (e.g., the clinic).

"Frankenstein" is another discourse through which somatic cell nuclear transfer has been rendered meaningful. By and large, the Frankenstein myth provides a vehicle for discussing the possibility, if not likelihood, of unanticipated consequences resulting from this technique that may be to the detriment of (some/all) humans in the future. Jon Turney (1998) has analyzed the Frankenstein myth as it developed across the nineteenth and twentieth centuries and in relationship to technical developments in biology. Despite how the myth has changed over time, Turney (1998: 23) contends that certain facets of Mary Shelley's

Frankenstein are almost always retained including: ambivalence toward biological knowledge production, the utilization of contemporary scientific practices in creating the story line, and a political response to these practices. The stories are always scary and the biologist is well intentioned but possibly blinded by his hubris. In turn, the Frankenstein myth is a means to consider and critique the materials that biologists use, the relationship between science and society, and the mechanization of "life itself" (Lederer, 2002; Turney, 1998).

Dolly the Sheep and the expanding use of somatic cell nuclear transfer have offered new vehicles for "Frankenstein" and "Brave New World" discourses to expand, be reinterpreted and reinvented (Turney, 1998). These discourses also offer a cultural repertoire through which concerns and fears about scientific practices are often articulated. One of the premises of this dissertation is that these discourses open our eyes to certain features of scientific practice, while obscuring others. My goal is to neither discredit these discourses nor to unpack them. Rather, I try to explore what meanings of somatic cell nuclear transfer are obscured by these discourses.

Alternative discourses: troubling "cloning"

Scholars from a range of disciplinary perspectives have sought to trouble the ways in which somatic cell nuclear transfer is prominently configured. One area of social science research has been to deconstruct some of the foundations of predominant bioethical, policy-based, and mass-mediated cloning discourses. In particular, scholars have critiqued the genetic essentialism that undermines most of the purported dangers of using somatic cell nuclear transfer with human bodies (J. Edwards, 1999; Hopkins, 1998; Lederer, 2002; Maienschein, 2003; Nelkin & Lindee, 1998; Nerlich et al., 1999; Petersen, 2002). The notion that a clone replicates an original reveals the extent to which DNA is conceptualized as the basis for and essence of “life itself”, personhood and individuality (J. Edwards, 1999; Hartouni, 1997; Nelkin & Lindee, 1998; Priest, 2001). This kind of reductionism has been vociferously critiqued across the sciences and social sciences for many years (e.g., D. J. Haraway, 1997; 1992; Lewontin, Rose, & Kamin, 1984; Lippman, 1998; Nelkin & Lindee, 1995). And genetic essentialism is increasingly being viewed as an inadequate basis to address pressing scientific and medical questions that defy a single gene answer (Keller, 2000; Maienschein, 2003).

While cultural criticisms of cloning discourses have been important sites for revealing the limits on how somatic cell nuclear transfer is currently conceptualized, these approaches do not necessarily offer new ways of theorizing emergent techniques such as somatic cell nuclear transfer. In response, others have sought to develop alternative analytics for conceptualizing somatic cell nuclear transfer and its consequences. Countering the position that there is nothing left to say about cloning and Dolly given the over-saturation of these topics across popular and academic fields, Sarah Franklin (2007: 1) argues “that we have only really just begun to develop a suitable critical language for parsing the significance of Dolly’s coming into being.” This dissertation seeks to contribute to the elaboration of this critical language.

Jane Maienschein (2001; 2002; 2003) offered one of the earliest alternatives disciplinary views of somatic cell nuclear transfer with her arguments for an historical approach to questions about cloning and human embryonic stem cell research. Maienschein situates the debates over embryo research in the U.S. not within “science-versus-religion” but rather in longstanding historical debates between preformationists, who hold that there is a moment at which life begins for an already formed individual, and epigenesists who understand life as “a continual process of becoming” through the course of development. In turn, she rejects the notion that techniques like somatic cell nuclear transfer and the corresponding concerns are “new”. On this basis, Maienschein calls for an historically cognizant understanding of both knowledge production and corresponding cultural critiques. She in turn provides an important overview of how somatic cell nuclear transfer became technically and epistemologically possible, reviewed in Chapter Two.

Sarah Franklin’s (2007) recent *Dolly Mixtures: The Remaking of Genealogy* offers another alternative for seeing Dolly the Sheep.[3] Franklin uses genealogy as an analytic through which she traces Dolly as an entity who embodies new biologies that are inseparable from extant social orders upon which her biology both reproduces and relies (Franklin, 2007: 3). Franklin asks what kinds of ties the (re)production of a sheep in Scotland using somatic cell nuclear transfer has with social orders built up around sex, capital, nation and colony. In using a genealogical method, Franklin (like Maienschein) critiques the future focus in most cloning discourses and shows how Dolly is bound up in historical processes. Franklin contends that “the most important questions the Dolly technique asks us are less about where we are headed than who we already are” (Franklin, 2007: 17).

While Maienschein and Franklin address the kinds of formations that made Dolly possible, Donna Haraway (2003a) has begun to work through alternative modes for addressing the productivities of varying techniques in her “Cloning Mutts, Saving Tigers:

[3] I should point out that Franklin’s (2007) *Dolly Mixtures* was just released in April 2007 and therefore was not available as I did the research and majority of writing for this dissertation. I have gone back to the substantive chapters in order to cite her work where my arguments coincide with hers. However, my arguments were developed without the benefit of her important book.

Ethical Emergents in Technocultural Dog Worlds". Haraway proposes an ethics that is based on questions of who flourishes and who does not where technoscience and reproduction meet kin and kind. She argues for a bioethics that engages in scientific work practices and the political economies in which these practices are both entrenched and constitutive.

METHODOLOGICAL TOOLS

This dissertation is situated in a dense web of scholarship that seeks to carve out alternative modes for seeing the productivities of somatic cell nuclear transfer. Rather than using moral philosophy to consider how cloning would shape humans if used on their bodies, I instead trace how somatic cell nuclear transfer has already been taken up in the contemporary moment within particular situations. This tracing forms the basis for my own considerations of how somatic cell nuclear transfer is productive of certain types of beings, as well as their relations, politics and discourses that render them meaningful. In turn, we see that somatic cell nuclear transfer travels through assemblages that bring together certain humans, nonhumans, logics, and practices. These assemblages both constitute somatic cell nuclear transfer and are reconstituted when somatic cell nuclear transfer becomes an element in circulation when it "travels".

I entered this project with a number of rather "simple" (D. J. Haraway, 2003b: 7) questions about cloning practices with endangered wildlife. How has somatic cell nuclear transfer traveled to endangered species and zoological parks? What kinds of practices and discourses are involved in and constituted by practices in cloning animals of endangered animals? How are relationships being forged between different sites, institutions, and epistemic communities in order to enact these projects? How are varying understandings of, and interests in, cloning endangered animals negotiated across social worlds? How is the use of somatic cell nuclear transfer constitutive of various humans, nonhumans and their relations with one another?

In order to study somatic cell nuclear transfer empirically in this manner, I have used grounded theory and situational analysis to organize the data collection and analysis of this project (discussed in detail below). Using these methodological tools, I explore the ways in which logics, circulations and varying modalities emerge, rupture and are remade as somatic cell nuclear transfer travels across varying arenas premised on different human-animal relations. This offers a means to consider the productivities of somatic cell nuclear transfer empirically, opening up questions about the kinds of futures being carved out and who is involved in carving them. Like bioethicists, I am interested in the kinds of potentialities somatic cell nuclear transfer can and is being used to carve out. However, I do not locate the critical juncture as the moment at which somatic cell nuclear transfer is used with and on human bodies. Rather, I contend that emergences, ruptures and revisions to logics, circulations and modes of relating are precisely what need to be attended to if we are to begin to understand somatic cell nuclear transfer and other biotechnologies.

Data collection

To address the questions above, I analyzed varying types of both extant and co-produced data. The co-produced data include transcribed interviews conducted by myself with individuals who were broadly defined as involved in and influenced by endeavors to clone endangered wildlife. This included: 1) reproductive scientists, physiologists, physicians and geneticists who worked at research centers affiliated with zoological societies, universities, and biotechnology companies; 2) individuals involved in the Taxonomic Advisory Groups and Species Survival Plans that manage captive populations of endangered species ex situ through the American Zoo and Aquarium Association (AZA); and 3) one field conservationist who works on habitat and species preservation in situ. The interviews were semi-structured and the questions were open-ended. The general interview guide can be found in Appendix I; however, specific questions were tailored to the individual in the context of what was known about their relationship to cloning endangered wildlife and in the interview itself. Twenty semi-structured interviews were conducted with seventeen individuals (three individuals were interviewed twice). Interviews were conducted in person when possible and over the telephone when in person meetings could not be arranged. All but three interviews were recorded and transcribed. When recording was not permitted, detailed notes were taken for analysis.

All study participants had the opportunity to speak "on the record" and/or "off the record" per the consent procedures approved by UCSF's Committee for Human Subjects. (See Appendix II for the consent form.) Because the people I interviewed while conducting this research are professionals, I wanted to ensure that their ideas would be attributed to them in the dissertation writing process if they so desired. All but one individual chose to speak with me on the record. Throughout the dissertation, I attribute both direct quotations and ideas to those individuals as appropriate.

In addition, I undertook participant observation while touring sites involved in using somatic cell nuclear transfer with endangered wildlife and attending professional conferences. I visited the San Diego Zoological Park to see the cloned banteng and toured the San Diego Zoological Society's research center, Conservation and Research for Endangered Species (CRES). I also visited the Audubon Center for Research of Endangered Species (ACRES) in New Orleans, where African wildcats have been cloned and there are on-going endeavors in using somatic cell nuclear transfer with other endangered felids. During my visit at ACRES, I was able to watch the procedures involved in surgically removing ova from domestic cats, the visual aspects of doing somatic cell nuclear transfer, and some of the work involved in maintaining a domestic cat colony for biomedical research. I also attended the 2006 annual meetings of the International Embryo Transfer Society and the 2006 annual meetings of the Felid Taxonomic Advisory Group. I wrote fieldnotes to reflect upon and analyze my experiences at these sites.

I also analyzed a number of different types of extant data. This included popular press reporting, scientific journal articles, book chapters in edited volumes, websites of organizations, position statements, and legislation related to practices in and questions about using somatic cell nuclear transfer with endangered wildlife. The sample of popular press reporting was taken from a search on Lexis-Nexis up to June 2005. Throughout the project, I continually searched PubMed for scientific journal articles on cloning endangered wildlife. I also reviewed articles and books recommended by research participants. I carefully analyzed the websites of key organizations involved or influenced by cloning endangered wildlife, including: ACRES, CRES, Advanced Cell Technology, Trans Ova Genetics, the Felid Taxonomic Advisory Group, the Bison Taxonomic Advisory Group, Convention on International Trade of Endangered Species (CITES), International Embryo Transfer Society (IETS), the Parent Committee on Companion Animals, Non-Domestic & Endangered Species (CANDES) of the IETS, and the International Species Information System (ISIS). I analyzed any position statements on the use of somatic cell nuclear transfer posted by any of these organizations. Finally, I analyzed the Endangered Species Act (ESA) of 1973.

Grounded theory

The research methodology of this project is in part based upon grounded theory, a qualitative research method that is premised upon inductively building up theoretical categories through engagement with data of varying kinds (Charmaz, 2000, 2006; A. Strauss & Corbin, 1998: 12). Grounded theory was initially articulated as a methodological approach by Barney Glaser and Anselm Strauss with their *Discovery of Grounded Theory* (1967). Glaser and Strauss developed the method in response to an increasing trend toward quantification in American sociology after World War II. With *Discovery*, they outlined a set of strategies, aimed at negating critiques that qualitative research lacked rigor, did not produce generalizable knowledge, and failed to be "theoretical" because the approach was generally descriptive. In turn, Glaser and Strauss offered one of the earliest discussions of how qualitative researchers engage in their work and thereby ruptured a long-standing silence surrounding fieldwork practices. In many ways, *Discovery* can be seen as a precursor to the reflexive turn in qualitative research, which was marked by the proliferation of critical essays in which researchers would address how they engaged in fieldwork, data analysis, and writing (e.g., Rosaldo, [1989] 1993; Wolf, 1992)

While Strauss was trained in the symbolic interactionist school of American sociology at the University of Chicago, Glaser was trained in the functionalist tradition at Columbia University. Given the different backgrounds of Glaser and Strauss, grounded theory initially represented a kind of hybridization between two schools of thought that are generally considered incongruent. Since the publication of *Discovery* some of these discrepancies became more and more apparent and Strauss and Glaser took the method in different directions (Clarke, 2005; B. Glaser, 1978; A. L. Strauss, 1987, 1995). In addition, grounded theory has been taken up in a number of different disciplines and in a variety of different ways (see A. Strauss, 1994). Some grounded theory advocates find the dispersal and heterogeneity of the method troubling, contending that grounded theory represents a set of rules that must be followed for a study to result in the best possible rendition of the phenomenon of interest (B. Glaser, 1978; Stern, 1994). This position is often linked with some of the positivist underpinnings of the approach. For others (including Glaser and Strauss in the initial publication of *Discovery*) grounded theory is a flexible set of strategies that should be used as and when appropriate by the researcher (see Charmaz, 2006). Today, this position is generally interlinked with "postmodern" approaches in qualitative field research, approaches that generally position the researcher as inextricably part of the phenomenon in question. Contra positivist assumptions that there are social phenomena "out there", waiting to be understood in totality from the privileged outsider perspective of the sociologist, qualitative researchers influenced by postmodern critiques generally acknowledge there is no one "correct" interpretation of a phenomenon in question because we must acknowledge our own active participation in our research.

I draw on the strands of grounded theory that critically address and try to move away from some of the positivist assumptions and aspirations of grounded theory and take postmodern critiques of qualitative research methods seriously (e.g. Charmaz, 2000, 2006; Clarke, 2005). I have used grounded theory as a helpful set of resources in going about studying somatic cell nuclear transfer empirically. I have not rigidly followed the procedures of grounded theory, but used these tools as appropriate in order to grasp the landscapes in cloning endangered wildlife in the United States. I will now clarify some of the general components of grounded theory and describe how I modified and used these procedures in conducting this research project.

<u>Coding and Memoing to Develop Process-Based Grounded Theories</u>

Grounded theory is predicated on the belief that the researcher should continually move between data collection and analysis (Charmaz, 2000; A. L. Strauss, 1987: 18-19). This represents an important rupture to longstanding beliefs that research should occur in a linear fashion. In grounded theory, sampling should not be predetermined, but rather extended in response to the researcher's changing understandings of the phenomenon in question as new data is acquired and analyzed. Drawing on this central element in grounded theory, I initially reviewed the landscapes of cloning endangered wildlife by reading articles in the popular press, articles in scientific journals and edited volumes, and studying websites of relevant organizations. I copiously documented these materials for coding, an analytic process discussed later. Based on this review, I began to schedule interviews with relevant people and asked for tours of particular sites. Analysis of these initial interviews and participant observation fieldnotes reshaped my understanding of the landscapes of cloning endangered wildlife, prompting me to collect other kinds of data.

With grounded theory, analytic categories are developed through studying data rather than testing preconceived theories, concepts and/or hypotheses (Charmaz, 2006). Data analysis occurs through two processes: coding and memoing. With coding, portions of text are closely read, interpreted, categorized and related (Charmaz, 2006: 46). Coding takes three different but interrelated forms, including open coding, focused coding and axial coding. It is important to point out that these different types of coding do not occur in a linear fashion. Certainly, earlier in the research project open coding predominates while later on focused coding and axial coding will be the focus. Nonetheless, throughout the research process I continually moved among these different types of coding because collecting new data would invariably give rise to new analytic categories as well as refashion or confirm already developed analytic categories. The other analytic process is referred to as writing "memos". Whereas coding creates short names or tags to facilitate the analytic process, memoing allows one to write out and elaborate upon thoughts one has regarding the analytic process. I used memoing to reflect on codes, to reflect on my data analysis vis-à-vis existing literature, and to consider other sites where data should be collected. Memos can take the form of more traditionally written narratives or can use "clustering" to diagram ideas (Charmaz, 2006). I will now turn to a more detailed description of both of these analytic processes and my use of these different strategies.

Open coding is a process wherein each line of and/or incident in the transcribed interview is carefully considered and defined (Charmaz, 2006; A. L. Strauss, 1987). It is important to emphasize that, with grounded theory, open coding is first and foremost an analytic exercise. The goal is to open up the text, *not* to sort the text into a series of categories for later analysis. In grounded theory, coding is particularly attuned to defining action and practice (Charmaz, 2006). When open coding texts, I would often ask: 1) what is the author doing with this narrative and 2) what process is the author describing with this narrative. I would try to answer these questions with a single word or short phrase. This focus on process and action in open coding makes grounded theory distinct from coding procedures that explore the thematic or linguistic elements of a text.

Line-by-line analysis often results in a large number of codes (over 250 in this project), providing a basis for comparing, collapsing and relating different codes. Through this process, coding began to move from the unit of the textual line to the incident. I began to clarify certain codes and move toward what is referred to as "focused coding" (Charmaz, 2006). Here, already created significant/frequent/interesting codes are used and developed when analyzing new data. This is the more "data basing" side of coding in grounded theory, which allowed me to gather sections of text that appeared to refer to a similar process. This data basing process facilitated my ability to make comparisons across data, incidents, and contexts, render variation, and further understand and elaborate upon the processes occurring in the multiple situations of cloning endangered wildlife, work that was facilitated by writing memos.

Once certain codes became more or less developed, I began to selectively use what Strauss and Corbin (1998) refer to as "axial coding". Here, the properties and dimensions of a code or series of inter-related codes that I was particularly interested in were elaborated. Often, this took the form of considering both the conditions for the actions in question and the consequences of those actions (see also Charmaz, 2006; A. Strauss & Corbin, 1998). Axial coding facilitates the development of what is known in grounded theory as the elaboration of a "basic social process" in the area of study. For example, in Chapter 3 I discuss how somatic cell nuclear transfer has traveled to endangered species preservation by "transposing the bodies and techniques" used with domestic animals. Transposing is a basic social process that I developed by using all three coding strategies to describe and theorize how somatic cell nuclear transfer travels.

In developing the notion of "transposing", I broke from one of the central strategies of early grounded theory, that the researcher should do the literature review after conducting the research project rather than before and/or during. The rationale behind this strategy is that doing a literature review will compel the researcher to use pre-existing findings, concepts and theories in order to understand the phenomenon in question. The critique of this strategy is that it presumes that the researcher enters the phenomenon in question as an empty slate, without preconceived ideas developed from life and/or literatures already read. More practically, this position fails to contend with the fact that most researchers are expected by funding agencies and institutional review boards to do a literature review before engaging in research using human subjects. Rather than trying to erase my own experiences and knowledge, I have used these to better understand the data at hand. For instance, an important component of my analytic process in developing the code "transposing" was to compare what I meant by this concept to other relevant concepts that I knew from "the literature".

Grounded theorists seek to develop middle-range theories regarding the basic social processes occurring in the phenomenon of interest (see Charmaz, 2006: 61). For some, the goal is to create a single basic social process that defines the main action occurring in the area of interest.[4] I do not think that the situations in cloning endangered wildlife can be adequately described by a single process and so I did not make this my goal. Rather, I used the coding strategies elaborated in grounded theory in order to consider some of the social processes involved in the practices of cloning endangered wildlife. Throughout this dissertation, I contend that these situations are fragmentary and therefore cannot be understood in and through a singular social process. I refer to many social processes and interlink these processes when appropriate. I do not, however, attempt to consolidate these social processes in any sort of totalizing manner.

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[4] Adele Clarke (2005) has critiqued this aspect of grounded theory as being excessively positivist and failing to account for multiplicity and heterogeneity.

Situational analysis

A significant criticism of grounded theory is that, in seeking to create basic social processes to explain a phenomenon, the resulting theories tend to appear suspended in time and space (Burawoy, 2003). As a corrective to this and other problematic aspects of grounded theory that link back to some of its positivist roots, Adele Clarke (2003; 2005) has pushed grounded theory "around the postmodern turn" with her situational analysis. She supplements the social process/action root metaphor of grounded theory with an ecological root metaphor. Clarke develops this methodological approach by bridging grounded theory with social worlds/arenas, a concept developed in the symbolic interactionist tradition by Anselm Strauss (1993) among others (see also H. S. Becker, 1982; Clarke, 1991, 1998; Clarke & Montini, 1993; Garrety, 1997; Shibutani, 1994) that will be discussed in the Theoretical Background section of this chapter.

With situational analysis, Clarke urges field researchers to situate the action or, in grounded theory terms, the basic social processes in question. She develops four types of mapping devices researchers can use toward this end: situational maps, relational maps, social worlds/arenas maps, and positional maps. For this project, I used situational, relational, and positional maps. Situational maps lay out all the elements involved in the situation in question.[5] Relational maps draw upon the situational maps by linking varying elements and considering their relations. I created situational and relational maps across the research project, from the very beginning of project design through writing the chapters of

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[5] Clarke (2005) provides the following cues for considering the elements in a situation: organizational/institutional, political economic, human, nonhuman, spatial and temporal, population and other discourses, discursive constructions of actors, symbolic, sociocultural, local to global, and other empirical elements.

the dissertation itself.[6] I used these maps to develop an understanding of the varying situations wherein animals of endangered species are cloned using somatic cell nuclear transfer and to compare these situations among one another. Positional maps lay out the varying positions taken and not taken in the data gathered regarding areas of concern or controversy. I selectively used positional maps to consider the varying positions on questions or areas of concern that seemed particularly controversial in the practices of using somatic cell nuclear transfer. This included creating positional maps on the significance of somatic cell nuclear transfer experiments to endangered species preservation (see Appendix III) and the significance of mitochondrial DNA in classifying resulting animals (see Figure 4).

I did not use social worlds/arenas maps because I did not find these units of analysis appropriate to practices in cloning endangered wildlife.[7] Social worlds are "groups with shared commitments to certain activities, sharing resources of many kinds to achieve their goals, and building shared ideologies about how to go about their business" (Clarke, 1991: 131). Varying social worlds come together in "arenas" when their commitments, activities, resources, goals and/or ideologies intersect (Clarke, 1991, 1998; Clarke & Montini, 1993; A. L. Strauss, 1993). While endeavors to clone animals of endangered species intersect with social worlds and arenas, to date the practices involved in cloning these animals is not itself a social world or an arena of sustained work. Current endeavors to clone animals of

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[6] I discussed my use of situational and relational maps in the book chapter "Grounded Theorizing Using Situational Analysis", by Adele Clarke and Carrie Friese (2007). Exemplars of situational maps developed across the course of this project can be found here as well.

[7] Thank you to Charis Thompson for pointing this out early on, which became increasingly clear to me as I began to make situational and relational maps.

endangered species are sporadic and fragmented. There are no organizations devoted solely to developing nuclear transfer with endangered species; nor are there any social worlds largely committed to using nuclear transfer with such animals. Moreover, this practice today remains highly contested and criticized with quite unclear futures.

I found the concept of the situation to be more useful for considering the kinds of tenuous and uncertain contemporary venues in which somatic cell nuclear transfer is being taken up. Citing Morrione, Clarke positions the situation as ‘both an object confronted and an ongoing process subsequent to that confrontation ... Situations have a career-like quality and are linked in various ways ... to other situations” (2005:21). Situations are thus objects of inquiry that can be analyzed and also productive forces to be understood as such. Situations have historical drag at varying temporal moments, but not necessarily in the more enduring organizational and institutional terms that are associated with social worlds and arenas.

One of the significant aspects of Clarke’s (2005) situational analysis is her focus on discourses of varying kinds, ranging from the more traditional interview transcripts and fieldnotes as well as visual images, historical documents, symbols, representations and narratives. By taking discourses seriously, Clarke is furthering the move in qualitative field methods “beyond the knowing subject” (e.g. Foucault, 1970; 1972) to study discourses or language and their inextricable relationships to practices and social orders. Throughout this dissertation, I attempt to unpack some of the discursive practices that situate endeavors to clone endangered wildlife, including: endangered species, domestic species, zoos, conservation, biomedicine, feasibility studies, cloning, and genetic value. I have drawn on secondary texts from sociology, anthropology, history, environmental studies, and science and technology studies alongside the other primary and secondary data sources described earlier to do so.

THEORETICAL PERSPECTIVES

This dissertation is located in the field of science, technology and medicine studies, particularly in the intersections between medical sociology and science and technology studies. My approach to science, technology and medicine studies is informed by symbolic interactionist approaches developed in American sociology and Foucaultian approaches to understanding biomedical knowledge and practices. In this section I provide an overview of some of the theoretical orientations that have informed this dissertation from its inception through writing. I reflexively consider my own theoretical background, while providing an introduction to some of the key "sensitizing concepts" (Blumer, 1969) referred to throughout this dissertation. Whereas received theory is used to explain the phenomenon under study, studying data using sensitizing concepts open our eyes to aspects of the data that may have not been readily visible. These fields of theorizing represent the "situated knowledges" (D. J. Haraway, 1991c) that I brought as I sought to partially understand the situations of cloning endangered wildlife.[8]

Science and technology studies

Science and technology studies (STS) is field of inquiry that began to coalesce during the 1970s.[9] Many of the assumptions and arguments that scholars in this field make link up

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[8] With situated knowledges, Haraway offers an approach to understanding and developing knowledges that are both contingent and deeply committed to materiality and worldly practices that critiques both realism and social constructionism. Visions provide the metaphor for this kind of situated knowledges, which is always an embodied, located mode of partial knowing.

[9] This section should not be read as a thorough review of the field, but rather an introduction of some of my theoretical engagements and commitments. For a more thorough overview of

with earlier works by Ludwick Fleck ([1935] 1979), Karl Mannheim (1936), and conflict theorists in the sociological tradition (see Hess, 1997). STS is a markedly trans- or non-disciplinary field, although there are on going attempts to discipline the field. Nonetheless, STS is marked by serious engagement between sociologists, anthropologists, historians, continental philosophers, feminism, cultural studies, and post-colonial studies in examining scientific knowledge production and practices as social endeavors. While the field varies, one feature of the scholarship in this field is to trouble positivist assumptions that science "discovers" the reality of the world that is put forth in the logics of positivism. Rather, science is a kind of social practice that brings a range of humans and nonhumans together in particular and very local ways, producing "situated knowledges" (D. J. Haraway, 1991c). In this section, I trace out some of the epistemological threads informing this field of inquiry that are taken up and/or drawn upon in this dissertation.

The sociology of scientific knowledge (SSK) developed in Britain during the 1970s with the Strong Program, located in Edinburgh, and the Bath School. Scholars including Barry Barnes, David Bloor, Steve Shapin and Harry Collins charged that functionalist approaches to science, specifically Merton's and related functionalists' work on the norms of science, failed to consider and problematize the knowledge that scientists produce (Hess, 1997; Pickering, 1992). SSK alternatively sought to empirically examine scientific knowledge as a social product (Pickering, 1992). Unlike previous studies of science, SSK focused on the "content" of science, including theories, methods, design choices and other technical aspects of scientific knowledge in the making (Hess, 1997). In *Knowledge and*

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the field, see Chapter 1 in Charis Thompson's (2005) *Making Parents: The Ontological Choreography of Reproductive Technologies* and David Hess's (1997) *Science Studies: An Advanced Introduction*.

Social Imagery (1991), David Bloor laid out four tenets for SSK that continue to be utilized, elaborated upon, and critiqued by STS scholars today. The tenets include: 1) a focus on causality; 2) impartial approaches to often bifurcated issues such as true/false, rational/irrational, success/failure, social/technical; 3) symmetrical analyses of science and society, and; 4) reflexive explanations that apply to both science and the social studies of science (Bloor in Hess, 1997: 86-87; Sismondo, 2004: 42).

Andrew Pickering (1992) points out that during the late 1970s and 1980s, scholarly works that linked up with, but were not directly connected to, SSK began to emerge in continental Europe, North America and Britain. Scholars in laboratory studies, ethnomethodology, discourse analysis, symbolic interactionism, anthropology, feminism, postcolonial studies, and cultural studies also began to study science empirically (Hess, 1997; Pickering, 1992). Like SSK, scholars used these approaches in a manner that rejected philosophical apriorism and highlighted the social components of scientific knowledge (Pickering, 1992). However, these approaches were also somewhat distinct when compared to SSK, in that much of this work made scientific *practices* central to the study of scientific knowledge. The focus on scientific work practices allowed for a more complex understanding of the "causes" of scientific knowledge by demonstrating that theories and social interests alone do not drive science (Pickering, 1992).

Symbolic interactionists have made a number of contributions to this field. Symbolic Interactionism is a school of thought rooted in American sociology that draws upon pragmatist philosophical traditions. The emphasis in pragmatism and symbolic interactionism is on action and interaction in the on-going constitution, reproduction and modification of selves, groups, meanings and social lives. The basic premise of symbolic interaction is that meaning is derived through, modified by and purposefully informs action and interaction between people and with objects (Blumer, 1969). Symbolic interaction has been used extensively to analyze the micro-level interactions in constituting socially-mediated selves (Charmaz, 1991; Goffman, 1959; 1963; Gubrium & Holstein, 2000; James, [1890] 1993; Mead, 1970; Snow & Anderson, 1995; A. Strauss, [1959] 1997). The theory has also been used for "meso-level" analyses of how social orders are enacted in a manner that resists the micro-macro division that has long been a source of contention in American sociology (Casper, 1998a; Clarke, 1991; Clarke & Montini, 1993; Hall, 1995; Shibutani, 1994; A. Strauss, 1978; 1997; 1993).

In STS, symbolic interactionists have analyzed science as a kind of practice and work that people engage in. Symbolic interactionists have long studied work practices in medicine (e.g., Baszanger, 1992; Bucher & Strauss, 1961; Casper, 1998b; Olesen & Bone, 1997; A. Strauss et al., 1997; Timmermans, 2006), providing precedents for similarly studying science as a kind of work (see Clarke & Star, 2003; 2007 for an overview). This approach to scientific work practices is most clearly articulated in the volume *The Right Tools for the Job: At Work in-Twentieth Century Life Sciences* (1992a) edited by Adele E. Clarke and Joan Fujimura. Taken together, the essays in this book demonstrate how "the nitty-gritty of scientific work" (1992a: 3) ruptures deterministic models for conceiving of scientific knowledge (e.g., science does not inevitably "discover" the truth of things). Rather, scientific knowledge is constituted in and through the choice of certain jobs, the availability of certain tools, and the articulations between jobs and tools as "right" in specific situations. With this volume, Clarke and Fujimura link up scientific practices with the argument that scientific knowledge is socially constituted in and through the bringing together of certain jobs and tools in particular spaces and times.

Over the course of the 1990s there was an increasing "cultural turn" in the field of STS. Feminist, postcolonial, and antiracist standpoints have persuasively argued that issues of culture and power are frequently eclipsed in the Sociology of Scientific Knowledge (SSK) and Actor Network Theory (ANT) (Hess, 1997: 113). This critique largely emerged as an increasing number of scholars began to show how cultural values and purported social differences are naturalized in and through scientific representations of sex, gender, sexuality, and race *across* purportedly "good" and "bad" sciences (Clarke, 1998; Duden, 1993; Fausto-Sterling, 2000; D. J. Haraway, 1989, 1991b, 1997; Harding, 1993; Jordanova, 1980; Nelkin & Lindee, 1995; Oudshoorn, 1990; Potter, 2001; Stepan, 2000; Stepan & Gilman, 1993). And these categories are constitutive of science-in-the-making.

In sum, drawing on the field of science and technology studies, I understand somatic cell nuclear transfer as a kind of work activity. By studying science in action, I am able to explore how somatic cell nuclear transfer is bound up in certain locales, knowledges, practices, logics, bodies, discourses, and political economic processes. STS provides a lens through which the very practices of and around doing somatic cell nuclear transfer are revealed as social and cultural. We can study the social lives of this technique in the here and now, rather that imagining its use in the future. And we can begin to see how emergent assemblages that somatic cell nuclear transfer circulates within also "have politics" (Winner, 1980).

Sensitizing Concepts for Conceiving of Science as Social: Actor Network Theory, Social Worlds/Arenas, and Assemblages

There are two predominant theory-method packages in STS that are used to conceive of and study science as practice. Actor network theory is probably the dominant theory-method package, with roots in semiotics and the works of Michel Foucault. Social worlds/arenas represents an alternative analytic, which is rooted in symbolic interactionism. While conceptualizing this project and doing the research and analysis, I continually referred to both of these theory-methods packages. In the end, however, I did not feel that the either of these modes for modeling scientific practices adequately represented the highly fragmentary situations in cloning endangered wildlife (see also Clarke & Friese, 2007). I instead have used the more flexible, if less explanatory, concept of "assemblages" (Deleuze & Guattari, 1987) to represent these situations. In this section, I will provide a brief overview to each of these sensitizing concepts that will be variously referred to throughout this dissertation.

Actor network theory, developed by Michel Callon ([1986] 1999), Bruno Latour (1987; 1999a; 1999b; (1983) 1999) and John Law (1999), is a prominent framework for studying science in STS (Sismondo, 2004). This model "follows" scientists or nonhuman actors as they engage with other humans and non-humans to build networks that sustain the authority of the laboratory (Latour, 1987; see also Sismondo, 2004). Proponents of actor network theory have argued that these engagements *produce* social structures (Latour, 1988) and reject the use of social structures as explanatory devices for science-in-the-making. An important component of actor network theory is that it is "symmetrical" (Bloor, 1991) in its approach to humans and nonhumans. Both humans and nonhumans are understood as agentic actors in the creation of networks. New actors are often "enrolled" into the network through the process of "translation" or making two different things equivalent (Callon, [1986] 1999; Law, 1999; Mol, 2002). With actor network theory, the contingencies and productivities of science-in-the-making become ever present through tracing the micro-practices of network building.

Social worlds/arenas is a concept that is embedded within pragmatist and symbolic interactionist traditions of American sociology (Clarke, 1991). The concept was originally defined by Anselm Strauss (1978) to denote the ways in which people come together to engage in certain activities, in particular locales, and with specific technologies. Challenging the totalizing and abstract sociological notion of "society," Strauss (1993) instead envisioned social life as a tapestry of overlapping social worlds wherein individuals and collectivities of all kinds are multiply situated. Central to Strauss's (1993) conceptualization of social worlds is the notion that the identities and activities of social worlds are not innate, but important sites of ongoing work. This kind of work becomes particularly apparent, and important, when social worlds come together in an "arena". Arenas are areas of sustained interest and concern that bring a number of social worlds together. Strauss's (1978; 1993) concept of "negotiated order" worked to draw analytic attention to the kinds of power relations that enable the perspectives of some social worlds to become predominant while others do not.

Social worlds/arenas has been an important theoretical and methodological intervention through which scientific knowledge production has been conceptualized as social practice amongst STS scholars (see Clarke & Star, 2003; 2007 for a review). This theory-method package is often used to study some arena of scientific activity, such as disciplining the reproductive sciences (Clarke, 1998), crafting genetic approaches to cancer

(Fujimura, 1996), making the unborn patient (Casper, 1998a), or locating gene-environment interaction in toxicogenomics (Shostak, 2003). Here, the researcher locates *all* the social worlds involved in *and implicated by* (Clarke & Montini, 1993) these endeavors. Social worlds are understood as collectivities of humans along with nonhumans, activities, knowledges, materials and locales (Clarke & Fujimura, 1992b). As such, social worlds/arenas directs the research toward a "multi-sited" (G. Marcus, 1995) research approach (Clarke, 2005; see also C. Thompson, 2005: 41-42).

For this project, I variously drew upon both actor network theory and social worlds/arenas, although I do not define the practices in endeavoring to clone and conserve endangered wildlife as either. From actor network theory, I drew especially on the notion of "following" key actors. Specifically, I followed the creation of alliances or networks that allowed each cloned, endangered animal to come into being. Drawing on social worlds/arenas, I attuned myself to considering which social worlds are and are not represented in the situations of cloning endangered wildlife, how somatic cell nuclear transfer fits or does not fit into these worlds, what arenas this practice intersects with, how somatic cell nuclear transfer comes to count or not count as the "right tool" (Clarke & Fujimura, 1992b) for the scientific activity people are engaging in and around.

In the end, however, I did not think that the situations in cloning endangered wildlife are best understood as either an actor network or an arena (see Clarke & Friese, 2007 for a discussion). The tenuousness and uncertainty of cloning endangered wildlife is not best grasped with either actor network theory or social worlds/arenas, both of which are more attuned to processes of stabilization (e.g., Clarke, 1998). For example, in my project individuals could not be considered spokespersons for any given social world given that the endeavor is so contentious *within* many social worlds and arenas. While some individuals are strongly in favor of and others oppose cloning animals of endangered species, many are still undecided about the utility of this experimental prospect and leery of its possible consequences.

I have instead used the more flexible and loose (even elusive) concept of "assemblages" (Deleuze & Guattari, 1987) to represent the varied situations in cloning endangered wildlife. Deleuze and Guattari's (1987) assemblages are emergent, temporary contingent sites wherein heterogeneous things come together because they more or less work together to pursue certain specific goals. George E. Marcus and Erkan Saka (2006) contend that "assemblage" is a flexible concept through which theorists can think through the heterogeneous, the ephemeral and the aesthetic while also holding on to the structural that is so integral to the social sciences. Marcus and Saka (2006: 102) also note that, not surprisingly, "assemblages" are in turn varyingly defined and taken up:

> There is an ambiguity in the referential frames in use of assemblage. It can refer to a subjective state of cognition and experience of society and culture in movement from a recent past toward a near future (the temporal span of emergence); or it can refer to objective relations, a material, structure-like formation, a describable product of emergent social conditions, a configuration of relationships among diverse sites and things.

It is worthwhile to point out that my dissertation takes up the latter use of assemblages, considering what kinds of relations, sites, and things somatic cell nuclear transfer has become bound up in and productive of. Significantly, I do not attempt to consolidate the analysis into a description of a singular assemblage but rather trace some of the varying assemblages that have emerged and even faded away to date. In concluding, as Marcus and Saka (2006) suggest, I found that assemblage is a good metaphor to work with in part because it is not tightly associated with formal properties, which both actor network theory and social worlds/arenas are. And so I do not try to formalize "assemblages" but instead continue to use this metaphor in a rather flexible manner.

Post-humanism

One of the more significant contributions made in and by the field of science and technology studies has been the acknowledgement and consideration of how humans are fully enmeshed with nonhumans of varying kinds, ranging from animals, plants, microscopes, etc. As already mention, actor network theory draws on Bloor's (1991) argument for symmetrical analyses to consider the ways in which nonhumans alongside humans must be agential actors for networks to be built and sustained (for a feminist approach to nonhuman actors see also Barad, [1998] 1999). This section provides a brief overview to some of the post-humanist theorizing developed in STS.

In *We Have Never Been Modern* (1993), Bruno Latour provocatively contends that the moderns have never separated nature from culture, objects from subjects, nonhumans from humans. Rather, Latour contends that modernity is premised upon normative co-constitutions of practices that create mixtures of humans and nonhumans as well as natures and cultures through the "work of translation" while also simultaneously separating humans from nonhumans, culture from nature through the "work of purification". For Latour, the *idea* that nonhuman hybrids are not involved in social and human affairs has unraveled as modernism has pursued itself. "The modern Constitution has collapsed under its own weight, submerged by the mixtures that it tolerated as material for experimentation because it simultaneously dissimulated their impact upon the fabric of society" (Latour, 1993: 49).

Much of Donna Haraway's scholarship over the years has engaged and debated Latour in an ongoing "conversation". She pushes Latour's provocation and further asserts that "we have never been human" (D. Haraway, 2004b). Donna Haraway's primate visions (D. J. Haraway, 1989; 1991b), cyborgs (D. J. Haraway, 1991a), and companion species (2003a; D. J. Haraway, 2003b) together demonstrated how humans and nonhumans are co-constitutive and have been so for centuries. *Primate Visions* (1989) examines how human social orders based on domination of various kinds (e.g., sex, race, class, gender, sexuality, family, nation, colony, and production) are written onto the lives and bodies of animals. Primates become the "raw material" for modeling a white, male human self and corresponding social order. Haraway (1991a) continued to explore the inseperabilities of humans and nonhumans, physical and nonphysical, natural and crafted, imagination and materiality with her argument that we are all cyborgs, around which she wrote a manifesto for feminist anti-racists that rejects the often divisive tropes of unity, wholeness and essentialisms. Central to Haraway's cyborg are the leakages between animal-human-machine, which rupture ideas about boundaries and makes new kinds of configurations possible. Haraway resists a naive celebration of these leakages, but instead points to the simultaneous possibilities of accelerated domination as well as new kinds of relations that can be forged. She contends that the binaries of male/female, human/animal, nature/culture are not adequate tools for understanding emergences in technoscientific worlds (such as biotechnologies including somatic cell nuclear transfer), or for developing politics that resist domination. Haraway's (2003b: 11-12) work on companion species furthers analysis of how humans and animals are inseparable, clearly emphasizing that dogs are not mirrors or projections for some kind of imagined human self but rather "species in obligatory, constitutive, historical, protean relationship". Haraway shows how humans and dogs have been thoroughly co-constituting in their socio-physico-politico-economic worlds (see also D. Haraway, 2004a).

In sum, the range of post-humanist theorizing ruptures the notion that practices in animal cloning can be held widely apart from the matters and meanings of humans. Humans and animals are together entrenched in experiments using somatic cell nuclear transfer, quite obviously in the very practices of doing somatic cell nuclear transfer, but also in rendering somatic cell nuclear transfer meaningful in and through what Karen Barad ([1998] 1999) terms "intra-action". Barad uses this term to represent the ways in which relations, knowledge and materialities are constrained, but not determined in and through action and the ways in which action is the process through which these are co-constituted over time. Intra-action provides a window through which we can recognize the agency of animals and other nonhumans in constituting this technique and the assemblages within which it circulates. And we can see how animals are not passive manipulates but instead may "act back", constraining attempts at cloning, domestication, selective reproduction and conservation.

Medical Sociology

Medical sociology is a subfield of sociology that takes up the following general areas of study: 1) biomedicine as a social institution; 2) healthcare organizations and delivery; 3) social production of health and illness; 4) social experience of health and illness, and; 5) social production and construction of medical knowledge and technologies. Social theorizing regarding biomedicine as an institution has taken many forms, ranging over time from: Talcott Parsons' sick role (Parsons, 1951), Eliot Friedson's medical professionalism (Freidson, 1970; 1981), medicalization, demedicalization and social control (Conrad, 1992;

2000; 2007; 2001; Conrad & Schneider, 1980; Estes & Binney, 1989; Foucault, 1994a; Fox, 1994; Zola, 1997), biopower (Armstrong, 1995; Foucault, 1973, 1977, 1978), biosociality (Rabinow, 1996a), and biomedicalization (Clarke, Shim, Mamo, Fosket, & Fishman, 2003). I will not elaborate upon each of these concepts, with one exception. Much of contemporary medical sociology that explores biomedicine as an institution goes through Michel Foucault, particularly his theorization of the clinic in medical knowledge and practice and the notion of biopower through which medicine becomes one of many governing insitutions in the operation of pastoral power. In this section, I focus specifically on Foucault's notion of biopower and its relation to recent theorizing regarding the shifting terrain of biomedicine as a social institution.

The making of "life" into an object of knowledge is central to Foucault's conceptualization of biopower. While cloning is a technique through which "life" is rendered an object of knowledge, and thereby amenable to a Foucauldian analysis, Sarah Franklin (1999a) has noted that there has been surprisingly little scholarly analysis through this lens. I draw upon the concept of biopower to consider the relationships between humans and animals as well as conservation and biomedicine by questioning who/what is made to live in what kinds of situations and who/what is disallowed life to the point of death, including species extinction. I offer a synopsis of Foucault's notion of biopower, its significance in the field of medical sociology, and its elaboration to understanding the changing landscape of medicine because these are theoretical frames to my project.

In *The History of Sexuality* (1978) Foucault contends that there was a shift in the operation of power from the sovereign's right to *take* life from those who rose up against him and his laws to a form of power premised upon *making* life by way of administrative practices. “One might say that the ancient right to *take* life or *let* live was replaced by a power to *foster* life or *disallow* it to the point of death . . . . Now it is over life, through its unfolding, that power establishes its dominion; death is power’s limit” (Foucault, 1978: 138 italics in original).

Foucault (1977) argued that biopower operates at two poles that were increasingly interconnected by the nineteenth century: the population body and the individual body. He contends that the individual body became a site of power in the seventeenth century and centered on conceptualizations of the body as a machine that could be disciplined and optimized in order to make it more docile, productive and efficient. The second pole of biopower developed somewhat later according to Foucault, and focuses on the species or population body. In conjunction with the emerging “life” sciences, and the attendant focus on how life reproduces itself, interventions in this process arose as a means to manage and control populations. The two poles of biopower began to converge in the nineteenth century by way of concrete arrangements that make up a vast network of power relationships at every level of the social body through which individual and population bodies are surveillance and ordered (Armstrong, 1995).

Foucault adamantly rejects a top-down power structure and thereby the conceptualization of power as a reified “thing” that some have and other do not. Rather, Foucault highlights the relationality of power through a technique that he calls “pastoral power” (1994b: 332). Specifically, Foucault contends that the modern state is an extension of the kind of power technique used by the church that is salvation-oriented, individualizing, continuous with life, and linked with the production of truth (Foucault, 1994b: 333). Whereas the church is concerned with salvation in the next life, the modern state makes its objective the continuation of life in this life through an expansion of public institutions (including the family, medicine, psychiatry, education and employment) that develop knowledges of the individual and population that are in turn subject-producing. "In effect, what defines a relationship of power is that it is a mode of action that does not act directly and immediately on others. Instead, it acts upon their actions: an action upon an action, on possible or actual future or present actions" (Foucault, 1994b: 340).

Foucault notes that the development of power relations based on making life has not meant that the taking of life has stopped. Rather, taking of life has been reconceptualized as a part of the making of life at the population level. "Wars are no longer waged in the name of a sovereign who must be defended; they are waged on behalf of the existence of everyone; entire populations are mobilized for the purpose of wholesale slaughter in the name of life necessity; massacres have become vital" (Foucault, 1978: 137). Foucault has argued that the category of "race" was essential to the accommodation of making death within the context of biopower (Foucault, 2003). In other words, the establishment of the "other" provided grounds for making death when the state operates in and through biopower.

Biopower is generally used to conceptualize the relations between human individuals and populations, but it is also deeply imbricated in the ways in which humans seek to organize and manage animal populations. According to the logics used by conservationists and population geneticists, the purpose of nuclear transfer is to produce a new animal of an endangered species that will diversify the genetic constitution of a small population (Ryder, 2002). In other words, cloning is now being used to change the population body of endangered species. As Adele Clarke (2007) has pointed out, we need to better understand the relationships and discontinuities between biopolitical apparatuses used with humans and animals alike. I use the lens of biopower to understand what kinds of management systems somatic cell nuclear transfer is bound up in and constitutive of.

Nikolas Rose (2001; 2007) traces the ways in which biopolitics is amplified and transformed at the turn of the twenty-first century. He argues that this has occurred through five shifts in the operation of biopolitics. The first shift is a move from the molar (e.g., bodily masses like limbs, organs, or tissues) to the molecular body in biomedical knowledge and practices, which allows for new kinds of mobilities to arise.

> Molecularization strips tissues, proteins, molecules, and drugs of their specific affinities – to a disease, to an organ, to an individual, to a species – and enables them to be regarding, in many respects, as manipulable and transferable elements or units, which can be delocalized – moved from place to place, from organisms to organisms, from disease to diseases, from person to person.
> (Rose, 2007: 15)

Second, biopolitics is no longer solely focused on healing the ailing body but also on optimizing the body through a future-oriented position in the present. Third, amplifications of individual responsibilities for health with the rise of neo-liberalism have in turn amplified the role of the corporeal in the processes of subjectification and governmentality. Fourth, the mobilization of biomedical modes of governing are today being less mobilized by the state and more so through laboratories, marketing and new professionals who occupy regulatory positions (e.g., bioethicists). The fifth process is the intensive capitalization and investment in life and vitality for the purpose of generating values of many kinds.

Rose's discussion of shifting biopolitics are overlaid with the rapid changes occurring in and around biomedicine as an institution over the past half century. Adele Clarke and colleague's (2003) notion of "biomedicalization" provides an important inroad. They delineate five intertwined processes. First is the political economic reconstruction of biomedicine through which private corporations and new philanthropies along with the state have become increasingly central to the funding of technoscientific biomedical research. This process is linked to "bioeconomics" (Rose, 2007), promissory capital (C. Thompson, 2005), and biocapital (Sunder Rajan, 2006). The second process is the increasing focus on health (rather than disease) and the extension of risk categories as well as surveillance mechanisms, making health both an individual goal and moral responsibility (see also Edgley & Brissett, 1990; Foucault, 1977; Rose, 2001; 2007). The third process involves increasing technoscientization and informationalization of the practices, innovations, and delivery of healthcare with digitalization and molecularization. The fourth process includes the changing modes in which biomedical knowledges and information are produced, distributed, and consumed with the rise of health care consumers as knowledge co-producers and market niches (see also Epstein, 1995, 1996). Finally, the fifth process includes the creation of new individual and collective technoscientific identities based on the ways in which bodies are being transformed (see also Rabinow, 1996a).

Reproductive and other biotechnologies occupy particularly important nodes in the changing landscapes of biomedicine and biopolitics (Clarke, 1995a; 2003; Rabinow, 1996a; Rapp, 2000; Rose, 2001; 2007; C. Thompson, 2005). These techniques are premised upon changing bodies and the relations between bodily parts (Rose, 2007; C. Thompson, 2005; Waldby & Mitchell, 2006). Their use is often associated with "boutique" medicine in the United States, accessible to those who can afford these self-fashioning technologies (Clarke, 1995a; C. Thompson, 2005). This dissertation contributes to the growing literature on the changing landscapes of biomedicine and biopower, but does so at the borderlands of these institutional dynamics where medicine, conservation and agriculture meet. The premise of this dissertation is that, by looking at the borderlands of biomedicine, we can come to understand how biomedicine is in flux in fresh ways.

I situate this dissertation in those strands of medical sociology that explore biomedicine as a social institution and site of knowledge production. This orientation allows me to consider the ways in which practices in cloning endangered wildlife straddle the institutions of conservation and biomedicine. The deep semiotic connections between endangered species and conservation can obscure the ways in which endeavoring to clone endangered wildlife is also exemplary of biomedicalization (Clarke et al., 2003), here the routinization of interventions utilizing sophisticated biomedical technologies as well as molecularization (Rose, 2007), here the ability to transform individuals and populations by disentangling genomic information from fully formed organisms.

OVERVIEW OF DISSERTATION

This dissertation explores the varying assemblages that somatic cell nuclear transfer has become bound up in and constitutive of in joint endeavors to clone and conserve endangered wildlife in the United States. These assemblages include technological development, animal models in biomedical research, domesticating animals, mobilizing vitality, producing value, genetically managing animals, keeping wild animals, and classifying bodies. They are being constituted at the borderlands of conservation and biomedicine, species bodies, the individual and population body, and human relations with domestic and wild animals. With each chapter, I juxtapose some of the ethical considerations that arose as I traced these assemblages to some of the more predominant concerns about human cloning.

Chapter Two provides an overview to the situations wherein somatic cell nuclear transfer has been used with endangered animals in the United States. I situate this landscape in the uptake in the technical development of somatic cell nuclear transfer, the history of zoological parks, and the discursive practices involved in preserving endangered species. I locate the development of somatic cell nuclear transfer with endangered wildlife in the expansion of reproductive and genetic sciences in U.S. zoological parks beginning in the late 1970s. This represents a new kind of biomedical approach to endangered species preservation within which somatic cell nuclear transfer is entrenched. I also introduce some of the controversies surrounding practices in cloning endangered animals in zoo and conservation worlds. These are located in some of the fissures between demographic approaches to species preservation, genetic management approaches to species preservation, feasibility studies, and questions regarding the suitability of domestic animal models for endangered species. Providing this overview of some of the "scapes" (Appadurai, 1996) that situate endeavors to clone and conserve endangered species, I contend that these fragmentary situations cannot be considered social worlds in an "arena" (Clarke, 1991; Clarke & Montini, 1993; A. L. Strauss, 1993) of sustained interest and concern. Rather, somatic cell nuclear transfer is circulating in "assemblages" (Deleuze & Guattari, 1987) that occasionally bring together bodies, techniques and knowledges of conservation and biomedicine in particular kinds of ways.

Chapter Three explores how somatic cell nuclear transfer has traveled from domestic to endangered animal bodies. I refer to this process as "transposing bodies and techniques", a process I distinguish from the more commonly used term of "technology transfer" and the process of "translation" (Callon, [1986] 1999; Law, 1999) that is frequently used in science and technology studies. I argue that transposing bodies and techniques, as a process, creates a dynamic set of relations between endangered and domestic bodies within particular situations. Transposition is in part a response to the lack of research materials. To do the work of using somatic cell nuclear transfer, an "ontological choreography" (Thompson [Cussins], 1996) between domestic and endangered positions must occur. In the case of cloning endangered wildlife, this ontological choreography is deeply politicized. I situate transpositions in the use of animal models and the "infrastructuration" (P. Edwards & Lee, 2006) of domestic animal bodies and relations. Here, contestations over the use of somatic cell nuclear transfer are linked up with varying modes of relating in and through the assemblages of biomedicine, conservation, agriculture, and corresponding bodies and techniques.

Chapter Four addresses the question of how somatic cell nuclear transfer becomes useful to species preservation projects. I trace how this technique has been used in conjunction with long-standing technologies associated with selective breeding, such as kinship charts and studbooks. Through this relation, somatic cell nuclear transfer becomes part of an assemblage that seeks to produce what I call "genomic nodes of value" across human relations with livestock, laboratory animals and endangered species. I contend that this is radically different from the metaphor of "the copy" that is most often used to conceive of the political economies of somatic cell nuclear transfer, but that is present in only some practices that use this technique. Specifically, I situate the production of genomic nodes of value in zoological parks within their colonial legacies of capturing and keeping wild animals. In part to "remediate" (Harrington, Becker, & Nachtigall, Forthcoming) such legacies, zoos are now attempting to use reproductive technologies to re-embody, retemporalize, and re-spatialize "founders" who bring new genetic information into closed captive population as cells rather than fully formed animals.

Chapter Five turns to the question of what cloned animals are and when they come to count as part of endangered species population bodies. Cloning an endangered animal using somatic cell nuclear transfer requires certain modifications. Rather than using an egg cell and surrogate of the same species, these projects involve what is often referred to as "interspecies nuclear transfer." While the nuclear donor is an animal of an endangered species, the ova donor and gestational surrogate are from a different, closely related, domestic species. The resulting animal has genetic relations with both the nuclear and ovum donor, giving rise to a number of different positions regarding whether or not animals produced by this technique "count" as part of endangered species. I begin by mapping out these different positions using Clarke's (2005) positional maps. I then situate these positions in the ways in which science is used to arbitrate and determine ontological status, the ways in which biological facts are not in and of themselves meaningful, the role of hybrids in species preservation discourses and practices, the move to "let domestics do the reproductive work for endangered species", and the prospects of genetically engineering endangered wildlife. I contend that the scenario of genetically engineering endangered wildlife would represent a rather radical shift in conservation practices and discourses.

I conclude in Chapter Six by summarizing the dissertation findings, provisionally thinking through what some of the processes and assemblages that somatic cell nuclear transfer is bound up in may mean vis-à-vis biomedicine itself. I do this by considering the implications this study has for both my participants and the intersecting fields of medical sociology and science and technology studies.

CHAPTER 2

Situating cloning:
Endeavoring to clone and conserve endangered animals in the United States

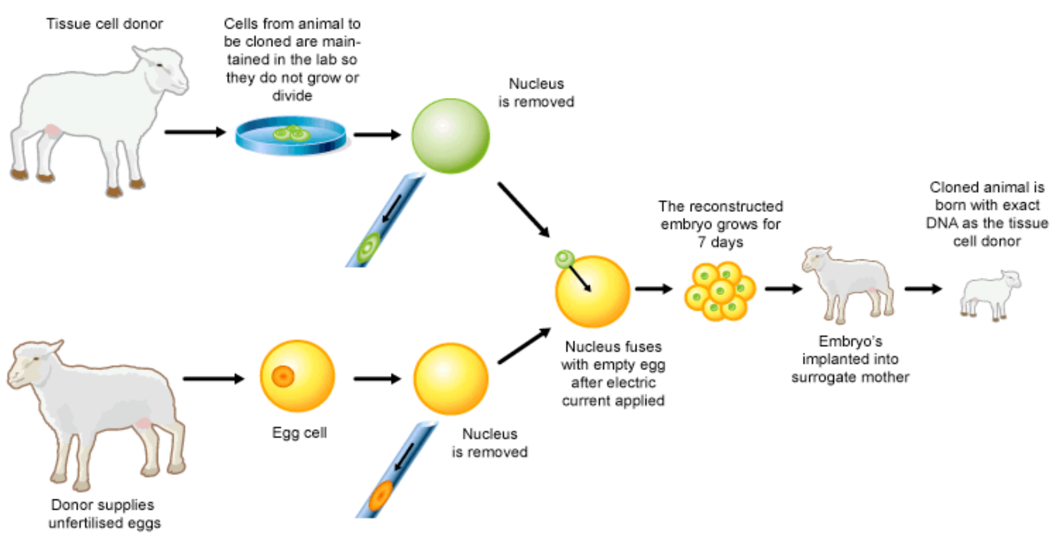
What is the right speculum for the job of opening up observation into the orifices of the technoscientific body politic?
Donna J. Haraway (1997: 193)

Since the birth of Dolly the Sheep, two images have become prominent in the discussions of cloning. These visuals have opened our eyes to cloning, allowing us to see particular kinds of meanings that somatic cell nuclear transfer may have. On the one hand, we have seen representations of Dolly the Sheep's face and body - along with those of other "world's first cloned animals" from the array of different species that followed (see Figure 1). These images have proliferated in mass media discussions of cloning and often link up with fantasies about the potential of human cloning, rather than the actual practices involved in animal cloning. Alternatively, somatic cell nuclear transfer has been represented through flow charts that demonstrate the bodily contributions and procedures of using somatic cell nuclear transfer (see Figure 2). These maps are prominent across popular, bioethical and scientific forums because they help explain how cloning works. Significantly, to my knowledge these maps are most always made on a white background, with the bodies in and processes of somatic cell nuclear transfer suspended in time and space.

While both images provide certain types of insights into the meanings and significances of cloning, these modes of representation have also obscured other meanings of somatic cell nuclear transfer that are currently in formation. This chapter uses an alternative mode of visualization in an attempt to see cloning in fresh ways,

FIGURE 1:
IMAGE OF DOLLY THE SHEEP
Time Magazine, March 10, 1997
Permission Required

FIGURE 2
REDISTRIBUTING REPRODUCTION: BODILY CONTRIBUTIONS AND PROCEDURES OF SOMATIC CELL NUCLEAR TRANSFER
Image from Biotechnology Online: An Australian Government Initiative
www.biotechnologyonline.gov.au/.../ img_scnt.cfm
Permission Required



thereby opening our eyes to alternative consequences that cloning is currently having. To do so, I use situational and positional maps (Clarke, 2005) to see the landscapes of cloning practices, as well as the social, political, economic, and historical processes that these landscapes are both entrenched in and productive of. Through these maps, I hope to situate cloning processes in time and space, in a manner that contrasts from Figure 2. I think that the kind of vision made possible with these mappings is particularly attuned to seeing "the orifices of technoscientific body politics" (D. J. Haraway, 1997: 193) in the making, while recognizing that all vision – including my own - is partial and deeply situated.

Figure 3 offers a map of the assemblages created in bringing together endeavors to clone and endeavors to conserve endangered wildlife in the U.S. This project map allows us to see the meanings of somatic cell nuclear transfer in new ways. The practices and processes of cloning are entrenched in the social situations whereby the technique is used. These situations are deeply historical, political and economic. By situating cloning in this manner, we can in turn better understand how this technique is productive. By entering into varying arenas, even if marginally to date, somatic cell nuclear transfer is not only constituted but also becomes constitutive of the varying arenas, social worlds, humans and nonhumans involved in the action of the situation. What I am positing here is that the consequences of cloning lay precisely in the kinds of relations and associations that are actually being made when somatic cell nuclear transfer is used in particular situations. We do not need to look to the future and fantasize about human cloning. Instead, we can understand the kinds of productive relations this technique is already involved in forging right now, in the present, that are already consequential for humans and nonhumans alike.

FIGURE 3: PROJECT MAP
ASSEMBLING ENDEAVORS TO CLONE AND TO CONSERVE ENDANGRED ANIMALS IN THE UNITED STATES

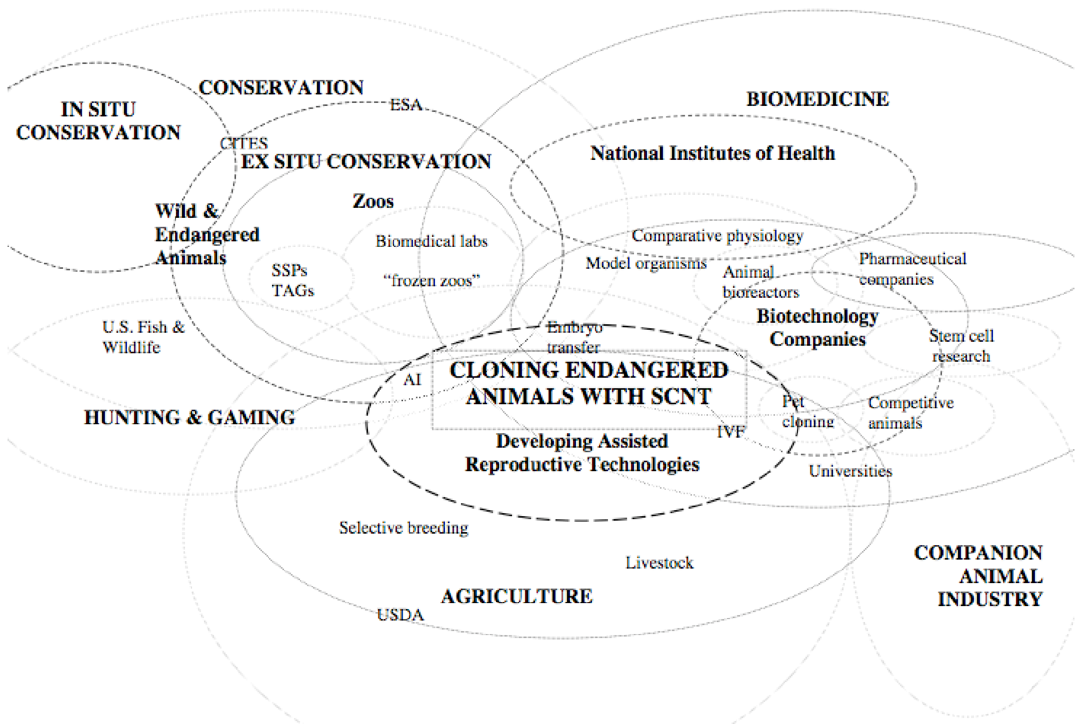


Figure 3 shows how the practice of cloning endangered animals occurs in the "borderlands" (Anzaldua, [1987] 1999) where conservation, biomedicine, agriculture, and the companion animal industry can be temporarily assembled. Significantly, the practice of cloning endangered animals is *not* represented as being firmly positioned within any of these "arenas". Arenas denote areas of sustained interest and concern that bring multiple social worlds together over time (Clarke, 1991; A. L. Strauss, 1993). Conservation, biomedicine, agriculture, and the companion animal industry are all arenas. However, somatic cell nuclear transfer is one of many tools developed and used by some social worlds in each of these arenas. As such, the development of somatic cell nuclear transfer is situated in and by the more general development of assisted reproductive technologies for cross species applications.

Cloning per se is more firmly situated in agriculture and biomedicine (e.g., with pharmaceutical production, model animal reproduction, livestock reproduction and stem cell research) than it is in conservation or the companion animal industry. As a result, we see in Figure 3 that cloning endangered animals is situated by varying human-animal relations, including in situ and ex situ wild and endangered species as well as livestock, model/laboratory animals, competitive animals, and companion animals. An important component of this dissertation is to explore the significance and consequences of developing assisted reproductive technologies across species for a variety of reproductive logics and practices.

I begin this chapter by reviewing the history of somatic cell nuclear transfer itself and its development in the work practices of life scientists across the twentieth century. This review is largely drawn upon secondary historical texts, particularly Jane Maienschein's (2001; 2002; 2003) important historical approach to questions about the meanings of embryos, stem cells, and cloning. I also draw upon information attained through interviews conducted for this research project regarding the more recent history of nuclear transfer research, particularly in the agricultural industry. Following this review of the development of somatic cell nuclear transfer, I turn to the institutional history of zoological parks in order to situate the uptake of somatic cell nuclear transfer with captive animals of endangered species. This allows me to situate the incorporation of genetic and reproductive sciences into zoological parks, drawing upon the interviews conducted as part of this dissertation.

I conclude by mapping the terrain of cloning endangered animals in the United States, which I contend is demarcated by the use of two different logics in going about conducting cloning projects. On the one hand, cloning endangered animals has been worked at using the logics associated with feasibility studies, which seek to assess whether or not using somatic cell nuclear transfer with a species is possible. Here it is assumed that questions regarding how this technique could be used to conserve species must come later, after the experimental process is demonstrated successfully. Alternatively, cloning endangered animals has also been pursued in a manner that links feasibility studies with conservation protocols based on genetic management. In the deeply contentious terrain of cloning endangered wildlife, we see that the way cloning projects are actually conducted informs the kinds of positions taken on the endeavor itself. The contestation surrounding many of these positions is quite intense. It reveals the co-constitutive role of techniques and discourses, cloning and conservation.

Through this mapping, I contend that the diffusion model does not provide an adequate basis for conceiving of the implications and consequences of techniques like somatic cell nuclear transfer. The diffusion model considers scientific knowledge and technology production as value-neutral, becoming social only upon leaving the laboratory. This mode of modeling relations between science and society is bound up in modernist discourses that view scientific knowledge as a universal reason, free from social biases and interests (W. Anderson, 2002). Science and technology studies have seriously criticized this bifurcation of science and society that is presupposed in the diffusion model (e.g., Bloor, 1991; for discussion see Figueroa & Harding, 2003; D. J. Haraway, 1989; Latour, 1993). This critique corresponds with postcolonial theory, which has explored multiple ways of knowing that are effaced through the universalizing discourses of Western modernity and science (for discussion see W. Anderson, 2002; Bhabha, 1994; Spivak, 1987, 1990; Verran, 2001). Instead, the field of science and technology studies contends that scientific knowledge and social orders are simultaneously "co-produced" (Jasanoff, 2004; Reardon, 2005).

Throughout this chapter, I show how experiments in cloning endangered wildlife co-produce conservation. This troubles the predominant notion that the use of somatic cell nuclear transfer is socially significant only if used with and on human bodies.

SITUATING THE DEVELOPMENT OF SOMATIC CELL NUCLEAR TRANSFER

This section begins to trace how cloning in general and somatic cell nuclear transfer in particular developed across the twentieth century and into the twenty-first through biology, agriculture, medicine, conservation, and the companion animal industry. I will begin by tracing the development of "cloning" as a concept, considering how this concept was transformed into three different techniques in the laboratory that resulted in the birth of Dolly the Sheep. I then trace how somatic cell nuclear transfer was taken up by researchers with varying interests in the kinds of reproductive potentials that somatic cell nuclear transfer offers. We see that cloning traveled rather quickly from pharmaceutical production to agriculture, biomedicine, conservation, and the companion animal industry. I conclude by discussing how somatic cell nuclear transfer was taken up specifically within ex situ species preservation and zoo worlds, the focus of the rest of this dissertation.

Developing cloning

The meanings of the concept of cloning have not been stable over time. Herbert John Webber first introduced the concept of cloning in 1903 to describe the propagation of plants through bulbs, tubers, cuttings and grafts. By the 1920s, the term cloning was used to describe many forms of asexual reproduction where genetic copies are propagated, including trees sending up runners, worms dividing into smaller worms, and genetically identical bacteria and cells dividing into tissue (Maienschein, 2001: 423; Wickware, 2002: 19). Cloning was then understood as a means through which naturally occurring reproductive phenomenon could be described and understood. In her historical analysis of cloning and stem cells, Jane Maienschein (2001: 424) points out that it was a short intellectual step for scientists to move a process interpreted as "natural" into the laboratory, so that new knowledge could be produced through experimentation. Cloning then became a tool for the experimental turn in the life sciences (Maienschein, 2003), where the new experimental focus was on understanding structure and function rather than description, which had long been the goal of natural history (Clarke, 1987). With experimental cloning, reproductive processes could be transformed to better understand cellular functioning.

Experimental embryologist Hans Spemann is often considered the initiator of nuclear transfer, having first inscribed cloning as a potential means through which questions about embryonic development could be answered (Maienschein, 2003). Spemann used experimental techniques, largely with frogs as his model, to answer questions about cell differentiation. For instance, Spemann and with his colleague Ross Harrison took cells that would normally give rise to eyes or ears and transplanted these cells onto different parts of frog bodies. With frogs, the body part developed wherever these cells were placed, causing Harrison and Spemann to conclude that cells are highly differentiated and preprogrammed to develop in specific ways and into specific body parts (Maienschein, 2003: 81-82). This finding provides one basis for the long-standing belief among scientists that unalterable changes occur when cells differentiate and become a particular body part, a belief that was challenged decades later by the birth of Dolly the Sheep.

In his later work, Spemann found that, if he constricted a frog egg so that one part did not have a nucleus, the enucleated cell fragment would remain inert while the other part of the cell with the nucleus would develop (Maienschein, 2003). Based on this experiment, Spemann later allowed a nucleus to pass through to the previously enucleated cell and he found that normal cell division proceeded. These findings prompted Spemann to question what would happen if the nuclei of cells at various stages of development were to be transplanted to enucleated eggs. Spemann thought that this experiment would address questions regarding the relationship between the cytoplasm and the nucleus, and reported on this prospect in his Silliman Lectures at Yale University in 1936, but never actually pursued this research (Maienschein, 2003: 115-116).

It was not until 1952 that a version of Spemann's experiment was conducted. Robert Briggs and Thomas J. King wanted to know whether individual cells differentiate as the different parts of the embryo differentiate (Maienschein, 2003). Briggs and King took nuclei from frogs of one species and put them in frog eggs of the same species as well as in eggs of another frog species. While Briggs and King were able to get nuclei from eggs in the early stages of division to cleave and develop, they were unable to get later stage transplants to develop. They concluded that the nuclei of cells in later stages of development were not able to reprogram and cleave because irreversible changes occur when a cell differentiates.

Significantly, the processes involved in somatic cell nuclear transfer that Spemann articulated and Briggs and King conducted were not understood as "cloning" at that time. Sarah Franklin (1999b) points out that somatic cell nuclear transfer is quite different from the kind of cloning that a gardener does to create a new plant from a cutting. As noted above, the term cloning was initially used to denote asexual reproduction, wherein one organism alone produces another. Nuclear transfer, on the other hand, requires bodily fragments from *several* individuals, including the nuclear donor, the egg donor, and one or two surrogates (Franklin, 1999b 211: 3). Given the multiple individuals involved in somatic cell nuclear transfer, the technique was not viewed as "asexual" reproduction.

However, two different techniques that were considered "cloning" began to be developed and routinized in laboratory work during the 1950s, 1960s and 1970s, cellular and molecular cloning. Cellular cloning mimics the ways in which somatic cells create identical copies through cell division. Cellular cloning thus allows for the replication of an entire genome of a specific cell type. This type of cloning is often used in infertility clinics when preimplantation genetic diagnosis is being used. By splitting cells, genetic copies can be made so that one set of cells is genetically tested and the other genetically identical set of cells can be used for reproduction. Molecular cloning, on the other hand, works by isolating a specific fragment of DNA using restriction enzymes and replicating this fragment in a bacterial plasmid (Maienschein, 2003: 127; Wickware, 2002). Molecular cloning in many ways allowed for the development of recombinant DNA (rDNA). Recombinant DNA puts the specific fragment of DNA that is of interest into a host cell so that it can integrate within the host DNA. One use of molecular cloning has been in the creation of transgenic organisms, such as genetically modified foods.

Nuclear transfer was first publicly described as "cloning" when, in the 1960s, John Gurdon announced that he had been able to reprogram a differentiated frog cell, challenging the notion that irreversible changes occur in the nucleus of amphibian cells (Franklin, 1999b). While this announcement reopened questions regarding differentiation, most biologists still believed that unalterable changes occur at the molecular level as cells divide, making reproduction by way of somatic cell nuclear transfer impossible.

While nuclear transfer research continued into the 1980s and 1990s, much of this research focused on developing and using embryonic stem cells rather than somatic cells as the nuclear donors. This research trajectory was premised upon the idea that a somatic cell, once differentiated, could not become another type of cell. However, biotechnology companies had a particular interest in challenging this assumption. Specifically, companies that produce transgenic animals whose milk produces peptides for pharmaceutical production thought that somatic cell nuclear transfer represented the best possible process to reproduce their new population of animals. The genetic "mixing" associated with sexual reproduction does not allow for the transgenic gene to consistently or efficiently be passed from one generation to the next (Franklin, 1997). Hence, a non-sexual mode of reproduction was preferred.

PPL Therapeutics, a company that produced transgenic animals, contracted with the Roslin Institute to find out whether somatic cell nuclear transfer was possible. The Roslin Institute is located in Edinburgh, Scotland and is one of seven research institutes in the UK's Biotechnology and Biological Science Research Council (Roslin Institute, 2007 website). In 1995, Ian Wilmutt's research team at the Roslin Institute transplanted differentiated sheep cells into donor ova and initiated cell division with an electrical shock (Maienschein, 2003). The resulting embryos were then transplanted into the womb of a gestational carrier. The experiment resulted in the births of Megan and Morag, the first mammals created with the use of differentiated cells. The birth of these sheep further challenged the assumption that irreversible changes occur as cells differentiate. However, these births did not become news and this development went largely unnoticed across both public and scientific worlds.

Wilmutt's team continued to experiment using different kinds of cells, including fetal neural roblasts (cells that give rise to nervous tissue) and adult mammary gland cells (Maienschein, 2003). One birth, which was Dolly, resulted from the use of an adult, differentiated cell. What was so surprising to scientists about the births of Megan, Morag and

Dolly was that long-standing beliefs about cells were challenged (Franklin, 2003; Maienschein, 2003). As Wilmutt's team interpreted their experiment, cells had to turn back time and dedifferentiate in order to become reprogrammed (Maienschein, 2003: 221). What made Dolly so controversial, while Megan and Morag had gone relatively unnoticed, was the use of an adult, animal somatic cell (rather than egg or sperm cells) from an already existing animal (Vajta & Gjerris, In press). This facet of the experiment provided proof that irreversible changes do not necessarily occur as cells differentiate, and prompted the question of whether or not this technique could be used to make "copies" of people.

Dolly was created as a prototype for Polly, a sheep subsequently created by Wilmutt's team also using nuclear transfer with a cell taken from a transgenic sheep. The transgenic sheep, born in July of 1997, provides milk that is used to make pharmacologies for cystic fibrosis sufferers (Franklin, 2003). By the time Polly was born, a short five months after the announcement of Dolly, the specter of cloning animals had largely been deemed unproblematic while the use of this technique on human bodies became the central and contentious discourse surrounding somatic cell nuclear transfer.

Taking up somatic cell nuclear transfer: Human Embryonic Stem Cell Research

Scholars of cloning often note that Dolly was so surprising in scientific arenas because her birth challenged the "facts" of cellular development (Franklin, 1997, 1999b; Maienschein, 2003). Sarah Franklin (1999b: 2) states that: "Dolly jumped right out of the biology rule book, and this is one of the features of her birth that has caused anxiety. Her very existence is counterfactual. Or at least it used to be." Dolly was "proof" that adult, differentiated cells could be used to produce a viable embryo and offspring (Vajta & Gjerris, In press). Somatic cells suddenly became viable research materials in a range of arenas with the successful demonstration of somatic cell nuclear transfer.

The idea that differentiated cells of mammals could be reprogrammed had epistemic implications particularly vis-a-vis the highly publicized and politicized arena of human embryonic stem cell research. Stem cells were first identified in 1896 by E.B. Wilson as a special type of cell because of their ability to develop into a variety of other specialized cells. During the 1950s, the significance of these cells was further clarified through work on marrow transplantation and serious research on animal stem cells began (Maienschein, 2003: 253). During the 1980s and 1990s, researchers working with mice classified stem cells into three different categories based on development: 1. totipotent cells can become an entire organism, including all the different cell types, 2. pluripotent cells can become any one of many but not all cell types, and 3. multipotent cells can become one of several cells, but not all cell types (Maienschein, 2003: 254). In the 1990s, researchers began to conduct research with human embryonic and fetal stem cells. In 1998 James Thompson announced that he had successfully cultured human fetal stem cells and John Gearhart announced that he had isolated and cultured human embryonic stem cells. In other words, these researchers had successfully immortalized human stem cells, meaning that they would continually reproduce through cell division but would not become programmed to develop into a certain kind of tissue without further intervention. They were an immortal cell line. Immortal cell lines, because of their homogeneity and ready availability, have been important research materials for decades (see Landecker, 1999 on the HeLa cell line). But an immortal line of stem cells was a true breakthrough.

The announcement that human stem cells can be sustained in culture through many generations *and still differentiate* brought stem cells research and cloning together into what is now commonly referred to as "therapeutic cloning."[10] Researchers and the biotechnology industry wanted to find out if, by using the patient's own cells for the culture that sustains the stem cells, the patient's immune system would not reject the transplanted cells (Maienschein, 2003: 266). The idea is that a somatic cell from the patient could be transplanted into a donor oocyte, allowed to divide to the blastocyst stage so that stem cells that match the patient's genome could be cultured, and then be reintroduced into the patient to heal a particular problem. However, this application of somatic cell nuclear transfer and stem cell research is nowhere near being realized. In fact, the difficulties associated with somatic cell nuclear transfer have caused many stem cell researchers to pursue the creation of stem cell banks that could be used for a range of different people instead of pursuing individually tailored, stem cell therapies.

Taking up somatic cell nuclear transfer: The Implications of Dolly Across Human-Animal Arenas

While human embryonic stem cells and somatic cell nuclear transfer were being brought together in biomedical research, the Dolly announcement had the different effect of untangling animal embryonic stem cell research and nuclear transfer in the agricultural industry. Before Dolly, research with nuclear transfer had focused on using un-differentiated embryonic stem cells with the hopes of producing large numbers of identical livestock that were particularly valued in the global meat industry. The idea at the time was that embryonic

[10] It is important to note that "therapeutic cloning" is a rather problematic term because many research programs that fall within this category are "basic" research endeavors that seek to better understand cellular development within the context of changing assumptions about differentiation (WellcomeTrust, 1998).

stem cells are totipotent, and thereby are the only cells really "right for the job" (Clarke & Fujimura, 1992a) of nuclear transfer. However, embryonic stem cells have particular disadvantages. First, embryonic stem cells are difficult to work with and this was slowing the research trajectory. Second, the embryo from which stem cells were derived could not be directly linked to an embodied individual who was a proven "good producer."

Somatic cells had the advantage of being both easier to work with and linked to a desired individual organism. One scientist, who has done nuclear transfer research since 1992 with livestock species, described the significance of Dolly to this work as follows (April 28, 2006):

> Carrie Friese: So you have been using nuclear transfer since 1992 and how significant was the birth of Dolly to your work?
>
> Kenneth White: Oh, it was very significant in the context of it kind of redirected some of our efforts. We were making large efforts to try and develop embryonic stem cells, the idea being at that time was that these embryonic stem cells were pluripotent and therefore would make perfect nuclear transfer donors. . . . The unfortunate part was that when most of these cell lines were used for nuclear transfer they universally failed to produce live offspring. . . . So when Dolly was produced from a somatic cell line it redirected in a significant way our efforts because no longer were we striving to achieve embryonic stem cells in domestic species because they're very difficult to culture, they're very difficult to maintain, and, frankly, at that stage of the game no one was really certain whether it was even possible . . . . So to be able to shift to just collecting skin cells and growing those – they were far easier to obtain, far easier to maintain and not to mention the fact that you wouldn't have to deal with, in a sense, an unknown quantity because up to that point everybody was using embryonic cells. Well, by being able to use somatic cells you could go to an animal with a proven production record of known characteristics and use that as the nuclear donor so it even further defined the type of animal that would be produced through nuclear transfer. So I think it had a huge impact for those reasons.

Dolly the Sheep thereby redirected both material resources and the research agenda itself in the area of developing nuclear transfer to reproduce livestock. Researchers were able to move away from developing embryonic stem cells and instead began to work with somatic cells, which are much easier to allocate and work with. This move may in part account for the rapid number of "successes" in cloning different species after the birth of Dolly. That is, researchers already had extensive experience using nuclear transfer and Dolly made it possible to use a kind of cell in this process that is far easier to work with. The announcement of Dolly also made it possible to link nuclear transfer with the selective breeding logics that have long governed the practices of agricultural production.

The birth of Dolly the Sheep also prompted new research in somatic cell nuclear transfer with varied species that are embedded in different human-animal relations. These projects have been enacted for an array of purposes. Vis-a-vis companion animals, there was an attempt to commercialize the practice of cloning pet cats and dogs with the now failed business venture of Genetic Savings and Clone. There have also been successfully birthed cloned racing animals, such as horses and mules, although many breed associations currently bar the incorporation of cloned animals into registries (Vanderwall et al., 2006). In the biomedical arena, there are ongoing attempts to incorporate somatic cell nuclear transfer to reproduce and further standardize laboratory animals (Bill Swanson, personal communication 4/8/06). There have also been discussions of using cloning in attempts to create animals that could act as donors for the xenotransplantation of organs (Dai, Vaught, Boone, Chen, & Phelps, 2002; Denning, Burl, Ainslie, Bracken, & Dinnyes, 2001).

Last and central to my project, there have been attempts to clone various species of wildlife via two trajectories. First, some researchers have attempted to clone wildlife species that are part of the hunting and gaming industry. For example, Texas A&M is using cloning to (re)populate the white tail deer in Texas (Duane Kraemer, personal communication 1/9/06). This work intersects with attempts to use cloning in order to create individual animals who are disease resistant (Denning et al., 2001). And second, the focus of this dissertation, somatic cell nuclear transfer has been taken up to clone endangered wildlife. I will now trace how conservation became part of the assemblages that have formed around somatic cell nuclear transfer.

Cloning endangered wildlife with interspecies nuclear transfer

In April 1997, two months after the announcement of Dolly the Sheep, Oliver Ryder and Kurt Benirschke (1997) of the Zoological Society of San Diego published a commentary in *Zoo Biology* on how somatic cell nuclear transfer might be used for conservation purposes. In their article, Ryder and Benirschke speculated that somatic cell nuclear transfer offered a new means to create genetic diversity in small populations by "rescuing" lost genetic material. The Zoological Society of San Diego has the most extensive frozen zoo in the United States and probably the world, wherein sperm, embryos and fibroblast cells from over 4000 now deceased individuals of endangered species are preserved using cryopreservation techniques. Somatic cell nuclear transfer represented a new way of using this collection and literally made the frozen zoo "vital" in the senses of both "vital politics" (Rose, 2007) and "ethical biocapital" (Franklin, 2003).[11]

In 2000, researchers announced that a cloned gaur, a species of endangered bovine native to South East Asia, had been born. Joining a growing list of species from which an individual had been cloned, the gaur also represented the first endangered species to be born by way of this set of techniques. The project had been established through relationships between Kurt Benirschke of the Zoological Society of San Diego, Advanced Cell Technology (ACT), and Trans Ova Genetics. Advanced Cell Technology is a biotechnology

[11] This point will be expanded upon in Chapter Five.

company that was, at the time, shifting its identity from a company that produces transgenic animals for pharmaceutical production to a company that produces therapeutics with human embryonic stem cells. The company thus had extensive experience with somatic cell nuclear transfer. Trans Ova Genetics is company that uses assisted reproductive technologies with cattle, and thereby had experience with embryo transfer as well as sufficient numbers of domestic cows to act as surrogates for the resulting embryos. While the birth was viewed as a success for those interested in somatic cell nuclear transfer and possibly for those working in conservation, the newborn gaur sadly died of dysentery shortly after birth.

Significantly, cloning an endangered animal required certain modifications to the somatic cell nuclear transfer process. Rather than using an egg cell and surrogate of the same species as the cloning subject, these projects used what is often referred to as "interspecies nuclear transfer." Here, nuclei are removed from preserved somatic cells taken from an animal of an endangered species. Ova taken from a different, closely related, domestic species are enucleated. The endangered species' nuclei are then inserted into the domestic species' enucleated ova. While in a specific culture, the cells are then pulsed with an electric shock and transferred to another culture solution so that cell division will begin. The resulting embryos are thereby made up of a nuclei taken from an endangered species and cytoplasm from a domestic species, making these embryos by definition chimeras. The resulting embryos are then implanted into surrogates of a domestic species that have to date been of the same species as the ova donor. In the case of the gaur, domestic cow eggs were used with gaur fibroblast cells to create the chimera cells, which were then transferred to domestic cow surrogates for gestation.

Since the announcement of the birth of the cloned gaur, interspecies nuclear transfer has been used to birth cloned animals from three additional endangered or threatened species, including two banteng (Janssen, Edwards, Koster, lanza, & Ryder, 2003), a mouflon (Ovis orientalis musimon) (Loi et al., 2001), and three African wildcats (Felis silvestris lybica) (Gomez et al., 2004). Of these four endeavors, the projects to clone the gaur, banteng, and African wildcat all took place within the United States. The banteng was cloned through project-based partnerships between the Zoological Society of San Diego, Advanced Cell Technology, and Trans Ova Genetics and is currently on display at the San Diego Zoo. The three African wildcats were cloned at the Audubon Center for Research of Endangered Species, a research facility in New Orleans that is affiliated with the Audubon Zoo. Two unrelated, African wildcat clones successfully reproduced. One cloned wildcat is currently housed at ACRES as part of the research colony and all but one offspring (who sadly died in an accident) are on display at a number of different U.S. zoological parks.[12]

Today, the still small landscape of cloning animals of endangered species is anchored in successes with cloning animals of endangered species using somatic cell nuclear transfer. Like other arenas where nuclear transfer is used to reproduce animals, success in cloning animals of endangered species has come to be largely defined across scientific and popular written medias as a live birth. Living animals become proof that interspecies nuclear transfer can work and that more knowledge is being gained about the technique itself and cellular development more generally (see Rosenthal, 2005 on the role of demonstration projects in

[12] The offspring of the cloned wildcats were sent to different zoological parks for safe keeping in the context of the Katrina hurricane (C. Earle Pope, personal communication, 7/27/06).

knowledge production). Without births, experiments in cloning endangered wildlife seldom make it into the popular press and only occasionally even make it into scientific journals.

Despite preferences for positive results among both popular and scientific journals, it has been reported that additional pregnancies have resulted from interspecies nuclear transfer, but did not come to term with both argali sheep (Ovis ammon) (White, Bunch, Mitalipov, & Reed, 1999) and banteng (Sansinena, Hylan, Herber, Denniston, & Godke, 2005). There are also reportedly ongoing attempts to clone pandas in China as well as endangered species of birds in Thailand. In addition, the concept and practice of *interspecies* nuclear transfer has recently been expanded by way of the *inter-genus* nuclear transfer of leopard cat (Prionailurus bengalensis) somatic cells to domestic cat (Felis silverstris catus) oocytes, wherein the resulting embryos were implanted into domestic cat gestational surrogates (Yin et al., In press - 2005).

Cloning endangered wildlife is most always represented as a positive endeavor in the mainstream U.S. print media. While media reports may warn that cloning should not be viewed as a "silver bullet" (Editor, 2003: 8b) for endangered species preservation, such concerns are generally subsumed under the general message that *any* step toward preserving these species is worthwhile. We can see cloning opponents become cloning supporters in the case of using this technique with endangered wildlife.

> Even some critics of cloning say the researchers may have stumbled upon a positive use of the technology. 'There are no moral problems with this,' said Michael Grodin, a professor in Boston University's School of Public Health who has opposed advances that could lead to the cloning of humans. 'There are a host of reasons why cloning humans is wrong, but this could be a positive step toward maintaining these species'
> (Associated Press, 2000: A1)

Presumably related to this positive press, public opinion polls also show that the use of somatic cell nuclear transfer with endangered wildlife garners greater support among U.S. publics than any other application of this technique (Fox News/Opinion Dynamics Poll, 2002). However, while the discourses of "conservation" and "endangered species" may help to generate public support for cloning, the application of this technique for species preservation among zoological park workers, scientists and conservationists remains highly contested.

SITUATING CAPTIVE ANIMALS AND ENDANGERED SPECIES

The activity of cloning animals of endangered species presumes the captive status of the resulting animal at some point in time. As a result, the endeavor to clone endangered animals is deeply entrenched in the history of keeping wild animals in captivity and the institutional history of zoological parks. In fact, most projects in cloning endangered animals within the United States rely on the cooperation of a zoological park at some point in time, whether it be to provide the necessary somatic cell or care for the resulting animal, which can be complicated.

I will now turn to the history of the modern zoological park to situate projects in cloning endangered wildlife. I begin by exploring how the modern zoological park is distinctive from previous modalities for keeping wild animals in captivity. I then discuss how the zoological park is situated in the arena of conservation more generally. Drawing on interviews conducted as part of this project, I next discuss how the reproductive and genetic sciences have been incorporated into zoological parks and species preservation since the 1970s. This move by zoological parks made it possible to clone endangered wildlife and undergirds much of the current contestation over whether or not cloning endangered animal counts as conservation and under what conditions.

Keeping wild animals: the institutionalization of 'modern' zoological parks

Collecting and displaying wild animals is an old and enduring social practice, with the first known zoo developing in Saqqara, Egypt around 2500 B.C. (Baratay & Hardouin-Fugier, 2002; Hoage, Roskell, & Mansour, 1996; Robinson, 1996: 32; Rothfels, 2002). Across this vast history, collections of wild animals are frequently positioned in locales defined by the joint processes of urbanization and developing trade routes. Historians conceptualize the desire to collect and exhibit wild animals in urban spaces as embedded in an ambiguous tension between freedom from danger associated with "nature" and "wildness" and nostalgia for wilderness (Kisling, 1996).

Captive wild animals are also frequently understood as symbols of human mastery, power and status (Baratay & Hardouin-Fugier, 2002; Hoage et al., 1996; Ritvo, 1987, 1996; Rothfels, 2002; Thomas, 1983). This meta-narrative for the practice of keeping wild animals in captivity does not, however, allow for a more nuanced understanding of the varying meanings these collections have had at different times and in different sites and spaces. In response to these critiques, Nigel Rothfels (2002) has recently argued that the zoo should be understood as a site that mediates varied historical and cultural meanings ascribed to wild animals and nature through the social relationships and practices that enable their collection and display over time (see also Veltre, 1996).

The modern zoological park is commonly understood as an institution that simultaneously focuses on science, education and entertainment. This represents a radical transformation of the personally held menageries that preceded them. The incorporation of

Louis XIV's Versailles menagerie into the natural history museum following the French Revolution (which became the Jardin des Plants) is often considered an important turning point in this transformation (Baratay & Hardouin-Fugier, 2002; Hoage et al., 1996; Lefkowitz-Horowitz, 1996; Veltre, 1996). After the fall of the monarchy, many of the animals at Versailles were either killed or let loose. Animals that survived were collected and placed within the natural history museum. What distinguished the Jardin des Plantes from Versailles was that it was open to the public. With Versailles and its transformation into the Jardin des Plantes, wild animals were becoming less private spectacles demonstrating personal power, but rather public entities that symbolized empire, nation-state, colony, reason, and democracy (Baratay & Hardouin-Fugier, 2002; Hoage et al., 1996; Mukerji, 2007; Rothfels, 2002).[13] This conceptualization of zoological parks emerged in Europe during the eighteenth century and generally stabilized during the nineteenth century (Hoage & Deiss, 1996).

Zoological parks premised upon similar cultural priorities emerged in the United States during the late nineteenth century (Hanson, 2002; Kisling, 1996). Like those in Europe, American zoological parks distinguished themselves from menageries and traveling shows by emphasizing education and the advancement of science, as well as state and city investments and identities (Hanson, 2002; Kisling, 1996). However, Elizabeth Hanson (2002) has argued that American zoos cannot simply be understood as an extension of European zoological parks. Instead, she positions American zoological parks within the public parks movement that emerged at the turn of the twentieth century as a social reform movement; it

[13] This theme is a site for expansion in further developing the dissertation into a book.

was based in the elite ideal of recreation and intent upon educating the working class and immigrants in middle class sensibilities (Hanson, 2002:28).

Ordering of wild animals in and through zoological parks is often considered an important departure from menageries, reflecting the priorities of natural history in the practices of collecting wild animals. Baratay and Hardouin-Fugier (2002) note that during the 16th century animals were rarely distinguished from one another despite varied uses and were often dispersed throughout residences rather than gathered into one isolated space defined for animals. In other words, animals were generally considered within the same conceptual category. This corresponds with Michel Foucault's argument in *The Order of Things* (1970) that resemblance was the basis of the European episteme that lasted throughout the sixteenth century. Foucault contends this epistemological foundation resulted in an understanding of animals that emphasized similitude rather than difference. Any animal was positioned "within the whole semantic network that connected it to the world" (Foucault, 1970: 129). For instance, the menagerie at Versaille, completed in 1670, is a premier exemplar of the Baroque style of displaying wild animals. Here, art historians have argued, we begin to see wild animals differentiated as they were gathered into one space and distinguished from other objects of curiosity. However, the animals themselves were not differentiated (Baratay & Hardouin-Fugier, 2002).

It is natural history and the corresponding changes in scientific classificatory practices that decidedly distinguished the organization and design of zoological parks when compared to menageries. Through natural history, animals become objects to represent so as to position them vis-à-vis one another and create a scientific and rational order of different living beings (Foucault, 1970). The zoo became a site where natural historians themselves could learn about the relationships and differences between animals by observing and pictorially representing them (Baratay & Hardouin-Fugier, 2002). However, Susan Hanson (2002) has pointed out that decisions about which animals to include in zoos and how to display those animals cannot be reduced to Linnean classificatory systems and taxonomic imperatives. Emphasizing the *practice* of ordering animals, she notes that the ways in which animals are classified in zoological parks often evokes multiple classificatory systems.[14] Nonetheless, natural history gave zoological parks their initial identity as institutions of science. And this identity governed the organization of zoological parks, wherein animals were placed in cages, usually alone, to be witnessed vis-a-vis one another in a comparative fashion.

However, the scientific utility of wild animals in zoological parks has always been problematic at best. Early natural historians catalogued the outwardly visible organs of plants and animals. Foucault (1970: 137) contends that this made plants the preferred object to represent and catalogue by natural historians, such as Linneaus and Buffon. Later, comparative anatomists classified animals according to their internal organs, a kind of knowledge production that requires dissection (Zuckerman, 1930; 1959; 1978). Animals in zoological parks were and remain today too valuable to dissect at will. Any knowledge gained from them had to be rather unsystematically acquired after the death of an individual (Ritvo, 1996). Thus, there has long been a tension in zoological parks between their mandate as sites of scientific inquiry and as locations for public education and entertainment.

Collecting and selling wild animals became a business with the establishment of colonial networks and the growing desire for exotic animals by zoological societies as well as

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[14] See also Harriet Ritvo (1997) for a discussion of how multiple, and at times contradictory, classificatory systems operate relationally.

menageries, circuses, and laboratories (Hanson, 2002; Rothfels, 2002). The live animal trade relied upon a set of social relationships that coalesced into an infrastructure that developed with colonialism. Elizabeth Hanson (2002) demonstrates this point in contrasting the National Zoo expeditions to acquire animals in colonized locations such as Tanganyika and the East Indies to the expedition to Liberia. Acquiring wild animals required permissions to collect, local people who would made collecting possible, and a local understanding of wildlife as a commodity that Westerners valued and desired (Hanson, 2002: 128). Without these infrastructural arrangements that were produced through colonial networks, collecting animals for zoological parks was nearly impossible. And colonial infrastructures exponentially increased global trafficking of wildlife.

Those engaged in animal catching included professional hunters, professional catchers, naturalists, explorers, soldiers in colonial armies, colonial settlers, and entrepreneurs (Rothfels, 2002). At the time, hunting was positioned as an honorable act wherein men (and they were men), encountered animals and fought on "equal" grounds (Hanson, 2002). The practice of catching, on the other hand, was not embedded in this kind of honored trope because the practice included killing adult animals as quickly as possible in order to capture their young (Rothfels, 2002). One of the foremost difficulties in catching wildlife was in keeping animals alive until they reached their final destination, and even thereafter. Today, it has been estimated that between 50 and 80 percent of live animals die while being transported (Emel & Wolch, 1998: 6).

World War II seriously disrupted the global animal trade, with Germany – the leading wild animal broker - loosing both its colonies and shipping companies (Hanson, 2002: 87). In addition, countries began restricting the importation of animals to prevent the spread of disease to livestock and quarantine regulations became more strict (Anderson, 1998b; Hanson, 2002). As colonized locales gained independence and became nation-states post-World War II, these newly founded countries began to restrict the number of animals that could be exported (Hanson, 2002). It quickly became apparent that the zoological park, much like other practices of consumptive colonialism more generally, resulted in the degradation of certain species. Given the co-constitutive identities of wild animals and zoological parks, the threat of extinction among wild species correspondingly threatened the zoological park as an institution. Breeding animals in zoological parks became a necessity for sustaining the institution itself (Hanson, 2002), rather than one of its many interests and curiosities (Anderson, 1998b). And breeding animals has become the principle contribution zoological parks currently make to species preservation efforts.

From wild animals to endangered species: The conservation turn among zoological parks

One of the distinguishing features of American zoological parks was the early centrality of conservation and preservation in defining the mission of the zoo. Historian of U.S. zoos, Elizabeth Hanson (2002: 20) notes that William Temple Hornaday – naturalist, big game hunter, taxidermist at the Smithsonian Institution's National Museum, and zoo proponent – became concerned with the declining number of bison in 1886 during a hunting expedition in Montana. Hornaday took this trip to "collect" (i.e., kill) bison to mount for an exhibit at the National Museum. Upon his return, Hornaday instead campaigned for a zoological park that would breed bison and other "endangered" animals. Hornaday was initially involved in planning the National Zoological Park and later became involved in the

New York Zoological Society.[15] For Hornaday, conservation was defined as preserving animals so that hunting and sportsmanship could continue, a common linkage throughout much of the history of conservation. Here, the zoological park became a site where species could be protected in a safe space where reproduction could be enforced and managed, away from hunters.

While early in the twentieth century the zoological park was positioned as a possible site for species preservation, by the middle of the twentieth century there were increasing criticisms of the practice of keeping wild animals in captivity. Many European and American zoos became run down and neglected as cities entered fiscal crises between the 1950s and 1970s (Baratay & Hardouin-Fugier, 2002; Hanson, 2002). Neglected animals living inside zoos coincided with an environmental movement in the 1960s that critiqued the practice of keeping wild animals in captivity. This was coupled with more widespread changes in sensibilities people had about wild animals from viewing animals on television (Hanson, 2002). Poor care of animals and animals behind bars became increasingly synonymous. The three Endangered Species Acts that U.S. Congress passed between 1966 and 1973 along with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) increased regulation over the practices of zoos, including importing practices and keeping wild animals. Since the 1970s, conservation both explicitly and symbolically became the primary mode through which zoological parks redefined themselves in order to regain public support for the zoological park as an institution.

The conservation turn among zoological parks is often symbolized by the reorganization of parks from individual animals taxonomically displayed vis-a-vis one

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[15] The New York Zoological Society was predominantly made up of sportsmen-naturalists, including Theodore Roosevelt (Hanson, 2002).

another in barred cages to immersion exhibits where animals are displayed in social groups and within settings that are meant to resemble the locales from which they originate. Landscape immersion seeks to position the zoo visitor in the animals' native environment and represents a radical departure from early modern zoos that deliberately positioned wild animals in human environments (Baratay & Hardouin-Fugier, 2002; Hanson, 2002). Immersion exhibits are often traced back to Carl Hagenbeck's innovative designs at the Stellingen Zoo in Germany. Hagenbeck used moats to enclose animals rather than bars. This method of displaying animals was deeply contested at the time, as many argued that this move degraded and foreclosed the scientific interests in classification (Rothfels, 2002). However, today Hagenbeck's design has become symbolic of the changing nature of zoos that emphasize animal well-being rather than human visual access.[16] Elizabeth Hanson has significantly pointed out that the Bronx Zoo also represents a precursor to immersion exhibits, having opened the African Plains exhibit in 1941. In many ways, this exhibit has more in common with the immersion exhibits of today because its designers rejected Hagenbecks's combination of species from different continents and instead sought to group species as they appear in nature.

In his historical analysis of Carl Hagenbeck, Nigel Rothfels (2002) persuasively counters the assumption that Hagenbeck's design can be necessarily aligned with better treatment of animals. Rothfels contends that the change in design and organization instead reflects changing human relationships with nature. Rothfels shows how Hagenbeck's cages without bars were derived from his experience in exhibiting people who originated from regions remote to Europe. These exhibits were part of the complex connections between

[16] For instance, this assumption undergirds David Hancocks' (2001) historical and ethical analysis of zoological parks past and present.

displaying and seeing "exotic" animals in zoos and human "freaks" in circuses, carnivals and fairs. What generated support for these exhibits among both professional anthropologists and the general public was the *illusion* of personal freedom, despite the fact that these people were essentially treated as property, servants and slaves. Hagenbeck brought this illusion of freedom developed in human exhibits to the zoological park's display of animals for the purpose of entertainment and profit. In turn, Hagenbeck initiated a discourse that has become the fourth justification for zoos: to provide refuge for endangered animals in places that are nicer, safer and healthier than the real wild (see also Hanson, 2002). Immersion exhibits continue to represent nature from the human zoo-goer's point of view – not the animals (see also Hanson, 2002).

Conservation practices in zoological parks have generally focused on particular species. This focus could be seen in Hornaday's development of the zoo as a site for breeding endangered species and in many ways persists today. The conservation practices and discourses found in zoological parks have been in tension with preservation efforts that focus on whole ecosystems (Mitman, 1999: 100; Takacs, 1996). Gregg Mitman (1999: 107) has pointed out that the practice of preserving individual species has often intersected with the entertainment value of animals whereas ecosystem approaches are situated in the links between the quality of land to the quality of life. While preserving species directs attention to modalities for managing animals, the ecosystem approach focuses on land management. With the shift to "biodiversity" from the 1980s forward, ecosystem approaches have become the predominant mode of conservation that federal government agencies and environmental organizations fund (Mitman, 1999). Since the 1980s, conservationists have increasingly directed their attention and language to biodiversity rather than endangered species (Takacs, 1996: 41).

In turn, many zoological parks have sought to create alliances between preserving individual species and preserving habitats in order to sustain their identities as conservation institutions. For instance, the American Aquarium and Zoological Association's (AZA) development of Species Survival Plans (SSPs) brings together its focus on captive breeding with habitat preservation and support for in situ and ex situ research. Elizabeth Hanson (2002: 171) states that these activities transformed the status of zoo animals from pets identified with particular cities to representatives of diminishing gene pools in nature, in far away places.

The incorporation of reproductive and genetic sciences into zoological parks

Across the twentieth century, the taxonomic focus of zoological parks waned as natural history fell out of favor as a scientific endeavor. Many zoological parks shifted their focus to conservation sciences, using the park as a base for developing land management programs around the country (Hanson, 2002). A small number of zoological parks also began to incorporate reproductive and genetic sciences into the activities of the park. This set up two different funding streams for zoological parks to pursue. Field work, land management, and animal reintroduction programs could garner funding from nonprofit and non-governmental agencies focused on conserving habitats and biodiversity. The reproductive and genetic sciences, on the other hand, began pursuing funding through the National Institutes of Health. Using laboratory animals as models for humans *and for endangered species*, funding could be allocated for biomedical research in zoological parks under the rubric of comparative medicine. This work has largely taken an approach wherein individual endangered species are the focus of attention.

When I asked how the reproductive sciences were incorporated into zoological parks in the United States, many people I spoke with began their narratives in the late 1970s and early 1980s, when three young reproductive physiologists joined different parks across the country. David Wildt joined the National Zoo in Washington D.C., while Barbara Durrant went with the San Diego Zoological Society, and Betsy Dresser the Cincinnati Zoo. It is significant that the incorporation of the reproductive sciences into zoological parks followed the birth of Louise Brown using in vitro fertilization in 1978. Reproductive scientists were excited by the possibilities these techniques held for breeding zoo animals and endangered wildlife.

> We were all very young and idealistic. And I remember that we all sort of felt that there would be a quick fix. There was the birth of Louise Brown. . . . So everybody in the late 1970s, early '80s sort of thought at the same time, "Well, how can we use these high tech approaches to enhance offspring production [of wild and endangered species]?
> *David Wildt, personal communication 7/18/06*

Many zoo scientists initially had high expectations that these techniques could be used to reproduce all zoo animals, ending the long-standing difficulties associated with captive "natural" breeding (Barbara Durrant, personal communication 5/16/06). During this time, the practice of preserving endangered species was understood demographically, vis-a-vis increasing the *number* of animals within a given species at the zoo (Oliver Ryder, personal communication 7/20/05; David Wildt, personal communication 7/18/06). As such, the reproductive sciences were considered an applied science in zoological parks. The goal was to use reproductive technologies, as developed with livestock and humans, to reproduce more zoo animals and at a faster rate.

The incorporation of the reproductive sciences into U.S. zoological parks occurred considerably later when compared to academic biology, medicine, and agriculture. Adele Clarke (1998) has shown how these professions came together in "disciplining the reproductive sciences" in the United States largely during the interwar years. Initially, the reproductive sciences focused on the structures and functions of reproductive organs. Clarke (1995a) has defined this as "modern reproduction," wherein the focus is on understanding so as to control. She distinguishes this from "postmodern reproduction," which developed somewhat later and focuses on transforming reproductive processes per se. Assisted reproductive technologies are a central endeavor here. Clarke points out that modern and postmodern reproduction are neither discrete nor temporally linear, but rather deeply inter-related and often operate in tandem.

It appears that zoological park scientists sought to get on the "bandwagon" (Fujimura, 1992) of post-modern reproduction in order to transform the reproduction of zoo animals. It was generally assumed that the species intensively studied during "modern" reproduction science would be adequate models for the species in the zoo. Reproductive scientists also initially thought that assisted reproductive technologies used with humans and domestic animals could be applied to other species rather easily. In other words, many reproductive scientists working with zoo animals hoped to bypass "modern" reproductive research on zoo animals and jump right into "postmodern" reproductive transformations.

The initial goal of the reproductive sciences in zoological parks was to remove reproduction from the bodies of zoo animals and transfer this work to the laboratory (David Wildt, personal communication 7/18/06). By limiting the physical involvement of zoo animals to retrieving their sperm and ova, it was hoped that the problems associated with captive breeding could be circumvented. However, it remained the case that if embryos were produced in the laboratory, surrogates would be required. For this reason, there was substantial initial interest in researching the potential of interspecies embryo transfer. The idea was that closely related domestic species could be gestational surrogates for embryos produced in the laboratory. These animals were more abundant, potentially allowing for an increase in both the numbers and pace of reproduction.

Betsy Dresser's laboratory at CREW had the first success with interspecies embyo transfer. Dresser's colleague C. Earle Pope was responsible for a project in which gaur embryos were transferred to a domestic cow, resulting in a live birth. This success was widely and positively reported in the popular news media, resulting in substantial positive public relations for the zoological park and research center. Some people believe that this report and other "first" births resulting from assisted reproductive technologies worked to both stabilize the role of reproductive sciences in zoological parks and to re-direct research funding to the development and application of assisted reproductive technologies in zoos (David Wildt, personal communication 7/18/06; Barbara Durrant, personal communication 5/16/06).

> And I think one of the really interesting events of those early '80s days was Betsy's [Dresser] ability to produce a few offspring by embryo transfer including a couple by – and they got incredible press – by interspecies embryo transfer and so forth. And that was interesting because it was a huge accomplishment and impressed many people including myself.
> *David Wildt, personal communication 7/18/06*

These early successes thereby worked to "enroll" (Callon, [1986] 1999) zoological parks in the development of assisted reproductive technologies. These techniques then stabilized as a "quick fix" to problems associated with small populations, whether they be zoo populations or endangered populations.

However, over the past twenty-five years there has been only limited success in developing and using assisted reproductive technologies with zoo and endangered species. Today, developing assisted reproductive technologies for endangered wildlife is increasingly viewed as a problematic research trajectory rather than a magic bullet by many of the individuals who themselves initiated this research trajectory. David Wildt, in describing the initial excitement about the reproductive technologies cited above, continued with the following statement.

> But in retrospect it probably set many people, including us, off on the wrong path because we did really believe that what we could do is – we could accomplish the quick fix and there is no quick fix. There is no quick fix.
> *David Wildt, personal communication 7/18/06*

In response to these disappointments, the directions taken with reproductive science research have diverged across the several institutions involved. While Betsy Dresser's lab continues to focus on developing assisted reproductive technologies for endangered species, David Wildt has refocused his attention to "basic" research problems regarding reproductive physiology that is species-specific. Wildt's early attempts to reproduce cheetahs using artificial insemination in the 1980s consistently failed. These failures led Wildt to what he has called his "ah-hah" moment, wherein he realized that "a cheetah is not a cow" (Wildt, 2004). In this moment, Wildt realized that the techniques and protocols used to reproduce domestic cows would not necessarily work to reproduce a cheetah. In response to this experience, researchers at the National Zoo began what turned out to be a fifteen-year study of the cheetah's reproductive biology (Wildt, 2004).

This project has also worked to refocus the overall mission of the research center at the National Zoo from technology development to basic research on the fertility of the whole animal in a species-specific manner (Wildt, 2004: 289). When applicable, this basic research then forms a basis for technology development. For instance, over the course of a fifteen-year research project regarding the reproductive physiology of the cheetah, Wildt's research team was eventually able to successfully do artificial insemination. In other words, Wildt works with wild and endangered species by working through "modern" reproductive processes first, followed by the "postmodern".

In turn, some of the reproductive scientists who were initially the most excited about the potential use of assisted reproductive technologies with endangered wildlife have become the more vociferous critics of developing highly invasive reproductive technologies. Many believed that the portrayal of assisted reproductive technologies as "magic bullets" to the problems of species extinction risked "overselling" (see Nelkin, 1995b) the potential of these techniques. This was associated with research agendas that were too exclusively focused on developing reproductive technologies, rather than developing more interdisciplinary approaches to studying wildlife (David Wildt, personal communication 7/18/06). In addition, some researchers found that the presentation of assisted reproductive technologies as a cure-all also worked to diminish the importance of preserving habitats in which these species can live (Barbara Durrant, personal communication 5/16/06).

Alongside these changes in the ways some reproductive scientists view their work, the practices involved in managing captive zoo populations have also been changing significantly since the late 1980s and early 1990s. Geneticists working both in the field and with captive populations have increasingly solidified the notion that the number of individuals is not the sole nor even the most significant factor in sustaining small populations. Rather, the extent of genetic diversity within a population is increasingly deemed the more salient unit of analysis. Species Survival Plans (SSPs) were developed within the American Zoo and Aquarium Association in part to selectively breed individuals that would maximize the genetic diversity of the captive population. Using studbooks and kinship charts, SSP organizers choose which two individuals should be bred and also make recommendations about which particular animals should not breed. In response, demographic approaches to reproducing zoo animals, where the goal is simply to create more individuals, fell out of favor. Through the institutionalization of genetic management practices with SSPs, the reproductive and genetic sciences have become more deeply interconnected in zoological parks.[17]

SITUATING CLONED ANIMALS OF ENDANGERED SPECIES: FEASIBILITY STUDIES AND THE GENETIC MANAGEMENT OF SMALL POPULATIONS

What is interesting about the initial development of somatic cell nuclear transfer to propagate endangered wildlife in captive settings is that geneticists, rather than reproductive scientists, initiated the research agenda in the United States. While Barbara Durrant was involved in collecting and preserving gametes and embryos at the San Diego Zoological Society's research center because of their reproductive potential, Benirschke and Ryder collected and preserved fibroblast cells largely as informational relics. The general idea has been to save as much information about the genomes of endangered species before they disappear. Somatic cell nuclear transfer represented a new way of using these fibroblast cells. Specifically, cloning could be used to rematerialize and embody these preserved

[17] It needs to be recognized, however, that the reproductive and genetic sciences were interconnected in important ways before SSPs were developed. For example, the genetic sciences began to be integrated into zoological parks during the 1960s when techniques became available to accurately assess the number of chromosomes for different species. Chromosomal research began with zoo animals in order to determine if individuals were hybrids as well as to detect possible reproductive problems (Oliver Ryder, personal communication 7/20/05).

fibroblast cells, making them “vital” participants in the genetic diversity of endangered populations rather than informatic relics of a more diverse past. Benirschke and Ryder presented this possible application of somatic cell nuclear transfer in their commentary that was published in the journal *Zoo Biology* (1997) just two months after the Dolly announcement.

Ryder and Benirschke’s early speculations about the potential application of somatic cell nuclear transfer are not close to being realized. Making somatic cell nuclear transfer work in different laboratories and with varying species requires significant investments of resources and time. In response, most projects to clone endangered wildlife have been pursued as “feasibility studies.” Here, the goal is to see whether or not and under what conditions it is possible to use interspecies nuclear transfer to clone an endangered species. Feasibility studies often engage a conservation logic that is premised upon demography, or increasing the number of individuals in a small population. However, there has also been one project in cloning endangered wildlife that has sought to “co-produce” (Jasanoff, 2004; Reardon, 2005) cloning and conservation based on genetic management.

In this section, I will map the landscape of cloning endangered animals in the United States to date. I show how the varying projects in cloning endangered wildlife are organized according to certain logics regarding technological development and conservation. I situate some of the contention and debate that swells around the practice of cloning endangered animals in how these logics are brought together in very particular ways when endangered animals are cloned.

Feasibility studies in cloning: Mapping the cloned gaur and African wildcats

The first animal of an endangered species born after the use of somatic cell nuclear transfer was a gaur named “Noah”. Noah was the result of a project-based collaboration between Kurt Benirschke of the Zoological Society of San Diego and two biotechnology companies, Advanced Cell Technology (ACT) and Trans Ova Genetics. Kurt Benirschke had requested that the Frozen Zoo of the Zoological Society of San Diego send frozen fibroblast cells taken from a gaur to ACT, where the nuclear transfer was done using the gaur cells and enucleated ova from domestic cows. The resulting embryos were then sent to Trans Ova Genetics, the company ACT had negotiated with to transfer the cloned embryos into domestic cows and to care for the surrogates. Trans Ova Genetics is a commercial embryo transfer company located in Iowa that uses advanced reproductive technologies to meet the breeding needs and desires of cattle ranchers.[18] Noah was born in November 2000, but died two days after birth. Had the gaur survived, he would have eventually been brought to the San Diego Zoo.

The birth and death of the cloned gaur was a rather substantial media event. While there has been significant concern about cloning humans and cloning animals that humans would consume as food, the use of somatic cell nuclear transfer to reproduce an endangered animal was largely viewed positively in the popular press. Philip Damiani, who worked on the project to clone the gaur through his employment at ACT, stated:

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[18] In a personal communication (7/18/06), Mike West, President of Advanced Cell Technology estimated that Trans Ova Genetic spent approximately $20,000 per surrogate cow and there were 10-20 surrogate recipients used for this project. This cost included lost revenue accrued because the cows were not available for commercial surrogacy. It was suggested by West that the company made this donation because they believed it would contribute to the public good. This company was less likely to directly benefit by the good public relations that resulted from the project given their stable relationship with ranchers who are often assumed to have antagonistic relations with conservationists.

> At that time when all this work was being done, Dolly was already born but there still wasn't a general acceptance of the cloning technology. But it was really unusual when we started to work with endangered species that the perception of the technology changed completely so it was acceptable to use this you know God-fearing technology for saving endangered species but it wasn't acceptable to clone animals that we would potentially eat or get into the food chain.. . . It *was* acceptable for conservation purposes. . . . So we, we kind of decided to do the endangered species project to test the technology but also to use it as a little bit of PR purposes, to kind of sway people's opinion of the technology.
> *Philip Damiani (personal communication 7/1/05)*

At the time, Advanced Cell Technology was shifting its identity from a company that produces transgenic animals for pharmaceutical production to a company that creates biomedical therapeutics using human stem cells. In both cases, it was important for the company to help change the discourse surrounding cloning. Endangered species have been a particularly useful rhetorical device for garnering support for controversial technoscience (see also D. J. Haraway, 2003a).

For many reproductive scientists working with zoo and endangered species, the media flurry surrounding the first cloned animal of an endangered species was a familiar experience to parallel "first time" successes with other reproductive technologies. The popular media often positioned somatic cell nuclear transfer as a "magic bullet" for species conservation. Many reproductive scientists, based on their experience regarding the limited success of assisted reproductive technologies in general, tended to respond the project critically. Just as the mass media was used to promote cloning with endangered wildlife, zoo workers responded with negative commentary to ensure that this technique not be viewed as a quick fix to the problems of habitat and species preservation.

Many people in zoo and conservation arenas were concerned that the "hype" of cloning endangered species would redirect funding to speculative research and away from "tried and true" conservation practices. Kaushik Sunder Rajan (2006) points out the importance of "hype" among biotechnology companies to garner the capital necessary for these kinds of speculative research endeavors. One could postulate that the "hype" surrounding speculative techniques like cloning endangered wildlife would generate "altruistic capital" for research centers associated with zoological parks and "venture capital" for biotechnology companies.

Most research centers affiliated with zoological parks remain skeptical of the potential of cloning for endangered species conservation and have not incorporated this technique into their research protocols. Some zoos have even formally banned the use of somatic cell nuclear transfer with their animals.[19] However, Betsy Dresser's laboratory, which had the early successes in using embryo transfer and interspecies embryo transfer, did decide to redirect much of their research focus to developing somatic cell nuclear transfer after the birth of Dolly and the gaur. Dresser's laboratory specifically focuses on developing this technique with endangered felids. At this point in time, Dresser's lab had recently moved from the Cincinnati Zoo to the Audubon Center for Research of Endangered Species (ACRES), which is part of the Audubon Institute in New Orleans. Founded in 1996, the mission of ACRES is to develop assisted reproductive technologies with animals of endangered species for the purpose of species preservation. Dresser and her colleagues believed that somatic cell nuclear transfer, as a reproductive technology, fell within their research protocol.

Shortly after arriving at ACRES, Dresser's long time colleague C. Earle Pope suggested that the laboratory hire an individual with experience using intractoplasmic sperm

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[19] Linda Penfold, personal communication 4/17/06

injection (ICSI).[20] Pope was finding that sperm samples taken from wild and endangered species were often of poor quality and believed that this technique would be useful for zoo fields. Martha Gomez, who had been trained in Australia to do ICSI with livestock, was hired. Gomez's experience with the micromanipulations associated with ICSI made her an ideal candidate for training in somatic cell nuclear transfer. However, the laboratory had to obtain the support of the Audubon Nature Institute, who were initially concerned that this research trajectory would be too controversial. Scientists at ACRES argued that nuclear transfer was just another reproductive technology that represented a logical next step in the laboratory's research trajectory. Once the Audubon Nature Institute agreed that experimenting with somatic cell nuclear transfer fell within the purview of the research center, Gomez returned to Australia to learn how to do somatic cell nuclear transfer.

To date, three African wildcats have been cloned at ACRES and two unrelated clones have themselves produced offspring (Gomez et al., 2003; Gomez et al., 2004). Unlike the social relations enacted in producing the cloned gaur and the banteng, all facets of the cloning process with the African wildcats took place at ACRES itself. The center maintains its own collection of gametes and fibroblast cells as well as a domestic cat colony from which donor ova and gestational surrogates are allocated. ACRES has the technical capability to do the nuclear transfer, embryo transfer, and care for the surrogate cats through birth. For a brief period, Gomez worked with scientists at Louisiana State University.

[20] ICSI is a "micromanipulation" wherein a single sperm is inserted into an oocyte using a pipette under a microscope. Micromanipulations, of which nuclear transfer is one kind, are time consuming, laborious modes of laboratory work that are quite different from the more surgery based assisted reproductive technologies like gamete retrieval and embryo transfer. Given the amount of time that must be devoted to micromanipulations, a laboratory would need an individual devoted to those procedures in order to make this a regular facet of the work done in a particular laboratory.

However, she found that moving materials between sites created too many uncontrollable conditions that could factor into the success or failure of the project (Pope, personal communication 3/14/06). The scientists decided it best to move all procedures in house.

ACRES continues to spend significant resources on cloning projects. Researchers do oocyte retrievals from domestic cats, the interspecies nuclear transfer process, and transfer resulting cloned embryos back to domestic cat surrogates approximately two times per week. They are currently doing this work with felid species that are more endangered than the African wildcat and that are managed as part of a Species Survival Plan. In addition, there is an on-going endeavor to develop an array of reproductive technologies, including cloning, with the bongo, an endangered animal that resembles an antelope. Philip Damiani, during his tenure at ACRES after having worked on the gaur project at ACT, worked on this project and there is now a post-doc at the laboratory who continues this work. However, felid cloning is the primary project in this laboratory and most of the time and resources are focused on these species.

These endeavors have sparked concern amongst and criticism from some in the Felid Taxonomic Advisory Group (TAG) of the American Zoo and Aquarium Association (AZA). Some believe that these techniques are being developed in the name of conservation, but have no foreseeable application in species conservation practices. However, the felid TAG has decided not to make any decisions regarding whether or not cloned individuals can become part of a Species Survival Plan (SSP) and studbook until an animals of a species that the group manages is successfully cloned.

The cultural logics of demography in feasibility studies

The focus of both the gaur project and the African wildcat projects has been to demonstrate and prove that it is possible to use somatic cell nuclear transfer to clone individuals of these species. The idea here is that feasibility studies must precede efforts to actually incorporate techniques like nuclear transfer into the conservation protocols for a particular species. This notion regarding the relationship between experimentation and conservation presumes the logic of the diffusion model. As discussed in the introduction to this chapter, the diffusion model is entrenched in modernization theory and holds that universalizing scientific innovation and knowledge production occurs in a value-neutral environment, and only becomes social through its application (see W. Anderson, 2002 for discussion and critique).

However, in cloning an "endangered" animal certain cultural logics and values are always already enacted regarding species preservation and conservation. In fact, most research articles describing a successful feasibility study in cloning endangered animals begin by describing the grave problem of rampant extinction rates among a slew of species. For example:

> "Given the current trends, many rare or endangered vertebrate species will soon be lost despite efforts to maintain biodiversity via habitat and wildlife conservation" (Lanza, Cibelli et al., 2000: 79).
>
> "The survival of most species in the Felidae family is considered as threatened or endangered. In fact, 36 of the 37 species of this family are at risk of extinction" (Gomez et al., 2004: 247).

The papers go on to position somatic cell nuclear transfer as a "tool" that can help prevent the extinction of these species. As such, cloning endangered animals does not precede conservation, *but instead co-constitutes conservation* ab ovo.

Across the scientific and popular reporting regarding the successful birth of a cloned endangered animal, it is often presumed that reproducing *any* endangered animal counts as conservation. The following quotes, taken from articles regarding the gaur cloning project, describe the significance of reproductive technologies to species conservation.

> "Advances in cloning offer a way to preserve and propagate endangered species that reproduce poorly in zoos until their habitats can be restored and they can be reintroduced to the wild" (Lanza, Dresser, & Damiani, 2000: 85).

> "Recent advances in assisted reproductive techniques such as cryogenics of gametes/embryos, artificial insemination, and embryo have allowed for new methods for the further propagation of endangered species" (Lanza, Cibelli et al., 2000: 80)

These scientists' statements emphasize the need to *propagate* new individuals in small populations, drawing upon and aligning themselves with the somewhat outdated practice in species preservation based on demography, or an effort to increase the number of individuals within a population. As noted above, this mode of species preservation has fallen out of favor among many in the zoological community as their focus has shifted to the genetic management of small populations.

At times, researchers conducting feasibility studies do link their work in developing somatic cell nuclear transfer to more current efforts at genetic management *in theory*.

> "Regarding endangered felids, nuclear transfer is a potentially valuable technique for assuring the continuation of species with few remaining numbers of animals. In fact, cloning could maintain genetic variability in endangered felids when there are few animals in a founder population by conserving the maximum number of alleles for future breeding projects" (Gomez et al., 2004: 248).

> "Cloning's main power, however, is that it allows researchers to introduce new genes back into the gene pool of a species that has few remaining animals. Most zoos are not equipped to collect and cryopreserve semen; similarly, eggs are difficult to obtain and are damaged by freezing. But by cloning animals whose body cells have been preserved, scientists can keep the genes of that individual alive, maintaining (and in some instances increasing)

> the overall genetic diversity of endangered populations of that species" (Lanza, Dresser et al., 2000: 85)

However, in practice the individuals cloned in these feasibility studies have not contributed to the genetic management of these species. It is argued that creating "genetically valuable" individuals with feasibility studies would slow the rate of technology development. Thus, techniques must be developed before genetic diversity is pursued.

In turn, the centrality of feasibility studies to the situation of cloning endangered wildlife has become a site of critique itself. Bill Swanson, a reproductive scientist at the Cincinnati Zoo and Co-chair of the felid Taxonomic Advisory Group stated in an interview (4/8/06) with me:

> A lot of the initial interest is in just showing the feasibility of it. You hear a lot about 'world's first' this or that. And it drives us crazy because to me that's the easiest part of anything. You do enough procedures and if that animal, if it's physiologically similar to something that's worked before, you do enough procedures, over time eventually something will work. And you point to the one offspring and say 'we've done it' and then you walk away and nothing else ever gets done with that. And to me the feasibility is the easiest part. It's making it efficient enough that you can consistently produce offspring that way [that is difficult].

In fact, many people in zoo communities would note that feasibility studies in using assisted reproductive technologies with wild and endangered species often represented an *end* to a situation rather than a beginning. Once researchers had successfully demonstrated that it was possible to use a technique with a species, the work would cease and no one would begin to consider how these techniques may actually be operationalized as part of existing conservation efforts. The following dialogue between Linda Penfold, a reproductive scientist who works with endangered species, and me demonstrates this point (4/17/06).

> LP: So you'll find many reports of ARTs with endangered animals but very few reports of where these techniques have been translated into a useful tool that's been used subsequently.

CF: Why do you think that is?

LP: I think generally speaking – I don't know why that is. I think one reason may be you really need to have a person or an institution championing the species and the technique. Where you've got an institution with a long history of working with a species – and I'm thinking of the National Zoo with both Black-Footed Ferrets and the cheetahs, in both those instances artificial insemination for example has been continued to be used after the techniques were established. But in other institutions where they've had a student perhaps do a study trying to do AI in whatever species, once that project's been fulfilled and the paper's been written up that project is usually not pursued.

CF: So sort of you have a post-doc who does a project and then sort of moves on.

LP: Exactly. And unless that post-doc decides to champion that particular species with whatever technique they've developed, the technique usually stops right there. And, of course, once the paper's been published, from a basic science standpoint it's not novel anymore so there are times when it just doesn't get translated into a useful tool and partly – oftentimes it's because it is so inefficient still.

With these quotes, we see how feasibility studies are being critiqued not only for failing to produce genetic diversity, but also for failing to create techniques that can be taken up and used regularly within a species survival program.

Genetic management with cloning: Mapping the cloned banteng

Following the birth and death of the gaur, both ACT and Trans Ova Genetics expressed interest in conducting another project in using somatic cell nuclear transfer with an endangered bovine. Within the San Diego Zoological Society, the successful birth of the cloned gaur prompted more discussions and debates at the organizational level regarding this research trajectory. These discussions focused on the potential use of cloning with endangered wildlife and the related question of whether or not another project of cloning an animal of an endangered species should be pursued. People questioned whether the organization should be involved in another attempt at cloning, if a gaur should be cloned again, and if the collaboration should again be forged with ACT.

Some critics argued: 1) that cloning is too expense and inefficient to ever prove viable for use among zoological parks; 2) that the birth of cloned animals risks being portrayed as a "quick fix" or "magic bullet" in the news media and thereby risks diluting messages about the primacy of habitat conservation and basic research; and 3) that interspecies nuclear transfer risks diluting the genetic composition of small species because mitochondrial DNA from the domestic cow is present in offspring. Here, critique focused on cloning practices per se. Others argued that gaur have no difficulty reproducing in captivity, thereby questioning whether this experiment actually had anything to do with species preservation per se. This critique here was less concerned with cloning, but rather centered on the reasons for which the project was ostensibly executed. There were also broader concerns that all these questions were not properly addressed organizationally before the experiment in cloning the gaur had been conducted.

In this context, the Board of Directors requested that Oliver Ryder, the head of the Genetics Division of the Conservation and Research of Endangered Species (CRES) and co-author of the initial article written regarding the potential use of nuclear transfer for conservation, write a white paper. In his white paper, Dr. Ryder outlined his position that empiricism provided the best means to address whether or not cloning may be a useful tool for conservation. However, he also argued that cloning had to be constituted as a tool for conserving endangered species in order to address this question. Ryder did this by focusing on the conditions under which experimenting with somatic cell nuclear transfer is appropriate. These conditions included: 1) sufficient knowledge of the species that includes not only reproductive biology but also neo-natal husbandry; 2) the existence of a Species Survival Plan that manages the gene pool of the captive population; and 3) the availability of a skin cell that embodies genetic information not represented in the captive population.

Through setting these conditions, Ryder made feasibility studies of cloning endangered animals into experiments in conservation based on genetic management *in practice*. That is, Ryder implicitly questioned the logic of the diffusion model for conceptualizing technological development and application, wherein techniques are first designed and later applied to certain existing efforts. Ryder disrupted this linear narrative and practice and instead asserts the "co-production" (Jasanoff, 2004 ; Reardon, 2005) of technological development and species preservation based on a genetic management model. He thereby positioned technological development and conservation as interdependent processes, co-constitutive rather than discrete.

Through the white paper and subsequent discussions, Ryder and the Board of Directors at the Zoological Society of San Diego decided that frozen fibroblast cells taken from a banteng at the San Diego Zoo before he died in puberty (and therefore did not reproduce) should be used in the next cloning experiment. After this decision was made, similar exchanges of materials were made between the San Diego Zoo, Advanced Cell Technology and Trans Ova Genetics. However, there were some important changes. The Zoological Society sent a team to Trans Ova Genetics made up of a veterinarian, a nutritionist, a neo-natologist, a curator, and a researcher to care for the banteng after birth (Oliver Ryder, personal communication 7/20/05). The practices and knowledge involved in husbandry of livestock were deemed insufficient for husbandry of endangered animals. It is impossible to say whether changing the procedures in this way made the difference, but one banteng did survive after birth and is currently on display at the San Diego Zoo.[21]

The successful birth of a surviving offspring then brought another set of organizational actors into the situation of cloning endangered animals: organizations responsible for managing the reproduction of zoo species to ensure that the captive population remains "viable" or genetically diverse. These organizations are the Species Survival Plan (SSP) and the Studbook that represent the banteng in the ungulates Taxonomic Advisory Group (TAG), all coordinated through the American Zoo and Aquarium Association. As previously noted, Species Survival Plans (SSPs) were developed within the American Zoo and Aquarium Association in part to selectively breed individuals that would maximize the genetic diversity of the captive population. After the birth of the banteng, the ungulates Taxonomic Advisory Group had their scientific meetings and asked Oliver Ryder and Philip Damiani to describe how nuclear transfer worked and how they envisioned the applicability of this technique in the zoo field. Following the presentation, the advisory group decided to continue the experiment and to see whether the banteng is capable of reproducing healthy offspring. The cloned banteng is currently included in the breeding protocols of the SSP. This kind of experimentation comes with the hope that the banteng SSP will reach its goals of genetic diversity in the captive population more rapidly than previously thought possible. But it is also pursued with the knowledge that future offspring

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[21] As many people now know, serious developmental disorders are associated with the somatic cell nuclear transfer process but for unknown reasons. This is the foundation for a serious critique of the possible use of somatic cell nuclear transfer to reproduce humans and animals alike, one that is surprising overshadowed (D. J. Haraway, 2003a). These matters of concern correspond with the political economies of care, when invasive techniques often require intensive care for newborns.

may not be possible or may have health problems associated with the interspecies nuclear transfer process (Linda Penfold, personal communication 4/17/06).[22]

For the Zoological Society of San Diego, the banteng SSP and studbook, and the Ungulates Taxonomic Advisory Group, the question of whether or not nuclear transfer can be a tool for conservation will be answered if, when and how the banteng reproduces. These groups have decided that cloning endangered wildlife is still in the process of experimentation. Success has been redefined from achieving a live birth to achieving the production of greater genetic diversity through the reproductive practices of cloned individuals. Presently, the banteng is old enough to produce to sperm and is in a breeding situation (Sharon Joseph, personal communication 10/18/05), but he is not "behaviorally competent" to engage either of the female bantengs in "natural" reproduction (Oliver Ryder, personal communication 10/25/05). At this time, neither the Zoological Society of San Diego nor ACT has any on-going or future plans to clone endangered wildlife (Oliver Ryder, personal communication 10/25/05; Michael West, personal communication 7/18/06).

PROVISIONAL CONCLUSIONS: SITUATING THE FRAGMENTARY 'SITUATIONS' OF CLONING ENDANGERED ANIMALS

This chapter has sought to situate the practice of cloning, thereby opening up new ways of seeing this technique and the kinds of consequences it may have for humans and animals alike and in relation to one another. I contend that the meanings of somatic cell nuclear transfer are entrenched in the situations whereby the technique is used. This type of analysis rejects the philosophical assumptions of technological determinism. Somatic cell

[22] Chapter 5 offers a full discussion of the ways in which somatic cell nuclear transfer was used in the case of the banteng project to manage the captive population. The chapter also more fully develops the rational for SSPs.

nuclear transfer is neither a value-neutral technique, nor does this mode of cloning deterministically create certain identities and socialities when applied to bodies. Rather, the meanings of somatic cell nuclear transfer are entrenched in the situations where the technique is actually used. As such, the meanings of somatic cell nuclear transfer cannot be clearly or directly mapped onto other species bodies through abstract mobilization. Practice situations are requisite.

Unlike the images seen in Figures 1 and 2, the analysis of cloning offered here does not rely upon the philosophical assumptions of the diffusion model. The logical apparatus of the diffusion model presumes that scientific knowledge and technologies are *produced* in a value-neutral environment that only becomes social and/or political once these objects "leave the laboratory" and "enter society". Discussions regarding the "ethical, legal, and social implications" of scientific knowledge and techniques often operate in this manner, assuming that scientific practices are pre-social and value-neutral.

Drawing on insights from the field of science and technology studies, I alternatively contend that the work of doing somatic cell nuclear transfer can and should be understood as always already enacting particular socialities that raise ethical questions from the outset (see Rabinow, 1999). It is precisely the way in which cloning experiments intrinsically enact certain modalities for doing conservation that prompts the contestation over this technique among species preservationists and zoological park workers. By reconceptualizing the relationships between science and society, new modes of engagement between the various actors and actants involved may become realizable in the highly contested practices of cloning. As the project to clone the banteng shows, how experiments are organized "matters" (Butler, 1993).

While cloning is certainly situated at the intersection of these varying social worlds and arenas, this chapter has made it clear that this positioning is rather precarious. Cloning animals of endangered species is to date a fragmentary and unstable practice. Despite the career-like quality of the situations in cloning endangered animals, these situations have not to date coalesced into the primary activity of any given "social world". Adele Clarke (1991: 131) has defined social worlds as "groups with shared commitments to certain activities, sharing resources of many kinds to achieve their goals, and building shared ideologies about how to go about their business." While cloning cuts across many social worlds, it is not firmly embedded within any one given social world.

This point is made clear in the following comments made in an interview I conducted with Barbara Durrant, Head of the Reproductive Science division at the Center for Research of Endangered Species, San Diego Zoological Society (5/16/06).

> Friese: So is there anything that I haven't asked that you think is important for me to know, or that I should be asking?
>
> Durrant: Well, I think you touched on it a little bit. I think that – before we even had this interview and we talked – maybe it was in one of your e-mails talking about the connections between zoos and people who are doing cloning. There really isn't any kind of a group that's interested in doing cloning and interested in doing collaborative efforts. Each zoo is kind of doing their own thing if they're doing it at all and they're doing it with biotech or some other outside entity. So there really isn't a network and there's a lot of – it's a very controversial topic. Even zoos like the one I work for are divided on this issue and even within our zoo, within our research department we're divided on this topic. This is not something that zoos in general think is a good idea. Some do, some are adamantly opposed to it, many are fairly passive about it because they don't have the research departments or resources to launch any kind of cloning efforts anyway so it doesn't really effect them. But it's not a coordinated effort by any means. And I'm sure you got that message by talking to numerous people.

Durrant's statement highlights that cloning cannot be understood as part of social worlds within a broader arena of sustained interest and concern that brings together multiple social worlds (Clarke, 1991; 1993). Cloning endangered species is too uncertain to have coalesced into any kind of durable, organized endeavor. In fact, the practice of cloning endangered species specifically and the use of somatic cell nuclear transfer more generally may never be "normalized" or "naturalized" (Cussins, 1998; C. Thompson, 2005).

However, the situations and occasional practices of cloning endangered animals are part of a growing endeavor to draw biomedicine and conservation more closely together. This broader endeavor could be considered an arena, a field of sustained concern and interest that already brings together multiple social worlds. The development of biomedical research centers at zoological parks during the late 1970s can be viewed as critical in initiating such an arena. Today, similar research centers are also developing at universities. For instance, Tufts University developed the Center for Conservation Medicine in 1997 that seeks to integrate the study of environmental health, human health, and animal health.[23] The implications that this arena has for both biomedicine and conservation require further research and analysis that are beyond the scope of this dissertation. Nonetheless, as a series of occasional events or situations within this arena, tracing the practices of cloning endangered wildlife offers opportunities for opening up this emergent arena for further consideration.

As Karen Garrety (1997: 757) has shown vis-à-vis cholesterol, arenas are often produced through a protracted series of situations that cannot be separated from cultural, political and economic circumstances. Endeavors in cloning endangered animals can be thought of as situations in the on-going and protracted efforts to bridge conservation and biomedicine into an arena. These efforts have garnered substantial public attention, in part

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[23] For a description of the Center for Conservation Medicine, see their website at http://www.tufts.edu/vet/ccm/.

because of the extraordinary public and scientific interest in cloning, the science fiction repertoires that make cloning endangered species render-able in mass mediated outlets (e.g., the film Jurassic Park), and the multiple levels of value that endangered species embody (see also D. J. Haraway, 2003a on this point). Situations in cloning endangered wildlife have in part become contentious because of the *ways* in which these endeavors link conservation and biomedicine. Specifically, cloning endangered wildlife raises questions about how domestic animals can and should "model" for endangered species bodies. These efforts at modeling are inextricably social and political, being linked to particular modalities of doing conservation itself.

At the same time, the practice of cloning animals of endangered species using somatic cell nuclear transfer is also part of a discourse that is stabilizing around cloning. These discourses link up humans and animals in particular ways, following long-standing traditions of modeling human and animal bodies and politics vis-à-vis one another (D. J. Haraway, 1989). These cloning discursivities are the focus of the remainder of this dissertation.

Chapter 3

Mobilizing Cloning:
Transposing bodies and techniques across the 'infrastructures' of domestic and endangered species.

The availability of and familiarity with particular biological materials surely did much to shape the pace, direction, and even the context of research in reproductive physiology and no doubt in other fields as well.
Adele E. Clarke (1987: 326)

One thread in public and professional discussions regarding somatic cell nuclear transfer has been the articulation of concern and fear over the development of knowledge and techniques in cloning animals that could one day be employed in order to clone humans. This concern is often implicitly or explicitly linked to the initial development of many assisted reproductive technologies, which are now commonly used for human infertility and family building, in the agricultural sector. Implicitly drawing upon this history, The President's Council on Bioethics (2002: xxi) states in its report on human cloning: "Although a cloned human child has yet to be born, and although the animal experiments have had low rates of success, the production of functioning mammalian cloned offspring suggests that the eventual cloning of humans must be considered a serious possibility." Central to the articulation of concern here are the ways in which techniques and their discourses travel from the social spaces in which they are developed to other arenas.

In much of the public and policy discussions of cloning, it is presumed that the mobilization of technologies also allows certain cultural assumptions to travel. This notion is deeply connected with the notion of "technology transfer" (Ann Rudinow Saetnan, 2000). For example, in cloning it is assumed that the application of somatic cell nuclear transfer to another species body "enrolls" (Callon, [1986] 1999 1998] 1999) that species body into the cultural logics of reproduction that govern livestock. So, when a technique like somatic cell nuclear transfer is used with another kind of body two distinctive processes occur: first, certain equivalences are made between these two bodies; and second, assumed differences are disrupted. Bioethics has largely been focused on ensuring that the boundary/difference between humans and animals is sustained and therefore argues that somatic cell nuclear transfer should not be used with and on human bodies. Exemplifying this move, Leon Kass (2002), Chairman of the President's Bioethics Council, has argued that both a "trench" and a "fence" need to be built between humans and animals to ensure that somatic cell nuclear transfer will not travel to human bodies, echoing other "border" defense strategies.

This discourse, which has preoccupied much of the bioethical work on cloning, has similarly been pursued in public discussions. In Figure 2, we again turn to an image of cloning that is quite familiar. This image is from the cover of *Time Magazine*, published shortly after the birth of Dolly the Sheep. Here we see two identical sheep faces converge into a singular stare that goes straight into our, the viewers' eyes. This image provides a medium through which we are encouraged to imagine the kinds of consequences cloning might have for humans. To date, the consequences of cloning for humans have been temporally located as beginning when this technique is first used with and on human bodies. In a rather technologically deterministic assessment, the actual use of somatic cell nuclear transfer with human bodies is thought to bring about the reduction of human beings as subjects to the ontological status of animals as objects. Kass's trench and fence strategy is believed to inhibit the travel of cloning to human bodies and thereby prevent the assumed collapse of human bodies into the ontological status of animals.

FIGURE 1:
IMAGE OF DOLLY THE SHEEP

Time Magazine, March 10, 1997
Permission Required

However, in the bioethical literature, this is largely rhetorical. That is, despite all this concern over the ways in which cloning may travel and the purported necessity of legislation to impede such movement, bioethicists pay relatively little attention to *how* techniques are actually mobilized across varying arenas and species. The President's Council on Bioethics assumes that cloning will travel, quite possibly even if forcefully inhibited. But the processes that allow for this mobilization across spaces and species bodies are deemed insignificant for the meanings that cloning may have. These presumptions obscure the work that goes into making a set of techniques work with different species, including the material, epistemic, and infrastructural requirements for doing so.

In sharp contrast, it is my contention that these requirements are constitutive of both cloning itself and the meanings it has for different species bodies. Specifically, by tracing the processes of mobilization, we can begin to conceptualize the co-constitutive aspects of modes of mobility, bodies, techniques, and their relations. This chapter thus addresses ongoing questions in science and technology studies regarding how techniques travel and the significance of such mobilities (W. Anderson, 2002; Clarke et al., 2003; Ann Rudinow Saetnan, Oudshoorn, & Kirejczyk, 2000). I show how cloning has traveled to zoological parks and endangered species preservation sites by "transposing" the techniques and bodies developed with domestic species to endangered species.[24] This modality of mobilizing cloning creates unexpected associations and equivalences between the spaces, places, bodies, and practices that have long been constitutive of "domestic" and "endangered" species. I develop and use the concept of transposition to explore one way technoscience travels and to consider how this mobility shapes bodies and relations in the process.

In the case of cloning animals of endangered species, I contend that domestic and endangered animals provide an "infrastructure" (Bowker & Star, 1999; Clarke & Star, 2007; Star & Ruhleder, 1996) for the movement of somatic cell nuclear transfer from arenas that focus on reproducing domestic animals (specifically livestock) to arenas focusing on reproducing animals of endangered species. Human relations with domestic animals provide the key means of doing this biologically-based research. I contend that these animals with

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[24] I assume here that species exist not only as genetico-physiological categories, but also within certain spaces and places that at times work to establish certain institutionalized forms of human-animal relations, such as livestock, laboratory animal, companion animal, zoo animal, domestic animal, endangered animal, or wild animal. Cultural geographers have made important contributions to the field of animal studies by highlighting the ways in which animals, spaces, and places are all co-constituted. For exemplars of this work in cultural geography, see the volumes edited by Jennifer Wolch and Jody Emel (1998) and Chris Philo and Chris Wilbert (2000).

their established spaces, places and modes of relating constitute infrastructures that make the creation of new kinds of assemblages possible.

However, tracing the processes of transposition highlights that somatic cell nuclear transfer does not collapse the differences between bodies. Endangered animals and domestic animals do not collapse into one another and become the same through the mobilization of somatic cell nuclear transfer. Rather, there is an "ontological choreography" (Thompson [Cussins], 1996) between domestic and endangered classifications when endangered animals are cloned. In the case of cloning endangered wildlife, this ontological choreography is deeply politicized. Counting or not counting as part of an endangered species can have life or death consequences. As such, cloning endangered animals becomes an important site for exploring the ontological quandaries that make cloning such a contentious topic. Of particular significance, I would argue, is that exploring the question of what cloning does to the "endangered species" classification may help address the ever-present question of what cloning may do to the category of human.[25]

I begin this chapter by briefly discussing how the mobility of technoscience has been conceptualized to date, a review that then situates my discussion of transposition as an analytic tool. I next explore how transposition has worked in the case of cloning endangered wildlife. I show how transposing bodies with somatic cell nuclear transfer has worked to open up questions regarding the ontology of the resulting cloned individual. Using the analytic of transposition reveals the ways in which cloning assemblages are created in and through the "infrastructure" of domestication. That is, domestic animals represent the cobbling together of relations developed over the centuries into a kind of "rhizomatic"

[25] This theme will be taken up more fully in Chapter 5.

(Deleuze & Guattari, 1987) infrastructure for experimental physiology and the production of assisted reproductive technologies. These infrastructures have worked to mobilize the assemblages prompted by the birth of Dolly the Sheep and the finding that somatic cells could have reproductive potential in conservation worlds. I frame disjunctures in the infrastructures of domestic and endangered animals as important sites through which we can begin to consider how the meanings of cloning endangered wildlife are produced, negotiated, and curtailed.

MOBILIZING TECHNOSCIENCE: CONCEPTS FROM SCIENCE & TECHNOLOGY STUDIES AND SCIENCE POLICY

The ways in which technoscience is mobilized across varying spaces has been a critical question to the field of science and technology studies as well as science policy. The most familiar analytic tool for such conceptualizing has been the trope of "technology transfer", which at its most basic describes the movement of a technology from the space in which it originated to a new setting. There are three general limitations to the technology transfer concept that make it difficult to use in order to understand how somatic cell nuclear transfer has traveled across species, which also serve as more general critiques of this approach. First, technology transfer presumes a clearly distinct, uni-directional relationship between basic research and application (Guston, 1999). Somatic cell nuclear transfer disrupts this notion because the "applied" work of technology development produced new kinds of basic knowledge about cellular development (Franklin, 1999b). Second, the language of technology transfer presumes a ready-made technique can be moved unchanged across varying socially engaged and materially mediated spaces. Third, technology transfer tells us nothing of how technologies are mobilized across varying social spaces. This question is precisely what is of interest in this chapter.

As this chapter will show, somatic cell nuclear transfer is not an off-the-shelf recipe, but instead a conceptualization of techniques using certain materials that must be "tinkered with" (Knorr Cetina, 1999) in and alongside the very local settings made up of humans and "nonhumans" (Latour, 1999c) in which these techniques "settle". In order to highlight these aspects of somatic cell nuclear transfer, I refer to this technique as "technical mediations" (Latour, 1999c) rather than a technology. The concept of "technical mediations" is derived from Latour's work that seeks to disrupt the notion of subject/object and corresponding humanist definitions of agency. Using the founding concept of symmetry in science and technology studies (Bloor, 1991), Latour argues that technology is neither an outcome of human mastery over the natural world, nor is technology some kind of ever-present determinant of human agency. Rather, technical mediations shows how distinctive forms of agency are produced in and through the interactions among humans and nonhumans that occur within particular temporalities and spatialities (see also Barad, [1998] 1999). By positioning nuclear transfer as technical mediations between humans and nonhumans we are able to grapple with the ways in which scientists working with this technique must tinker with it, in the particular situations of their laboratories, to make it work as they interact with particular species and a complex array of other nonhumans. Nuclear transfer does not travel *or settle down* in a preformed, universal fashion. Basic and applied research are always intertwined as somatic cell nuclear transfer travels.

The notion of technical mediations is linked up with the conceptual apparatus of actor network theory, ostensibly the most noted analytic tool for conceptualizing how technoscience is mobilized in the field of science and technology studies. As discussed in Chapter One, actor network theory was developed by Michel Callon ([1986] 1999), Bruno Latour (1987; 1999a; 1999b; (1983) 1999) and John Law (1999). This model "follows scientists" or nonhuman actants as they engage with other human and non-human actors to build networks that sustain the authority of the laboratory (Latour, 1987; see also Sismondo, 2004). The concept of translation has been an important component of actor network theory for questions of mobility. With translation, certain equivalences and associations are produced between seeming unlike and unrelated human and nonhuman actors that work to mobilize scientific knowledge and techniques (Latour, 2005; Law, 1999), readying them for travel.

A number of significant critiques have been made of actor network theory. First, this analytic tool has often resulted in prescriptive readings of scientific knowledge practices that often evoke too much stability and an "executive" managerial sensibility than is encountered in empirical studies of scientific practices (Law, 1999; G. E. Marcus & Saka, 2006; Star, 1991). Others have argued that the method of "following scientists" too often obscures those actors who are implicated by scientific knowledge practices, but are not "brought to the table" so to speak (Clarke & Montini, 1993; Hess, 1997; Ann Rudinow Saetnan et al., 2000; Star, 1991). Finally, in focusing on the ways in which science is productive of new social arrangements, actor networks often lack a kind of historical complexity that is essential if we are going to understand the politics of science on the move.[26] Actor networks suffer from a lack of situatedness (Clarke, 2005).

[26] Warwick Anderson made this point at the session "Intersections and Dialogues Across Postcolonial, Feminist and Laboratory Studies of Science" at the 2006 meetings of the Society for Social Studies of Science. See also Adele Clarke (2005).

CONCEPTUALIZING MOBILE TECHNIQUES: TRANSPOSING TECHNIQUES & BODIES

Based on my ethnographic research of endeavors to clone animals of endangered species, I contend that somatic cell nuclear transfer has traveled to arenas based on working with endangered species by transposing the bodies and techniques of domestic animals to endangered wildlife. In using the word transpose I refer to both definitions given in the *Oxford American Dictionary*: to cause to change places with each other as well as to transfer to a different place or context (Jewell & Abate, 2001). While the concept of technology transfer is able to linguistically grasp the notion of transferring the nuclear transfer technology to another place or context, it does not point us to the ways in which domestic animals and endangered species are changing places with one another in a bodily fashion. And while "translation" could direct attention to the associations that are made between domestic and endangered animal bodies, it does not highlight the temporal and relational aspects of these bodies that make them different. The concept of transposition directs our attention to both socio-cultural and historical meanings given to bodies, spaces, and techniques. The word transpose implies the spatial movement of bodies and processes that make certain places and corresponding bodies meaningful.

As an analytic tool, then, transposition refers to the processes whereby bodies and techniques that come with certain infrastructural arrangements are moved to another area of interest. This creates a dynamic and co-constitutive set of relations between unlike bodies and arenas, requiring the coordination of different logics, practices and bodies vis-a-vis one another. In short, equivalences and associations are made between domestic and endangered animal bodies *in particular situations*. However, domestic and endangered animal bodies do not collapse into one another in any kind of totalizing manner. Rather, an "ontological choreography" (Thompson [Cussins], 1996) results. The concept of transposition is thereby able to highlight when and under what conditions equivalences are or are *not* made as well as how this "matters" (Butler, 1993) for the ontology of the resulting cloned animal.

Transposing: to transfer to a different place or context

Cloning animals of endangered species was often described as transposing the nuclear transfer techniques as they are used with domestic animals - such as livestock or laboratory animals - to use with animals of endangered species. Historically, assisted reproductive technologies have been developed in the highly capitalized arenas of agriculture and biomedicine, putting zoological parks in the United States on the "receiving end" (Inhorn, 2003) of reproductive technology transfers. Public funding through the U.S. Department of Agriculture, alongside the extensive capitalization of biomedical and agricultural technoscience, currently propels technological developments in and for these arenas (Fuglie, Narrod, & Neumeyer, 2000). No such funding structures are so extensively at work in conservation. Thus, since the 1980s there has been an increasing trend in the zoological community to take reproductive technologies developed elsewhere and try to refashion these techniques locally in order to reproduce animals of endangered species as well as other zoo animals. There are on-going endeavors in using artificial insemination, in vitro fertilization, and embryo transfer techniques that were originally developed in the agricultural industry with endangered and zoo animals in research centers affiliated with zoological parks. The uptake of the nuclear transfer technology with animals of endangered species can and should be understood as an extension of such endeavors.

The following statements made by people involved in cloning animals of endangered species frame their interpretations of the social processes of transposing nuclear transfer, or moving this set of techniques to another context.

> Originally I was working for Advanced Cell Technology, which is a commercial cloning company back in Massachusetts, and their main focus was cloning particularly cattle species. But my interests have always been in endangered species fields. So I kind of thought that, well, since we know how to clone domestic cattle, and there are some endangered species that are similar to domestic cattle, and that actually hybridize in the wild with their domestic counterparts, I thought it may be possible that we could take the tools or the techniques that we currently have right now and see if we could apply them to the endangered species. And that's kind of how it really started was just to basically say 'okay, we can clone one species, why not try another species.'
> *Philip Damiani, personal interview 7/1/05*

> We've been doing various types of nuclear transfer work since maybe – probably 1992. . . . The vast majority of our work has been, for the last several years, since the late '90s up until today, using cattle as models. So the bulk of our research is done there. I have a colleagues who's interested in wild animals, specifically wild sheep, has done a lot of chromosome work on those, and we basically got together and decided to see whether or not we could generate some embryos with the argali. She had access to a cell line fibroblast cells, and we used those as the nuclear donor cells. We collected oocytes – actually mature oocytes from domestic sheep donors and combined those.
> *Kenneth White, personal interview 4/28/06*

> Because there is a lot of funding for research with livestock from the USDA because we eat livestock, the research and the technologies used with these animals is much further ahead than what you have for endangered species. So I would say there is sort of a trickle down, it would look like a funnel.
> *Philip Damiani, personal interview 1/8/06*

> Each species has its own pecularities of reproduction, and availability, and resources, and all those things so that each one has to be adapted. I pretty much spent my career adapting embryo transfer technology to the whole gambit of species. And that really is what is going on now with the nuclear transfer is it's being adapted to different species.
> *Duane Kraemer, personal interview*

These quotes all highlight how a technique is developed with a particular species and those species are situated in certain social and historical processes that have coalesced into established and institutionalized human-animal relations, such as livestock. The goal is then to make these techniques applicable to other species, which in turn legitimates the technique itself. That is, part of what gave Dolly such significance was the slew of reports that other species were subsequently also cloned using the somatic cell nuclear transfer technique. If it appeared possible to only use this technique with sheep, the technique itself and the research that makes the technique feasible would have slowed considerably.

Transposing a technique like nuclear transfer, or any other assisted reproductive technology, requires much work. This work is often effaced in discussions about technology transfer. If a research center decides to do nuclear transfer, personnel must be trained in the micromanipulations involved in the process, donor oocytes and skin cells must be obtained, allocated and stored, surrogates must be procured and cared for, and microscopes, cultures, and many other (often quite expensive) materials must be at hand. But even this list of necessary humans, nonhumans and tacit knowledges does not really begin to express the work that goes into making techniques work in other, very local settings. For the nuclear transfer process to work, a whole slew of humans and nonhumans must be brought together *and must learn how to relate to one another*.

The following quote, in which a scientist describes the process of developing somatic cell nuclear transfer in the specific situation of the laboratory in which he works, demonstrates these points.

> I mean it's not like we had this recipe book, that we just followed this recipe. You can build on other's work. You can take other's work and decide whether you think that's how you want to approach it or whether you want to do it differently, whether you can – I don't want to say do it better but at least

> in your hands you think it's a better way to do it. It may not be the same in somebody else's hands. So we feel like we have had to develop the knowledge and the techniques to be able to do what we're doing and it wasn't just something that we just went in the lab one day and produced embryos and transferred them and had a baby. I mean this whole system that we use has evolved over – well, as I said earlier in the conversation, I began this in the late '80s. So I will soon have spent most of my time the last twenty years doing this at least a large portion of it.
> *C. Earle Pope, personal interview 3/14/06*

Techniques like nuclear transfer do travel across journals or through apprenticeships, allowing for the development of "golden hands". But C. Earl Pope supplements this metaphor by described the laboratory as a system, one in which techniques and knowledges developed elsewhere are taken up and made to fit the very local setting of a particular laboratory that has developed over time. Having developed an embryo laboratory over the years is the starting point. Yet making nuclear transfer viable in that setting took many years of work and tinkering. It meant buying new equipment, training new personnel, creating new laboratory protocols, and re-distributing work. As such, the basic premise of nuclear transfer is transposed, but the process and the local circumstances in which it is used need to co-constituted, typically a long and costly process requiring major commitments.

<u>Animal models in transposition</u>

Viewed from the perspective of transposition, domestic animals are being used as "models" for developing assisted reproductive technologies with endangered species. Here, the word "transposing" itself productively points us toward certain historical tensions and shifts around the use of animal models in the life sciences generally and zoologically parks specifically. The word "transpose" is often used to denote the transposition of facts about one species physiology to another species and is deeply interconnected with the use of animal models in the life sciences and biomedical research (Clarke, 1987; 1995b; 1998; Hanson, 2004; Rader, 2004). Animal models have historically been positioned as research objects through which facts about biological structures and functioning as well as biological reactions to certain interventions can be ascertained and those facts are then transposed to other species. For instance, primate research has been used to learn about the facts of human biology (Clarke, 1998; Hanson, 2004). The use of certain species as models for learning the facts of another's biology is premised upon notions of who/what can be sacrificed for the betterment of whom, and who/what cannot (Lynch, 1989; Rader, 2004). There are always tensions here and consensus on such questions is difficult to sustain. For instance, primates are considered usable models because of their evolutionary proximity to humans and yet this proximity draws into question the legitimacy of their sacrifice-ability (D. J. Haraway, 1989).

As discussed in the previous chapter, in "modern" zoological parks, animals were collected in part as objects for studying the natural history of species; zoological parks thus became sites for natural historians to learn about relationships between species by pictorially representing them (Baratay & Hardouin-Fugier, 2002). However, the utility of zoo animals as research objects has always been tenuous at best. The shift from descriptive to experimental approaches in the life sciences made the status of zoo animals as research objects even more uncertain. As Adele Clarke (1987: 324) has pointed out, the shift from descriptive approaches in natural history to experimental approaches in American physiology worked to shift scientists' material needs from a limited number of specimen from a range of different species (the approach that zoological parks were premised upon) to a large number of "sacrifice-able" (Lynch, 1989) live animals of the same species. Zoo animals have not been the "right tool for the job" (Clarke & Fujimura, 1992b) of physiology with the turn to experimental approaches.

The tension between zoo animals as entertainment and education versus zoo animals as research subjects/objects persists today and deeply informs the research trajectory of the reproductive sciences in zoological parks. Up until the 1980s most researchers studying a wild species from a physiological perspective would often do so by working directly with captive animals of the species in question. However, researchers have not been able to justify taking animals out of species breeding protocols in order to test and develop invasive, experimental assisted reproductive technologies that often have low rates of healthy pregnancies and births.

> And, of course, the other thing that I haven't mentioned is as with any research project, you need individuals to do the research with and when you're working with lab mice or whatever or domestic cows it's very easy to go out and get a group of animals to work with. Well, when you're working in a zoo you may have maybe – we count ourselves lucky if we have three or four females and of those females they're all involved in a captive breeding program. You may only have access to them for very short periods of time. The resources are incredibly limited for the researchers in the zoo community anyway, which also makes it extremely challenging to try and develop a technique that can become commonplace because you don't have herds of animals or a group of research animals to perfect a technique on. It's really trying to work with what you have.
> *Linda Penfold, personal interview 4/17/06*

In response to this lack of research materials needed to assess the reproductive physiologies of wild and endangered species as well as develop assisted reproductive technologies, researchers at institutions such as the National Zoo or the Cincinnati Zoo began to work with closely related, domestic species before working with the wild species in question. Working with domestic animals has been a pragmatic response to the lack of research materials that necessarily curtails physiological research of endangered species. The limitation of the model animal approach is that physiologies of one species do not necessarily map neatly upon another and there are differences that often must be researched. These points are demonstrated in the following statement about the use of model animals in zoo research programs.

> As most of our cats studies go, a big chunk of the research was done on domestic cat models, using model species. You can do a lot of hypothesis testing with them under lab situations because it's a lot more controlled, you have a relatively unlimited access to these animals. You can do a lot more experiments with these guys, with domestic cats, then getting access to some of these [wild] cats in various institutions. So the way we've done it in our program is that any big question that we have an interest in answering is tackled with the domestic cat. And once we've thought that 'well, we've got some answers', *then* we go see if we can extrapolate into other species. Sometimes it works out that way, sometimes we just, it does not happen. That's where models do have limitations in how it does apply to reproduction itself.
> *Budhan Pukazhenthi, personal interview 4/11/06*

Here we see how researchers in zoos use domesticated animals to produce knowledges and technical mediations, informing their understanding and modes of interacting with wild and endangered species.

Transposing focuses our on how technical mediations are developed with domestic animals first, and then transposed in working with wild and endangered species. Transposition does not mark the verbatim mapping of technical mediations from one situation onto another. Rather, a wide range of humans and nonhumans must come together and learn how to work with one another when techniques are transposed. Learning how to work with a domestic animal is more easily achieved when compared to working with a wild or endangered species for a slew of reasons, including their abundance in numbers, their legal status as sacrifice-able, and the easier face-to-face interaction with domestic when compared to wild animals. As Philip Damiani (personal communication, 1/8/06) noted, "Yeah, I mean I wouldn't want to do that [cloning process] with a gaur. He'd kill me. No way. I'd much rather do that with a domestic counterpart." Because it is easier and physically safer to form biologically-mediated relations with domestic animals, researchers are moving toward using domestic animals as models to the greatest extent possible before working with wild species.

Transposing: to cause to change places with each other

In the case of cloning animals of endangered species, there is no longer a linear relationship between domestic and wild species in the model animal paradigm. Rather, the domestic animals used themselves also physically become part of the technical mediations in cloning animals of endangered species. To date, all animals of endangered species have been cloned using interspecies nuclear transfer. As discussed in Chapter Two, interspecies nuclear transfer creates embryos using an egg cell from a domestic animal that is evolutionarily closely-related to the somatic cell donor of the endangered species that is meant to be reproduced. Domestic animals also serve as gestational surrogates. This results in a dynamic, rather than linear and discrete, relationship between “domestic” and “endangered” bodies and bodily parts.

It appears to be impossible in the current socio-cultural-technoscientific moment to clone an adult animal of endangered species without incorporating the bodies and bodily parts of domestic species. Nuclear transfer remains relatively inefficient in terms of the material resources that are required to produce a limited number of embryos and offspring. Specifically, it requires both a large number of ova for the nuclear transfer procedure and gestational surrogates for the development of resulting embryos. Yet, relatively few animals are actually birthed. Given the endangered status of endangered species it is considered unethical and probably materially impossible to use the bodies and bodily parts of animals of endangered species for all facets of the cloning process. Therefore all projects in cloning animals of endangered species have included domestic animal bodies and bodily parts in the technical mediations. As such, interspecies nuclear transfer is premised upon the ability of researchers to label the bodies they work with as domestic in certain instances. Oliver Ryder stated in the interview (7/20/05):

> You need the infrastructure like what Trans Ova has in order to do something like this. They clone transgenic cows to make pharmaceuticals and for them there is nothing different in implanting a cloned banteng embryo into a domestic cow than there is in implanting a cow embryo. Functionally, there is no difference.

Through interspecies nuclear transfer, domestic and endangered species literally change places with each other. As such, transposition requires that the cloned endangered animal engage in what Charis Thompson (2005; 1996) has called an "ontological choreography" or dynamic coordination of elements considered ontologically distinct including domestic and wild, plentiful and endangered, zoo and farm, as well as sacrifice-able and protected. Thompson (2005) states that: "What might appear to be an undifferentiated hybrid mess is actually a deftly balanced coming together of things that are generally considered parts of different ontological orders (part of nature, part of the self, part of society). These elements have to be coordinated in highly staged ways so as to get on with the task at hand" (C. Thompson, 2005: 8). It is precisely the ways in which things considered ontologically different are to be ordered that remains contested and uncertain in the case of cloning endangered animals.

SITUATED TRANSPOSITIONS OF SOMATIC CELL NUCLEAR TRANSFER

Having discussed the concept of transposing technical mediations as a process whereby somatic cell nuclear transfer has traveled to arenas based on preserving endangered animals, I now turn to how this process worked in the endeavors to clone specific endangered animals. I highlight the ways in which the techniques and bodies used to clone domestic animals were transposed in order to clone animals of endangered species. These cases of transposition show how the technical mediations of cloning work to make domestic animals the primary subjects of a research agenda whose objective is to preserve endangered species. By tracing these cases of transposition, we can begin to see how this process of transposition is caught up in contestations over differing modalities of working with wildlife.

Cases of transposition: the gaur and banteng

In their book on the work of classification, Geoffrey Bowker and Susan Leigh Star (1999: 303) ask: "Would it be possible to design boundary objects?" This question is premised upon Star and James Griesemer's ([1989] 1999) conceptualization of a boundary object as that which is made meaningful in a manner that is both flexible enough to bring a range of divergent social worlds together in a shared endeavor and yet durable enough to allow certain kinds of jobs to get done. The question Bowker and Star are asking is whether an object can be engineered to do this kind of collaborative work that allows for moblization through (partial) consensus. In some ways, the endeavor to clone the gaur and banteng could be conceptualized as an attempt to engineer a boundary object in order to bridge two infrastructures. As the outcomes of collaborations between the Zoological San Diego Society, Advanced Cell Technology, and TransOva Genetics, the cloned gaur and banteng were configured as boundary objects that would suit multiple needs and desires. These projects also show some of the difficulties that occur when attempting to do this.

The decision to clone a gaur and then a banteng can be understood as attempts to work around two different kinds of inaccessibilities simultaneously. Advanced Cell Technology was in the process of shifting its business identity from a company that produces transgenic animals for human therapeutics to a company that produces human stem cell therapies. The gaur project was deeply positioned in this shift. Advanced Cell Technology wanted to find out whether it was possible to do nuclear transfer using somatic cells from one species and ova from another. This was part of its attempt to work around difficult to allocate and politically contentious human oocytes that are at presented needed to produce patient-specific stem cells. Specifically, Advanced Cell Technology was interested in using domestic cow ova, which are plentiful in slaughterhouses, to produce embryos using human somatic cells so as to derive stem cells. The idea was that cow ova are easier to procure and the resulting embryo would not count as human and could thereby be disentangled from political debates.[27]

When the President of Advanced Cell Technology, Michael West, was considering this project, Robert Lanza informed him that some people working with endangered species would also be interested in this kind of research for different reasons. Some scientists at the Zoological Society of San Diego had already published commentaries on the potential use of somatic cell nuclear transfer to regenerate preserved fibroblast cells from endangered and wild animals as part of species conservation work (Ryder, 2002; Ryder & Benirschke, 1997). In addition, the Zoological Society of San Diego had invited Ian Wilmut of the Roslin Institute to give a lecture about his team's work in developing somatic cell nuclear transfer with Dolly the Sheep. Rather than conducting this potentially contentious research for the first time using human somatic cells, Lanza suggested that somatic cells from an endangered animal be used (Michael West, personal communication 7/18/06). Like human oocytes, ova from endangered animals are difficult to access and allocate. Thus, those working with

[27] Sarah Franklin (2003) has explored another attempt to work around the inaccessibilities of human oocytes, wherein research was done to see if a somatic cell could be reprogrammed without the use of oocytes at all.

endangered animals would also need to work around the inaccessibility of these bodily parts in order to regenerate preserved fibroblast cells. Working with endangered species allowed Advanced Cell Technology to work through two inaccessibilities simultaneously. Working around the inaccessibilites of endangered species in turn proved to be beneficial for the public relations of the organization.

The projects to clone both the gaur and banteng were premised upon Advanced Cell Technology's ability to clone domestic cattle. The idea was that these species were evolutionarily close enough to: first, allow the bodies of domestic cows to enter into the technical mediations of cloning a gaur and banteng and; second, it was assumed that the technical mediations used with the domestic cow would work in cloning a gaur and banteng. Through interspecies nuclear transfer, domestic cows were the primary subjects with which researchers were working. Both the nuclear transfer and the embryo transfer processes could be done as if all body fragments were from domestic cows. The gaur and banteng could, in certain moments, be treated like a cow and this allowed researchers to exploit the extensive infrastructure that already supports human relations with domestic cattle.

As such, transposing the bodies and techniques of domestic animal bodies required an "ontological choreography" (Thompson [Cussins], 1996) to take place. However, just how the relations between domestic and endangered were to be managed remains an on-going question. This is nicely demonstrated by comparing the ontological choreography of the cloned gaur and banteng. With both projects, the fibroblast cells were of their respective endangered species upon leaving the Zoological Society of San Diego. These fibroblast cells became part of embryos understood as chimeras through the somatic cell nuclear transfer process at Advanced Cell Technology. When the embryos were received by Trans Ova

Genetics to be transferred into domestic cows for gestation, these embryos became materially and relationally equivalent to domestic cow embryos. In the case of the gaur project, the fetuses were treated like domestic cows up until birth.

Then, at this juncture in the ontological choreography, two critical problems arose that had life and death consequences. First, researchers from Advanced Cell Technology sacrificed three fetuses resulting from the gaur-cow chimera embryos in order to assess for normal development and genetic origins. After announcing this practice in a scientific journal article, some conservationists argued that these sacrifices violated the Endangered Species Act. The ESA states that no animal of an endangered species, nor part of such an animal, can be harmed in any way. Philip Damiani (personal communication, 7/1/05) told me that if the gaur had not been reclassified from endangered to threatened, the entire project would have been found in violation of the Endangered Species Act.

Second, in defining birth as the moment at which the cow fetus became gaur, the researchers found themselves in a position where they needed to rear the newborn. It was assumed that the domestic cow would not be able or willing to care for her now alien offspring. Researchers decided that since the gaur was wild and of nature then he probably should not consume the homogenized milk of culture. Researchers from ACT and Trans Ova Genetics decided to feed the gaur milk that had not been homogenized. This ontological shift proved too much for the newborn gaur's system and he died of dysentery.

In response to these tragic mistakes in the ontological choreography of the cloned gaur, in the banteng cloning project the fetuses were deemed banteng *before* birth. A scientist, banteng keeper, nutritionist, and curator were sent to Trans Ova Genetics to oversee the care of the domestic cows and the birth of the banteng. The banteng is now five years old and on display at the San Diego Zoo. And his ontological choreography has continued since his arrival in the park. In 2002, Oliver Ryder and Philip Damiani attended the meetings of the Taxonomic Advisory Group for hoof stock and explained how they understood this cloned animal to be significant to the captive population. The group decided to consider the cloned offspring as a banteng and continue the experiment. Meanwhile, the U.S. Fish & Wildlife considers the cloned offspring a hybrid. Changing the classification here would only bring the San Diego Zoo more paperwork, and so no one has to date contested this definition of the cloned individual in this context.

Cases of transposition: Cloning a Sand Cat

The Audubon Center for Research on Endangered Species focuses specifically on developing assisted reproductive technologies so that they can be used with wild and endangered species. Unlike the projects in cloning the gaur and banteng, which were project-based and not long-standing, ACRES continues to consistently work on developing somatic cell nuclear transfer to clone endangered animals. Their work was not preceded by having successfully cloned a domestic cat but rather by years of experience in working with domestic and wild cats through the development of assisted reproductive technologies for wildlife. Their success in cloning the African wildcat, which is not considered to be endangered, has provided the basis for their sustained commitment to developing nuclear transfer and the expansion of their efforts to other, more endangered, felids. All of their work has used domestic cats as ova donors and surrogates.

I spent a day at ACRES watching researchers do the work involved in creating cloned embryos of a sand cat. In the morning, two surgeries were scheduled in which ova were removed from domestic cats. After the ova were counted, they were brought from the surgery room to the embryo laboratory where the interspecies nuclear transfer process was done. The embryos were first cleaned or "denuded," cultured, enucleated, and sand cat somatic cells were transferred into the enucleated domestic cat ova. The resulting embryos were then transferred into the cats who had been ova donors for the creation of these embryos.

Of significance here is the primacy of interactions laboratory workers have with domestic cats in their work practices. Throughout the day, I watched as laboratory workers interacted with domestic cats in multiple ways. Domestic cats were patients in surgery. Domestic cat ova were counted, cleaned, enucleated, and transformed into sand cat embryos. The cats in the colony made up a collection of sentient beings that were fed, petted, consoled, tested, and whose living spaces required cleaning and maintenance. The policy at ACRES is that no domestic cats are euthanized and, once a cat has fulfilled her working obligation (loosely defined as 10 oocyte retrievals), she is moved to another room that serves as a quasi-adoption center. Domestic cats are very much part of the laboratory.

While I spent much of the day interacting with domestic cats and with people who were interacting with domestic cats, my closest sighting of a sand cat came in the form of a somatic cell (re)imaged on a monitor. While participating in some of the visualized processes involved doing somatic cell nuclear transfer, I watched as the mature domestic cat ova were carefully enucleated and somatic cells, that I was told were from a sand cat, were inserted into the ova. While sand cats were the object of the experiment for much of the day in the lab, the work done with sand cats was minimized and reduced to the presence of somatic cells. All other work that day was done with domestic cats.

TRANSPOSING TECHNICAL MEDIATIONS ALONG 'INFRASTRUCTURES'

In a review of 10 reproductive biology journals, David Wildt (2004) found that more than 90% of text was devoted to 14 species including humans, cows, pigs, and mice. Wildt (2004: 284) concludes that: "experimental biology is disproportionately directed at already well-studied species." Historian Harriet Ritvo (1995: 422) similarly found that domesticated animals occupied "more than their share of space" in the natural histories of taxonomists over two centuries ago, in the late eighteenth century (see also Ritvo, 1997). Wildt suggests that this excessive focus may be due to financial and logistical troubles of studying other species, as well as researchers' lack of initiative to study other species. Ritvo contends that domestic animals were over-represented due to their economic importance and accessibility.

Expanding Wildt and Ritvo's general assessments, I would suggest that in the laboratory well-studied species - including species of livestock, laboratory animals, and humans - represent an infrastructure for doing the work of experimental biology. Experimental biology has been established by working with and for these bodies, resulting in the "infrastructuration" (P. Edwards & Lee, 2006) of relations. This infrastructure is made of up established knowledge about species that provides a basis for conceptualizing the significance of research findings, accessible and standardized organisms, extensive funding sources, and the elaboration of husbandry requirements that are all necessary for making scientific work "doable" (Clarke & Fujimura, 1992b). As Geoffrey Bowker (2005: 149) points out, we tend to study entities that have been studied before and, correspondingly, that which is easy to study. The infrastructure of relations based on domestication means that certain species are studied more extensively than others.

As mentioned in Chapter Two, U.S. zoological parks were late in coming to the reproductive sciences compared to academic biology, medicine, and agriculture (Clarke, 1998). In the late 1970s, the success of assisted reproductive technologies such as in vitro fertilization and embryo transfer with humans propelled the incorporation of the reproductive sciences into some zoological parks. However, developing and using assisted reproductive technologies with species that do not correspond with extant biologically-mediated infrastructure has posed challenges.

One persistent difficulty that occurs in working with wild and endangered species is the sheer number of different species there are and the lack of resources available for studying any extensively, with the exception of "charismatic mega-vertebrate" (C. Thompson, In preparation) like the panda. Whereas reproductive scientists in agriculture and biomedicine may spend their lifetime working with one species or more commonly a few different species (Clarke, 1987, 2004), most researchers working with wild and endangered species must study a range of different species.

> [There is] tremendous pressure [because] there are so many species that need assistance, so many species that are not self-sustaining. We try to spread ourselves a little bit too thin sometimes and think, "Well, if I could do twelve species this year" where really you need to spend a year on each species to even begin to understand it. It's a complicated thing. And we do feel torn between doing things really thoroughly, really well. Outside of the zoo world you see people who spend their entire professional careers on reproduction in wombats or something like that and we don't have that luxury.
> *Barbara Durrant, personal interview 5/16/06*

As such, there is often little or no information about the physiologies, much less reproductive physiologies, of many wild and endangered species. This has meant that most of the research in zoological parks addresses questions that are often taken for granted in livestock, companion animals and humans. The following quote demonstrates this point.

> One of the limitations with these captive animals with endangered species is we have such a lack of basic information about their basic biology. So whenever we're starting with a new species you have to figure out how long is the estro cycle, are they seasonal, what does a sperm sample look like, how do

> you synchronize them. So basic techniques, basic information that we very much take for granted with domestic animals we know nothing about the biology of these endangered species so we have to go way, way back and start over at a very basic level. And then species differences are so great that when we learn enough about one species we try and then apply it to another species and quite often we have to – occasionally that might work but really with every different species we have to go all the way back to basics. So we're always coming from so far behind is one of the limitations with these assisted reproductive techniques.
> *Linda Penfold, personal interview 4/17/06*

The lack of basic knowledge about the reproductive physiologies of wild and endangered species means that a significant amount of work must be done with animals of that species before assisted reproductive technologies can even be considered. Specifically, infrastructural arrangements need to be established for the biologically-mediated relation to take place.

> Any of these techniques will only be as good as the information we have to base it on. So with both IVF and embryo transfer, there are constant questions that are being asked. What is the ideal time interval when you go in and aspirate the eggs from a female? And if you do aspirate, are these eggs mature or have they required some sort of in vitro culture to ensure that both sides are mature before they can be fertilized? That, so that's an unknown there. So there is a lot of effort to understand that. Second, post-fertilization, presuming that the sperm that you're going to use for fertilizing is functional fully. Sometimes, when you take sperm from a male and use it in an in vitro system you do interfere with that functionality because you're changing the media. They're not normally in a chemically-defined media, so you may have to treat some of those conditions. And even if you produce the embryos, then you need to have information on what is the ideal condition for transferring these embryos so that you can establish a pregnancy. So these are some of the presumptions that we need to keep in mind, that we have this information before we can say any of these things are actually going to work.
> *Budhan Pukazhenthi, personal interview 4/11/06*

Thus, researchers not only need to learn how to interact with animals of different species in order to do the work of reproductive physiology, they need to understand the reproductive physiology and morphology of a given species in order to take a basic set of techniques associated with ART and make them work.

Interspecies nuclear transfer can therefore be conceptualized as a potential means for overcoming the lack of a biologically-mediated infrastructure for some endangered species. Rather than working largely with wild and endangered species, much of the work is actually done with domestic animals and domestic animal body parts. This draws upon and extends the logic that prompted much of the work that was done on interspecies embryo transfer. As David Wildt told me in an interview, "I mean the whole idea behind some of the original work was that we could use interspecies embryo transfer so you could put zebra embryos into horses and bongo embryos into cows." The hope was that this interspecies work would allow researchers to "work around" (see Star, 1995) their lack of knowledge regarding how to superovulate, retrieve and transfer embryos in animals of endangered species. Hypothetically, one would not need to know very much about the reproductive physiology of the species that is being cloned because the majority of the work is done with well-understood, domestic species. All that is needed is a preserved fibroblast cell from an animal of an endangered species, a technical mediation that has already been fairly well established in zoological societies like San Diego's. In other words, domestic animals do not just provide models through which researchers can learn about reproductive physiology or tinker with experimental techniques before working with rare and endangered animals. Rather, domestic animals represent an "infrastructure" (Bowker & Star, 1999; Star & Ruhleder, 1996) for a relations that can be deployed in order to reproduce animals of endangered species that are, by definition, inaccessible both in their bodies and in human knowledge of those bodies.

In *Sorting Things Out*, Geoffrey C. Bowker and Susan Leigh Star (Bowker & Star, 1999: 35-36) render visible largely invisible infrastructural arrangements. They define "infrastructure" as: 1. embedded, 2. transparent, 3. spatial and temporal, 4. taken-for-granted by users, 5. shaping of and shaped by conventions of practice, 6. standardized, 7. built up from an installed base, 8. visible when broken down, and 9. fixed incrementally and locally. Bowker and Star, drawing on the edited volume *The Right Tools for the Job* (Clarke & Fujimura, 1992a), argue that analyzing infrastructures is important because these often unseen arrangements make certain kinds of work doable while also constraining other kinds of work. I would add that infrastructures also allow for the mobilization of technoscience across social worlds, by being usable by many "communities of practice" (Bowker & Star, 1999: 313). Specifically, by traveling along infrastructures, techniques like somatic cell nuclear transfer move to varying communities of practices and make established things work in new ways with the incorporation of new knowledge and new research materials that constitute new and "doable" (Clarke & Fujimura, 1992a; Fujimura, 1996) possibilities.

It should be pointed out that this desire to transpose domestic species and their infrastructural arrangements into technical mediations with endangered animals so as to overcome the inaccessibilities of the endangered species is not at all an established, ongoing reality at this point in time. All animals of endangered species that have been cloned are actually quite well understood from a physiological perspective. Additionally, some basic knowledge about the reproductive physiology of the animal being cloned appears to be required in order to design a doable cloning experiment. For instance, Kurt Benirschke (personal communication 9/15/05) recalled an unsuccessful attempt to clone an anoa using interspecies nuclear transfer with domestic cow ova and surrogates. The project was unsuccessful, as he predicted, because the anoa and domestic cow have different placentation patterns.

Nonetheless, the notion that domestic species offer a kind of infrastructure for reproducing animals of endangered species does appear to be blossoming and is also considered in technical mediations beyond somatic cell nuclear transfer. That is, this work is always already embedded in the logic of interspecies embryo transfer and persists in emergent techniques. For instance, there was much enthusiasm at the 2006 International Embryo Transfer Society Meetings about a paper given on interspecies xenotransplantation of testes stem cells. Here, testes stem cells were transferred from an individual of a more desired breed of cattle to an individual of a less desired breed so that the individual of a less desired breed would reproduce the genetic material of another. These experiments were done in hopes of changing both the population and profitability of cattle in Australia. This is certainly a site where biopower (Foucault, 1978) and "biocapital" (Sunder Rajan, 2006) converge (see also Clarke, 2007). At least two individuals at the meetings mentioned to me that this technique could have implications for endangered species. For instance, it was speculated that a domestic dog could hypothetically reproduce an endangered canine's genomic information.

As such, long established and hence well understood *livestock and laboratory animals are infrastructures that have allowed somatic cell nuclear transfer to travel*. The development of knowledge about the physiology, genomics, and husbandry of domestic animals like cattle, sheep and pigs alongside the development of exchange network for garnering research materials that allow for physiological approaches to be pursued have constituted a biologically-mediated infrastructure for the development of technical mediation that work to further manage and "control" (Pauly, 1987) these species. This infrastructure is not so much like a set of highways or a railroad, both of which are purposefully designed infrastructures, although often used in ways not necessarily conceived of by the designers. Rather, domestic animals represent a means of cobbling together trails that have developed over the centuries of human-animal domesticating interactions into a kind of infrastructure for experimental physiology and the production of assisted reproductive technologies.[28] In other words, the infrastructure of domestic animals is "rhizomatic" (Deleuze & Guattari, 1987). These rhizomatic infrastructures have worked to mobilize the assemblages prompted by the birth of Dolly the Sheep and the finding that somatic cells could have reproductive potential.

NEGOTIATING HUMAN-ENDANGERED SPECIES RELATIONS

My argument here is that interspecies nuclear transfer seeks to overcome some of the difficulties associated with forging biologically-mediated human relations with endangered species by working around the material limitations and lack of human knowledge regarding their bodies. By using domestic cattle or cats as ova donors and surrogates, the work that is actually done with an endangered species is limited and the lack of a biologically-mediated infrastructure for endangered species is – it is hoped – overcome. However, domesticating the inaccessibility of endangered species in this manner enacts a certain set of relations that are, in fact, quite contested in ways that are unlikely to be overcome.

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[28] The image I have in mind here is of the canine-human "trails" at the park I go to on a near-daily basis. In the middle of the park is large, rocky hill that has a series of pathways produced over the years by humans and dogs walking together. Having not been purposefully created as trails, they are somewhat randomly positioned and are more or less amenable for traversing. Some sections have two parallel trails, while other parts of the hill have none. While some would like to close down these trails because they were not "meant to be," the trails nonetheless allow for convenient travel across the two sides of the park. Significantly here, it is quite difficult for humans to follow their dogs to sections of the hill that do not have these trails. I have, on occasion, had to help humans negotiate their way down the steep hill after having roamed off a trail.

For some in zoological communities, the inaccessibility of endangered species is something that should be addressed rather than worked around. Those scientists who focus their research agenda on the reproductive physiologies and practices of endangered species were often critical of endeavors to clone endangered animals. I would like to suggest that these critiques are in part embedded in the ways in which interspecies nuclear transfer enacts a relationship with endangered species that conflicts with others' understandings of human relations with endangered species.

Specifically, some scientists argue that what is needed is more research on the reproductive physiologies, reproductive practices, social worlds, and habitats of these species. Researchers often pointed to the lack of basic knowledge as the primary barrier to sustaining genetically diverse captive populations. For these scientists, the focus on reproductive technologies represents an elusive "quick technological fix" to far more difficult and significant problems that should be approached more "naturally" and less invasively.

> It's our obligation to find better ways to get these animals to reproduce, more naturally. . . . [We should] focus on giving the animals what they need to reproduce on their own and that could be better enclosures, better nutrition, better medical care. Find out in your fieldwork how do these animals live in the wild, what kinds of sex ratios do they have in their groups, do the male or female offspring leave the group, all of these very basic things about the natural history of the species – incorporate them to the extent possible in a new situation or a captive situation and then do the minimum that is required. I mean ultimately if you have done an excellent job of providing the animals what they need socially, nutritionally, spatially they should reproduce. If they don't, do the minimum to get them – to stimulate them to reproduce, don't do it for them.
> *Barbara Durrant, personal interview 5/16/06*

In the logics of this research agenda, the development of assisted reproductive technologies and cloning with domestic species did provide an opportunity for gathering more information about different species and species differences. But these developments were not viewed as significant for the project of producing offspring.

> [A]ll these species have these unique physiological characteristics and that itself dictates whether or not a particular technique has any relevance. So the bottom line is that for me the technology – whether we're talking about semen collection and sperm evaluation or we're talking about cloning, the value of that technology is really as a tool to understand species uniqueness, the different mechanisms among species that make them so different from one another and allow them to be reproductively successful and able to transfer their genes from generation to generation. It's not – actually, it has very little to do with the ability to produce offspring.
> *David Wildt, personal interview 7/18/06*

Related to this, research on cloning domestic animals was viewed as useful because it provides information about species that are used as models for endangered species. Here, the basic physiological knowledge that must be generated in order to develop a technology becomes useful as opposed to the technological development per se.

> I've benefited from the research that's gone into the preliminary work for cloning the dog . . . on the issue of in vitro maturation of dog's eggs, which is something that if you don't have mature dog eggs you don't get clones. . . . [T]hey were able to spend millions of dollars on that one aspect of physiology of one species which we will never be able to do in a zoo. And the dog – we have always historically used the dog as a model for endangered canids but also for felids and ursids and we have a huge bear program. We work with polar bears, sun bears, black bears, brown bears, pandas. So we work with a variety of bears and the dog is an excellent model for bear physiology. So we were able to, by learning from these people who were doing this full-time, we were able to learn in two years what would have taken us twenty years to do in our own lab. So I do recognize the spin-off benefits of this kind of technology for pets but also if we – but not – I'm not looking at "Oh, they've cloned a dog, now I can use that technology to clone a bear." I'm looking at what they can focus on in the way of basic science. So that I think can be a benefit, the basic science.
> *Barbara Durrant, personal interview 5/16/06*

Scientists here contend that, rather than working around the inaccessibility of endangered species bodies, they must go through "modern" reproduction with individual species before approaching "postmodern" reproduction (Clarke, 1995a). Adele Clarke

(1995a; 1998) has argued that solidification of a physiological approach to reproduction during the first decades of the twentieth century was demarcated by a focus on controlling reproductive processes, or what she calls "modern" reproduction. Clarke (2007) notes that the parameters of study with modern reproduction, as delineated by F.H.A. Marshall's in his seminal 1910 text *Physiology of Reproduction*, included: the breeding season, the estrus cycle, spermatogenesis, insemination, fertilization, sex organs, lactation, fertility, sex determination, and the life cycle. By 1925, reproductive endocrinology was prominently added to this list (Clarke, 1998, 2007). Many reproductive scientists I spoke with argued that these parameters should be the focus of research with under-studied species. The research program associated with modern reproduction had to be approached with individual species, which would provide a basis for "post-modern reproduction" (Clarke, 1995a) or the purposeful transformation of reproductive processes with reproductive technologies like in vitro fertilization, embryo transfer, and somatic cell nuclear transfer.

I would like to suggest that these critiques and different approaches to working with endangered species are shaped by contestations over the ontology of endangered species and human relations with these species. Developing assisted reproductive technologies across species is premised upon the idea that there are continuities across species, the same principle/logic as animal modeling. One researcher stated to me that she believed any reproductive technology can be used with any species if sufficient resources are allocated to conducting all steps required. That is, by focusing on similarities across species, working with any species will help produce knowledge about other species. John Critser stated in an interview (4/20/06): "The more we learn about the mouse, the more we learn about the pig, the more we learn about other species. . . . The underlying premise for comparative medicine is that the more we understand about the physiology, medicine of multiple species, the more we're able to help related species in terms of developing – more completely understanding of their physiology and medicine." Considering the similarities across species becomes the explicit objective, while also enhancing an appreciation of species differences.

Alternatively, some researchers make the exploration of species differences the explicit objective of their work. David Wildt demonstrates this point in the following statement on the development of the National Zoo's research philosophy:

> My big ah-hah moment that was about 1982, '83 was that a cheetah is not a cow and therefore a gorilla is not a human, a bongo is not a Holstein, and so it's incredibly naive for us to think that any of the technologies or even some of the general knowledge and techniques that have been developed for humans or livestock have much application at all to any of these wildlife species. If you think about it a minute, it makes sense because the species by definition are different.
> *David Wildt, personal interview 718/06*

By focusing on species differences, Wildt argues for a physiological research agenda that examines a variety of species. He questions whether more knowledge about select species provides a greater understanding of lesser-studied species and, relatedly, whether it informs the transposition of technical mediations across species and their infrastructures. Instead, he advocates for technical mediations that are species-specific, developed in and through basic research with that species.

> One of the most recent high-profile accomplishments that we've had out here, of course, is the production of Tai Shan, the giant panda cub. That animal was produced not using cow technology or human technology but it was from a database that we had developed over the course of about nine years working in China with our Chinese colleagues, worrying about Giant panda sperm and how to collect it, how to keep it alive, how to put it in a female at the right time, which is totally different than what you might expect for a cow.
> *David Wildt, personal interview 7/18/06*

While the National Zoo certainly uses animal models in conducting its research, it keeps endangered species as the primary objects of inquiry.

We could say that contestation over the ontology of endangered species is, here, centered on the "species" component of this terminology and revolves around the extent to which species can be conceptualized as similar or different. I do not want to overstate this difference. Those who focus on species similarities are fully aware that species differ and those who focus on species differences often employ animal models in their work and thereby acknowledge species similarities. Nonetheless, it would appear that a focus on species similarities or differences does shape both research trajectories and definitions of endangered species. There is a tendency among those who focus on species similarities to want to conserve endangered species for aesthetic and moral purposes. With this goal in mind, working around the inaccessibility of endangered species bodies so as to preserve the population body is understood as a pragmatic route to take. On the other hand, a focus on species differences is more interlinked with discussions on biodiversity and bioprospecting, in that the extinction of an endangered species represents lost knowledge about and opportunities with the diversity of life itself (see Hayden, 2003; Takacs, 1996). Working around inaccessible bodies is in part critiqued because this work does not allow for the creation of knowledge about the physiologies of understudied species, thereby *keeping* endangered species inaccessible.

CONCLUSIONS AND ONTOLOGICAL QUESTIONS: CHOREOGRAPHING RELATIONS WITH ENDANGERED WILDLIFE

This chapter has positioned transposition as a major social process through which the set of techniques involved in somatic cell nuclear transfer has traveled to zoological parks and endangered species preservation sites. This process is both embedded in and reconfigures the use of animal models in both wild and endangered species research. The temporal relations established in the animal model paradigm persist, in that techniques are first developed with domestic animals and then transposed to wild and endangered species. What is added to the animal models paradigm in the case of interspecies nuclear transfer is the embodied involvement of domestic animals along with the institutional infrastructures that have developed over centuries to support human relations with domestic animals. By bringing domestic animal bodies along into the transposition of technical mediations, it is hoped that researchers can limit and work around the inaccessible bodies of endangered animals. Contestations over such endeavors are in part reactions to the ways in which transposing technical mediations across domestic and endangered species as well as between the laboratory, the ranch and the zoological park enacts a set of contested relations with endangered animals. What is at stake here is the ontology of endangered species. What, after all that, are they? This set of questions will be taken up more fully in Chapter 5.

In exploring the micro-practices of "translation" (Callon, [1986] 1999; Latour, (1983) 1999; Law, 1999), here conceptualized as transposition, I have explicitly argued that this social process requires fairly elaborate infrastructural arrangements. Transposition can occur where there is an infrastructure that can be exploited in order to ask new kinds of questions with different kinds of subject-objects. In the case of cloning animals of endangered species, the infrastructures established by and for domesticating relations allow for the (re)constitution of "assemblages" (Deleuze & Guattari, 1987) that can do so. In other words, infrastructures are means through which established associations can be reworked to make new kinds of action possible. But traveling along the infrastructures created in and through human relations with domestic animals raises certain questions regarding the ontology of resulting cloned animals as individual beings and endangered species more generally.

In concluding I would like to return to Leon Kass's (2002) call for building a trench and fence between humans and nonhumans in matters of cloning, discussed at the outset of this chapter. For Kass along with many other bioethicists and legislators, cloning animals is unproblematic because the practice is discrete and separate from the human and the social. Reciprocally, the human is erased from endeavors in cloning animals. In this discourse, cloning poses trouble in so far as it may be used with human bodies, potentially blurring the lines between humans and animals. Contestation revolves around how to deem bodies as human or nonhuman in determining which cloning activities are ethical and unethical.

Just as Donna Haraway (D. J. Haraway, 1989; 1991b; 1997; 2003b) and Bruno Latour (1993) have shown how the nonhuman is always engaged in human affairs, this chapter has begun to show how humans are always engaged in endeavors to clone animals. Here, biomedicine, conservation and agriculture are currently enmeshed in loose assemblages around wild/endangered/domesticated species. While a trench and fence may be built by bioethics to purify humans from animals, the subway of technoscientific practices running beneath the trench and the fence are connecting humans and animals in particular ways, ways that require analytic attention. [29]

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[29] I would like to thank Joseph T. Rouse for this helpful metaphor that draws upon Latour's (1993) arguments regarding translational and purification practices in modernity.

CHAPTER 4

Producing Genomic Nodes of Value: Beyond "the Copy" in the Bio-Political Economies of Cloning

A prominent metaphor through which cloning has been rendered meaningful in popular and technical imaginations is the "copy" (J. Edwards, 1999; Hopkins, 1998; Lederer, 2002; Maienschein, 2003; Nelkin & Lindee, 1998; Nerlich et al., 1999; Petersen, 2002). As discussed in Chapter 2, Herbert John Webber first introduced the concept of cloning to describe the propagation of plants through forms of asexual reproduction, wherein genetic copies are made. As the discourse of cloning developed across the twentieth century, the idea that genetic copies produce phenotypic copies has become "reified" (D. J. Haraway, 1989; 1997).[30] Sociologists have argued that the notion of the clone as an exact replication of an original reveals the extent to which DNA is conceptualized as the basis for and essence of "life itself" and personhood in many of the cultural landscapes of the United States (J. Edwards, 1999; Hartouni, 1997; Nelkin & Lindee, 1998; Priest, 2001). Dorothy Nelkin (1998: 145) has argued: "Underlying the fascination with cloning is the idea that human beings in all their complexity are simply readouts of a powerful molecular text."

The idea that genomic copies result in phenotypic copies is an ever-present facet of the visual cultures surrounding cloning to date. Here it is assumed that somatic cell nuclear transfer operates at the level of reproducing the totality of phenotypic traits exhibited in and by a given individual. The cover of Francis Fukuyama's *Our Posthuman Future* (2002) provides one exemplar depicting hundreds of identical, white, male babies. Each infant sits up in the exact same pose, starring straight at the viewer. All the infants are neatly organized

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[30] Science studies scholars use the notion of reification to delineate the ways in which cultural values come to be seen as natural through scientific work and representation (Hess, 1997: 114-15).

in consecutive rows that extend well beyond our field of vision in all directions. We, the viewers, recognize this effect as having been created by digitally reproducing a single image of one infant and linking these images together.[31] What the cover hopes to convey, in this case to elicit fear and concern, is the possible collapse of sexual reproduction into "mechanical reproduction" (Benjamin, 1968) and "life" into a materiality that can be transformed into an ever replicable commodity.

This cloning discourse has worked to bring certain political economic fears to the forefront in frequent speculations regarding the consequences of this technique. Specifically, the idea is that certain human individuals who exhibit physical and other traits considered desirable will be mass-produced and commodified. This process is often imagined as linked with a fascist, state regime through references to the novel *Brave New World* (Huxley, 1950). The concern is that existing social orders and hierarchies will be reproduced technologically and physiologically as humans become commodified objects. For example, sociologists Steven Best and Douglas Kellner (2002: 455) argue: "A strong objection against human cloning and genetic engineering technologies is that they could be combined to design and mass reproduce desirable traits, bringing about a society organized around rigid social hierarchies and genetic discrimination – as vividly portrayed in the film Gattaca (1997)."

It should be pointed out again, however, that the products of somatic cell nuclear transfer are not necessarily genetic "copies" per se in the technical sense of the word (Franklin, 1999b), nor are they necessarily phenotypic copies. While the DNA from the nucleus of one individual is replicated, the egg cell donor also contributes mitochondrial

[31] See also Sarah Franklin's book *Dolly Mixtures* (1997) on the ways digital reproduction of images is necessary to see animals produced by way of somatic cell nuclear transfer as "clones" or "copies".

DNA.[32] In fact, some have even questioned whether or not somatic cell nuclear transfer counts as a technique that can be bundled into/subsequent with the category of "cloning" (Franklin, 1999b).

In this chapter, I explore how the limitations of the copy metaphor for technically understanding somatic cell nuclear transfer are coupled with limitations for social analyses of the processes, products and sites of value in many cloning projects to date. I reinterpret the political economies of somatic cell nuclear transfer in making this argument. A number of scholars examining the life sciences generally and the biotechnology industry in particular have argued that value is here produced by domesticating, altering and reformulating biological materials and processes (Clarke, 2007; Clarke et al., 2003; Franklin, 1997; Novas & Rose, 2000; Rabinow, 1996b; Rose, 2007; Sunder Rajan, 2006; C. Thompson, 2005; Waldby, 2002; Waldby & Mitchell, 2006; Yoxen, 1984). I explore how value is produced by way of somatic cell nuclear transfer through the reworking of bodies and biological processes, drawing upon Catherine Waldby's (2000; 2002; 2006) notion of "biovalue."

Waldby's usage of the concept biovalue refers to the ways in which bodies, bodily fragments and biological processes are reformulated to produce surplus "yields of vitality." In the case of cloning endangered wildlife, biovalue is produced when bodily fragments are brought together in new ways through technoscientific means. One goal is to enhance the population bodies of endangered species. The new, individual, biotechnological bodies produced through somatic cell nuclear transfer and related techniques are then placed in productive relations with other bodies using extant kinship charts and studbooks to produce,

[32] This point will become abundantly clear in the next chapter, which discusses how problematic the genetic contribution of the egg cell is in attempts to define the species and human-animal relations of cloned endangered wildlife.

what I call, *genomic nodes of value*. Genomic nodes of value produced through somatic cell nuclear transfer and other assisted reproductive technologies are quite different from "copies" and entail different kinds of political economic heritages, legacies, and productivities.

Drawing on Waldby's notion of biovalue, I position the political economies of cloning endangered wildlife in the processes through which bodily parts are exchanged. Somatic cell nuclear transfer is viewed as one reproductive technique among others that may allow zoological parks to bring in new genomic "individuals" in the form of somatic cells and gamete cells rather than as fully formed individual organisms. The goal here is to "remediate" (Harrington et al., Forthcoming) or correct faulty colonial relations based on consumptive practices that contributed to the endangerment of many species. That is, to maintain their animal populations both in situ and ex situ, zoos today try to pursue non-consumptive practices in previously colonized territories by pursuing other means of reproduction. Not surprisingly, this assemblage of logics, techniques, humans and nonhumans that seeks to reckon with the political economic legacies of colonialism in particular kinds of ways is deeply contested. I address these contestations by following Charis Thompson's (2005: 255-258) argument that it is bodily parts, rather than labor, that are at systematic risk of being alienated in the "biomedical mode of reproduction." More specifically, she contends that alienation in this instance does not center around commodification but rather around custody disputes.

Across this chapter, I show that somatic cell nuclear transfer is one of many techniques used to pursue certain logics of reproduction that generate value. In doing so, I contend that the consequences of cloning cannot be understood in isolation, but rather must be theorized vis-à-vis the broader of reproductive logics, practices, relations and bodies with and through which this technique is always assembled and situated. In the case of cloning endangered animals, somatic cell nuclear transfer is bundled together with a range of other technologies (e.g., artificial insemination, in vitro fertilization, embryo transfer, cryopreservation, kinship charts and studbooks), reproductive logics (e.g., natural selection, selective breeding, and disaggregating bodies and reproductive processes), discursive practices (e.g., in situ and ex situ species preservation, endangered species), and political economies (e.g., colonialism, imperialism, biovalue, and biocapital) in a loose assemblage. The concept of assemblage is key here. George E. Marcus and Erkan Saka (2006: 102) define assemblage as a conceptual resource "to address in analysis and writing the modernist problem of the heterogeneous within the ephemeral, while preserving some concept of the structural so embedded in the enterprise of social science research." It is precisely the looseness and ad-hoc-ness of this organizational metaphor that makes it particularly useful for understanding emergent phenomenon.

I argue that it is these assemblages that require analytic attention, rather than a single technique in isolation, precisely because in practice the techniques are used/performed in such assemblages. For example, by tracing how cloning is assembled as conservation, we see that under the veil of the copy discourse, somatic cell nuclear transfer is more quietly being used to produce genomic nodes of value. By examining the elements of the assemblages of cloning, then, we see not only the "roots" of somatic cell nuclear transfer as a technological capacity but also its "biosocialities" (Rabinow, 1996a) and biovalues, past, present, and implied futures.

I begin this chapter by problematizing the copy metaphor in cloning discourses by distinguishing projects that use somatic cell nuclear transfer according to a) the level at which such projects work (e.g., phenotypic versus molecular) and b) the ways in which cloned animals become valuable (e.g., as copies versus as genomic nodes of value). Drawing on this distinction, made by briefly comparing projects in cloning transgenic animals, livestock and companion animals, I then trace how somatic cell nuclear transfer operates at the molecular level in projects with endangered wildlife so as to produce genomic nodes of value. The concept of genomic nodes of value denotes the bringing together of "biovalue" with kinship charts and studbooks that, in the case of endangered species preservation, seek to enhance the "population body" (Foucault, 1978). I elaborate upon what this type of valuation means and how it both connects up with and diverges from selective breeding practices historically. Using Waldby's notion of biovalue, I conclude by considering how somatic cell nuclear transfer is one technique being utilized in a larger attempt to re-embody "founders"[33] in zoological parks, a project that is both an outcome of and contested within the legacies of colonialism.

(RE)PRODUCING CLONING LOGICS & DISCOURSES

In this section, I lay out the different logics that have been coupled with the practice of somatic cell nuclear transfer by comparing the use of this technique in biopharming transgenic animals, farming agricultural livestock, and reproducing companion animals. I distinguish these logics along two different axes of comparison. First, I compare and contrast projects that use somatic cell nuclear transfer at the molecular versus the phenotypic level.

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[33] Founders refer to individuals who do not have kin relations within the captive population, which by default generally means an animal captured from the wild and brought into a zoological park.

Second, I compare how somatic cell nuclear transfer is used to produce "copies" with those projects that use this technique to produce "genomic nodes of value."

Produce copies	Work at the phenotypic level
Produce genomic nodes of value	Work at the molecular level

Through these comparisons, I show the limits of the copy metaphor for understanding the range of projects that utilize somatic cell nuclear transfer in order to produce biovalue. In doing so, I introduce the notion that somatic cell nuclear transfer is at times coupled with kinship charts and studbooks to produce "genomic nodes of value." This provides an introduction to my discussion of how somatic cell nuclear transfer is used to clone endangered animals by working at the molecular level in a manner that produces genomic nodes that garner value by virtue of being able to transform the population body.

Cloning in the Pharmaceutical Industry

Dolly the Sheep was developed as "prototype" (Lash, 2001) for a new mode of reproducing transgenic animals, or animals who have DNA from two different species, and was situated in a particular intersection between agribusiness and the pharmaceutical industry (Franklin, 2007). Scott Lash (2001) has pointed out that if mechanical reproduction was premised upon making copies, as Walter Benjamin (1968) so famously described, creating new technological forms of life is premised upon making prototypes. PPL Therapeutics was a leading company in the endeavor to transpose human genes into sheep to enable the sheep to produce peptides that can be used for human pharmaceuticals. PPL merged with the Roslin Institute to conduct the research on nuclear transfer that resulted in the birth of Dolly

(Franklin, 1997). Their goal was specifically to standardize the reproduction of transgenic sheep that produce milk with human genes that can be harvested to create therapeutics for cystic fibrosis sufferers (Franklin, 1997, 2003).

Dolly was viewed as a copy in popular discourses, but she was also a prototype for making highly lucrative therapeutics. Specifically, this sheep was part of a research endeavor that sought to reproduce the exact genome of sheep that act as "bioreactors," or living makers of pharmaceutical properties. In order to maintain the human gene across generations of sheep, alternatives modes of reproduction were deemed necessary. Genetic mixtures produced in standard sexual reproduction simply would not work (Franklin, 1999a, 2003). After Dolly was born, a mammary gland cell was taken from a transgenic sheep to give birth to the clone Polly, the first birth of a cloned "bioreactor" that PPL Therapeutics had sought to produce.

At present, transgenic animals represent the most cost-effective means to produce peptides essential for certain pharmaceuticals (Michael West, personal communication 7/18/06). Synthetic peptides remain extremely expensive to manufacture, which limits the extent to which resulting pharmaceuticals can be produced and distributed. As such, transgenic animals represent an important site of convergence between the newer biotechnology industry (based on life sciences) and the more longstanding pharmaceutical industry (based on chemistry).[34] Somatic cell nuclear transfer was developed in order *to copy a particular genomic configuration* that allows for the production of biotechnological peptides. In other words, the goal was to copy a *genomic* configuration rather than particular

[34] For a discussion of the differences between and connections among the pharmaceutical and biotechnology industries, see Kaushik Sunder Rajan (2006: 21-27).

phenotypic traits. This, as I will show later, represents a significant shift in the logics of selective breeding.

Cloning in the Agricultural Industries

Somatic cell nuclear transfer was almost immediately viewed as having implications for (re)producing livestock in the agricultural industry. As discussed in Chapter Two, research into nuclear transfer was well underway in the agricultural industry by the time of Dolly's birth. Those working with livestock are centrally concerned with the reproduction and concentration of certain phenotypic traits. This follows long-standing practices associated with selective breeding. It is generally assumed that somatic cell nuclear transfer is here used to make many "copies" of animals that possess particular characteristics. Philip Damiani (personal communication, 7/1/05) described this logic to me as follows: "So for instance if they had a cow that might be, say for instance a Holstein cow that produces a lot of milk, the idea was to clone that animal so that the producer would potentially have a small, elite herd of identical animals." Here we see the logic of the copy combined with the reproduction of traits at the phenotypic level that instantiates the predominant historical and contemporary discourse of cloning.

However, there are cases in agricultural research and practices wherein somatic cell nuclear transfer is used to produce value by working at the phenotypic level but in a manner wherein genomic nodes of value are produced. For instance, one researcher told me how cloning was envisioned as a means to reproduce cattle with the highest-grade carcass score. At this point in time, carcass scores cannot be determined before death, making it impossible to selectively breed those select individuals who end up having the highest carcass score. Here, somatic cell nuclear transfer becomes a tool through which carcass score could be rationalized as a selected trait. That is, a skin cell can be taken from the slaughtered cow after death and after the assessment of a high carcass score and then used with somatic cell nuclear transfer to create another individual of the same genetic composition. Resulting cloned bulls would likely serve downstream as studs in selective breeding protocols. Kenneth White (personal communication 4/28/06) described this to me as follows:

> [With] livestock species, there are some very specific applications where it [somatic cell nuclear transfer] is extremely useful as a technology. For example, carcasses are graded and they get a carcass score. . . . I won't get into the particulars of this, but suffice it to say that there's extremely – the best carcass quality is extremely, extremely rare. And unfortunately we don't have the technology to be able to – even after years and years of work – there's no effective way currently to be able to predict, looking at a live animal, how its carcass is going to grade out. The animal has to be sacrificed and it takes about 48 hours after the animal has been sacrificed before the carcass can be effectively graded. And so nuclear transfer's a valuable tool in this case, when you have one of these really, the highest grade carcass. Probably less than a half a percent, if not even rarer, of all the carcasses killed in one-year grade out at this highest quality. So you can take a sample from a carcass, take the cells back to the lab and you can get cells to grow and then you can use those as nuclear donor cells and produce offspring that have the genetic potential to produce that type of a carcass.

Here we see how somatic cell nuclear transfer potentially allows for a carcass score to become a selectively bred for trait. Cells and cloned animals here become genomic nodes of value in the selective breeding protocols of livestock that aim to create more individuals with high quality carcasses in the global meat industry.

This raises an important question: is carcass score an inherited trait that is determined by one's genetic configuration? In response, I asked Dr. White what was known about the correlation between genomic inheritance and carcass score. He responded:

> Right. In some of that data – we're currently collecting it, but we already know – heritability estimates on carcass traits, some of those are calculated to be 60%. Some of the animals that we've already produced and are starting to monitor have very similar growth rates with the animals that the cell line was originally derived from, their donor. And we're also looking at milk

> production. Animals that have exceptional milk production are animals that we're cloning. And so we're trying to collect those milk records to see how in fact they compare to the original donor animal. Now we also recognize that in some of these production traits the environment is also going to play a very important role in how the animal performs, but we're still – everybody's still collecting data and we don't know for sure but some of the preliminary stuff is pretty good.

White is clearly hopeful that genetic inheritance significantly contributes to carcass scores. However, White also points out that carcass scores and milk production are traits not solely determined by an individual's genetic configuration. As such, a significant portion of the research on somatic cell nuclear transfer in the agricultural industry seeks to understand the extent to which genetic inheritance contributes to the constitution of highly desired and deeply capitalized animal traits. Techniques like cloning gain their valence by increasing the *probability* of reproducing animals whose carcass will grade out at the highest quality indicator.

Cloning companion animals

Cherished pets and winning racing animals have also become the subjects of cloning experiments (Vanderwall et al., 2006; Westhusin et al., 2000). Drawing on the ways in which somatic cell nuclear transfer was being used to reproduce the exact genome of livestock with desired traits in the agricultural industry, the technique has been taken up in the companion animal arena according to a similar reproductive logic. The reproductive logic pursued here is that cherished and/or valuable individuals in all their glory of exact embodiments can be replicated by reproducing their exact genome. These practices, probably more than any other cloning endeavor, follow the discourse of cloning as copying in the use of somatic cell nuclear transfer. As such, these practices in many ways presume

Dorothy Nelkin's (1998) argument that the fascination with cloning is embedded in the presumptions of genetic determinism.

However, these endeavors have also faced some serious impediments. On the one hand, the complex relationships between genetic inheritance, development, and phenotypic expression have led to some rather disappointing results. For instance, the first cloned mule was created using somatic cells from the champion racing mule Taz. The goal of this cloning experiment was to use somatic cell nuclear transfer as a mode of reproducing prized mules that run fast, win races and thereby garner many financial rewards. The birth of Taz's clone Idaho Gem was significant. However, for somatic cell nuclear transfer to be feasible in this context, Idaho Gem also had to run fast and win. At his first major professional race, the cloned mule came in a disappointing seventh place (Gormon, 2006).

Another example of how the copy metaphor becomes problematic in projects that use somatic cell nuclear transfer can be seen in the results of the first successful project in cloning a domestic cat. The cloned cat CC (short for carbon copy) did not have the same coloration as the somatic cell donor and thereby looked rather different from the "original" cloned. This is because coloring is not determined by genetic inheritance among domestic cats (Winstead, 2002). Presumably, pet fanciers who wanted their beloved cat to be replicated using somatic cell nuclear transfer would be disappointed if the "carbon copy" did not look at all like the original.[35]

REPRODUCTION AND THE (RE)MAKING OF ZOO POPULATIONS

[35] The (in)famous company Genetic Savings & Clone was a pet cloning company whose business plan was premised upon replicating beloved pets after their death. The company has since gone out of business.

I will now turn to how somatic cell nuclear transfer has been rationalized in the practices of endangered species preservation. In this situation, the reproductive logic underlying selective breeding practices already focuses on the molecular/genomic rather than phenotypic level through the Species Survival Plans (SSPs). SSPs "genetically manage" the small, captive populations of endangered species across U.S. zoological parks using selective breeding techniques ranging from kinship charts to assisted reproductive technologies. The goal is to maximize the genetic diversity of the population so as to sustain zoological park populations in a manner that does not further endanger in situ populations. This reproductive logic sets the stage for the ways in which somatic cell nuclear transfer represents a possible means through which genomic nodes of value can be created in the kinship charts, which gain value by virtue of their ability to diversify the genetic composition of the population. In other words, "biovalue" (Waldby, 2000; 2002) is produced here by reorganizing biological fragments to create "yields of vitality" that, when positioned in the kinship charts and studbooks, act as genomic nodes generating valuable biodiversity.

Incorporating somatic cell nuclear transfer into genetic management protocols of zoos

As discussed in Chapter Two, to date most projects in cloning endangered animals have been feasibility studies. Here, the goal is to find out if and how it is possible to use somatic cell nuclear transfer with an endangered species. The guiding assumption that undergirds this approach is that these tools need to be developed first before they can be properly linked up with a reproductive logic. As a result, the selection of nuclei donors has been conducted opportunistically, according to availability. However, these projects have been critiqued for both the absence of a reproductive logic and for implicitly assuming a demographic logic vis-à-vis endangered animal reproduction, an approach that has fallen out of favor (as discussed in Chapter Two).

In the project to clone the banteng, however, the decision was made to use fibroblast cells from a banteng who had died in the 1970s before reproducing. This strategic decision was made in order to link somatic cell nuclear transfer up with a logic and corresponding apparatus for reproducing endangered wildlife. The banteng from whom this cell was obtained was considered "genetically valuable" because he did not have extensive kin relations within the captive population and thereby was not genetically well represented (or over-represented). By reincorporating the genome of this banteng into the breeding population, the San Diego Zoological Society hoped to use somatic cell nuclear transfer in a manner that would diversify the captive population to the greatest extent possible without adding new bantengs captured from the wild. This project thus links up with the reproductive logics operating at the molecular/genetic level, as seen in the transgenic animal projects discussed above, and produce value by way of genomic nodes rather than copies. As such, the resulting cloned banteng represents the embodiment of a genomic node of value in the (re)production systems of biodiversity in zoological parks.

The cloned banteng was the outcome of a reproductive decision-making model that Oliver Ryder, Division Head/Senior Scientist of the Genetics Division at the San Diego Zoological Society's Conservation and Research for Endangered Species (CRES), created in the context of organizational questions regarding the potential utility of somatic cell nuclear transfer for conservation. Ryder created a Venn diagram made up of three necessary conditions under which this technique could be beneficial for captive breeding practices (Oliver Ryder, personal communication 7/20/05). The first condition is available technology, which Ryder defined broadly to include knowledge of the reproductive biology of the particular species in question, the availability of surrogate ova, the availability of appropriate gestational surrogates, knowledge of neo-natal husbandry requirements, and the ability of zoo staff to interact with off-spring who need to be hand-reared. The second condition is the existence of a gene pool management program for the species, specifically a Species Survival Plan for management of captive breeding. The cloned individual should provide the greatest possible genetic diversity within the specifications of SSP protocols. The third condition is the availability of saved fibroblast cells from a "genetically valuable" endangered animal. The San Diego Zoo has specialized in preserving cells since the 1970s through its Frozen Zoo™. Here, Ryder linked somatic cell nuclear transfer up with the now predominant reproductive logic of creating genetic diversity in zoological parks. The goal was to create previously impossible animals whose "promissory" (C. Thompson, 2005: 258-60) reproduction would productively contribute to the species' genomically configured body.[36] I next situate this rationale for the use of somatic cell nuclear transfer to create genomic nodes of value with endangered wildlife in the breeding practices and predicaments of zoological parks.

Breeding in the zoo

Over the past twenty years, zoos in the United States and beyond have become deeply invested in making the reproduction of captive animals more efficient. Breeding zoo animals has long been a curiosity (Anderson, 1998b). However, this interest turned into a necessity for zoological parks as nations began to restrict the importation and exportation of wild

[36] Charis Thompson (2005: 258-260) argues that in the biomedical mode of reproduction, reproduction is capitalized according to its promissory capacity for the future rather than accumulated in the present.

animals, many of which were rapidly becoming classified as endangered species (Hanson, 2002). As it became more and more difficult to sustain zoological parks by capturing wild animals, these institutions came to focus on sustaining captive populations through selective breeding rather than importing animals from "the wild".

Beginning in the early 1980s, zoological parks began to share the goal of creating "self-sustaining" (Benirschke, 1986) ex situ animal populations, whose maintenance would not require capturing wild animals. The idea was that eventually these populations could even serve as a resource for in situ, endangered populations. A field conservationist described this move among zoological parks to me as follows (4/25/06):

> I think the zoos at this point had realized they did have a very fundamental role to play [in species preservation] . . . believing that they needed to establish self-sustaining populations which were genetically diverse. They were not dependent on the wild, they weren't drawing genetic material from the wild, and they weren't drawing down the wild population. But ultimately somewhere down the line they would actually contribute by putting animals back into the wild. And I think there's some very good examples where that's worked.

Breeding endangered animals has become one of the primary justifications for zoological parks as institutions. Through captivity, endangered animals can be managed in ways that simply are not possible with animals in in situ settings.

Yet, captive breeding has long been difficult with many species found in zoological parks (Hanson, 2002). These difficulties are well known, in large part due to the problems associated with reproducing the highly charismatic giant panda in captive settings. In response, breeding practices among zoological parks have historically not been conducted purposefully but rather opportunistically. That is, if two individuals would breed, this success would often prompt many successive attempts. This strategy has now resulted in highly in-bred captive populations and "genetic bottlenecks". Oliver Ryder remarked in an interview (7/20/05): “A lot of people at zoos will tout that they got two animals to have 32 offspring. But from a population genetics point of view, this has led to the problem of bottlenecks in zoo animal populations.”

Once a captive population becomes bottlenecked, zoological parks once again need to capture wild animals in order to sustain the captive population. Many people working in zoos view this as a last resort and highly undesirable practice. Keeping animals of endangered species in habitats supports structures that preserve those ecosystems, which links up with the focus on biodiversity in conservation discourses and practices today. By taking animals of out these habitats, the conservation value of zoological parks is deeply questioned. In response to the problems associated with genetic bottlenecks that resulted from demographic approaches to breeding zoo animals, parks increasingly began to focus on producing genetic diversity in small populations through highly selective breeding practices.

To help achieve self-sustaining populations, the American Zoo and Aquarium Association developed Species Survival Plans (SSPs) to breed individuals in the captive population more strategically. The goal of SSPs is to produce as much genetic diversity within captive zoo populations as is possible rather than create as many offspring as possible. Bill Swanson, SSP coordinator for the fishing cat, described this facet of breeding zoo animals to me as follows (personal communication, 4/8/06):

> One thing we can do in zoos is we can manage these animals more intensively. So it’s not a randomly breeding population. It’s not a matter of who runs into who, whose genes get passed on and whose don’t. We control that. We basically say this male needs to breed with this female because their genes are not very well represented in the population. And we can intensely manage them if we know enough about normal reproduction to get the right animals to breed and breed as frequently as we need them to.

Here we see how the small size of zoo populations requires that reproduction be highly managed to ensure that the "right" genetic combinations are purposefully made, rather than randomly generated as seen in natural selection.

Studbooks and kinship charts are the primary technologies used by Species Survival Plans to determine which animals should breed and which should not in order to maximize the genetic diversity of the captive population. Sharon Joseph, studbook keeper and SSP coordinator for the banteng, described her role in selective breeding to me as follows (personal communication, 10/18/05):

> When you're the studbook keeper, you keep the pedigree, the historical pedigree of all the animals that we know about that have ever existed in the captive population. There's some real slick software that you can use to establish things like the diversity within the population, mean kinship. You use these mean kinship values to help you set up the best pairings, or the pairings that will ideally help you preserve the most amount of gene diversity that you can possibly preserve.

As such, Species Survival Plans use the tools developed for selective breeding in agriculture, but towards different ends. Whereas studbooks are used to in-breed livestock, companion animals, and laboratory animals, SSPs use this recordkeeping tool to ensure that zoo animals are *not* in-bred. As one speaker at the 2006 Felid Taxonomic Advisory Group meeting remarked, "I often have to remind people that purebreds are all the sick, deformed, and unproductive animals we want to get *out* of our zoo populations." Using techniques developed to in-breed animals with certain traits, zoological parks seek to out-breed animals to create genetic diversity. Here, "better" breeding strategies associated with eugenics are now applied to zoo animals.

Taking up tools developed in agriculture: Studbooks, kinship charts, and "genetic value" in agriculture and the zoo

How did agricultural breeding practices "travel" to zoological parks? To answer this classic science and technology studies question, I explore the development of studbooks with domestic animals ultimately to compare the techniques and logics moving between different human-animal relations. There is a substantial body of historical, sociological and anthropological analysis of selective breeding of domestic animals as livestock, companion animals and laboratory animals (Derry, 2003; Franklin, 1997; D. J. Haraway, 2003a; Orland, 2003; Rader, 2004; Ritvo, 1987, 1995; Schrepfer & Scranton, 2004). This vast literature is too broad to review in full here. I want to specifically focus on the ways in which selective breeding has been considered vis-à-vis the production of often capital-intense forms of "value". I will focus on the logics and practices of selective breeding in agriculture, providing a basis for comparison to the selective breeding of endangered and zoo animals.

The selective breeding of plants and animals is one of the key arenas where there has been sustained interest in producing capital-intensive bodies by exploiting biogenetic relations. British agriculturalist Robert Bakewell (1725-95) is most famously known for his role in elaborating a new system in the eighteenth century for valuing animals based upon their biological lineage. Historian Harriet Ritvo (1995) has analyzed his breeding practices, arguing that Bakewell was able to create "genetic capital" by transferring the value of an animal from the location and environment in which the animal dwells to the biogenetic genealogy from which the animal came (see also Orland, 2003). Agriculturalists of Bakewell's time generally located the agricultural value of animals in the health and size of their herd or flock. Bakewell instead looked to the reproductive potential of individual organisms that displayed exceptional and highly desired traits as the source of value. Historian Fernand Braudel has argued that this kind of selective breeding was a precondition for industrialization in England (in Franklin, 1997: 431). Sarah Franklin (1997: 431) has called this kind of selective breeding the "industrialization of reproduction", a process that I will further specify as industrializing the mechanisms of inheritance.[37]

The logics and practices that informed Bakewell's production of value through selective breeding are important here. Bakewell innovatively capitalized on the reproductive potential of prized male sheep, loaning out such individuals for a breeding season in exchange for a stud fee. Purchasers bought the reproductive potential of such individuals and its transformative powers for an agriculturalists' herd. Ritvo (1995: 417) states:

> Bakewell claimed that when he sold one of his carefully bred animals, or, as in the case of stud fees, when he sold the procreative powers of one of these animals, he was selling something much more specific, more predictable, and more efficacious than mere reproduction. In effect, he was selling a template for the continued production of animals of a special type; that is, the distinction of his rams consisted not only in their constellation of personal virtues, but in their ability to pass this constellation down their family line. . . . Thus it was possible for a disciple like George Culley of Durham to transform his own flocks by hiring a ram from Bakewell each year.

As such, Bakewell created a system of value that was based on the inheritance of traits, thereby producing a kind of reliability in reproduction (Ritvo, 1995: 415-16). Through this kind of specification, agriculturalists could have a flock that *looked* quite different well within the agriculturalists' lifetime.

By selecting particular rams, Bakewell was commodifying not only a prized individual but also the genealogical potential of that individual and the continuance of that

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[37] Adele Clarke (2007) also uses the concept "industrialization of reproduction", but to refer to control over reproduction *processes* as opposed to the mechanisms of inheritance. These processes through which Clarke defines reproduction as being industrialized include: rationalization, standardization, efficiency, planning, specialization, professionalization, commodity development, commodity promotion and distribution, technological development, and profitability. SSPs can be viewed as an instantiation of the industrialization of reproduction processes. See also Clarke (1995a).

lineage into the future (Ritvo, 1995: 415). Record-keeping practices, specifically studbooks, had to be produced in order to demonstrate this valuation system. As Ritvo (1995: 419) points out, these records were hard to come by, and quite possibly were unimaginable in the eighteenth century when individuals within herds were understood as interchangeable parts. As such, Ritvo argues that the creation of studbooks had to *follow* the practice of selective breeding, but this practice was also simultaneously constitutive of breeds. Studbooks thus organize agricultural industrialization via standardization and record keeping, parallel to actuarial risk reduction in the insurance industry.

Bakewell was uncertain of the mechanisms through which traits were passed down through the generations. After all, the mechanisms of inheritance were no better understood by Charles Darwin almost a century later, when he developed his theory of evolution in the *Origin of Species* ([1859] 1996). And, as noted, the mechanisms of inheritance remain uncertain today. Nonetheless, the genetic sciences are generally held as confirmation of Bakewell's practices in selective breeding. However, it is important to point out that the objectives of selective breeding (alongside evolutionary work on the corollary notion of natural selection more generally) are quite different from genetics. In regards to evolutionary theory, feminist theorist Elizabeth Grosz (2004) contends that, whereas genetics explore the *mechanisms* of inheritance, both breeders and evolutionary theorists are more concerned with the *effects* that inheritance has.

In selectively breeding animals for their genomic difference, Species Survival Plans can be understood as an instantiation in the move to industrialize the mechanisms of inheritance. However, selective breeding for *genomic difference* is, at the same time, a radical departure from the logics seen in both the natural selection of Darwinian evolution and artificial selection. SSPs focus on reproducing animals that embody certain *genetic information*, which is symbolized through kinship charts. In sharp contrast, selective breeding has traditionally focused on reproducing the desired *physical traits* of certain individuals, symbolized through their lineage. In her feminist consideration of temporality through the works of Darwin, Nietzsche and Bergson, Elizabeth Grosz (2004: 48) states that:

> Natural selection functions only at the level of phenotype. Mayr argues that natural selection never functions on the level of genes, particularly never on the level of individual genes; rather, it operates only on the phenotype, whose characteristics are always structured by clusters or combinations of genes that function only in relation to environmental factors, as Oyama (2000b) affirms. . . . If artificial selection – selection according to the criteria provided by human breeders of flora and fauna – functions to select characteristics that are visible and manifest, natural selection functions according to the usefulness, that is, the functional benefit, of phenotypic variations in all organs and functions.

As such, we see in the SSPs a shift in selective breeding from a focus on the phenotype to the genotype.

The mechanisms of inheritance are here being industrialized using the same set of general techniques across varying human-animal relations, but for different ends. By industrializing reproduction to reproduce genomes rather than physical traits in the case of Species Survival Plans, we see evolution and genetics become more intricately entwined. The focus is no longer on producing certain types of animals that exhibit certain phenotypic traits, but rather on producing certain kinds of genomic configurations. This is a new direction and a form of managing evolution and has important implications, discussed next.

THE TROUBLE WITH SMALL POPULATIONS: ALTERNATIVE EMBODIMENTS OF FOUNDERS

Somatic cell nuclear transfer and other assisted reproductive technologies have now become enmeshed in the studbooks and kinship charts used with endangered species in the

SSPs to solve problems associated with small populations and with the difficulty in trafficking wild and endangered animals. By bringing somatic cell nuclear transfer together with a reproductive logic that operates at the molecular/genetic level, facilitated by the use of studbooks and kinship charts, somatic cell nuclear transfer is used to produce genomic nodes of value. To recap a bit, SSPs have taken up the technologies of studbooks and kinships charts developed with domestic animals and have applied these techniques with endangered species. These technologies have been vital to the goal of linking genetically diverse captive populations with in situ populations for the purpose of creating multi-faceted (and at time multi-sited) approaches to conserving endangered species and their habitats. If the reproduction of individuals in captive populations is carefully managed, the idea is that the zoological park can reproduce itself without having to take animals from in situ sites. Captive populations can in turn provide individuals who can be reintroduced into native habitats on an as needed basis. Here we see one identity of the zoological park in the process of being reversed. Rather than being a site where wild animals are collected and brought together in captivity, captive animals of endangered species are reproduced in order to maintain wild populations.

This is in many ways an idealized goal for zoological parks. In reality, it is very difficult to sustain a genetically diverse population with the necessarily small number of individuals zoological parks can house. This point is made clear in the following statement made by Bill Swanson (personal communication, 4/8/06), SSP coordinator and Taxonomic Advisory Group Co-Chair for endangered felids.

> And with the small cats that we work with, you know we've got 25 black-footed cats. You've got maybe 120 ocelots, so it's kind of a range, but it's still a very small population. Especially when you compare it to what you would consider a genetically viable population in the wild. You talk to

> people, and maybe the lower estimate is 500 animals, but the reality is you probably need two or three thousand animals in an interbreeding population, in a big geographic area, to keep them genetically viable over the next 100 years. Well, we don't have that in zoos. We've got this tiny population, you know, maybe 100 animals.

Even with the highly managed breeding protocols instituted by SSPs and with the technologies of kinship charts and studbooks, it remains difficult for zoological parks to sustain genetic diversity across many generations. Bill Swanson continued:

> But even being able to do [managed breeding], we loose genetic variation over time. And it's mainly because of genetic drift. And that basically means that every time these animals reproduce they only pass on half of their genetic component to their offspring. If you've got a big population that averages out over time. If you've got a very small population and maybe some of those animals are not reproducing and some of those are, you loose that genetic variation over 10, 20 generations. Every time these animals breed, every time you get a new generation, you're loosing genetic variation. No matter how intensively you manage this population, you can't stop that if you've got a small population, a closed population. Now the way to fix that is to have 3000 animals or have 500 animals, but we can't do that in the zoos. I can't. I have a hard time finding 100 spaces. . . . The other way is introducing new founders. And the way we've done that traditionally is we've gone out to catch wild cats and we bring them into the zoo. We don't like doing that. But we need founders. So you have to have some sort of gene flow into the captive population.
> *Bill Swanson, personal communication, 4/8/06*

What Swanson points out here is that, even with highly managed breeding protocols, genetic diversity is lost across the generations within a set population. The only way zoological parks can sustain genetically diverse populations is to bring in "outside" genetic information in the form of founders. However, there are other means of obtaining founders to add to captive zoological park populations than securing them from the wild.

The ability to rework bodies and biological processes, a process I have been referring to with the concept of producing "biovalue" (Waldby, 2000; 2002), allows outside genetic information to potentially come into captive zoo populations without capturing and transporting fully formed animals from the wild. In other words, reformulating bodies and biological processes allows for the production of alternative embodiments of founders.

In this section, I examine how the potential to alternatively embody founders in zoo populations is part of a logic based on saving time and saving space. I show how nuclear transfer is being configured as a potential technology of transportation across previously impermeable temporal, spatial, and territorial divides. Kaushik Sunder Rajan (2006: 42) points out that genetics as information "can travel globally, in circuits of exchange tied to, yet independent of, the (in the case of biocapital) living material (often DNA, protein, cell, or tissue) that the information comes from or relates to."[38] It is this move to separate living material and genetic information in certain instances that allows for the production of "biovalue." Here I trace how somatic cell nuclear transfer refashions the temporalities and spatialities of both both endangered individual and population bodies.

Re-synchronizing the temporalities and spatialities of populations

In an article published two months after the announcement of Dolly the Sheep's birth, Oliver Ryder and Kurt Benirschke (1997) speculated that somatic cell nuclear transfer represented a potentially promising technique for long-term conservation practices. Specifically, Ryder and Benirschke argued that nuclear transfer represented a possible future wherein the genetic diversity of a population would not only be considered vis-à-vis embodied animals but also vis-à-vis the collections of cells containing DNA suspended through cryopreservation (e.g., frozen zoos). Endangered species populations could be made up of both embodied individuals whose genetic information is materialized in embodied form

[38] For social science analyses of the issues related to the separation of and continuities between living material and information in the life sciences, see also Paul Rabinow (1996b), Hannah Landecker (1999), and Donna Haraway (1997)

and skin cells wherein genetic information is suspended in a liminal state. *In other words, Ryder and Benirschke offer the possibility that DNA embodied in cryopreserved fibroblast cells, which take up considerably less space than a living animal, could be considered a protoanimal in the specific context of biopolitical apparatuses that assess and produce the total genomic diversity of a captive population.*[39] Living animals *and* suspended genomic information could be rationalized in such a way that fewer embodied individuals of an endangered species would be required to viably maintain a population. For Ryder and Benirschke, relocating genetic diversity in this way would free up already limited herd spaces, allowing for the preservation of a greater number of endangered species.

Limited space is something that conservationists working both in situ and ex situ must continually work with and around. The leading cause of species endangerment today is habitat loss. For example, the gaur and banteng are both threatened in large part due to habitat loss (Joseph & Piltz, 2007). In addition, zoological parks have a limited number of spaces available for animals. Part of the work that the Taxonomic Advisory Groups and Species Survival Plans do is rationalize the kinds of animals the parks want with the number of spaces available. This is because space delimits the size of any given population, and thereby the vitality of that population, into the future. As such, endangered species preservation is a well-known spatial problem. I am also arguing here that species conservation is a temporal problem in the biopolitical apparatuses that link up individual and

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[39] I am here drawing upon Charis Thompson's (2005: 250) argument that the human embryo is also considered a protohuman in particular contexts.

population bodies.[40] The linear life course of an individual organism delimits the population bodies of endangered species over time, particularly in captive populations.

Ryder and Benirschke were in particular institutional positions at the San Diego Zoological Society that greatly facilitated their argument for this kind of incorporation of somatic cell nuclear transfer into conservation practices. The San Diego Zoological Society's Frozen Zoo™ is probably one of the longest standing and largest collections of fibroblast cells taken from animals of endangered species on the planet today.[41] Kurt Benirschke started the Frozen Zoo™ in 1965 in New Hampshire; it then became institutionalized at the San Diego Zoological Society in the 1970s. What prompted the frozen zoo was the availability of technology in the 1960s that allowed for the reliable determination of the number of chromosomes in the nucleus of a cell (Oliver Ryder, personal communication 7/20/06). For zoos, this technology was applied to identify hybrid individuals and consider genetic sources of infertility. The Frozen Zoo™ began to opportunistically preserve fibroblast cells from ear notches of hoof animals. These tissue samples had to be taken due to federal laws governing the movement of animals from the San Diego Zoological Park to the Wild Animal Park. From there, the frozen zoo began to take and preserve skin samples from zoo animals of a number of different species after the animal died. Barbara Durrant also spent significant time ensuring that the collection included gamete cells, such as sperm, ova, and embryos (Barbara Durrant, personal communication 5/16/06).

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[40] I am here drawing upon and extending Lawrence Cohen's (2007) argument that "the human" is a temporal problem, which he delineated at the conference What's Left of Life at UC Berkeley.

[41] The San Diego Zoological Society has trade marked the name Frozen Zoo for its collection. However, the term has also become shorthand for the practices associated with preserving gamete and skin cells from endangered wildlife. When I refer to the generalized notion of keeping frozen zoos, I use the lower case.

Today, the Frozen Zoo™ holds about 7300 cell lines from 770 different taxa including mammals, birds, reptiles and fish (Oliver Ryder, personal communication 7/20/05). Oliver Ryder is the current Division Head/Senior Scientist of the Genetics Division at CRES, which oversees the Frozen Zoo™. The collection of cells has expanded primarily through donations from other zoological parks and secondarily through fieldworkers affiliated with the San Diego Zoological Society. The Frozen Zoo™ has formal policies for archiving and utilization management. Precautions are taken to ensure the survivability of the collection itself. Every cell sample is propagated to get eight vials, with four vials stored in the Genetics Division of CRES and the remaining four vials stored at an undisclosed location. At least two vials must be stored in perpetuity; if the number of vials for an individual is down to four and there is a request for a vial to be used in research, the vial is first propagated and one is frozen and the other is made available for research.

Fibroblast cells have largely been collected as a means of doing genetic analyses of wild and endangered animals and populations. Gametes, on the other hand, have been collected with the idea of reanimating genetic information of endangered animals at a future date. We see in the statement below how gametes are actively incorporated into the breeding protocols at zoological parks that seek to ensure the diversity of small, endangered, captive populations.

> You can bring dead animals into the [kinship] analysis. So you could go and incorporate all the animals for which there are frozen gametes and bring them into your living population. So say if we did an AI using sperm from this animal that is currently dead, what would that do to our population. And you could do the same thing if you wanted to bring these other animals for which there are tissue samples.
> *Sharon Joseph, personal communication10/18/05*

What the advent of somatic cell nuclear transfer made possible was the ability to re-embody stored genetic information preserved as fibroblast cells. In turn, this segment of the collection could be conceptually transformed from an informational relic through which the genetic information of the past could be understood to a "vital" or living cell that is part of the total population body, as Ryder and Benirschke (1997) suggested in their article.

In the discussions I had with people while conducting this research, it appeared that one of the greatest impacts somatic cell nuclear transfer has had for zoo worlds to date is in legitimating and expanding the practices surrounding keeping frozen zoos. The practice of collecting and preserving fibroblast and gametes cells from animals of endangered species has become "vital" and actually made (to) "live". These collections are considered by some to be absolutely important, necessary, essential, and indispensable for the continuance of endangered life forms.[42] And the possibility that life could emerge from collections of fibroblast cells has already changed the practices of some zoological parks to some extent. Philip Damiani (7/1/05) told me in an interview that, whereas many zoos previously would freeze tissue so that DNA analysis could be conducted in order to determine how closely related individuals or species are, many zoos are now also preserving cell lines that could potentially be used in conjunction with techniques like somatic cell nuclear transfer. When cell lines were being preserved for DNA analysis, the collections were often described as "repositories" of "information." With the prospect of cloning, these collections have become "vital" in that they "reinject genes" into the captive populations of endangered species.

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[42] I am here drawing upon the definitions of the adjective "vital" in the New Oxford American Dictionary (Jewell & Abate, 2001: 1888). My use of this word 'vital" was inspired by the conference on Vital Politics at the London School of Economics. See also Nikolas Rose (2001; 2007).

Gene banking allows the temporalities of captive animal reproduction to be reformulated so that these processes are not bound up with the life course and spatial needs of individual organisms. The individual body has traditionally been constrained in its possibilities through the processes of aging and eventual death, which in the case of species preservation contributes to the death of a small population. Assisted reproductive technologies allow for the individual to be alternatively temporalized. For example, the cloned banteng along with sperm samples from a now deceased banteng are today deemed the two most valuable "individuals" in the U.S. captive population (Sharon Joseph, personal communication 10/18/05). Through reassembling the relations among individual bodies and bodily parts, the goal is to rework the species body to make it larger, more diverse, and hopefully viable into the future.

Gene banking also allows for "new" genetic information to enter into the captive population through alternative embodiments. Skin cells and gametes can be taken from endangered animals living in situ. These cells, rather than fully formed animals, can be brought to the zoo and incorporated into the breeding protocols of the captive population. These techniques offer zoological parks the possibility of reproducing their populations without having to capture and transport, house, and maintain fully formed, living animals into captive settings.

> It's very difficult to import animals into the United States. It's also very stressful and a lot of animals die during transport. I think it would be great to bring in new genetics just via cell lines. And leave the animals back in the wild where they belong, instead of having to capture an animal or two to bring it back to the zoo. This serves two purposes. It would leave the animals back in the wild where they belong. It would also allow for further habitat conservation because we need to preserve the habitat for those animals to be there. Using cell lines we could potentially increase genetic diversity in our captive population, by bringing in so-called new individuals without removing the original animal.

Philip Damiani, personal communication 7/1/05

It is important to point out that this move is already taking place using other more "low-tech" reproductive technologies, particularly sperm drying, sperm freezing, and artificial insemination. For instance, reproductive scientist Bill Swanson works with species conservationists working in situ to garner sperm cells. Field conservationists will routinely capture wild animals to take samples and/or attach tracking devices. The animal is then released. Through collaborations between in situ and ex situ workers, Swanson and others have been able to add sperm samples to the list of samples taken from these animals (Bill Swanson, personal communication 4/8/06). The sperm samples are then frozen or dried and sent back to the zoo in order to become part of the reproducing captive population. With somatic cell nuclear transfer, the idea is that a skin samples can similarly be taken from wild animals and sent to zoological parks (Philip Damiani, personal communication 7/1/05). The benefit of skin cells over gametes lies in the greater ease fieldworkers would have in collecting these cells. It is simply easier to take a skin cell sample from an animal than to collect gametes, which can be difficult and at times dangerous for all involved. In addition, the full genome of wild animals could be brought into the captive population, allowing for a greater degree of genetic diversity (Duane Kramer, personal communication 1/9/06).

The goal of all these endeavors is to make new kinds of genomic nodes in the SSP's studbooks and kinship charts. On the one hand, the ways in which genomic nodes are conceptualized has broadened with assisted reproductive technologies. A population can be made up not only of living animals, but also of cells. This move is already underway with the incorporation of gametes into zoo animal inventories.

> The new ZIMS, Zoo Information Management System, is going to be at least a national if not an international repository or database that we can all access.

> The designers have incorporated semen collection, semen evaluation, embryo collection, embryo classification. So it [gene banking] really has become very well integrated into the thinking and the operation of zoos today.
> *Barbara Durrant, personal communication 4/11/06*

Somatic cell nuclear transfer offers the possibility that preserved somatic cells can also be considered reproductively viable genomic nodes in the kinship charts used in endangered animal reproduction. These available genomic nodes can be strategically used in the context of a particular situation in order to generate optimal genetic diversity.

> The way I see the cloning technology to be used in the zoo field is not to actually clone individuals that are already alive. So the idea is that if these animals are already represented in the genetic pool as breeding individuals then there's really no reason to clone them. What I really think the technology should be used for is for animals that are not represented in the genetic or the captive population. But we could potentially reintroduce those individuals that may have died before puberty and never sired any offspring. And what that does is actually the reverse of what people perceive as cloning. So people perceive cloning as decreasing genetic diversity because they're all genetic copies of each other. But if you cloned an individual that's not represented in the population you actually increase significantly genetic diversity.
> *Philip Damiani, personal communication 7/1/05*

In other words, genomic nodes – whether embodied in fully formed animals or suspended in a cryopreserved cell – gain value in conservation worlds when interlinked with the biopolitical apparatus of selective breeding for genetic variation.

THE BIOPOLITICAL ECONOMIES OF GENOMIC NODES OF VALUE

I will now turn to the bio-political economies of producing genomic nodes of value in zoos. I trace how bodies and bodily parts are exchanged between in situ sites that are often in less developed nations and ex situ sites that are often in more developed nations. By tracing these different types of exchanges, we see the production of genomic nodes of value, as a form of biovalue that requires exchange relations. These relations then become sites for contesting the colonial legacies and forms of human-animal relations that the zoological park has been both constituted by and constitutive of over the past century plus.

Charis Thompson (2005: 255) has pointed out that in what she terms *the biomedical mode of reproduction*, "body parts rather than labor are at systematic risk of being alienated from the person."[43] Thompson asserts that these problems are not so much linked with commodification, which in the Marxist sense implies becoming a fetishized thing unto itself. Rather, the problem lies in issues of custodianship (C. Thompson, 2005: 258). In the case of cloning endangered wildlife, I similarly found that body parts are at systematic risk of being alienated not only from individual animals, but also from the groups charged with caring for those animals, including zoological parks and nation states. Who gets to decide what happens to the individual and species bodies of endangered wildlife is played out through the negotiations over custodianship of cells and animals.

In tracing tissue economies of blood, organs and cell lines, Catherine Waldby and Robert Mitchel (2006: 8) note that exchanges of biological materials often travel along unequal relations, wherein those with less social power and wealth provide biological materials to those with greater social power and capital. This represents a partial truth in

[43] Drawing upon and expanding Marx's notion of the mode of reproduction through which social order are conceived vis-à-vis modes of production in terms of class, Thompson develops the notion of the biomedical mode of reproduction in the Chapter "The Sacred and Profane human Embryo: A Biomedical Mode of Reproduction" of her book *Making Parents: The Ontological Choreography of Reproductive Technologies* (2005). With the biomedical mode of reproduction, she denotes elements that shift social orders when reproduction becomes a central activity to capitalism. Thompson develops this notion by contrasting the mode of production from the biomedical mode of reproduction along several axes, including: alienation from labor to alienation from body parts; commodity based capitalism to promissory capital; efficiency to success; waste disposal to waste designation; and public understanding of science to private implication of science. In this section, I draw upon Thompson's designations of the shifts in alienation.

matters of exchange where endangered wildlife are concerned. Zoological parks without the resources to have extensive biomedical facilities donate samples to be preserved by parks with more resources and acclaim. Nations with less capital (often postcolonies) are requested to provide tissue samples to zoological parks that are both located in more wealthy nations and garner capital by displaying animals to paying visitors. However, these exchanges also become sites wherein values, orders and relations become contested terrains.

Biopolitical economies of the zoo: colonial legacies

As mentioned in Chapter Two, the modern zoological park was built upon and remains symbolic of colonial relations. Capturing wild animals and keeping them in a captive setting simultaneously represented man's power over nature as well as the power of the colonizer over the colonized (Ritvo, 1987; Thomas, 1983). The practices of trafficking wild animals for zoological parks (alongside menageries, circuses, and medical research) in turn worked to seriously diminish the number of individuals of varying species in many colonial locales. In other words, capturing wild animals contributed to the endangerment of many species. In response, the three Endangered Species Acts that U.S. Congress passed between 1966 and 1973 along with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) worked to increase regulation over the practices of zoos, specifically around importing and keeping wild animals (Hanson, 2002).

The use of reproductive technologies, including somatic cell nuclear transfer and cryopreservation, thereby represents a new means of sustaining the zoological park over many generations of captive wildlife without engaging in the consumptive, colonial practice of capturing wild animals and transporting them great distances to captive settings. The production of genomic nodes of value among zoological parks is thereby "situated" (Clarke,

2005) and "overdetermined" (Althusser, [1965] 1969) by colonialism and postcolonialism. As Kaushik Sunder Rajan (2006) points out, Louis Althusser's notion of overdetermination denotes a contextual rather than causal relationship. Rajan (2006: 6) states: "[E]ven if a particular set of political economic formations do not in any direct and simplistic way lead to particular epistemic emergences, they could still disproportionately set the stage within which the latter take shape in particular ways." In order to sustain the institution of the zoological park itself, techniques were needed to "remediate" (Harrington et al., Forthcoming) or correct faulty colonial relations that zoological parks have historically depended upon. However, the production of genomic nodes of value are themselves contested due to the political economic relations that these values are both situated by and productive of.

Some nations have rejected involvement in creating alternatively embodied founders that act as genomic nodes of value on the basis that this reproduces colonizing relations. This is done through intervening in exchanges of biological materials, on the basis that this constitutes a kind of biopiracy that is akin to the consumptive practices of colonialism. The following story demonstrates this point:

> I haven't really talked about the Brazilian ocelot at the meeting, but we produced a lot of embryos in Brazil of this particular subspecies that we want to establish in North American zoos. Those embryos were frozen five years ago. They're still sitting in the liquid nitrogen tank and we can't get a permit to get them out of Brazil. We got the permit from the U.S. government. And this is part of this huge Brazilian ocelot conservation program. We're putting $100,000 into Brazil to conserve ocelots in captivity and in the wild. So there's this tremendous payoff to Brazil. And in exchange we want to establish the Brazilian ocelot population in U.S. zoos and then manage them together because they have captive ocelot as well. So this is a way that we can expand the space size. It benefits everybody. It benefits Brazil, it benefits the United States, and it certainly benefits Brazilian ocelot. And we had all this set up with the government. The government changed. And the new government came in and said: "We don't agree. This isn't something we want

> to be involved in." And we spent the last three years trying to get back to the point of where we were three years ago where we had this agreement, we would take some of these embryos out to produce these offspring. All of the ocelots brought to the United States belong to the Brazilian government. That doesn't change. If we produce an embryo, or an offspring with embryo transfer, it belongs to Brazil. They have a right to say we want our ocelots back. We have to send them back. We signed an agreement to that effect. But the politicians again, it's this idea that Americans want to take our genetic resources to the United States. And you can tell them about all these other things, but all they see is the United States taking things out.
> *Bill Swanson, personal communication 4/8/06*

While this agreement maintained that Brazil was the official custodian of embryos and any animals created from these embryos, the state still felt that the practice was a form of biopiracy. Exchanges of biological materials became a way of asserting the "entanglement" (Callon, 1998) of endangered animal bodies and bodily parts in the legacies of colonialism and were resisted.

I would like to point out, however, that biopiracy is not sufficient for understanding the range of contestations that have emerged around exchanging endangered animal bodily parts from previously colonized territories to colonizing territories. Concerns are also at times embedded in how relations with endangered wildlife are to be forged. A field conservationist working in Kenya eloquently described these risks to me as follows (4/25/06):

> So if the technologists had the technology to be able to stuff our freezers with the full range of genetic diversity we've got all over the world and they can pull it out of the freezer and recreate it at any one point, what does it overlook? It overlooks the fact that they have made themselves the god of the new creation. There are a large number of countries, and particularly Third World countries, which have conserved their wildlife whereas North America hasn't; it's lost most of its big and dramatic animals. We're very dedicated to conserving them in the natural setting and to living with them as a part of our heritage. We do. We live alongside the species and we take a very dim view of people who would say, "Well, don't worry about your species, you might fail. We can pop them in the freezer and we'll pull them out and give them back to you." We don't want the technologist to be the

> arbitrator of our heritage and future anymore than they were in the past. So I think there's an issue of control of your own – just as you would like to see the control of your own reproductive future, so in many countries we would like to see the control over our own biodiversity future from the past through the present to the future.

This individual argues that genomic nodes of value exert too much control, not only over animals but also over people. Endangered species remain dependent upon humans when their reproduction is technologized in such a way. Post-colonial nations, where animals reside in their habitats, also remain dependent on the United States, where future "indigenous" animals reside as frozen cells. This reproduces a patriarchical relationship, one in which Euro American science arbitrates heritage by transforming human-animal relationships from being premised upon co-evolution to control, transformation, and manipulation (Austin & Short, 1972).

Geoffrey Bowker (2005) has discussed the move to molecularize memory in conservation practices in order to save space. This is part of an attempt to "database the world" (Bowker, 2005: 107) so as to remember the past. Frozen zoos are precisely this type of endeavor, seeking to remember the genetic diversity of the past and present for a future. Bowker points out that every memory system must incorporate forgetting in order to make the practices of remembering feasible. However, for Bowker, molecularized memory may forget precisely that which matters most: processes of change. For many conservationists, the goal is to preserve conditions in which change can flourish. The field conservationist cited above stated:

> My inclination - perhaps because I'm an old-fashioned conservationist in that sense - I would like to think that in the process of creating a more human-dominated world, we can find space within that world to accommodate other species and to give them space, if you like, to follow their own evolutionary pathway.

If the goal of conservation is to allow co-evolution between species to “flourish” (D. J. Haraway, 2003a), the practices of frozen zoos can be seen as quite problematic modes for relating with endangered wildlife.

CONCLUSIONS

This chapter has sought to trouble the metaphor of the copy that is assumed in cloning discourses by tracing how somatic cell nuclear transfer is being used to instead create genomic nodes of value in captive, endangered populations. Following the metaphor of the copy, somatic cell nuclear transfer is believed to allow for the endless reproduction of phenotypically identical life forms. The technique is presumed to standardize and replicate life in a manner that parallels the industrialization of inanimate and animate materials into commodities. Cloning has in turn been configured as a technique that deterministically creates situations wherein excessive social control will be enacted and human life will be commodified. For instance, The Wellcome Trust’s report *Public Perspectives on Human Cloning: A Social Research Study* (1998) found that study participants largely found human reproductive cloning unacceptable and described clones as mass produced, carbon copies of people created by the military, megalomaniacs or rogue scientists for the purpose of excessive social control. Popular cultural references like *Frankenstein*, *Brave New World*, and, to a lesser extent, *The Boys from Brazil* were often used in reference to these political economic fears surrounding the use of somatic cell nuclear transfer. Alan Petersen (2002) found a similar discourse at work in his analysis of news reporting in three Australian newspapers from the time of the Dolly announcement to the end of May 1999. Petersen’s goal was to consider how this reporting reconstructs a moral order that delimits how publics can understand cloning. He points out that the news largely framed cloning as risky by deploying fictional descriptions of cloning as the mass production of copies, wherein bodies are essentially viewed as containers for deterministic genes.

This chapter has shown that the logical apparatus that positions somatic cell nuclear transfer as a means to copy phenotypic traits is at work in some present day cloning projects. Commercial ventures in cloning companion animals most clearly align with this type of logic. However, we have also seen that the complexities of genomic inheritance and expression across the developmental process delimit the applicability of somatic cell nuclear transfer in these efforts. One may be able to "clone" their cat or dog using somatic cell nuclear transfer, but the resulting clone may not look like the "original" and very likely will behave quite differently as well – violating certain understandings of somatic cell nuclear transfer emphasized in the visual culture of popular media.

If somatic cell nuclear transfer does not generate value by producing endless copies of an original, then what kinds of value does this technique constitute? Across this chapter, I have argued that somatic cell nuclear transfer produces value by yielding genomic nodes of value. The concept of genomic nodes of value refers to the ways in which "biovalue" (Waldby, 2000; 2002; Waldby & Mitchell, 2006) is brought together with technologies of selective breeding (e.g., kinship charts and stud books) to transform individual and population bodies. Cloned endangered animals must occupy a particular space in kinship relations in order to generate value in the form of genetic diversity. It is important to point out here that somatic cell nuclear transfer alone does not generate value. Rather, the technology becomes one of many techniques grouped together in a loose assemblage. Many cloned animals require record-keeping practices in order to ensure that value is intact and realizable.

These assemblages cannot be extracted from political economic legacies and present day contestations. Transporting bodies across re-temporalized and re-spatialized fields to produce genomic nodes of value is offered as a means to remediate consumptive colonial relations through which the modern zoological park was originally established. The reproductive capacities of individual captive animals are reorganized in a manner that seeks to overcome the limits of the life course (see also C. Thompson, 2005 on this theme in relation to human use of assisted reproductive technologies). In addition, founders' bodies are reconceived as skin cells or sperm samples in order to sustain the survivability of both in situ and ex situ populations. However, these remediation practices are contested on the basis of their ability to re-colonize both animals and people. The political economic quandaries that have given rise in the production of genomic nodes of value do not necessarily revolve around labor per se. Rather, these contestations center around issues of custodial care (C. Thompson, 2005).

The notion of genomic nodes of value raises interesting questions in terms of the contemporary moment in the history of selective breeding itself. In this chapter, I have emphasized that selective breeding has historically operated at the level of the phenotype. The selective breeding of endangered wildlife at the level of the genotype represents a significant shift in selective breeding practices. I believe that this shift requires further analytic attention that goes beyond the purview of this dissertation. Fernand Braudel (in Franklin, 1997) has argued that selective breeding was a necessary precondition for industrialization in England. Further consideration of the significances of working at the phenotypic versus molecular level in selective breeding practices may provide a provocative window into emergent valuation systems (see also Rose, 2007).

The production of genomic nodes of value with animal species also offers a site of important comparison to the ways in which biovalue operates in the field of human biomedicine. In contemporary biomedical practices such as blood transfusion and organ transplantation, "one body can share its vitality with another through the redistribution of tissues, from donor to recipient, through biotechnical intervention" (Waldby & Mitchell, 2006: 2). The imaginaries of regenerative medicine promote these practices with the hope that the redistribution of one's own tissues could in turn serve to revitalize one's own body on an as needed basis (Cooper, 2006). Here, the focus is on enhancing the individual body in the operation of biopower (Foucault, 1978). In the case of cloning endangered wildlife, however, bodily parts are redistributed to revitalize the population body. Reproduction is here made productive in a manner that follows the productive techniques of biotechnology and agriculture (C. Thompson, 2005: 253), but for purposes of diversification that link up with but cannot be reduced to market value.

CHAPTER 5

Troubling Ontology.
Or, when is an animal part of an endangered species?

Are the animals we're producing true species or are they in fact a composite of a domestic animal and endangered species? And what impact does that have?
Linda Penfold, personal communication 4/17/06

[T]ransgenic creatures, which carry the genes from 'unrelated' organisms, simultaneously fit into well-established taxonomic and evolutionary discourses and also blast widely understood senses of natural limit.
Donna J. Haraway (1997: 56)

[E]ach category valorizes some point of view and silences another. This is not inherently a bad thing – indeed it is inescapable. But it is an ethical choice, and as such it is dangerous – not bad, but dangerous.
Geoffrey Bowker and Susan Leigh Star (1999: 7)

It appears impossible to wade through the situations of cloning endangered wildlife without attempting to relate the wide range of biological organisms to a species body. *Gaur* fibroblast cells, *domestic cow* ova, *African wildcat* somatic cells, *domestic cat* surrogates, and the cloned *banteng* populate the situations of cloning endangered animals. It is not enough to say "fibroblast cells" or "ova" in explaining the naturecultures[44] of cloned wildlife. Rather, we must signify biological fragments, continually moving between species bodies and typologies of human-animal relations. Both the classification of bodies and of human relations to those bodies may appear, on the surface, straightforward enough. However, it is precisely how bodies get signified that has, in particular situations, become an important site

[44] "Natureculures" is a term used in science and technology studies to denote the co-constitutive relationships between that which has been labeled "nature" and "culture". Naturecultures is a short-hand for epistemological approaches that reject deterministic approaches, whether it be biological, genetic, or cultural determinism (see especially D. J. Haraway, 2003b: 6).

of contestation in some of the arenas involved here. Who counts as a member of what population and under what conditions is the significant, and often contentious, question.

This chapter considers the significance of these questions for cloned animals in conservation worlds by tracing the troubling ontology of cloned endangered wildlife. I use the word "troubling" here in two senses. First, cloned endangered animals do not have a straightforward ontology in the current classification systems of endangered wildlife, resulting in an ontology that is troubling or difficult to pin down and define. Second, cloned endangered animals are troubling the notion of a foundational, "biologically-based" ontology that works to delimit "endangered" species, the individuals that constitute those entities, the legal justifications that grant protection, and the technologies used to manage these species bodies.

As discussed in Chapter 2, cloning an endangered animal using somatic cell nuclear transfer requires certain modifications. Rather than using an egg cell and surrogate of the same species, these projects use what is often referred to as "interspecies nuclear transfer." While the nuclear donor is an animal of an endangered species, the ova donor and gestational surrogate are from a different, closely related, domestic species. The embryos produced through this process are by definition "chimeras".[45] This chapter asks what the products of chimeras become. I ask this question not so much to find a definitive answer, but rather to trace how varying actors – including myself – *go about* addressing this question. As this

[45] Chimeras are historically understood as monsters made up of bodily parts of different animal species. They are a standard characters in Greek mythology and beyond, such as "goat-men" or "mermaid". Chimeras has also more recently come to denote cells and bodies that contain DNA from different organisms and/or species (see Robert & Baylis, 2003 for an overview and ethical discussion).

chapter will make clear, the situations in which the question is asked cannot be separated from the epistemological framework used to address the question.

Questions regarding the moral and ethical status of chimeras often intersect with cloning discourses. After all, Dolly the Sheep was next of kin to Polly, a transgenic sheep whose milk can be used to harvest peptides for human pharmaceuticals due to the presence of human genetic information in that milk. Much of the bioethical and public concern surrounding chimeras centers around the consequences that human-animal chimeras may have for the legal standing of persons. Some contend that these chimeras are an unnatural breaching of fixed species lines, a critique that bioethicists Jason Scott Roberts and Francoise Baylis consider and problematize in their influential article "Crossing Species Boundaries" (2003). Indeed, Sarah Franklin (2007: 33) contends that the advent of techniques like somatic cell nuclear transfer represents a fissure in the idea that there are fixed biological barriers to human activities. Roberts and Baylis contend that the more significant danger of chimeras lies in their ability to break down the social divide between humans and nonhumans and corresponding social orders and relations, resulting in moral confusion. The ultimate concern regarding this moral confusion is the possible loss of hard won rights based on the status of being a person. As I will show, conservationists similarly have concerns about how animals produced by way of chimeras fit in the hard won social orders produced to protect endangered wildlife.

For many of the people I spoke with, the ways in which interspecies nuclear transfer has traveled along the infrastructure of human relations with domestic animals becomes problematic because this relation is inscribed in and on the resulting cloned animal's body. This marking takes the form of mitochondrial DNA inherited from the domestic animal who served as the egg cell donor, calling into question the species relation of the cloned animal. This inheritance gives rise to questions about what resulting cloned animals actually *are* and whether these animals can embody "genetic value" for endangered populations. This chapter maps out the varying positions on the ontological status of cloned endangered animals. I situate these positions vis-à-vis the ways somatic cell nuclear transfer has traveled (as discussed in Chapter 3), the ways cloned animals are positioned as "genomic nodes of value" (as discussed in Chapter 4), the role of hybrids in legal frameworks that support endangered wildlife, the move to 'let domestics do the reproductive work' for endangered wildlife in zoological parks, and the question of what role genetic engineering could have to "help" endangered wildlife.

The epigraphs that opened this chapter provoke us to consider what is brought to the fore and what is erased in classifying an animal as domestic, endangered, hybrid, or something else that cannot be articulated at this point in time. These classifications represent a kind of "memory practice" (Bowker, 2005) that allows conservationists to get on with the work of selectively breeding endangered wildlife. Geoffrey Bowker (2005: 6-7) uses memory practices to denote the action of committing certain things and experiences to record so that these traces can be carried out in the future. Bowker emphasizes that all memory practices necessitate that certain traces be forgotten. Kinship charts are a kind of memory practice that allows endangered species to exist into the future.

How the transgenic animals made up of wild/endangered and domestic/common bodies are to be classified remains an open question and is linked up with questions regarding how these individuals should be remembered and what facets of their origins should be forgotten. Possibly ironically, the genetic relations of these animals may complicate or "blast" the kinship charts and species boundaries through which their value as endangered becomes realized. I conclude by arguing that the sites of articulation and erasure in particular situations, which are necessary to stabilize the classification of these animals, may have as much of an impact as the stabilized classification itself.

I next map the varied positions taken in this research regarding what animals produced by way of somatic cell nuclear transfer are. These positions on the ontology of cloned wildlife link up with positions regarding the validity of transposing bodies and techniques in order to produce genomic nodes of value. I situate these positions in the discourse of hybridity in zoo and conservation worlds. I then explore the silenced position in this map that cloned animals are *not* endangered species, but mitochondrial DNA per se is also not significant to this assessment. I situate this silence in the generally accepted move among reproductive scientists to "let the domestics do the reproductive work for endangered species" so long as this relation is not marked upon endangered animals' bodies. I then trouble this position by opening up the definition of "domestic" and showing how captive endangered animals always already occupy a borderland position between domestic and wild. I conclude by discussing how somatic cell nuclear transfer is quietly being imagined as a means to genetically engineer endangered wildlife, constituting a new discourse in species preservation.

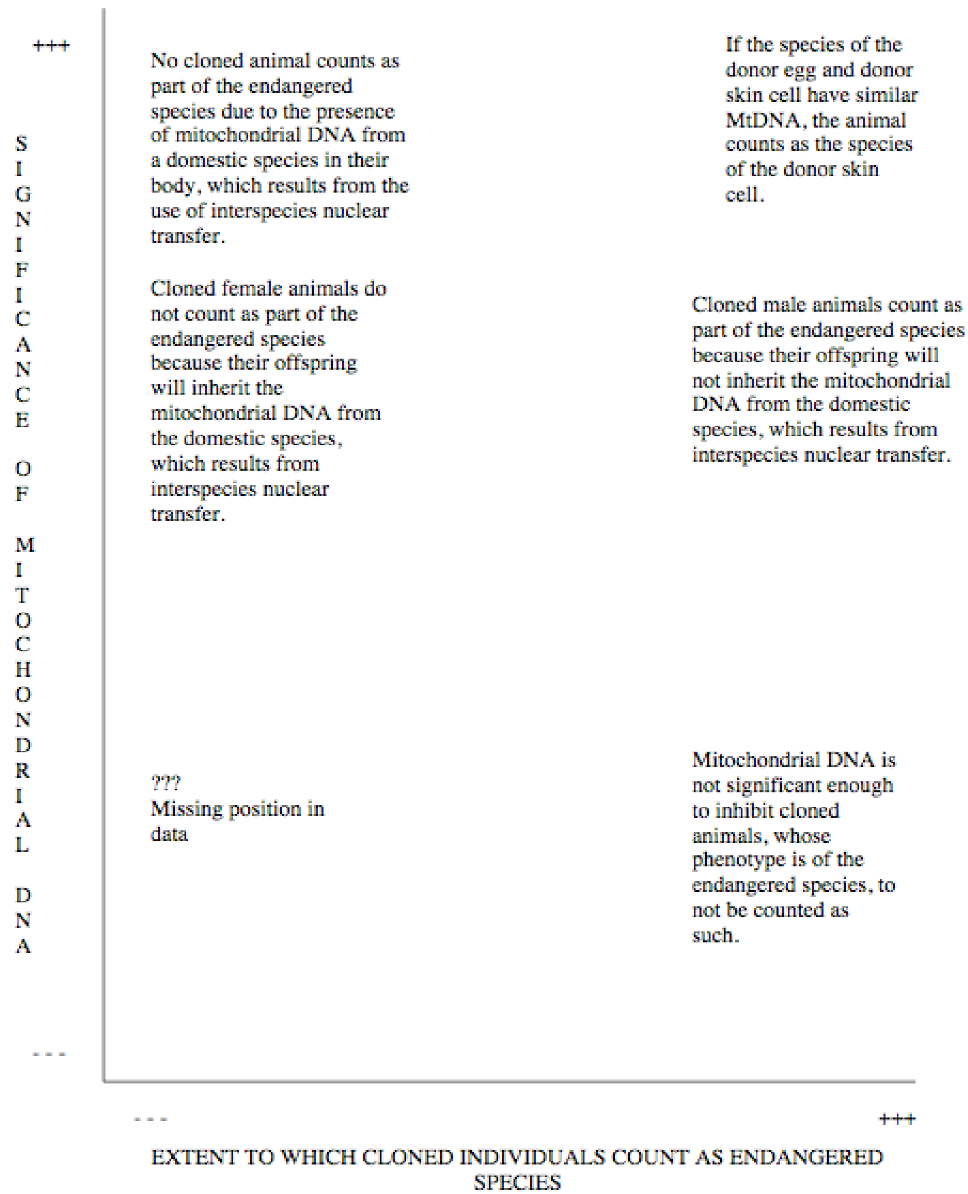
MAPPING POSITIONS: THE MEANINGS OF MITOCHONDRIAL DNA TO THE SPECIES QUESTION

One of the normative features of “modernity” is the use of objective “science” to arbitrate and determine ontological status, or to determine what something is.[46] Nonhumans of varying kinds are used as arbiters in defining reality (Latour, 1993; Shapin & Schaffer, 1985). Ontology is often presumed to be stable, singular and foundational. According to this logical apparatus, physical reality provides the basis for social order.[47] While there are different ways to define a “species”, many of the people I spoke with used genetics as the final arbiter in determining what a species is and where the lines are that divide two species from one another. Following the logic of this understanding, one could say that genetic definitions provide the basis for and essence of a species, creating a foundation for the mobilization of certain types of human-animal relations among those whose genome is at risk of extinction. Whereas it is okay to kill and eat a domestic cow, a threatened gaur or endangered banteng instead garners life saving protections. This is because the gaur and banteng are both genetically different from the domestic cow and the number of individuals who embody that genetic information are rapidly declining.

Figure 4 lays out the varying positions taken in the discourse regarding the status of cloned endangered animals.[48] These positions are organized according to two axes: a) the significance of mitochondrial DNA to species boundaries; and b) the degree to which animals produced by interspecies nuclear transfer count as part of the endangered species

[46] Both “modernity” and “science” come in various forms and themselves are never neutral categories (Latour, 1993; Stengers, 2000).
[47] Social scientists, feminists, and anti-racists have extensively critiqued this biologically reductionistic logic.
[48] As discussed in Chapter One, it is important to remember that positional maps consider the range of positions taken on an issue. The benefit of these maps is that positions are disentangled from people or social groups. Any quotations used in this section should not be understood as representing the particular person’s position, but should instead be taken as representing a position. Individuals and social groups can and do take multiple and even contradictory positions (see Clarke, 2005: 126).

FIGURE 4: Positional Map
Positions on the Status of Cloned Endangered Animals



population in question. We see that most positions hold that mitochondrial DNA is significant in determining what species are and where species boundaries are located. Almost all positions taken are located on the upper half of the map, wherein mitochondrial DNA is viewed as important or very important. Despite the generally consistent view that mitochondrial DNA is significant for determining a cloned individual's relation to species bodies, we do not see a consolidation in the perspectives regarding the ontological status of wildlife created using interspecies nuclear transfer. Multiple and conflicting positions emerge.

There is one significant exception, however. On the bottom right hand side of the grid, we see the position that mitochondrial DNA is *not* significant enough to inhibit the classification of "cloned endangered animals" into the endangered animal population body. Despite the seemingly "outside" status of this position, it is the default position in most discourses surrounding the practice of cloning endangered wildlife. The very language of "cloned endangered animals" (that I have used throughout this dissertation) positions animals produced by way of interspecies nuclear transfer as part of the endangered species population that is in question. Here it is implicitly (if unknowingly) posited that mitochondrial DNA is *not* so polluting, *not* significant enough to make this kind of move out of the question.

This position is interlinked with the processes of transposing bodies and techniques in order to mobilize somatic cell nuclear transfer across human-animal relations. As stated in Chapter Three, it is simply not possible to get enough ova from the endangered species in question to do somatic cell nuclear transfer. In response, this position posits that it is better to use somatic cell nuclear transfer with endangered wildlife – even if some domestic mitochondrial DNA travels along with the technique – than not to use the technique at all.

We see this point demonstrated in the following statement, made by John Critser (personal communication 4/20/06) after I asked him about the significance of mitochondrial DNA inheritance from the domestic egg cell donor:

> Well, I think that's an obvious way around some of the problems of getting oocytes from the species that you're specifically interested in. In terms of having the mitochondria and the mitochondrial DNA from a different species, it's just that. I think it's a trade-off. I think if you could get around it you would, but if you cannot it's a reasonable approach. We certainly understand that many inherited diseases and many fundamental metabolic processes are mitochondrial driven, and so it's true that you won't be able to recapitulate the species exactly as they are in the wild. But, still, I think that's a reasonable approach to solving the problem.

Here, we see the notion that "heteroplasmic" individuals produced by interspecies nuclear transfer may not be precisely the same as endangered wildlife, but they are "close enough". Using interspecies nuclear transfer thus becomes a reasonable solution to the conjoint problems of limited research materials and species extinction.

While the position that mitochondrial DNA is *not* significant enough to bar the resulting animal from being part of the endangered species in question, the positional map shows that a number of counter-vailing positions are circulating, which require analytic attention. On the top left hand side of Figure 4, we see the position that could be seen as the polar opposite to the dominant position outlined above. Here it is posited that no animal produced by way of interspecies nuclear transfer should be considered part of an endangered species population because these animals embody mitochondrial DNA from a different, domestic species. Within this position equivalencies are often posited between the products of hybrid embryos and chimera cells and/or between the sperm and the egg and the nucleus and the cytoplams. In other words, hybridity offers an analytic lens to understand heteroplasmic individuals, effacing the differences between these two different types of cells.

This position also often links up questions regarding which species require protection and which individuals can be considered part of those species bodies. In addition, drawing on the language used in Chapter Four, this position links up with questions about how genomic nodes are deemed valuable in the kinship charts used by SSPs in making reproductive decisions. In creating equivalences between hybrid individuals and heteroplasmic individuals, this positions devalues the genomic value of individuals produced by interspecies nuclear transfer.

As previously mentioned, kinship charts used by Species Survival Plans can be understood as a productive kind of "memory practice" (Bowker, 2005) that allows for captive animal bodies to be remembered and remade over time. Hybrid animals are often forgotten in the memory practices of Species Survival Plans because their genetic mixtures are not viewed as valuable. For some, the genetic mixtures produced by way of somatic cell nuclear transfer should similarly be forgotten by excluding cloned animals from extant memory practices. This position is exemplified in the following statement made by SSP coordinator Bill Swanson (personal communication 4/8/06):

> In my opinion, as the coordinator of an endangered cat SSP, I would not let that [cloned] animal be part of the managed population. Because it's not an endangered cat anymore. It's something else. And it's just like if I got a fishing cat-domestic cat hybrid. I'm not going to manage that in the population.

This position is also interlinked with the desire to avoid "moral confusion" (Robert & Baylis, 2003) or "legal confusion" regarding the difference between endangered and domestic animals, which serves to justify the special protections provided for endangered wildlife under the law. During an interview, Linda Penfold (personal communication

4/17/06) explicitly positioned the inheritance of mitochondrial DNA as such a political and legal issue:

> If you track the [cloned] animal, now the DNA of the mitochondria is from a domestic cow. So we feel that by doing that you're basically forming a chimera. You no longer have a pure strained banteng because the mitochondria are from a domestic cow whereas the nuclear DNA is from a banteng. So right there we run into problems and these may spill over potentially into legal and legislative issues – is it a banteng? If people can argue it's chimera, it no longer becomes a protected species. So politically – there are political aspects for us to at least be aware of.

With continual threats made to the Endangered Species Act, the desire for a "safe" position in the ontology of endangered species is, in many ways, understandable. It is difficult to argue for protections for individuals and species that are hard to define and bound. And yet, even those who held this position often labeled it "extreme".

Beyond these polarized "extreme" perspectives regarding the status of cloned animals, a number of alternative positions were also articulated. Significantly, across each of these positions, mitochondrial DNA remains important. However, what distinguishes these positions from the two polarized positions discussed above is the body for which mitochondrial DNA is deemed important. In the polar positions, mitochondrial DNA was primarily deemed important for the individual body of the cloned endangered animal and its relation to the species population body. In contrast, in the positions outlined below, mitochondrial DNA is primarily deemed important for the species population body and the relation of the cloned individual to that body. Individual and population bodies thus represent a third axis on this positional map.

In the upper, middle section of the map we see a prevalent position, which holds male animals produced by way of somatic cell nuclear transfer count as part of the endangered population, but female animals do not. This perspective is premised upon generally held beliefs regarding the inheritance of mitochondrial DNA. Whereas nuclear DNA represents a combination of both the male and female genetic information in sexual reproduction, mitochondrial DNA is believed to pass through generations by way of the ovum alone. In other words, it is generally held that mitochondrial DNA is solely maternally derived among mammals. Whether or not this holds true in all species is not known at this point in time.

In this position, males produced by way of somatic cell nuclear transfer represent "bridge" individuals. Such individuals represent particularly valuable genomic nodes in the kinship charts that the SSPs use, as discussed in Chapter Four. They gain value by re-spatializing and re-temporalizing genomic inheritance in a manner that can be used to generate previously impossible genomic diversity in captive populations. According to this position, the corresponding re-speciation of their individual body is contained. The "dilution" of domestication in their genomic bodies can be "forgotten" or "erased" in the memory practices of the SSPs because this information will not in fact spread into the population body. In other words, the *biological* processes of forgetting male mitochondrial DNA justify the *social* forgetting of mitochondrial DNA inherited from domestic animals in male animals.

In turn, we see the corresponding position that female animals produced by way of somatic cell nuclear transfer should not be included in SSP memory practices. Whereas sexual reproduction quarantines male mitochondrial DNA in the individual bodies, sexual reproduction spreads the "contamination" or "pollution" of domestic DNA in individual female bodies through the population body. Such animals represent less valuable genomic nodes because of their compromised genomic identities. Female clones may also represent dangerous nodes that will transform the population body by making it more linked up with another, domesticated species through its genetic relations.

Finally, on the upper right hand side of Figure 4 we see the position that the significance of mitochondrial DNA to the status of cloned animals is species specific. While certain species may be distinct in their nuclear DNA, population geneticists have recently begun to argue that some species are similar in their mitochondrial DNA. This is referred to as cyto-nuclear discordance (Oliver Ryder, personal communication 7/20/05). As such, certain endangered species may already have mitochondrial DNA that is similar to the domestic species in question, making the question of pollution irrelevant. This position was less frequently discussed, probably because it is based on emerging findings in population genetics regarding the genomic relations between species bodies in natural history.

This set of positions is deeply interlinked with the practices of producing genomic nodes of value that focus on transforming the population body through technoscientific means. There is less concern here about how the individual body is transformed toward these ends. Indeed, it is the ability to transform individual bodies that allows for new ways to make endangered species population bodies more diverse and thereby more sustainable. However, the natural history of the differences between species continues to guide how the population body is to be technoscientifically configured. While individual bodies can transgress species boundaries, population bodies may not.

In sum, this section has shown that biological facts do not consolidate into a singular meaning. Rather, the meanings of mitochondrial DNA are situated in the assemblages through which it is rendered meaningful, situations that range from mobilizing techniques, creating genomic nodes of value, and/or legally defending the rights of endangered wildlife.

As social scientists have argued in a myriad of other contentious terrains, "biological facts" are not inherently meaningful and therefore tend to be used in a myriad of ways rather than consolidating positions (Duden, 1993; Franklin, 1995).

SITUATING THE POSITIONS: HYBRIDS IN CONSERVATION DISCOURSES AND PRACTICES

The positions described above that seek to define what cloned endangered animals are all rely upon genetic definition. However, genomics provides just one of many ways to define species and the boundaries between them. R.L. Mayden (1997) has outlined twenty-two different definitions of species circulating in the biological literature. In the case of cloned endangered wildlife, genetic definitions of species at times contradict another prominent mode through which species are defined: the ability to sexually reproduce successfully. According to the logic of genetic boundaries, African wildcats and domestic cats, gaur and domestic cow, and banteng and domestic cow are all different species. According to the logic of reproductive isolation, African wildcats and domestic cats, gaur and domestic cow, and banteng and domestic cow are the same species. Each can and does successfully interbreed in "the wild". Nonetheless, the offspring of such sexual relations are labeled "hybrids".

In order to understand some of the disputes over how to classify animals produced through interspecies nuclear transfer, it is important to situate these positions in the discourses of hybridity in endangered species preservation in the United States. This provides a background for understanding why some people voice concern that cloned endangered animal may represent a problem in the legal arenas of conservation in the U.S., which has historically relied on the notion of fixed species boundaries in justifying intervention. This will also provide a background to why and how the "genomic value" of animals produced by way of somatic cell nuclear transfer is contested as compromised through "dilution".[49] As I next discuss, hybrids are often considered particularly *un-valuable* genomic configurations in endangered species preservation practices and are often barred from becoming "nodes" in the kinship charts used to manage the reproductive practices of endangered species.

Hybridity in conservation discourses and practices

Hybridization is often considered an un-natural, inferior, and even dangerous mode of sexual reproduction. And the ability of some endangered species to hybridize with domestic counterparts has worked to deem hybridization itself a cause of endangerment. In an article entitled "Hybridization and extinction: in protecting rare species, conservationists should consider the dangers of interbreeding, which compound the more well-known threats to wildlife" Donald Levine (2002: 254 emphasis added) states:

> [D]ifferent species in the same genera do not normally interbreed. . . . Although such hybridization never takes place in the vast majority of genera, it is quite common in some. . . With hybridization so rampant, one wonders how species ever maintain their distinctness. They do, in part, because the production of hybrids does not necessarily shift genetic material between species. For genes to traffic in this way, hybrids must cross with at least one of the parent species. In many instances that doesn't happen. Why? As Darwin had observed, most hybrids are inferior to their parents.

Here we see articulated the position that hybrids are inferior, which works to support species distinctions both rhetorically and in natural history.

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[49] It is interesting that people I spoke with often used the word "diluted" rather than the "polluted" (Douglas, [1966] 2005) discourse. Domestic animals don't "pollute" endangered animals, but "water them down" to the status of a "lowly" domestic animal in a type of hierarchical relationship.

From the mid-nineteenth century onward, however, there has been increasing recognition that hybrids are not always inferior and can at times outperform parent populations (Levine, 2002). Such hybrids are positioned as a kind of "invasive species" that overtakes local populations, causing "native" species to diminish in number. In response, there are increasing discussions in conservation worlds about the role hybridization plays in the endangerment and extinction of small parent populations. This is particularly true among those working to preserve plant species. But, a tour of a zoological park will also often show that hybridization is considered a primary source of endangerment for an array of animal species.

For the most part, hybrids are considered less valuable than "pure" animals with a lineage in one specie or sub-specie. For example, in an interview Budhan Pukazhenthi (personal communication 4/11/06) recalled a story about the decision to "phase out" hybrid lions at U.S. zoos. For some time, U.S. zoos had intentionally bred Asiatic and African lions, resulting in a number of hybrid individuals. The decision was later made to "phase out" the Asiatic lions because it became clear that no new Asiatic lion genetic material would be brought into the U.S. captive population. This decision raised the question of what should become of the hybrids already in the park. The felid TAG decided that all hybrids should also be phased out of the U.S. parks. For several years, all institutions were asked to stop breeding all lions. African lions were brought into the captive population and interbred. The hybrid lions and Asiatic lions lived their lifecourse without breeding, effectively ending the trajectory of these populations in zoos, and altering the U.S. captive zoo population of lions. Whereas the U.S. captive population had once been comprised of Asiatic, African and hybrid lions, today it is solely made up of African lions. This is generally considered a more valuable genomic configuration because it is unified, sustainable and "pure."

But Pukazhenthi also emphasized in an interview that hybridization is not always considered a liability for endangered populations, taking the Florida panther as a case in point (see also Levine, 2002). The U.S. Fish and Wildlife management plan aims to recover in situ, self-sustaining populations of Florida panthers by protecting habitats, engaging publics so that panthers are not harmed, and reintroducing panthers to these habitats (U.S. Fish & Wildlife, 1993). Part of creating a self-sustaining Florida panther population has required introducing new genetic information into this very small population. Given the small number of Florida panthers, new genetic information has been created by breeding the Florida panther with the Texas puma. What made this kind of hybridization acceptable, whereas other forms of hybridization are viewed as dangerous, was scientific evidence that the Florida panther had at one point in time dwelled across North, Central and South America in co-existence with the puma (Budhan Pukazhenthi, personal communication 4/11/06). Thus, the two species have a history of co-habitation; today their differences are the result of disruption in landscapes brought about by human "society". In other words, the difference between Florida panthers and Texas pumas is a biological artifact of the social processes of human intervention. The Florida panther sets a precedent wherein it is permissible to use hybrids to reanimate what was or is now waning, but not to create something new.

This brief overview of the discourses and practices of and around hybridity in endangered species preservation and zoological park management schemes is meant to situate present day dialogues surrounding heteroplasmic individuals. The discourses and practices through which hybrids become dangerous, valuable, social, and natural provide a platform for discussing heteroplasmic individuals. This raises an important question. Is the concept of hybridity an adequate metaphor for understanding heteroplasmic individuals? For many people I spoke with, regardless of the position they took on the status of individual animals produced through somatic cell nuclear transfer, hybridity and heteroplasmia could not adequately be collapsed into one another. Barbara Durant (personal communication 5/16/06) commented to me:

> The charge that I've heard leveled is that the banteng or the gaur was actually a hybrid. That's not technically true. It's not a hybrid, but certainly is contaminated with mitochondrial DNA. To what extent the male bantang is contaminated with mitochondrial DNA is unknown. But to call that cloned bantang – as much as I don't agree with doing cloning – to call that animal hybrid is actually incorrect.

For the purposes of this dissertation, a slightly different question may more aptly be: What does the metaphor of hybridity obscure when applied to heteroplasmic individuals? Collapsing hybridity and heteroplasmia obscures the differences between the "material semiotic" (D. J. Haraway, 1997) genetic mixtures produced through sexual reproduction when compared to those mixtures produced through interspecies nuclear transfer. The material semiotic sperm and egg provide a field through which the relationship between the cytoplasm and the nucleus is (re)articulated (Keller, 1995; Martin, 1991). The question becomes when do these differences matter, a theme I take up briefly in the conclusion.

SITUATING SILENCED POSITIONS: DOMESTICATING WILDLIFE

I now turn to the lower left hand corner of the positional map, where we see the absence of a position or a site of silence in the discourse (Clarke, 2005). If articulated, this position would hold that cloned animals are not part of endangered species, but not because mitochondrial DNA of another species is present. This silence first and foremost reiterates the salience of genetic definitions of species among the people I spoke to in conducting this research. However, this silence also requires analytic attention.

In this section, I therefore situate and contrast the use of interspecies nuclear transfer in the move to redistribute reproduction via interspecies *embryo* transfer. Whereas interspecies nuclear transfer is contested because of the genetic markings of an interspecies relation, interspecies embryo transfer is not contested because the relations formed through gestation are effectively erased at birth. In other words, the goal is often– as one scientist referred to it at a meeting – to "let the domestics do the reproductive work for the endangered species" without creating a species relation between domestic and wild life. I conclude this section by asking what "domestic species" means in order to question what kinds of relations are opened up by using assisted reproductive technologies more generally with endangered wildlife.

"Let the domestic do the work"

One of the initial interests in developing assisted reproductive technologies for zoo and endangered animals was to find out whether reproduction could be removed from the bodies of zoo and endangered animals and transferred to the laboratory. It was hoped that by having humans rather than the animals do the reproductive work, difficulties associated with captive breeding could be circumvented. However, even if humans could create embryos in the laboratory, gestational surrogates were still required for embryos to become individual animals. Shulamith Firestone's (1970) (in)famous dream of a reproductive apparatus that is fully removed from the body has not been realized in humans or animals. Thus, much of the early work of reproductive scientists in zoological parks focused on determining whether domestic animals could serve as gestational surrogates for the wild species embryos that humans were creating in the laboratory. David Wildt remarked in an interview (7/18/06):

> I mean the whole idea behind some of the original work was that we could use interspecies embryo transfer, so you could put zebra embryos into horses and bongo embryos into cows and all that. And the interesting thing was that a few of those original offspring took and got a lot of press. . . . Zoo directors sort of got caught up in this and they started thinking, "Well, you know, this is one way to solve all of our problems."

It is important to point out that the feasibility of this logic, wherein domestic animals do the work of gestation for endangered species, is today deeply contested. Many in zoological parks contend that there simply have not been enough successful and repeatable demonstration projects to prove definitively that one species or subspecies can gestate for another. Some hold that species differences make the routinization of this logic into practice unlikely, upholding the notion that species differences *do* represent biological limits. Nonetheless, there remains a great deal of hope surrounding interspecies work across species conservation worlds.[50] I am interested here in exploring the cultural presuppositions that underlie its formation.

Unpacking the terminology

The notion of letting another do one's reproductive work enacts a set of cultural assumptions through which varying aspects of reproductive labor are differentially valued. Shelley Colen (1995) coined the term "stratified reproduction" to refer to these cultural assumptions, based on her study of diasporic West Indian childcare workers and their white

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[50] For example, I presented a paper entitled "Let the domestics do the reproductive work for the endangered species: Reworking the species body" at the 2006 annual meetings of the Society for Social Studies of Science (4S). The beginning part of the title generated giggles throughout the audience. However, a zoologist approached me afterwards and explained that, despite all the problems of this logic, there is something very appealing about this idea.

U.S.-born employers in New York City. Colen's focus is on the sustained devaluation of women's labor in rearing children. She shows how this has persisted with the commodification of "domestic" labor that has arisen in the United States as bourgeois white women with children began to enter or remain in the arena of paid labor by hiring childcare workers. This dramatically expanded a class of domestic paid laborers who are largely women of color with few economic resources and whose work continues to be low paying, conceived as unskilled, and is relatively under-valued in the U.S. social landscape. Following Marx ([1867] 1978) in her use of the term "commodification", Colen emphasizes that these women are literally alienated from their own domestic labor. They care for another couples' child(ren) while their own children reside a great physical distance away. Colen argues that stratified reproduction becomes a site wherein inequalities are reproduced along the axes of race, gender, migration status, and position in the global economy.

In the case of reproducing zoo animals and endangered species, the reproductive labor of genetic inheritance is deeply valued whereas gestation is devalued.[51] This mode of valuation has made it conceivable to "contract out" the reproductive labor involved in gestation to animals who are considered of lesser value individually, specifically to closely-related domestic species.[52] While tremendous resources are spent on domestic cows as a population, many individuals within this population are considered expendable. In the

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[51] The same is often true in reproducing domestic animals, particularly livestock. Embryo transfer is considered such an important technique because it allowed female traits to be "industrialized" through selective breeding practices in a manner akin to the ways stud books have historically worked. By disentangling genetic inheritance and gestation, the genome of a valued, female individual can be reproduced many times in a breeding season by a number of different gestational surrogates who are not themselves considered "genetically valuable".

[52] This logic also makes it possible for genetically over-represented females in zoos to do the gestational work for genetically under-represented females in the zoo (Budhan Pukazhenthi, personal communication 4/11/06; Duane Kraemer, personal communication 1/9/06).

stratified reproduction of animals, lesser-valued individuals can do lesser-valued reproductive work for more highly valued individuals of endangered species. The reproductive labor of domestic cows is commodified and her offspring are literally "alien" to her, being of another species.

Contra the " bio-terrorist" implications that inter-species gestation conjures up when humans are involved (C. C. Thompson, 1999), these practices have generally not been understood as problematic with animal bodies. Here the ontology of organisms reproduced through interspecies embryo transfer has been firmly positioned within the endangered species from whom the embryo was derived. The reproductive labor of the domestic animal has thereby been effectively erased in the ontology of the resulting individual. This coincides with moves in biomedicine more generally, through which gestation is equated with care and "nurture" (Casper, 1998a; C. Thompson, 2005). In relation to its use in human reproduction, Charis Thompson (2005: 156) states: "When gestational surrogacy is uncontested, everything except for fertilization is equated to child care, despite its biological nature. This makes genetics the essential natural component that confers kinship and minimizes the role of gestation." In other words, interspecies gestational surrogacy is deemed as a "cultural" and "social" relation across humans, domestic animals, and endangered wildlife. The biological relations produced through pregnancy are effectively erased, while genetic relations become more difficult to untangle. With endangered wildlife, this erasure is linked up with the use of population genetics to understand what endangered species are and to develop management schemes to try to preserve such species.

Domestic Relations

It is important here to address the obvious but all too easily obscured point that domestic and endangered species are more than their genetic configurations. Rather, these are both modes of relating that shape the bodies and practices of individual and species bodies. Hence, in this section, I open up the question of what "domestic" species are and the deeply interrelated question of how "domestic" species are co-constituted and co-constituting.

Broadly speaking, domestication is a form of inter-species relations wherein inter-dependencies are forged. Many species engage in relations that result in domestication and the presence of Homo sapiens is not required (Anderson, 1998a; Noske, 1997; O'Connor, 1997). For example, Barbara Noske (1997: 3) points out that some species of ants "milk" aphids. Citing Donald R. Griffin, Noske (1997: 176) explains: "Certain species of ants feed on the sugary faeces exuded by aphids, a kind of plant-house which adheres to the plants. The ants gather and care for their 'domesticates' and sometimes even build shelters around them."

Beyond this broad definition, there are many ways of conceptualizing domestication. The most prominent understanding is, according to Barbara Noske (1997: 6) "the capture and taming by man of animals of a species with particular behavioural characteristics, their removal from their natural living area and breeding community, and their maintenance under controlled breeding conditions for profit." Or, put somewhat differently by Donna Haraway (2003b: 27-28):

> Humanist technophiliacs depict domestication as the paradigmatic act of masculine, single-parent, self-birthing, whereby man makes himself repetitively as he invents (creates) his tools. The domestic animal is the epoch-changing tool, realizing human intention in the flesh, in a dogsbody version of onanism. Man took the (free) wolf and made the (servant) dog and so made civilization possible.

According to this familiar definition, domestication is purposeful human mastery that reconfigures the “other’s” body to fit the specifications of human desire through a hierarchical relationship.

Central to this definition of domestication is the selective breeding of individuals within a species according to the desires and designs of humans. Harriet Ritvo (1995) has shown how eighteenth century taxonomists would often position domesticated *breeds* of cattle, pigs and dogs as equivalent to a wild *species*. She contends that practices in selective breeding – specifically inbreeding and keeping studbooks – worked to reconfigure the boundaries of nature and culture in the eighteenth century. Specifically, domestic animals came to be viewed as *species that humans created*. This served as the epistemic basis for the understanding of domestic animals as objects produced by humans, which can legitimately be owned, used and consumed.

The predominant mode of defining domestication has been critiqued from a number of vantage points. Scholars have established evidence that this is an erroneous reading of socio-historical relations between humans and animals and have, in turn, argued that this narrative historically corresponds with racist, sexist and colonialist agendas (Anderson, 1998a; Noske, 1997). In addition, the privileged position of humans in predominant definitions of domestication has been critiqued. Both evolutionary biologists and critical science studies scholars have noted that, while domestication may be an asymmetrical relationship, it certainly shapes *both* species involved (Anderson, 1998a; D. J. Haraway, 2003b). At times, reconfigurations of domestic relations have taken a form wherein human *culture* is understood as being shaped through the reshaping of animal *bodies* (Anderson, 1998a, 1998b; Yarwood & Evans, 1998). For example, this move is linked to some geographers' work in emphasizing that domestication is not only a technical process - which is how domestication is predominantly understood in the discipline of geography - but also a deeply cultural endeavor (Anderson, 1998a; Yarwood & Evans, 1998).

However, this reconfiguration itself risks reinstating the nature/culture, animal/human, and implicitly female/male bifurcations on which the predominant version of domestication is always already based. In resisting this nature/culture binary, Donna Haraway (2003b: 31) contends that:

> [I]t is a mistake to see the alterations of dogs' bodies and minds as biological and the changes in human bodies and lives, for example, in the emergence of herding or agricultural societies, as cultural, and so not about co-evolution. At the least, I suspect that human genomes contain a considerable molecular record of the pathogens of their companion species, including dogs. Immune systems are not a minor part of naturecultures; they determine where organisms, including people, can live and with whom.

That is, relations between species shape both the bodies and practices of both/all species involved in relating as well as the naturecultures in which we/they live together (D. J. Haraway, 2003b). Helen Leach (as quoted in Franklin, 2007: 31) states:

> However it is defined, domestication was a process initiated by people who had not the slightest idea that its alliance with agriculture would change the face of their planet almost as drastically as an ice age, lead to nearly as many extinctions as an asteroid impact, revolutionize the lives of all subsequent human generations, and cause a demographic explosion in the elite group of organisms caught up in the process.

Leach thus points out how deeply ignored the history and consequences of human-animal relations have largely been, at least since "modernity".

Rethinking the meanings of domestication intersects with the ambiguous ontology of zoo animals. On the one hand, zoo animals are not generally considered domesticated in a technical sense because most do not breed in captivity over a number of generations (Anderson, 1998a), despite sustained efforts. In addition, what defines a zoo animal is its status as “wild” and therefore not domesticated. On the other hand, meta-narratives often simultaneously position captive wild animals as symbols of human mastery (Baratay & Hardouin-Fugier, 2002; Hoage et al., 1996; Ritvo, 1987, 1996; Rothfels, 2002), thereby linking up with predominant definitions of domestication (Anderson, 1998a).

In addition, keeping animals in captivity certainly shapes their naturecultures. Attempts at reintroduction have shown that captive animals of most species are ill-adapted at survival without their human companions when suddenly placed in non-captive environments. Not only do these animals lack the knowledge necessary to manage their new environment, reintroduction itself has been shown to change individual hormonal levels that may be linked to low reproduction rates. As such, then, the naturecultures of wild animals are shaped by captivity. They are “captive” and not “wild”.

Zoo animals thereby exist in the borderlands of domestic and wild. As zoo animals have increasingly become protected ambassadors of their endangered species (Hanson, 2002: 171), endangered species too occupy this borderland position. Drawing upon Kay Anderson’s definition of domestication, one could say that endangered species are domesticated in that these species are brought into areas of human concern and their preservation becomes a matter of human management. However, the ostensible goal in forging a human relation with an endangered species is not based on captivity per se, but rather to help a population eventually become “self sustaining” (Benirschke, 1986) or viable without ongoing human intervention. Thus, the endangered species relation is premised upon being short-term.

Some people I spoke with voiced concerns that a focus on developing and using assisted reproductive technologies could work to create permanently domesticated endangered species. We see this sentiment in the following statement:

> *Barbara Durrant (personal communication 5/16/06)*
> For a while it was so popular and so sexy to do all these assisted reproductive technologies. We were thinking, "Well, gosh, we'll never have to have animals together anymore, we can do it all artificially." Well, if our eventual goal truly is re-introduction or self-sustaining populations that doesn't – those two things don't work because you don't want to produce a whole generation of animals that can't reproduce on their own. It makes no sense.

Here we see the idea that using assisted reproductive technologies with endangered wildlife changes the bodies of these individual endangered animals and their populations. Hence, the difference between domestic and endangered animals is effaced, not so much in and through their genetic makeup but through their bodies and practices.

This then creates another set of questions regarding the ontology of endangered wildlife and what it means to forge relations with these species.

> *Field conservationist (personal communication 4/25/06)*
> So how do they draw a distinction then between cloned animals of endangered species and domesticated dogs and cats, which are wards of human goodwill and interest. We've genetically modified them down the ages, albeit not by high tech means. But essentially you end up with the same thing. You end up with animals which are domesticated and are there by virtue of our having taken over their genetic futures.

Interestingly, the location of differentiation in this statement comes close to filling the silenced positioned in the positional map. Here, a cloned endangered animal is not necessarily an endangered species. Rather, it is another domestic animal that has a presence in the world because of human goodwill and interest in its genetic future. Mitochondrial DNA is simply a mark. What is more significant is the form of relating that shapes endangered species and human bodies in currently unknown ways.

GENETIC FUTURES: EMERGING DISCOURSES IN BRAVE NEW CONSERVATION WORLDS

The prospects of genetically engineering endangered wildlife only came up in the study as murmurs and whispers. There are no currently existing programs in genetically engineering endangered wildlife. However, the prospects of using somatic cell nuclear transfer with endangered animals does open up the possibility of using this technique to change the individual and population bodies of these species in ways that diverge from the logic of the kinship chart. Specifically, some scientists raised the possible future wherein the genomic configurations of endangered wildlife could be altered to make individuals of these species more amenable to life in the worlds that we are forging today, which is premised upon the overwhelming presence of homo sapiens.

Genetic engineering mainly arose as a site of speculation, but one that would denote a different way of relating with endangered wildlife. For instance, Oliver Ryder (7/20/05) told me about the ways in which avian malaria was causing a number of bird species to become endangered and may result in mass extinction. Ryder speculated that genetic engineering could be a solution to these kinds of problems. More generally, others speculated that genetic engineering offers a means to make species that can inhabit a planetary landscape deeply marked by the immense presence of humans:

> *Duane Kraemer (personal communication 1/9/06)*
> Right now, the most predictable way of doing genetic engineering is through cloning, if indeed we can do that with those species. So it has some merit there and I, but the conservation community is generally abhorred by any, by the thought of any genetic engineering. My thought is that it is just causing evolution to happen a little bit more rapidly. We're causing, we're part of the problem, the human species, so we ought to use our intellect to try to help them out with that, with the changing world we are imposing upon them and genetic engineering is just one of these ways to help.
>
> *Field conservationist (personal communication 4/25/06)*
> My inclination – perhaps because I'm an old-fashioned conservationist in that sense, I would like to think that in the process of creating a more human-dominated world we can find space within that world to accommodate other species and to give them space, if you like, to follow their own evolutionary pathway without us being the gods who create the animal in our own images. That's what I'd like to see but I'm not sure that that's going to be a view that persists too far in the future. Why? Because what ultimately matters to us are our children. And if the big dramatic species like elephants and lions and so on pose a threat to our kids there's going to be a whole lot of people who say: 'Well, why should we have species which threaten our children? Why don't we just tweak their genes and have elephants that are a lot friendlier towards people? Why don't we just tweak the genes slightly in a lion and have lions that might kill antelopes but actually are predisposed not to kill people?' Those are the sorts of things I think we're going to be up against and they're very hard moral choices.

In both of these statements we see speculations that available technology opens up the possibility of changing wild animals to fit into human landscapes. We also see a fair amount of reticence in moving explicitly toward this alternative configuration of endangered species bodies and human relations to those bodies. As the field conservationist stated, these are hard moral choices. I would add that these are also important questions about how we want to forge naturecultures and acknowledge doing so.

This domain of possibility opens up a very different landscape in the discourses and practices of doing species preservation. In particular, we no longer see endangered species as gaining their status as organisms vis-à-vis their genetic configuration. This genetic configuration is not a site of preservation practices set upon keeping the configuration as it stands today.[53] Rather, the goal would be to change the genomic configurations of individuals and species by "blasting" the genetic divide between species.

> *Field conservationist (personal communication 4/25/06)*
> We now have the technology to create any hybrid that we care [to create] and we have the technology potentially on the horizon to create diversity like the world has never seen. So if we want diversity let's create it genetically. If we want to have animals fulfill a particular ecological niche, which is emerging and which was not there before, we potentially have the genetic and the technical skills shortly coming up to be able to accelerate the rate at which species will fill newly emergent niches in the world that we create, the human dominated niches. That's a whole new landscape. So we have some very hard decisions to make.

In this statement, hybrids take on a new meaning. Rather than being abnormal and devious, new kinds of genetically engineered hybrids become a way to change individuals and populations to enable them to live alongside humans.

The boundaries between species become a new kind of problem in the context of genetically engineering endangered wildlife. Rather than establishing and maintaining the boundaries between species, the goal is to rework species bodies so that one can benefit from the genetic configurations of another in living alongside humans. This position links up with emerging utopian visions being articulated vis-à-vis findings that microbes transfer genetic information not only vertically through sexual reproduction but also horizontally, between individuals within the same generation (e.g., Dyson, 2006; for an anthropological analysis see Helmreich, 2003). For instance, Freeman Dyson (2006) has recently argued that the

[53] Whereas somatic cell nuclear transfer is currently being used to produce what I have been calling "genomic nodes of value" in a manner that is consistent with current species preservation discourses and practices, genetically engineering endangered wildlife to ensure that they fit the existing habitats represents a departure.

mechanisms of inheritance with biotechnologies should be conceived of as lateral rather than vertical gene transfer. Dyson envisions a world in which amateur breeders could have tool kits available to make new varieties of hybrid fauna and vertebrates, propelling a kind of domestication based on diversification rather than the proliferation of sameness currently seen in corporate agricultural use of such technologies. Dyson anticipates that this could represent a better future: "We are moving rapidly into the post-Darwinian era, when species will no longer exist, and the rules of 'open source' sharing will be extended from the exchange of software to the exchange of genes. Then the evolution of life will once again be communal, as it was in the good old days before separate species and intellectual property were invented." Here, species boundaries become the problem that should be overcome in a free market exchange of genetic information.

PARTIAL CONCLUSIONS

This chapter is difficult to conclude, given that its purpose has been to outline some of the emerging questions regarding what "cloned animals" and "endangered species" are and may become. The goal of this chapter has been to map and situate the varying positions I encountered while conducting this research. In doing so, I have resisted the positivist impulse to provide a singular, stable and foundation ontology. As we have seen across the chapter, the question of what cloned animals and endangered species are is bound up in the intra-actions of chromosomes, proteins, cells, bodies, management regimes, techniques of various kinds, discourses, and spaces. Because of the complexity of these intra-actions, we cannot adequately answer questions like "what is a cloned animal" or "what is an endangered species" in a totalizing manner.

Based on this review, I would also contend that the logical apparatus of nature/culture and biological/social does not provide an adequate epistemological basis for addressing these questions. Nonetheless, species conservation in the United States remains deeply bound up with/in this logical apparatus. Nature and biology are used to determine the "Truth" of what a species is and where the lines between species are located. Such biological "facts" work to support social interventions aimed to recover endangered wildlife and other species of flora and fauna with which they dwell. As many other social scientists have similarly shown, dividing the world up into "biological" and "social" domains becomes a difficult agenda because the two domains are co-constituting rather than discrete (D. J. Haraway, 1989; 1991a; 1991b; 1997; 2003b; Latour, 1993; 2005; Rheinberger, 2000). However, I do recognize that the logical apparatus of nature/culture and biological/social is an important nonhuman actor that everyone I spoke with had to engage. I contend that this logical apparatus is best viewed in this manner, as an actor in the situation rather than an explanatory device for sciences.

In making this argument, I contend that the variable ontology produced by transposing bodies and techniques (Chapter Three) or generating interspecies "biovalue" (Waldby, 2000; 2002; Waldby & Mitchell, 2006) to create genomic nodes of value (Chapter 4) cannot be understood as unique to the contemporary moment, nor to outlaw chimeras, hybrids, heteroplasmic individuals and other individuals who queer the notion of fixed boundaries between species bodies. Bruno Latour (1993) contends that modernity is premised upon separating the work of translation from the work of purification, exemplified by the separation between the natural and social sciences (as discussed in Chapter One). And he argues that the work of purification allows for – rather than inhibits – the flourishing of hybrids produced through translational practices. “The essential point of this modern Constitution is that it renders the work of mediation that assembles hybrids invisible, unthinkable, unrepresentable. Does this lack of representation limit the work of mediation in any way? No, for the modern world would immediately cease to function. Like all other collectives it lives on that blending.” (Latour, 1993: 34). Latour contends that the problematic status of some of the naturecultures in which we live results not from hybridizing nature and culture, but rather from the proliferation of hybrids that cannot be purified fast enough.

In many respects, this chapter demonstrates Latour’s arguments. For example, both mitochondrial DNA inheritance and pregnancy can be described as biological processes. The mediations between the biological and the social are effectively erased in the case of interspecies embryo transfer as pregnancy is firmly positioned as a social relation. However, the mediations between the biological and the social are not so easily erased in the case of interspecies nuclear transfer. While mitochondrial DNA is often positioned as biological and therefore foundational, the meanings this inheritance has depends upon the assemblages within which this actor intra-acts. The meanings of mitochondrial DNA shift when this actor moves between endangered species legal assemblages, endangered species management schemes, and technological development protocols. Both interspecies embryo transfer and interspecies nuclear transfer are hybrid practices. But interspecies embryo transfer has been purified, whereas interspecies nuclear transfer has not.

This Chapter thus opens up two sets of questions of pressing concern for those working to conserve endangered wildlife. The first question centers on how the relations of heteroplasmic individuals are to be conceived if they are not equated with hybrids. I would posit that, whereas hybrids are best understood in terms of vertical gene transfer, somatic cell nuclear transfer sets up a kind of horizontal gene transfer. As Stefan Helmreich (2003: 342) has pointed out, "sex" provided a pivotal nexus in tying together individuals and populations in the classic biopolitical regimes described by Foucault. Helmreich contends that "transfer" provides the pivotal nexus tying together emergent biopolitical regimes today, within what Rose (2007) calls the "molecular gaze". Whereas kinship charts and studbooks provide a modality for representing the relations produced through vertical gene transfer, how horizontal gene transfers are to be visualized and operationalized remains an open question. It appears that, at the current moment and in the situation of endangered wildlife, neither forgetting cloned animals nor forgetting mitochondrial DNA inheritance is an adequate strategy for the job at hand. The question becomes how to engage in memory practices that remember *both* horizontal and vertical gene transfer. How, then, does the kinship chart get rescaled in the process?

The question of remembering vertical gene transfer links up with the second question haunting this chapter, which centers on how relations with endangered wildlife are to be pursued into the future. This chapter has outlined three typologies for normative relations with endangered wildlife. The classic species preservation model seeks to remember and preserve species as they exist today. This model has been variously critiqued for failing to engage and promote the processes of change (Bowker, 2005; Takacs, 1996). And so we also now see an alternative position in which species conservationists seek to preserve spaces wherein varying species of flora and fauna can continue to co-evolve, at times alongside humans and at other times without the presence of humans. This model of conservation is most clearly articulated through the discourses and practices of biodiversity (Takacs, 1996) and is centrally focused on preserving habitats. The potentialities of genetic engineering have opened up the possibility of a third model, one in which the genomic configurations of endangered species are intentionally changed by humans so that they can better survive in emerging landscapes punctuated by the proliferation of homo sapiens and corresponding diseases, fear-based hunting, and habitat loses.

The ramifications of these models for relating with wildlife cannot be adequately assessed in this dissertation. As a medical sociologist, I am certainly not in the best position to address how to proceed in preserving endangered wildlife in particular situations. However, I would like to conclude by pointing out that the dialectics of holism and reductionism do not need to provide the philosophical basis for these debates. In many ways, this chapter has shown that this dialectic is inadequate for the task at hand.[54] I think that we need to find ways of pursuing relations with endangered wildlife that do not seek to reduce these species to their genes or save them by completely "blasting" (D. J. Haraway, 1997: 56; 2003a) species differences to pieces. The challenge is therefore not only in addressing the question of how to relate with endangered wildlife, but also in finding new ways of seeing through this question.

[54] For a critique of reductionism and holism, see Charis Thompson (2002). I would like to thank Donna Haraway for this point, which she made as the Discussant for the panel "Re/producing and Endangering Species: Questions of Survival in the Remakings of Kin and Kind" at the annual meetings of the Society for Society Studies of Science, Vancouver BC, 2006. This theme is taken up in more detail in Chapter Six.

Chapter 6

Partial Conclusions: From cloning animals of endangered species to modeling assemblages

> I arrived at the San Diego Zoological Society's center for Conservation and Research for Endangered Species (CRES) today to conduct an interview about the cloned gaur and banteng - both endangered bovine – as well as tour the research facilities. CRES in many ways looked like the world-class, biomedically-based, endangered species research center that I had imagined. Somewhat surprisingly, CRES smelled rather profusely of cow manure, being as it is located next door to a farm. Whereas the zoo is in San Diego, the Wild Animal Park and CRES are located thirty-five miles north in the agricultural town of Escondido. I thought that the smell may have been a permanent feature of CRES, but was told no, this was a particularly smelly day given the direction of the wind. Walking through the corridors of CRES, my tour guide was frequently greeted with friendly hellos, introductions were made, and jokes about the smell of manure upon my day of arrival often followed. During these exchanges, I was often asked what species I worked with. I responded that I was a doctoral student in medical sociology, so I mainly worked with people. I explained that I had previously talked to people who used reproductive technologies, but was now interested in studying how these techniques are used with animals. I concluded that my 'species' (a term used here that seemed resonate with the anthropologist's 'tribe') probably were people who work with endangered animals. There seemed to be a bit of disdain for this answer each time I retold it. People who work with endangered species aren't really a "species" per se. But possibly more importantly, I could tell that many felt exacerbated with the human obsession that my answer seemed to reinstate, an obsession that my dissertation - or so I think - is trying to disrupt. Throughout the tour there seemed to be a kind of gentle humor taken in shocking me into the life worlds of animals and the people who study them. I was amusedly shown a picture of a man ejaculating an endangered horse to get a sperm sample and a slew of vials containing elephant feces awaiting analysis. It was as if I was naive voyeur who had to be shocked out of my human-centric discipline of sociology with pungent odors, images of ejaculation and bundled feces if I were to begin to understand endangered animal reproduction worlds, the people who work with/in them, and the tasks they routinely do.
> Fieldnotes, July 20, 2005

These fieldnotes were written early in my research process. I use them to conclude this dissertation because this narrative points to many of the tensions that informed project design, ran throughout the research process, and shaped my writing. These tensions include:

1) agriculture, biomedicine, and conservation; 2) domestic and endangered species; 3) farms and zoological parks; 4) humans and animals; and 5) knowledge and practice. I move in and through these tensions in this chapter to summarize my dissertation findings. I conclude that animals produced by way of somatic cell nuclear transfer can be understood as model "assemblages" (Deleuze & Guattari, 1987) for creating relations between techniques, bodies, politics, socialities and economies to achieve particular kinds of goals. This overview informs my discussion regarding the implications of this research for species conservation (in which this project is situated) and the field of science, technology and medicine studies (in which I situate myself).

REVIEW OF DISSERTATION AND FINDINGS

This dissertation project has sought to carve out an alternative mode for conceptualizing the meanings of somatic cell nuclear transfer as "cloning". I do not presume that this set of techniques is inherently meaningful, but rather that this process becomes meaningful in and through its enactments. That is, I contend that to understand the meanings of "cloning" we need to study this technoscientific process as a form of ongoing, uncertain, and "situated" (Clarke & Friese, 2007) action.

This analytic move required that I do two things methodologically. First, it forced me to consider how somatic cell nuclear transfer is actually being used with animal bodies today, rather than imagining what it would mean if the technique were applied to human bodies in the future. Second, it required that I make full use of my own bodily senses and become physically involved in those worlds where somatic cell nuclear transfer is settling down. I had to visit sites, see techniques being used, talk with people involved in and "implicated by" (Clarke & Montini, 1993) cloning endangered wildlife, read papers, transcribe interviews, smell bodies, and (if permitted and safe) grasp with my own hands some of the tools and bodies involved. And then I had to “situate” (Clarke, 2005) these experiences. Neither I the researcher nor “the human” occupies a privileged position outside the action in this theoretical-methodological approach to questions about the meanings of cloning.

Tracing somatic cell nuclear transfer “in action” (Latour, 1987) reshapes how we consider the potentialities of this set of techniques and the terms we use to do so. For example, “the copy” has been the primary metaphor through which somatic cell nuclear transfer has been rendered meaningful to date. The idea that this technique creates genotypic and phenotypic copies is presumed in concerns that somatic cell nuclear transfer will be used to “mass produce” people. However, as demonstrated in Chapter Four, this metaphor is insufficient for understanding many of the ways in which somatic cell nuclear transfer is actually being used today. Indeed, many present day projects using this set of techniques do not seek to make copies per se, but instead what I have called “genomic nodes of value”.

Significantly, the concept of genomic nodes of value directs us to the ways in which somatic cell nuclear transfer is linked up with other technologies in particular situations, often with uncertain results and for unknown durations. Here, somatic cell nuclear transfer becomes actively involved in bridging two more established practices in zoological parks: frozen zoos and Species Survival Plans. Across this dissertation I have argued that somatic cell nuclear transfer cannot be studied in isolation, but rather must be viewed in and through the “assemblages” (Deleuze & Guattari, 1987) that have shaped and continue to shape its use. As discussed in Chapter One, Deleuze and Guattari’s (1987) assemblages are emergent, temporary, and contingent sites wherein heterogeneous things are brought together to pursue certain goals because they more or less work together. Following this concept, George E.

Marcus and Erkan Saka (2006) contend that "assemblage" is a flexible concept for thinking about social structures while attending to issues of heterogeneity, uncertainty, temporality, and transformation.

Tracing the practices involved in doing somatic cell nuclear transfer highlights how this set of techniques is interconnected with other technologies, cells, discourses, bodies, practices, logics, political economies, and management strategies. The ways in which somatic cell nuclear transfer gets bundled up can have both short-term and/or enduring consequences. In turn, *the form* that these assemblages take is often the critical site of contestation. For example, Chapter Two refocuses some of the debates in zoo and conservation worlds regarding *whether or not* endangered animals should be cloned to address questions about *how* these experiments in cloning should be assembled. This theme is also taken up in Chapter Five, which addresses how somatic cell nuclear transfer is not only bound up in present day conservation practices but could also be used to produce new kinds of conservation goals. As such, somatic cell is neither a neutral technique, nor does it deterministically produce specific kinds of social orders. Rather, we need to attend to the ways in which techniques, bodies, and social orders are "co-produced" (Jasanoff, 2004; Reardon, 2005).

How somatic cell nuclear transfer is assembled becomes a critical question, one that I address in Chapter Three. I contend that the social process of transposing bodies and techniques across infrastructures establishes cloning assemblages. As an analytic tool, the concept of transposition refers to processes whereby bodies and techniques that come with certain "rhizomatic" (Deleuze & Guattari, 1987) infrastructural arrangements are moved to another area of interest. This creates a dynamic and co-constitutive set of relations between unlike bodies and arenas, requiring the coordination of different logics, practices and bodies vis-à-vis one another.[55] In the case of cloning endangered wildlife, equivalences and associations are made between domestic and endangered animal bodies in particular situations. However, domestic and endangered animal bodies do not collapse into one another in any kind of totalizing manner. The concept of transposition allows us to consider how *both* the processes of historical drag as well as the productivities of transformations literally become embodied.

The process of transposing bodies and techniques raises questions about ontology, or what cloned animals, endangered species, and domestic species *are*. In Chapter Three, I use Charis Thompson's (2005; 1996) concept of "ontological choreography" to argue that the bodies produced throughout the interspecies nuclear transfer process must move between domestic and endangered classifications in order to do the work of cloning endangered animals. In Chapter Five, I show how, in conservation worlds, this ontological choreography contradicts the desire to establish foundational definitions of individual and species bodies. Across these chapters, I have tried to open up the question of what cloned endangered animals are, arguing that neither biological nor cultural determinism will suffice (see D. J. Haraway, 1991a, 1997; Latour, 1993; Rheinberger, 2000). In other words, these categories cannot be reduced to some pre-given genetic determinant; nor can they be viewed as social fabrications that have no relation to physical and material bodies. Rather, we need to seek out new ways of talking about heteroplasmic individuals in a manner that appreciates both the materialities of these bodies and the discursive fields within which they are situated. To do so, scholars and Species Survival Plan coordinators alike will need to rethink the

[55] Anselm Strauss's (1985; 1988; 1993) "articulation work" offers a useful sensitizing concept for further unpacking transposing as a kind of work process in the future.

temporalities and embodiments of individuals that make up nodes in kinship charts. How these temporalities and embodiments are reconsidered will likely have consequences that simply cannot be known today.

It needs to be emphasized that somatic cell nuclear transfer may turn out to be rather ephemeral. This set of techniques requires substantial material and other investments, while also being rather inefficient in terms of its output. And there are well-known physical problems for offspring produced through this set of techniques. By most standards, somatic cell nuclear transfer remains highly problematic for both reproduction and regenerative medicine ten years after Dolly's birth. If another "tool" becomes better for the "job" (Clarke & Fujimura, 1992a), somatic cell nuclear transfer is unlikely to continue to be bound up in and work to constitute the assemblages described in this dissertation. As Couze Venn (2006: 107) points out, the concept of assemblages is premised upon adaptivity and co-articulation. As such, it is important that we pay attention to not only the meanings of somatic cell nuclear transfer as it is enacted, but also the assemblages through which this technique and corresponding goals get accomplished. Some of these assemblages will likely take on more durable forms.

The significance of this dissertation lies not only in delineating the meanings of cloning as constituted in present day practices, but also in outlining the forms of assemblages that this technique is co-constituting. I suggest that somatic cell nuclear transfer is bound up in emergent logics and goals made possible by transformations in the life sciences that cut across agriculture, biomedicine and conservation. Projects in cloning endangered wildlife represent one site where the assemblages needed to achieve these newly imagine-able goals are being "tinkered with" (Knorr Cetina, 1999). It is these assemblages, rather than a single technique in isolation, that require analytic attention if we are to actively carve out desired futures in the present (see also Rabinow, 1999).

By way of concluding, I suggest that the subjects of somatic cell nuclear transfer act as "models" for more than a set of techniques and/or their species bodies. *These organisms also model for bio-political economic goals and corresponding assemblages in formation.* Model assemblages are not so much about representing the natural world in order to know it (better) (see de Chadarevian & Hopwood, 2004). Rather, model assemblages are about "tinkering" (Knorr Cetina, 1999) with relations of various kinds to create examples of how previously unthinkable naturecultures could become feasible and valuable. I address the significance of these model assemblages in the next two sections that explore the implications of this research for zoological parks and conservationists as well as for the field of science, technology and medicine studies.

IMPLICATIONS FOR ZOOLOGICAL PARKS AND CONSERVATIONISTS

I entered the worlds of cloning endangered animals using interspecies nuclear transfer having first analyzed popular media accounts of this activity as well as websites. This initial analysis did not prepare me for just how controversial the development of somatic cell nuclear transfer with endangered wildlife is across zoological parks and other species preservation sites. I hope that this dissertation will prove useful to those entrenched in these highly charged debates. However, as stated in Chapter One, I do not take a position regarding whether or not certain species should or should not be cloned using somatic cell nuclear transfer. Instead, I have tried to situate varying positions regarding this practice. I have sought to elaborate upon both the meanings of cloning vis-à-vis conservation as well as some of the contested assemblages in which this technique is entrenched and also produces.

This focus moves discussion away from cloning per se to how biomedically-based technologies like somatic cell nuclear transfer are assembled into conservation practices.

There are many meanings associated with cloning endangered wildlife. Somatic cell nuclear transfer represents a new technique that may be useful to future conservation practices. Cloned endangered animals produce public support for both controversial technologies and the companies that develop them. Interspecies nuclear transfer is one more way to transfer reproductive labor from often unwilling endangered animals to laboratories and domestic animal bodies. It is also a mode for proceeding with human embryonic stem cell research without having to go through human oocytes.[56] Somatic cell nuclear transfer offers the possibility of using somatic cells in new ways, thereby retemporalizing individual and species bodies to help sustain small populations. This set of techniques is also imagined as a means to move cell lines rather than fully-formed, individual organisms from in situ to ex situ sites. Finally, somatic cell nuclear transfer represents the possibility of conceiving conservation in whole new ways, wherein animals are created to fit into habitats via genetic engineering rather than preserving habitats for animals to live in and with which to co-evolve.

The meanings of cloning endangered animals are "complex" (Law & Mol, 2002; see specifically C. Thompson, 2002: 185) because they are multiple and produced by making connections among varied kinds of different practices, orders, discourses, bodies, and economies. Cloning is not an inherently meaningful technique. Science, technology,

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[56] As discussed in Chapter Two, Advanced Cell Technology became involved in using interspecies nuclear transfer with endangered wildlife in order to find out if egg cells from one species could "reprogram" somatic cells from another species. The idea was that domestic cow egg cells could potentially be used in human embryonic stem cell research. With this in mind, researchers hoped to overcome the material and ethical difficulties associated with collecting human oocytes for this research agenda.

conservation, biomedicine, politics, nations, public relations, zoological parks, biotechnology companies, frozen zoos, habitat preserves, kinship charts, individuals, populations, and cells are varyingly linked up in making "cloning" meaningful. At times, some resulting meanings of cloning and their corresponding assemblages are coordinated, while other meanings and assemblages remain incompatible (see also Mol, 2002 on the coordination and incommensurabilities of multiple enactments of atherosclerosis).

The multiple meanings of cloning endangered animals in turn reveals much about the varying practices, orders, discourses, bodies, and economies in which this practice is situated. As a result, this dissertation has at times displaced "cloning" per se and instead opened up the contours of some of the larger questions and debates that are on-going among zoological parks and species preservationists. These debates center on: 1) how biologically-based research should proceed vis-à-vis wild and endangered species; 2) how human relations with endangered and other endangered species should be forged; 3) how species boundaries are to be determined and coordinated across different sites; 4) how the vestiges of colonial relations are managed; and 5) how the meanings and practices of conservation itself are to be negotiated and coordinated.

Clearly significant is the question of who will make such decisions and how they will do so. A field conservationist I spoke with while conducting this research makes this point as follows (4/25/06):

> These are not questions for the technologists alone. These are much, much broader questions. Knowing a lot of these individuals – I don't think they're sinister, I don't think they're Frankenstein creators. I think they simply haven't thought about this. They're so gung ho on the technology that they think "here is a new solution that is going to prevent the death of endangered species and we've made a wonderful creation." True. But in context. Like any technology it has to be seen in context and it has to be arbitrated and mediated in context.

This dissertation has revealed that these questions are partially addressed in the actual practices of technological development and cannot be deferred until after a technique is developed (Chapter Two). This raises the question of how multiple and at times incompatible positions regarding research, relations, classifications, and conservation are actually arbitrated and mediated in context, while science is "co-producing" social orders (Jasanoff, 2004; Reardon, 2005). Assemblages for this kind of negotiation will likely require far more modeling into the future.

In concluding, I would like to suggest that neither reductionism nor holism will suffice in attempts to arbitrate the meanings of cloning, research, relations, classifications, and conservation (see C. Thompson, 2002 for a critique of reductionism and holism). I do not believe that questions about these assemblages require a unified and singular answer. Most people I spoke with understood and appreciated conservation as a multivalent discourse and set of practices. Reductionism would require silencing too many voices and too many practices.

It is also important to point out that holism does not provide a suitable alternative to the problems of reductionism. All meanings, positions and assemblages are not equally important to conservation practices. Rather, meanings, positions and assemblages become important in and through the creation of connections between different practices, orders, economies and actors. It is for this reason that the cloned banteng has taken up so much space in this dissertation. This individual animal embodies many connections between and tensions among the varying meanings of cloning endangered wildlife and corresponding questions regarding what kinds of assemblages species conservationists want to develop and coordinate.

IMPLICATIONS FOR SCIENCE, TECHNOLOGY & MEDICINE STUDIES

There is admittedly something a bit strange, at first glance, about a medical sociologist in training writing a dissertation about cloning endangered wildlife. This practice is often positioned as a site of "conservation" and thereby possibly more aligned with environmental sociology. But somatic cell nuclear transfer has largely been defined as a medical technology, either as one more reproductive technology or as a tool for personalized, regenerative medicine. And, it is *as* a medical technology that somatic cell nuclear transfer has become controversial. Somatic cell nuclear transfer becomes problematic when it is "medical", which pertains to human bodies. In contrast, this dissertation has sought to disrupt the equivalences made between medicine and humans that work to exclude animals from the field of medical sociology. I have done this by exploring the connections between biomedicine and conservation. In this section I explore what the implications these connections have for the intersecting fields of medical sociology and science and technology studies.

Cloning animals of endangered species is one site wherein medical approaches are taken to help resolve problems associated with species extinction. The development of assisted reproductive technologies with zoo animals and the corresponding incorporation of reproductive sciences into zoological parks could be situated as a site of "medicalization" (Conrad, 1992, 2000, 2007; Conrad & Markens, 2001; Conrad & Schneider, 1980; Estes & Binney, 1989; Foucault, 1994a; Fox, 1994; Zola, 1997). Medicalization refers to the expanding jurisdiction of medicine into new areas of human life, a process that began at the end of World War II (for a discussion, see Clarke, Mamo, Fosket, Fishman, & Shim, 2007; Clarke et al., 2003; Conrad, 1992, 2007; Starr, 1982). The concept was initially used to describe the social processes whereby human behaviors defined as "deviant" fell under the professional purview of medicine rather than law, such as alcoholism, homosexuality and drug abuse (Conrad & Schneider, 1980). However, the concept expanded to denote any area of human life that came to be seen as a medical problem, a problem falling under the jurisdiction of medicine (e.g., G. Becker & Nachtigall, 1992 on the medicalization of infertility). We can similarly say that the initial incorporation of the reproductive sciences into zoological parks for the express purpose of developing assisted reproduction may be seen as indicative of medicalizing endangered species reproduction.

Across this dissertation, I have also shown that agriculture, biomedicine and conservation have come together in and through the co-constitution of certain biopolitical apparatuses (Foucault, 1978). The cloned gaur and banteng embodied these connections, which initially motivated this dissertation research project. Both of these animals were created through collaborations between a biotechnology company focusing on regenerative medicine, a biotechnology company focusing on industrializing the reproductive processes of livestock (see Clarke, 2007), and a zoological park. As a result, these animals simultaneously modeled for: 1) the potential of interspecies nuclear transfer to produce embryos without human oocytes in human embryonic stem cell research; 2) the potential of cloning endangered bovine and other species; 3) the potential of reformulating the temporalities and embodiments of individual bodies to transform populations. These animals were models, or examples, of how to create "mixed-use" assemblages of techniques, bodies, politics and economies (e.g., modes of circulation and exchange) that cut across medicine, agriculture and conservation and between humans and animals.

Across this dissertation I have drawn on Michel Foucault's (1978) concept of biopower to discuss the politics of cloning endangered wildlife. Biopower denotes the ways in which life is fostered through knowledge and corresponding techniques, which both operate upon and connect individual and population bodies. Clarke and her colleagues (2007 (forthcoming): 2-5) succinctly define biopower as "the form of knowledges coupled with technologies to exert diffuse yet constant forces of surveillance and control over human bodies and their behaviors, sensations, physiological processes, and pleasures – both individually and in terms of populations." Biopower has largely been used to understand the relations between bios and politics with and between humans. However, biopower certainly operates in human-animal relations as well (Baratay & Hardouin-Fugier, 2002; Clarke, 2007). Sites where endangered animal bodies are inventoried (e.g., kinship books and international computerized inventories), studied (e.g., biomedical research regarding species physiologies), and managed (e.g., Species Survival Plans, Endangered Species Act, and Convention of International Trade of Endangered Species) all represent forms of biopower.

A number of scholars have pointed out that biopower and biomedicine more generally have been and continue to be shifting (Clarke et al., 2007; Clarke et al., 2007 (forthcoming); Clarke et al., 2003; Rabinow, 1996a; Rose, 2007; C. Thompson, 2005). Nikolas Rose has argued that biopolitics began to shift at the end of the twentieth century and continues to change today. Rose describes this changing terrain through five transformations, including: 1) from the molar to the molecular; 2) from curing disease to optimizing bodies; 3) from public health to individual responsibility; 4) from political mobilization to professional networks; and 5) the intensification of financial investments in "life itself" and corresponding intensifications in "economies of vitality" (Rose, 2007:11-39). At the core of each of these shifts are the limits of biological essentialism and a move toward "engineering" bodies by transforming the vitality of life itself (on the engineering model in the life sciences across the twentieth century see also Clarke, 1998; Franklin, 2007; Pauly, 1987; Yoxen, 1984).

Clarke and her colleagues (Clarke et al., 2007 (forthcoming); Clarke et al., 2003) describe biomedicalization as a set of processes that began to occur c1985, representing a second major transformation of American medicine. These processes, also described in Chapter One, include: 1) political economic reconstructions of biomedicine; 2) an increasing focus on health; 3) an increasing technoscientization and informationalization of the practices, innovations, and delivery of healthcare with digitalization and molecularization; 4) changing modes in which biomedical knowledges and information production, consumption and distribution; and 5) the creation of new individual and collective identities based on the ways in which bodies are being transformed. The "bio" of biomedicalization emphasizes the importance of biology and "biopower" (Foucault, 1978) across these transformations (Clarke et al., 2007 (forthcoming)). Transforming bodies is a key facet to the processes of biomedicalization, which in many instances involves the immediate use of complex technoscientific interventions rather than proceding "one step at a time" up the ladder of care in medicine.

Cloned animals of endangered species are already deeply entrenched in some of these processes of biopolitical and biomedical transformation. In the situation of cloning endangered wildlife, we see the increasing definition of species health made at the genomic/molecular level with the shift from demographic approaches to species management to genetic approaches. In zoological parks, the longstanding focus on individual animal health and finding cures for illness is supplemented with the incorporation of reproductive and genetic sciences, which seek to optimize both individual and population bodies. As such, the zoo is recreated not so much through the city or nation-state in which the park is located, but rather through networks of professionals. Digitalized software and molecularized bodies become critical sources of information through which these networked professionals make decisions about endangered animal reproduction. This in turn creates new kinds of identities for zoo animals and zoological parks, which no longer capture wild animals for display but instead use technoscience to (re)create captive populations that are threatened elsewhere (see also Hanson, 2002). This requires new kinds of financial investments, most prominently from the National Institutes of Health and biotechnology companies. In the process, the animal model paradigm becomes less linear and more dynamic through the development of "mixed purpose" models. The linear approach of solving problems with less technological and then more technoscientific interventions is at times replaced by an immediate turn to technoscientific interventions, which is part of the processes of biomedicalization.[57] Here, domestic animals model for the physiologies, technical mediations and/or biopolitics of humans and endangered species simultaneously.

The cloning of endangered animals can also be seen as a site for exploring the micro-practices of such transformations in biopower and biomedicine along with the attendant questions raised. It is likely that many biopolitical quandaries emerging in this post-genomic era will first be worked out with and on animal bodies. This research project has emphasized that assemblages are not cleanly mapped from one species body to another, but rather "tinkered with" (Knorr Cetina, 1999) and made to fit very local settings. Nonetheless, there are dynamic connections made between the assemblages produced to pursue varying human-animal and human-human relations. By tracing these assemblages as they are being

[57] Thank you to Adele Clarke for this point. It is important to point out that this shift is deeply contested in conservation worlds.

produced, we can in turn begin to think through problematic issues in order to carve out desired futures.

For example, the classificatory status of chimeras is a prominent question in discourses regarding the transgenics and cloning. Much of the bioethical and public concern surrounding chimeras has focused on the consequences human-animal chimeras may have for the legal standing of persons. Interspecies nuclear transfer raises similar questions for endangered animals because the process requires that both the bodies and the infrastructures of both domestic and endangered species be transposable. Drawing on Charis Thompson's (2005; 1996) concept "ontological choreography", I argued in Chapter Three that bodily parts and bodies must move between the categories of endangered and domestic species to do the work of cloning endangered wildlife. Comparing the ontological choreography of the cloned gaur and banteng, I contend that *how* this shifting ontology is choreographed has serious implications for the physical wellbeing of the varying organisms involved. In other words, being considered domestic or endangered matters because these classifications come with certain kinds of "built-in" relations that can be more or less helpful in a particular situation. Thompson (1996) found that being "objectified" in the infertility clinic was not so much the problem for the women she spoke with, but rather being inappropriately objectified in the context of a particular situation. I similarly found an endangered animal being "domesticated" in a particular situation was not necessarily a problem, but rather that the ontological choreography was at times not appropriate and this had life or death consequences. For example, the cloned gaur's ontological choreography became problematic when he was categorized as "wild", given non-homogenized milk because of this classification, contracted dysentery, and died. This raises a very different set of concerns than solely considering ontological questions vis-à-vis the law, which to date has required a foundational ontology in matters of conservation (Chapter Five). When and how the incommensurabilities between an ontological choreography in technoscientific reproductive practices and the need for a foundational ontology in law will matter remains an open question.

In addition, this dissertation has shown how emergent transformations in biopolitics are coordinated with more long-standing biopolitical technologies. This is exemplified with the concept of genomic nodes of value. This notion is premised upon the ability to disaggregate genetic information from individual bodies (see also Landecker, 1999; Rabinow, 1996b; Sunder Rajan, 2006; C. Thompson, 2005; Waldby, 2002; Waldby & Mitchell, 2006). Stefan Helmreich (2003) has argued that this kind of disaggregated body is indicative of an emergent biopolitics based on transfer rather than genealogy. However, genomic nodes of value shows how new biopolitical practices (e.g., disaggregating genetic information from individual bodies) are integrated into older biopolitical technologies (e.g., kinship charts). The meanings this has for both traditional and emergent forms of biopower are yet to be seen. But this concept shows that it is not enough to map out transformations in biopolitical apparatuses. Rather, we need to attend to the ways in which long-standing and emergent biopolitical assemblages are being re- and co-constituted.

Finally, this dissertation has begun the work of opening up the animal models paradigm that is so central to biomedical knowledge and technology production. I believe that this critical institution requires further sociological consideration in a manner that parallels how medical sociologists and anthropologists have recently approached clinical trials (e.g., Cartwright, 2007; Fosket, 2002; Lakoff, 2007; Petryna, 2007). I suggest that the animal model paradigm may be shifting in the contemporary moment. This paradigm has been built upon the assumptions of the "great chain of being", evident in the logic that scientists "work up" to humans, from the least to the most complex organism. However, this dissertation has shown how the animal model paradigm does not always operate in such a linear, progressive manner. Barbara Durrant (personal communication, 5/16/06) mentioned to me: "I like to tell people that I use the human to model for endangered species." The interacting dynamics of animal modeling for physiologies, techniques, politics and economies is certainly an area that is open for much further study.

PROVISIONAL CONCLUSIONS

Most cloning discourses focus on how this technique will shape humans, human bodies, subjectivities, and social orders. It is presumed that this shaping only occurs if the technique is used on human bodies. This dissertation ruptures this assumption by showing how humans are implicated in and by animal cloning practices. Developing somatic cell nuclear transfer enacts particular kinds of human-animal and human-human relations. It is used in conjunction with other technologies to generate new kinds of valuation systems in the political economies within which humans are entrenched. Somatic cell nuclear transfer is integrated into assemblages to work out the relations needed between organizations, bodies, techniques, and politics to achieve certain goals based on transforming bodies. While humans may never be cloned using somatic cell nuclear transfer, the development of this technique tells us much about where humans have been (Franklin, 2007) and where humans are going.

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APPENDIX I

INTERVIEW QUESTIONS

Enacting Conservation and Biomedicine: Cloning Animals of Endangered Species in the Cultures of Late Modernity

Researcher/Doctoral Student: Carrie Friese
Department of Social and Behavioral Sciences, UCSF
Principle Investigator/Professor: Adele E. Clarke, Ph.D.
Department of Social and Behavioral Sciences, UCSF

This interview will be open-ended, allowing participants to articulate their own perspectives and experiences. The questions will serve to guide the interview and other questions may be asked in response to the participant's statements.

History of involvement with cloning endangered animals:

1. To start off with, if you could just tell me about your training and how you came to be involved in cloning endangered species?

2. How does your professional background inform this endeavor? What are the professional backgrounds of the people you are working with?

3. How does cloning endangered animals fit within this mission of your department? Within the mission of the overall organization that you are part of?

4. What benefits and/or drawbacks does cloning animals of endangered species have for your department and/or organization?

5. Has your organized received any particular support for pursuing this endeavor? If so, how so and how has your organization responded?

6. Has your organization experienced any particular resistance as you have pursued this endeavor? If so, how has your organization responded?

7. Have the particular publics that your organization interfaces with (e.g. zoo goers, pharmaceutical consumers, farmers, and/or ranchers) influenced your decision to pursue cloning animals endangered animals? If so, how so? Do you think that this has in part shaped the ways in which you have engaged in the project? If so, how so?

Cloning practices:

1. I would like to ask you about the actual projects you and your organization have been involved in. Can you walk me through and describe the steps in cloning _______? (Ask these questions for each animal cloned.)

- How was the project initiated?
- Who funded the research?
- Who did you work with on this project?
- What aspects of the project was your organization responsible for? What aspects were other organizations responsible for? How was this negotiated?
- Did all the organizations involved have the same interests in cloning endangered animal? How were different interests negotiated?
- What difficulties did you experience in the project? What went easily?
- How were materials transported between different groups?
- Was the project a success? Why or why not?
- Do you and your partners have different definitions of a success or a failure?
- It seems to me that in the mass media, the birth of a cloned animal constitutes a success. How does that meet with your own definition of success?

2. I have asked you about projects in cloning endangered animals that I learned about through the news media. Are there any other projects in cloning endangered species that you have been involved in that I haven't asked about?

3. What are your current endeavors in cloning endangered animals? Are these endeavors organized differently than the projects that you told me about previously?

4. Do you have any future plans in terms of cloning endangered animals within your organization? How do you envision the organization of these endeavors?

Thoughts about nuclear transfer in conservation and biomedical research:

1. How do you envision nuclear transfer fitting in with conservation projects? Does this mark a new way of doing conservation? If so, how so? What are the benefits/drawbacks of using nuclear transfer in this context?

2. How do you envision nuclear transfer as fitting in with biomedical research? Does this mark a new way of doing biomedical research? What are the benefits/drawbacks of using nuclear transfer in this context?

3. Where do you see overlaps and/or discrepancies between the use of nuclear transfer in conservation and in biomedical research?

4. How would you describe the relationships between the uses of nuclear transfer with animal tissue to the use of nuclear transfer with human tissue?

5. From my initial review of the use of nuclear transfer with endangered animals, the groups involved in cloning endangered species seem to be biotechnology firms; endangered species research centers, zoos, and veterinary medicine colleges. What are your thoughts about these relationships being forged between these groups? Is there an historical precedent for these kinds of relationships? If so, what kind of history is there? If there isn't a history, why do you think these relationships are being forged now?

6. It seems to me that there would be different understandings of nuclear transfer in the context of different scientific disciplines (e.g. reproductive sciences, population genetics, stem cell research). Do you find this to be so? If so, how so? How are these discrepancies negotiated?

7. What do you think about the metaphor of "reprogramming" in the context of cloning? How do you see that metaphor fitting in with conservation as a project? With biomedicine as project?

8. Those are all the questions that I have at this time. Is there anything else you would like to add?

If I need further information in the future, may I contact your in the future?

APPENDIX II

INTERVIEW CONSENT FORM

UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

CONSENT TO BE A RESEARCH SUBJECT

Enacting Conservation and Biomedicine:
Cloning Animals of Endangered Species in the Cultures of Late Modernity

A. PURPOSE AND BACKGROUND:

Carrie Friese, a doctoral candidate of the Department of Social and Behavioral Sciences at the University of California, San Francisco, is conducting a study about the practice of cloning endangered species in the United States. This project is part of Carrie Friese's dissertation, which is being directed by Professor Adele E. Clarke, Ph.D. Using a sociological approach and drawing upon the concept of "social worlds" this project examines: 1.) how relationships are forged between the different sites, institutions, and scientific communities where cloning endangered species is occurring; 2.) how cloning endangered species is done across these sites and the ways in which differing understandings of the practice are negotiated across social worlds; and 3.) how particular publics (or representations of these publics) are engaged in and by the practice of cloning endangered species. In turn, this dissertation considers what cloning endangered species as a practice tell us about the current socio-historical moment in terms of medicine, science, and human-animal relations. You are being asked to participate because you have been identified as involved in the cloning endangered species endeavor.

B. PROCEDURES:

If you agree to be in the study, the following will occur:

You will be interviewed at a time and place that is convenient for you. The interview will take about one hour. You will be asked about: your work in relationship to cloning endangered species, why you believe cloning endangered species to be important, and your beliefs about cloning in the context of conservation, science, and medicine. If you agree, an audiotape will be made of the interview. Otherwise the interviewer will take notes.

C. RISKS AND DISCOMFORTS:

1. Confidentiality: Participation in research may involve a loss of privacy; however, your records will be handled as confidentially as possible. In order to limit this risk, tapes of the interview and transcribed interviews will be identified only by code number. All study information will be kept in locked files and only study personnel will have access to the files. The tapes will be destroyed after the study has been completed.

2. The interview can be done in one of the following two formats:

A.) **"On the Record,"** meaning you can be quoted or cited by name in reports of the research. If you choose to do an "On the Record" interview, you may designate at any time during the interview that any particular remarks or topic of your choosing should be handled as "Off the Record" and may not be quoted or cited to you;

B.) **"Off the Record,"** in which case you will neither be quoted or cited by name in reports of the research. All personally identifying information will be removed from all interview excerpts and a pseudonym will be used.

3. Regardless of which option you choose, you may refuse to answer any particular question or refuse to be interviewed at all.

E. BENEFITS: There is no direct benefit to any individual participant in the study.

F. COSTS: Aside from your time, there will be no costs to you as a result of taking part in this study.

G. PAYMENT: There will be no payment to you as a result of taking part in this study.

H. QUESTIONS: You have talked to Carrie Friese or Dr. Adele Clarke about this study and have had your questions answered. If you have further questions, you may call Dr. Adele Clarke at (415) 476-0694 or Carrie Friese at (415) 643-4558. If for some reason you do not wish to do this, you can contact the Committee for Human Research, which is concerned with the protection of volunteers in research projects. You may research the committee office between 8:00 a.m. and 5:00 p.m., Monday through Friday, by calling (415) 476-1814 or by writing: Committee on Human Research, Box 0962, University of California, San Francisco / San Francisco, CA 94143.

I. CONSENT: You will be given a copy of this consent form to keep. A copy of the Experimental Subject's Bill of Rights of UC San Francisco is attached for your information.

J. PARTICIPATION IN RESEARCH IS VOLUNTARY: You are free to decline to be in this study, or to withdraw from it at any point.

If you wish to participate, you should check one option and sign below:
You would like your interview to be:
"On the Record" (with limits noted above): ____________
"Off the Record" (nothing will be quoted or cited to you): ____________

Signature of person agreeing to participate:

____

Date: ____

Signature of person obtaining consent:

____

Date: ____

Experimental Subject's Bill of Rights
University of California, San Francisco

The rights below are the rights of every person who is asked to be in a research study. As an experimental subject I have the following rights:

1. To be told what the study is trying to find out,

2. To be told what will happen to me and whether any of the procedures, drugs, or devices is different from what would be used in standard practice,

3. To be told about the frequent and/or important risks, side effects, or discomforts of the things that will happen to me for research purposes,

4. To be told if I can expect any benefit from participating, and, if so, what the benefit might be,

5. To be told of the other choices I have and how they may be better or worse than being in the study,

6. To be allowed to ask any questions concerning the study both before agreeing to be involved and during the course of the study,

7. To be told what sort of medical treatment is available if any complications arise,

8. To refuse to participate at all or to change my mind about participation after the study is started. This decision will not affect my right to receive the care I would receive if I were not in the study,

9. To receive a copy of the signed and dated consent form,

10. To be free of pressure when considering whether I wish to agree to be in the study.

If I have other questions I should ask the researcher or the research assistant. In addition, I may contact the Committee on Human Research, which is concerned with protection of volunteers in research projects. I may reach the committee office by calling: (415) 476-1814 from 8:00 AM to 5:00 PM, Monday to Friday, or by writing to the Committee on Human Research, Box 0962, University of California, San Francisco, CA 94143.

Call 476-1814 for information on translations.

APPENDIX III Positional Map
Positions on the Significance of Somatic Cell Nuclear Transfer to Conservation Practices

DEGREE OF USEFULNESS / TYPES OF EXPERIMENTS

DEGREE OF USEFULNESS	FEASIBILITY STUDIES IN CLONING	STUDIES IN CLONING & GENETIC MANAGEMENT
VERY USEFUL	No position	Cloning creates genetic diversity in small and endangered populations, using existing materials in new and innovative ways that would otherwise be impossible.
MAYBE USEFUL	Cloning represents a tool that may be useful in the future. We need to develop the technique now, with available individuals who may not be genetically valuable, in order to use it with genetically valuable individuals in the future.	May be useful, but there need to be more experiments to see if this could be used more broadly. Also, may be useful because cells rather than animals would be removed from the wild to sustain the genetic diversity of the captive population.
NOT USEFUL	Cloned animals produced through feasibility studies that do not help contribute to the genetic diversity of a small population are not useful. Also, these techniques are unlikely to be incorporated to achieve such a goal.	No position
A DIS-SERVICE	Cloning is represented as a magic bullet, thereby diluting messages about the importance of sustaining habitats.	If mitochondrial DNA is inherited from another species through the cloning process, this will dilute the population and political support for it.

Publishing Agreement

It is the policy of the University to encourage the distribution of all theses and dissertations. Copies of all UCSF theses and dissertations will be routed to the library via the Graduate Division. The library will make all theses and dissertations accessible to the public and will preserve these to the best of their abilities, in perpetuity.

Please sign the following statement:
I hereby grant permission to the Graduate Division of the University of California, San Francisco to release copies of my thesis or dissertation to the Campus Library to provide access and preservation, in whole or in part, in perpetuity.

Carrie Frieso — Author Signature

8/28/07 — Date