CHAPTER 4

Kinship in Hypertext: Transubstantiating Fatherhood and Information Flow in Artificial Life

Stefan Helmreich

I want to introduce to you a unique device for recording the flow of a family history: Bailey's Family Ancestral Album (fifth edition), patented by the Reverend Frederic W. Bailey in 1915 and in use in the United States at about the same time. Its somewhat complex operation is explained and depicted in figures 4.1 and 4.2. Briefly, the device allows a person to record paternal and maternal lines of ancestry in a kind of hypertext book, with links between pages furnished by strategically placed cutaways. An examination of figure 4.2, the first page of a genealogy for George and Martha Washington, illustrates the technique.

KINSHIP IN HYPERTEXT 1

Imagine for a moment that you are Martha Washington. Your husband's line of forefathers is traced up the left side of figure 4.2, matched, on the right side, with their corresponding wives—all, with the exception of George's mother, foremothers of George on his father's side. To trace your own ancestry, you must turn to the page corresponding to your maiden name, Dandridge. It turns out that the Washington page is linked to Dandridge through a cutaway rectangle just to George's right, the rectangle through which you can see your own full maiden name. Poking your finger through this cutaway and lifting the intervening pages brings you to the Dandridge page, which is organized somewhat like the Washington page. Here, you will find your father's patriline as well as cutaways leading to your mother's patriline and those of your paternal foremothers.

By this point you will have noticed that learning about lineages of foremothers in Bailey's odd contrivance requires traveling through the time-space

Bailey's Photo=Ancestral Record

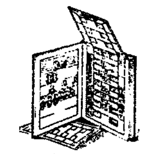
—— OR ——

Family Ancestral Album

"THE RECORD OF MY ANCESTRY"

Fifth Edition, Enlarged and Improved

(PATENTED)



Showing Pages 6 and 7 of Bailey's Ancestral Record filled. (2d Edition.)

DIRECTIONS

To begin your Ancestral Record, turn to page 7 and there, in the lowest left hand square—top line—write (if a married man) your own Christian name.

If a single man or woman, write therein the Christian name of your father.

If a married woman, write therein the Christian name of your husband, while the surname in each case is to be written in the vignette at top and center of the page.

The date of birth and locality follow on line indicated in the square; and to the right of the name add the date and place of marriage; and still farther to the right in the upper line of the square (on page 39) you will write the *full maiden name* of the wife. Now add the names and dates of the birth of the children in space between and below (page 7) and you have a generation recorded.

It is well to complete page 7 as far as possible before attempting any of the others; and so, now proceed to fill the left hand square above the first one already written in. Herein write the Christian name of his father with birth, death, locality; when and where married; and then, over to the right as before, the full maiden name of his wife (on page 23).

Please note here that as we are recording ancestors only, no wife's name is to appear in any square except she be the mother of the succeeding generation and your own ancestress. All the children are to be recorded in the space designed for them and if, of several mothers, their names written at the head of each group; but remember that only your maternal occupies the square opposite your paternal. Proceed thus with page 7 upward from square to square, generation to generation till as far as possible the page is made complete and with all the details supplied. The Washington chart herewith will well illustrate the method of the page.

You will now perceive that to every maternal is devoted a separate page of the book on which to carry back her individual ancestry in the same way as on page 7. Each page arranged for the surname at the top; and with a continuation of cuttings to provide for other maternals farther back.

Proceed now to fill the first maternal page (39), that of your wife or your mother, according as you have begun your book. After recording her birth in square as indicated, write in the lowest left hand square of page 39, the Christian name of her father, and add his surname at top and center of that page. Then as before add his birth and marriage; and over to the right, through the cutting in page, the full maiden name of his wife. Their children will appear on page 39 and will include the name repeated of that daughter in whom you are especially interested.

With this beginning one needs but little additional instruction in the use of the book other than the suggestions noted in detail therein.

The Supplement for attachment to the top of each page where required for a record of the more remote ancestors will be found very useful, though sometimes it may be as well, where only one or two generations are to be recorded, to employ the upper division of the left hand page. Space there is also afforded for a brief account of the early origin of the family and other interesting matter.

We would also call attention to the Appendix at the back of the book. Its sections will be of service for the record of distant maternal lines, which, named in one or other of the upper right hand squares of the book, must by reference be continued here.

Note also that a maternal name appearing in a square thus and referred back, would then be written under the head of the "Children" in the lowest space.

☞ The photographic features of the book deserve special mention. No other ancestral record provides in any way for such an opportunity. And yet, we feel free to say, that if there is a branch of ancestral study more fascinating, it lies here in the gathering of ancestral pictures of persons, homesteads, gravestones, coats of arms, historic scenes, etc., and their preservation as provided for. Oil paintings, silhouettes, daguerreotypes, photographs, likenesses of any kind can be reduced or enlarged to uniform size at very small expense, and unmounted, inserted herein. Space for photographs of the collateral lines with notes is provided in the continued divisions of the left hand pages. And as the faces, etc., of each generation are preserved, no more valuable heir-loom can be found in any family. We are pleased to learn that many Records are used in this way for a Pictorial Family History.

Do not fail to make use of the Index page and there gather together for ready reference all the surnames found in the book.

In proof of your recorded statements add the references in every case. A place is provided. It will make your work more valuable and authoritative.

Use photographers' paste only and good ink always.

The writer, appreciating the popular favor in which the Record is held and desirous of making it of the greatest practical benefit to its possessors, would be pleased to hear from anyone seeking further explanation or suggestion.

FREDERIC W. BAILEY,
33 Harvard Street, Worcester, Mass.

September, 1915.

FIG. 4.1 Instructions for Bailey's Family Ancestral Album.

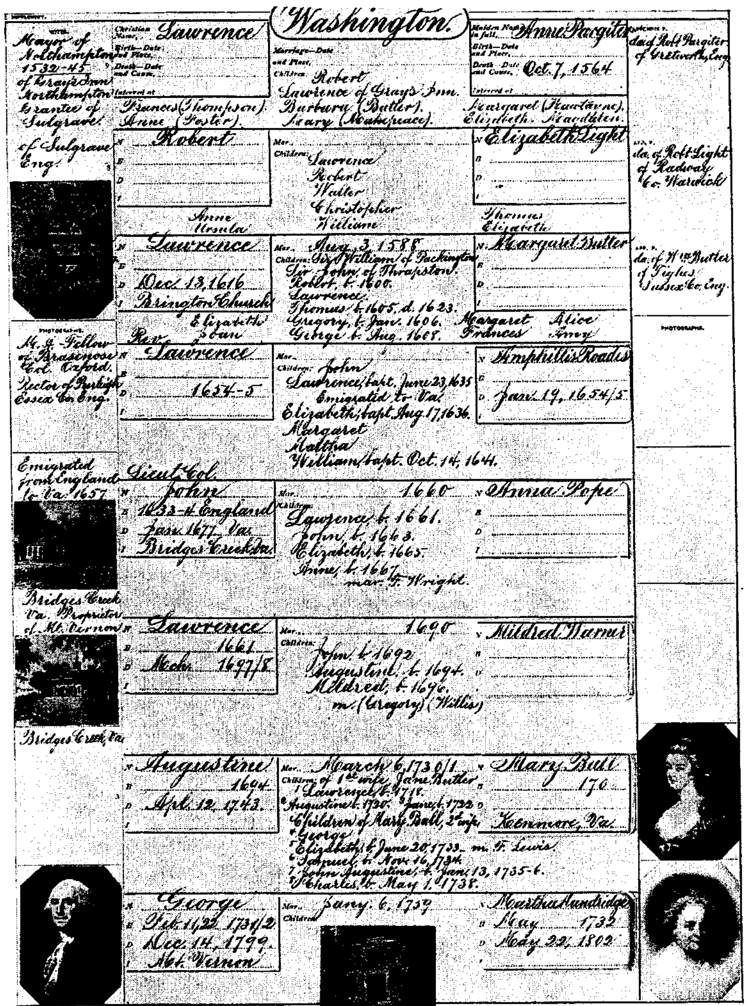


FIG. 4.2 First page of genealogy for George and Martha Washington. Used as an example by Bailey's Family Ancestral Album.

corridors that link mothers to patrilines. If you want to satisfy your curiosity about George's ancestry on his mother's side, for example, you need to turn back to the Washington page and follow the wormhole that leads to Mary Ball and her patriline, recorded on a page leaved somewhere between Washington and Dandridge. Though somewhat cumbersome, this format is meant to allow the tracing of matrilines, often lost in forests of patronyms. As ad copy for Bailey's book puts it, "Every man living has many fathers and mothers great and grand, and he ought to keep a personal record of them and not trust it all to memory or to someone else to keep for him. To be sure it is a complicated problem, especially when it comes to the many mothers every man has who are just as worthy as the many fathers" (Bailey 1915). Bailey's device for tracing Euro-American kinship intends to preserve matrilines through employing something akin to hypertext: a database format in which interconnections between documents can be represented and accessed from within documents themselves, leading the reader into a dense, proliferating net of overlapping and sometimes recursive connections between texts. But even if Bailey means well, his book fortifies the logics by which women's lineages are subordinated to patrilines. Caught between patrinominalism and the bilateralism of a recently rediscovered Mendelian genetics, Bailey's book affirms the flow of blood down lines of fathers.

As a logic and practice, hypertext finds its most recent resonances in computing, in the ways that links are forged between bundles of information on, say, the package of Internet services known as the World Wide Web. In the life worlds of turn-of-the-millennium computing, relationships of shared connection materialize in configurations far messier than those of Euro-American genealogy. But not always. In this essay, I examine how genealogical tales like George and Martha's—tales that focus on fathers—often get downloaded into the work of computer scientists who seek to model populations of real and virtual organisms in cyberspace simulations.

In the mid-1990s, I conducted fieldwork among scientists in the field of Artificial Life, a new science devoted to mimicking the logic of biology in computers. My work was centered at the Santa Fe Institute (SFI) for the Sciences of Complexity in New Mexico, an interdisciplinary research center organized around the notion that computer simulation can provide new tools for theory and experiment in fields ranging from evolutionary biology to economics. Artificial Life researchers claim that life is a property of the formal organization of matter, and they hold that this makes sensible the attempt to model vitality in a computer. Many have found this assertion so compelling that they maintain that alternative, real, artificial life-forms can exist in a computer, and some hope that the creation of computer life will expand biology's purview to include not just *life-as-we-know-it*, but also *life-as-it-could-be*. They hope that through creating swarms of self-replicating entities in virtual worlds, they might add to the dominion of life a new kingdom of organisms existing in the universe of cyberspace.

It is a wish powered in large part by the science-fiction-inspired imagination that many of these relatively young scientists, mostly Euro-American men, possess. SFI is a magnet for scientists who imagine themselves as unorthodox, maverick thinkers; many have histories of participation in the 1960s' counterculture and 1970s' hacker culture, and are attracted to Santa Fe's image as a frontier town, as a place to do pioneering art and science. Unlike nearby Los Alamos National Laboratory with which it once maintained strong links of personnel (SFI was founded by semiretired physicists from the lab), the much smaller institute (only about forty people are in residence at any one time) promotes unclassified research. Its funding from the public-sector National Science Foundation and Department of Energy is joined by moneys from the MacArthur Foundation, private companies, and philanthropic agencies; many locals have quipped that it is meant to be a site for producing technologies of life rather than death. The institute promotes this image, and encourages researchers' speculations on virtual worlds and the realities that might unfold within them (for more on the anthropology of SFI and Artificial Life, see Helmreich 1998).

I argue here that the desire that "life" might emerge through the replication of information structures in cyberspace depends crucially on understandings of genealogy particular to secularized Judeo-Christian patriarchal culture, especially in an age when life has been compressed into genes and genes have become synonymous with information. The digital creations of Artificial Life scientists are linked to their creators through a kind of informatic paternity. "Information" is the shared substance that produces a kinship bond between these scientists and their program progeny. But if information can be used to cement rather conservative narratives of kinship, it can also unglue these stories in surprising ways. Information has properties of its own that contort the landscapes of geneaology and patrilineality, as I hope to show toward the end of this essay.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InstExec  = 0,005911  Cells =   7     Genotypes =     1 Sizes =    1
Extracted =
InstExeC      =        0  Generations   =      0   Mon May  9 21:08:29 1994
     NumCells =        1  NumGenotypes  =      1   NumSizes  =       1
     AvgSize  =       80  NumGenDG      =      1   NumGenRQ  =       1
     RateMut  =     3191  RateMovMut    =    640   RateFlaw  =    9600
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FIG. 4.3 Tierra simulator display.

ARTIFICIAL LIFE CREATION STORIES AND MASCULINE MONOGENESIS

Let me introduce Artificial Life through one of its canonical artifacts: a popular computer program that acts as a model of evolutionary dynamics in populations. This system, crafted by biologist Tom Ray, is called "Tierra," and consists of a large program containing packs of small self-replicating programs. To use Tierra, one must first "inoculate" the system with an "ancestral" self-replicating program. To demonstrate how this works, I narrate the creation in Tierra as it appeared to me when I used the system myself.

To use the Tierra simulator, the user types "tierra" at the prompt. As soon as this word of creation is entered, the user is presented with a display like that in figure 4.3, which includes information about the history of the world as it unfolds. When Tierra is running, these numbers are constantly updating, showing the user how many instructions have been executed, how many generations have been cycled through, how many creatures exist, what the average size of a Tierran organism is, and so on.

The screen text frozen in figure 4.3 is taken from the beginning of a run and reports information sampled from the dawn of a Tierran history. Studying this text, we can see that we are at generation zero and that there is only one digital organism in existence, indicated by NUMCELLS = 1. This is the self-replicating program Ray created from scratch, the program he used and provides to start up the system. Ray explains what we are seeing: "Evolutionary runs of the simulator are begun by inoculating the soup of 60,000 instructions with a single individual of the 80 instruction ancestral genotype" (1992a, 382).

Ray calls this individual the "ancestor" and describes it as a "'seed' self-replicating program" (1992b, 37). Seed is a common word in computer science, usually used in the phrase "random number seed," referring to a pseudo-random number employed as a starting point for a set of computational processes. Ray's phrase echoes this, but also evokes the meaning of seed as a germinal entity that has latent within it the potential to develop into a living thing capable of producing more seeds. Yet the use of the word seed does more than this. Carol Delaney has argued that in cultures influenced by Judeo-Christian narratives of creation and procreation, using the word seed to speak of the impetus of creation summons forth gendered images. In the creation tales of these traditions, God, imagined as masculine, sparks the formless matter of earth to life with a kind of divine seed: the word of creation or *logos spermatikos*. In tales of procreation, males made in the image of a masculine god plant their active "seed" in the passive, receptive, yielding, and nutritive "soil" of females, "fertilizing" them (see Delaney 1986, 1991). Creation and procreation in these narratives are "monogenetic," generated from one source, symbolically masculine. Man and God take after one another. I suggest that the creation in Tierra—and note that Tierra means "soil" as well as "Earth" in Spanish—symbolically mimics the story of creation in the Bible. The programmer is akin to a masculine god who sets life in motion with a word—a word that plants a seed in a receptive computational matrix; a seed that in its search for nourishment, organizes an initially undifferentiated "soup." We might see in Tierra images of a symbolically "male programmer mating with a female program to create progeny whose biomorphic diversity surpasses the father's imagination" (Hayles 1994, 125).

Chris Langton, the computer scientist who gave the field of Artificial Life its name, has claimed that Artificial Life is about "the attempt to abstract the logical form of life in different material forms" (cited in Kelly 1991, 1), a definition that holds that formal and material properties can be usefully partitioned, and that what matters is form. But form and material, like seed and soil, also have gendered valences for those of us swimming down the stream of Western natural philosophy and life sciences. Aristotle proclaimed in his *Generation of Animals* that in procreation, "the male provides the 'form' and the 'principle of movement,' the female provides the body, in other words, the material" (1979, I.XX.729a). Images of form and seed easily overlap in Artificial Life when practitioners make analogies between computer codes (information) and genetic codes. When Ray writes of single-handedly creating digital life in Tierra with a seed, when he remarks that this "digital life exists in a logical, not material, informational universe" (1994, 183), and when he asserts that he occupies the position of God with respect to Tierra, it is hard not

to hear echoes of a masculine monogenetic creation. Certainly this language is playful, especially as most Artificial Life researchers are ardent atheists and enjoy poking fun at institutionalized religion. But it is also essential. The God imagery allows programmers to indulge in the notion that they have created life one moment and to imagine themselves as objective observers, as digital naturalists, the next. Theological and evolutionary language are both needed to bring artificial life-forms to life.

The masculine imagery of seed shows up again and again in Artificial Life, with several programmers going so far as to call their seeds "Adam." Imagery of a masculine creation also surfaces in researchers' casual comments, jokes, and occasionally, confessions about why they do Artificial Life at all. The links between masculinity, paternity, and the creation of Artificial Life worlds were evoked for me one day when, at an institute workshop, a male researcher claimed to have a "grandfatherly pride" in a program he had had the inspiration for, yet had not himself programmed. The symbolically masculine creation of silicon life is a theme some men in Artificial Life explicitly play with; some joke that their wives take care of the kids while they take care of the virtual creatures. Craig Reynolds, in acknowledgments for an article in *Artificial Life IV*, writes, "Special thanks to my wife Lisa and to our first child Eric, who was born at just about the same time as individual 15653 of run C" (1994, 68). Ray quotes his wife, Isabel Ray, in one epigraph: "I'm glad they're not real, because if they were, I would have to feed them and they would be all over the house" (1994, 202). Journalist Steven Levy's pop description of Ray's "creation of life" reruns a Frankensteinian tale of male creation: "On January 3 [1990], working at night on a table in the bedroom of his apartment while his wife slept, Ray 'inoculated' the soup with his single test organism, eighty instructions long. He called it the 'Ancestor'" (1992b, 221). This story also illustrates the way that scientific invention is often understood as analogous to fathering (see Franklin 1995).

In spite of the fathering motifs quilted into Artificial Life talk and programming, some people I interviewed wondered whether Artificial Life might be seen as an expression of male researchers' birth envy. As one biologist told me:

> Women create things, right? We have babies and we certainly know the role of males in that, but it's not clear how much men feel that role, and maybe that's what Artificial Life is. Maybe men would like to give birth to something, and here it is, this is it. They're saying to us, "We're going to beat you guys. We're going to create entire worlds."

One male computer scientist, after several beers, confessed to me that he created artificial worlds in part because he felt frustrated he was not a woman and could not create "naturally" (by birthing). Another person suggested that if pressed to account for the fact that there were more men in Artificial Life than women, he would "propose the theory that men are more frustrated in the urge to create life than women, and that Artificial Life gives an outlet to this frustration." At one conference, I met a young man who had a remarkable set of reflections on this topic:

> In the Middle Ages, male alchemists tried to come up with ways to bypass women in reproduction. I was thinking that Artificial Life research could very easily be just another way of being a surrogate, for males to bear children knowing that they actually can't. It reminds me of something which no one has yet asked me, but which I have thought about—and I still haven't come up with an answer—which is: why it is that I'm interested in Artificial Life and how I can reconcile that with the fact that I'm gay. Of course, the mistake that many people make is that they assume that anyone who is other than straight is going to incorporate their sexuality into everything they do. I am interested in the idea of evolution and reproduction. I've never particularly been interested in *sexual* reproduction. I don't know if that's an artifact of my sexuality or not. [But] it's amusing to think that Artificial Life is overrun by males because it's their way of having babies.

This man's ironic and reflexive musings reveal an intriguing inconsistency. Artificial Life is figured as a practice in potential dissonance with (normatively nonreproductive) gay masculinity, but it is simultaneously construed as something in which men in general—and perhaps gay men in particular—should be interested.

In all these pronouncements, male creation is imagined as fundamentally artificial and female creation as fundamentally natural. Men create artificial life, while women create natural life. There is a curious contradiction here. On one side, females supposedly create naturally and birthing is conflated with reproduction, with males vanishing from the scene. On the other, males are the sole creative force in creation and procreation, with feminine contributions regarded as simply supportive. Female birthing is everything at one moment and nothing in the next—so much nothing that reproduction can proceed without women, can even be pristinely transferred to a different vessel—the computer. Some Christians believe that the pure and uncorrupted Virgin Mary was the perfect vessel for the seed of God, birthing a child who was not half-God, half-Mary, but all God. Computers might be seen as capable of the same clean conception as Mary, bearing faithfully those formal self-reproducing seed programs that are the conceptions of Artificial Life scientists.

Stories of masculine creation usurping or bettering female creation can be found in many scientific narratives. Physicist Brian Easlea (1983) has written of how male nuclear weapons scientists often speak of the bombs they produce as babies, and has interpreted this as bespeaking the desires of a masculine science to appropriate and transcend female reproductive abilities. Hugh Gusterson (1996), in his ethnographic study of weapons scientists, has argued that while there is something notable in how mostly male researchers use this language, it is ultimately unconvincing as a key to their psychology. After all, women can easily use this language, and sometimes do. This language does not reference subconscious motives—like supposed male birth envy—so much as it draws on shared imagery to provide a lexicon for producing artifacts. This is not to say the language is strictly utilitarian; it also reproduces essentialized notions of gender difference. In an effective way, masculine God imagery allows researchers to imagine themselves engaged in fathering new, improved forms of life.

FATHERING ARTIFICIAL LIFE THROUGH THE FIGURE OF INFORMATION

The "vitality" of Tierran "organisms" is not simply or only the effect of narratives of masculine monogenetic creation. The popular and scientific conceit that organisms are merely the readout of a "genetic code" makes possible a collateral collapse of "life" into "program." The kinship that Artificial Life researchers have with their coded creations—the paternity they claim for their virtual organisms—is mediated through their intellect, through the abstraction of information. In fact, some scientists have called artificial life-forms "mind children" (Moravec 1988). This is not surprising given that in Euro-American kinship epistemology, as Marilyn Strathern has observed, "thoughts can be conceived as children are" (1998, 3).

Many researchers I interviewed felt that the near future will see an efflorescence of many new, mostly artificial life-forms, engineered (initially) by humans. Life will exist as pure information in computer networks, as robots, and as genetically engineered organisms. To one researcher, it seemed that the evolutionary process that created humans was continuing as we humans manufacture via artificial means our own evolutionary successors. To be afraid of this process, he said, was perhaps understandable, but was also anthropocentric. There were plenty of things wrong with humans that might be improved or done away with, and he would not be sad to see something "better" emerge, though he admitted that it might take getting used to the idea that "life, instead of being generally mushy and carbon based, like fuzzy teddy bears, could be shiny and metallic." In a way, he felt we humans "owed it to the evolutionary process that created us" to continue its evolutionary work.

Computer scientist Danny Hillis, in a published interview with Steven Levy, put similar thoughts this way:

> I guess I'm not overly perturbed by the prospect that there might be something better than us that might replace us. Because as far as I'm concerned we've just kind of recently crawled out of the muck. We've got a lot of bugs, sort of left over history back from when we were animals. And I see no reason to believe that we're the end of the chain and I think better than us is possible. (cited in Levy 1992a, 39)

In his work, Hillis envisions himself as taking after God in making intelligent computational systems—systems that may potentially, eventually, overtake or surpass him:

> If I put a system inside some future Connection Machine that's the right fertilizer, and I give it the seed of human intelligence by talking to it and interacting with it and telling it what I know, and it grows and flowers into a living being, an intelligent being or something like that, then I created it in exactly the same sense that I've created [a] flower [from planting a seed]. I've made it possible for it to exist, and I've nurtured it, but I didn't make up the rules that made it possible for such a thing to exist. I mean that's a sense in which it's mystic, I mean that's what God did. God made it possible to do that. (cited in Levy 1992a, 41)

The seeds Hillis speaks of are oddly immaterial. They are seeds made of information, the unearthly stuff through which Artificial Life researchers produce their paternity of virtual creatures; it is an updated version of Aristotle's form (see Oyama 1985). Information is understood as a spiritual, masculinized force that can transcend the material, feminized world. With this inflection, quite against the grain of most biological evolutionary theory, Artificial Life stories read as narratives of progress. Evolution reaches into a more perfect future in Artificial Life as information flows down lines of fathers. In this sense, the

evolutionism of Artificial Life actually looks more like the progressivist social evolutionism of nineteenth-century theorists such as Lewis Henry Morgan (see McKinnon, this volume).

Like George Washington, popularly known as the "father" of that transcendent entity known as the United States of America, Artificial Life researchers see themselves as progenitors of abstractions, as fathers of creations that express and embody more elevated, more noble purposes than their own. George Washington came from a line of illustrious fathers, but was transported onto a higher plane when he fathered the nation. So Artificial Life researchers, sprouting from the branches of biological evolution, hope to find their true calling, their true fame, in fathering the next stage of evolution.

KINSHIP IN HYPERTEXT 2

This vision of paternity as primary, as eclipsing all other flows of substance, is central in Euro-American systems of patronymic inheritance. It is codified in such genealogical tools as Bailey's Family Ancestral Album as well as in its late-twentieth-century descendants—like Family Tree Maker 4.0, a program produced by Broderbund Software, Inc., that allows users to create family tree Web pages and link these pages via hypertext to the similarly constructed pages of on-line relatives (see www.familytreemaker.com). The family tales told within these webs are messy, but bend persistently to the logics of paternity.

More informal Web links between people and their relatives exist, and I want to look at just one example here: the link between Artificial Life scientist Ray's Web page and a page constructed by Ray for his toddler daughter, Ariel Ivy Ray. Tom Ray's page affords links to a variety of sites he feels are important, including a host of pages that detail the workings of his Tierra system. But amid this thicket of hypertext links, there is also one leading to a page documenting his family tie to his only child. This page, containing a collection of baby photos, is narrated by Ray in the voice of his daughter:

> I began in August of 1993 when I was conceived by my parents in Santa Fe, New Mexico, where my father was working at the Santa Fe Institute. . . . While I was in my mother's womb, my father spoke to me and played music for me. I like to hear him and I moved when he spoke to me. Then one day I stopped moving, even when he spoke to me. . . . The next morning I arrived by surprise. They called my father at work and

> told him to come to the hospital. He met me in the elevator because they had already taken me out. When I was born, the nurses wrapped me in a blanket. But my father loosened the blanket and freed my arms. He said that he wanted his daughter to be free to feel and manipulate the world. (www.hip.atr.co.jp/-ray/ariel/ivy.html, January 1996)

What jumps out of this text, of course, is Ray's focus on himself as Ariel Ivy's father and his almost complete erasure of Ariel's mother, who appears as a body with virtually no agency. We might well ask how Isabel Ray, named only at the top of this Web page, figures in this story. Perhaps she occupies the same place as Ray's Tierran computer: the nurturing though not generative site for reproduction. After all, as the narrative indicates, Ariel Ivy's life begins at the moment of conception, the moment of the planting of the seed, the point where Ray begins his story. Leaping through hypertext and hyperspace to learn about Ray's human daughter, one sees an affirmation of the logic of paternity.[1]

But this, of course, makes the story too simple. Artificial Life workers are hardly ignorant of the logic of bilateral, biogenetic inheritance. As Ray notes, in an article contending that Artificial Life should not be seen as a sublimation of a "religious" desire to achieve immortality,

> I prefer to achieve immortality in the old-fashioned organic evolutionary way, through my children. I hope to die in my patch of Costa Rican rain forest, surrounded by many thousands of wet and squishy species, and leave it all to my daughter. Let them set my body out in the jungle to be recycled into the ecosystem by the scavengers and decomposers. I will live on through the rain forest I preserved, the ongoing life in the ecosystem into which my material self is recycled, the memes spawned by my scientific works, and the genes in the daughter that my wife and I created. (1994, 204)

In contrast to the monogenetic God Ray played in Tierra, here he is coshareholder in the genetic endowment of his child. Kinship through informatic connection is obviously not essentially monogenetic—or necessarily bilateral or biological, since Ray identifies several streams of informatic transmission—even if the focus is still on transcendence.[2] There are manifold sorts of inheritance that information can underwrite. More than this, though, there are possibilities in the substance of information that quite exceed even Ray's polyglot picture of multiple geneaologies, as I will try to demonstrate below.

RECOMBINATION AND REPRODUCING THE FUTURE

Many Artificial Life scientists are keen to produce evolutionary models that contain sexual recombination, and so, in several simulations, virtual organisms can "mate." Because Artificial Life organisms are made of information, mating really refers to the mutual exchange of computer code.

Mating is usually accomplished though a "genetic algorithm"—a computational procedure that can "evolve" solutions to complex problems by generating populations of possible solutions, and by treating these solutions metaphorically as individuals that can "mate," "mutate," and "compete" to "survive" and "reproduce." In Artificial Life systems, solutions stand for different variants of a kind of program organism. Individuals in the genetic algorithm are represented ultimately as strings of zeroes and ones, and they can produce so-called offspring using a procedure called crossover, thought of as analogous to "sexual recombination." As the inventor of the genetic algorithm puts it, "Biological chromosomes cross over one another when the two gametes meet to form a zygote, and so the process of crossover in genetic algorithms does in fact closely mimic its biological model" (Holland 1992, 68). Algorithmist Lawrence Davis writes, "In nature, crossover occurs when two parents exchange parts of their corresponding chromosomes. In a genetic algorithm, crossover recombines the genetic material in two parent chromosomes to make two children" (1991, 16) (note that the use of familiar language papers over the disanalogy concealed in the example: "in nature," such recombination would not often produce two children). The terms "parents" and "children" are routinely used to refer to genetic algorithm bit strings' "generational" relation to one another: "In reproduction, we use the parent selection technique to pick two *parent* chromosomes. The Reproduction Module applies the one-point crossover and mutate operator to those two parents to generate two new chromosomes, called *children*" (Davis 1991, 12).

There are a number of ways one might understand the exchange of code between programs, but the metaphor of productive heterosexual coupling is consistently emphasized by most researchers. Computer scientist David Goldberg observes, "With an active pool of strings looking for mates, simple crossover happens in two steps: (1) strings are mated randomly, using coin tosses to pair off the happy couples, and (2) mated string couples cross over, using coin tosses to select the crossing sites" (1989, 16). John Holland, the inventor of the procedure, maintains, "As the genetic algorithm proceeds, strong rules mate and form offspring rules that combine their parents' building blocks"

(1992, 71). In a popular account in *Artificial Life,* Steven Levy tells us that "next, the strings mated. In a mass marriage ceremony worthy of Rev. Moon, each string was randomly paired with another" (1992b, 163). A notable algorithmist once said at SFI that he thought intuitively about crossover in the genetic algorithm by "thinking about what it means to recombine my genes and my wife's genes." In these descriptions, monogamous heterosexual marriage (even if pairs are randomly selected) is considered a productive template for natural processes of sexual coupling for reproduction. The commonsensicality of male-female procreative couplings is a resource for thinking about how crossover works in the genetic algorithm. Cultural assumptions and biological reductionisms, even as they sometimes contradict one another, are both enlisted to craft this computational procedure.

In the folk kinship constructs of middle-class Euro-America, the act of heterosexual intercourse that "produces" children is thought to be the generative knot that produces "families" and makes people "related" (Schneider 1968). In Artificial Life, the relatedness of digital organisms is produced through couplings fashioned after this model. The people I interviewed were overwhelmingly Euro-Americans, and David Schneider's reflections on American kinship are directly relevant here: "In American cultural conception, kinship is defined as biogenetic. This definition says that kinship is whatever the biogenetic relationship is. If science discovers new facts about biogenetic relationship, then this is what kinship is and was all along" (1968, 23). For Artificial Lifers, who inhabit a world in which genetics has become an information science, kinship is becoming fundamentally informatic. It should be no surprise that Artificial Life researchers can speak of the "relatedness" of the information structures they think of as organisms. In short, it is no wonder that information has become a kind of shared substance, since as Strathern notes, "in popular parlance [genes] are both substance (the 'blood' that is inherited) and information (codes for saying how cells will develop)" (1998, 19). In an age of genetic fetishism—when genes encode the secret of life itself—this sort of silicon transubstantiation of kinship is not far behind.

But there is something fishy (bacterial?) about the way genetic algorithm bit strings "reproduce." Although people routinely invoke human heterosexual coupling to talk about what goes on in the genetic algorithm, there is no "sexual" difference between genetic algorithm bit strings. The idea that mating can happen between structurally identical entities recalls what Evelyn Fox Keller has labeled the masculine bias of mathematical population genetics. In this discourse, all individuals are structurally equal, all just bags of genes. As Keller remarks,

> Effectively bypassed with this representation were all the problems entailed by sexual difference, by the contingencies of mating and fertilization that resulted from the finitude of actual populations and also, simultaneously, all the ambiguities of the term reproduction as applied to organisms that neither make copies of themselves nor reproduce by themselves. (1992, 132)

Sex becomes an informational affair; no disorderly bodies intervene, and everything is reduced to the all-important seed. Evidence of the popular currency of this definition of sex can be found in conflicting claims to parental custody in some cases of surrogacy and in vitro fertilization, where "parenthood" is sometimes proved by the out-of-body donation of an "essence" of reproduction, genes, that turns mothers into "father-equivalents" (Rothman 1989). Or as one male Artificial Life researcher put it to me, in a sentence that is iconic of the ways genetic relatedness has been culturally isolated as the essential connection between organisms: "Pregnancy is merely an implementation problem."

When virtual organisms reproduce, they do so in artificial worlds that have been provided with a sort of computational imitation of natural selection; in this way, they "evolve." Under this regime, parent programs are understood to be eugenically fit, and productive of offspring that are different from and fitter than they. Computer scientist John Koza writes that "the crossover operation produces two offspring. The two offspring are usually different from their two parents and different from each other. Each offspring contains some genetic material from each of its parents" (1992, 23). Holland continues, "The algorithm favors the fittest strings as parents, and so above-average strings will have more offspring in the next generation" (1992, 68). Computer scientists Larry Eshelman, Richard Caruana, and J. David Schaffer assert that "two parents are selected according to fitness and material between them is exchanged to produce two children which replace them" (1989, 11). And Koza says, "The genetic process of sexual reproduction between two parental computer programs is used to create new offspring computer programs from two parental programs selected in proportion to fitness" (1992, 74–75). Figure 4.4 shows two parental programs from Koza's book, poised to exchange subroutines and create a new, perhaps more effective program.

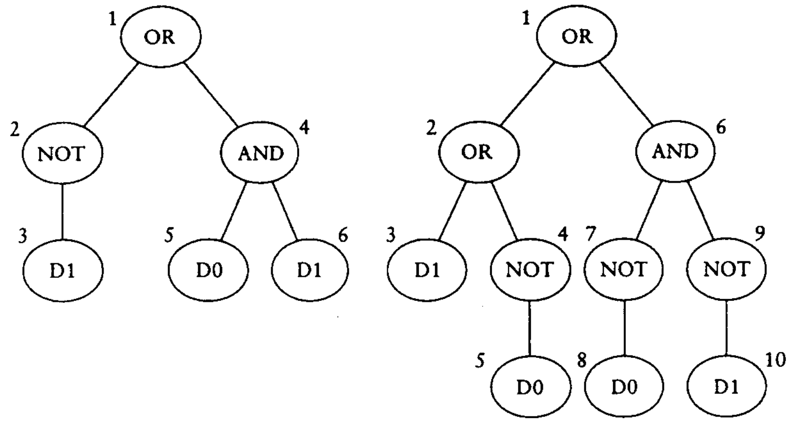

FIG. 4.4 Parent programs from John Koza, *Genetic Programming: On the Programming of Computers by Means of Natural Selection* (Cambridge: MIT Press, 1992), fig. 6.5. Reprinted by permission.

This commitment to the proposition that children should be better off than their parents relies in part on an understanding of kinship as a system that continually generates future possibilities. Marilyn Strathern describes this English and Euro-American view of the future: "Increased variation and differentiation invariably lie ahead, a fragmented future as compared with a communal past. To be new is to be different. Time increases complexity" (1992a, 21). Strathern maintains that for Euro-Americans, "kinship delineated a developmental process that guaranteed diversity, the individuality of persons and the generation of future possibilities" (39). In this system, children are "new" "individuals" that emerge from parental relations. She argues that the Euro-American reproductive model is itself an algorithm for the generation of future possibilities—something of great use to those who would write programs that produce new programs.[3] The synopsis Strathern provides of a child's genetic "individuality" might equally well be applied to the brave new organisms of Artificial Life and genetic algorithms:

> The child's guarantee of individuality lies in genetic origin: its characteristics are the outcome of a chance combination from a range of possibilities. . . . Genetic potential . . . maintains an array of possible characteristics from which an entity might emerge; the future is known . . . by its unpredictability, and one would not necessarily wish to anticipate it. (1992b, 172)

All this talk of ever newer and fitter organisms reproduced by recombination in artificial worlds suggests that not all recombinations are equal. There is a strong eugenicist charge to this digital Darwinism. In my survey of the genetic algorithm literature, I found declarations that programs should be prevented from crossing with programs *too similar* to themselves—an operation that could stall the generation of new solutions. To accomplish this, one set of researchers has proposed the installation of an "incest taboo" in their system (Eshelman and Schaffer 1991). And in an effort to keep populations of genetic algorithm individuals "evolving" toward better solutions, some researchers have proposed regulating the kinds of individuals that can cross, introducing what they call "marriage restrictions" (see Goldberg 1989). They reason that crosses between strings that are *too different* might disrupt a population's accumulation of useful and potentially optimal genetic combinations. In discussions around this strategy, researchers often employ highly racialized imagery. For instance, in an Artificial Life system named PolyWorld, restrictions can be enforced in order to encourage the divergence of populations (as genetically interbreeding groups) using a tool called the

> "miscegenation function" (so dubbed by Richard Dawkins), that may be used to probabilistically influence the likelihood of genetically dissimilar organisms producing viable offspring; the greater the dissimilarity, the lower the probability of their successfully reproducing. (Yaeger 1994, 272)

Miscegenation is, of course, a loaded term, referring not to mixing between species or incipient species but to mixing between so-called races. The racial and eugenic logics skittering below the surface of genetic algorithms are made explicit here, and key one into a notion of races as distinct genetic groups, rather than socially constructed groupings. Genetic difference, coded here as biological race, is to be handled carefully, with one population kept pure of information contamination from others. In the universes of Artificial Life, sexual recombination, which produces new combinations of traits, must be kept within boundaries, lest lineages lose their vigor. Donna Haraway has suggested that "racial hygiene and its typological syntax are not supported by genome discourse, or by artificial life discourses in general" (1997, 248). This is not always true; early-twentieth-century notions of race can still shape the biology of bits and bytes.

Artificial Life scientists see themselves as ushering in a new stage of evolution, one in which new life-forms will be birthed through scientific conceptions that lead to self-reproducing computer programs. They view biological reproduction and the machinic reproduction they are engineering as parts of a larger evolutionary story, and see themselves as "in the employ" of evolution, creating new life-forms that will unchain themselves from carbon chemistry, perhaps traveling off-planet in the silicon splendor of robot bodies. Artificial Life researchers can claim that organic biological reproduction can be subsumed, transcended, and devoured by new techno-biological reproduction because they participate in a culture that uses the word reproduction to refer to both the perpetuation of practices and ideas and the generation of new organic beings (see Harris and Young 1981). This is how Artificial Life has become thinkable.

Strathern has commented that the Euro-American reproductive model "makes us greedy for both change and continuity, as though one could bring about momentous (episodic) change while still being regarded as the continuous (evolutionary) originators of it" (1992b, 177). These words illuminate the cultural logic beneath Artificial Life researchers' contentions that the manufacture of Artificial Life is both novel and evolutionarily inevitable. When Christopher Langton writes, "The creation of life is not an act to be undertaken lightly. We must do what we can to ensure that the future is equally bright for both our technological and our biological offspring" (1992, 22), we learn that reproduction is the real fuel for Euro-American time travel into the future.

MUTATING KINSHIP IN THE AGE OF INFORMATION

But reproduction can never be counted on to work perfectly, to copy faithfully its objects and subjects indefinitely. As Strathern notes, "The ideas that reproduce themselves in our communications *never reproduce themselves exactly.* They are always found in environments or contexts that have their own properties or characteristics" (1992b, 6). Reproduction always reconfigures the kinship structures in which it works. And kinship, in the age of recombinant information, is no longer so easy to delineate.

In traditional anthropology, kinship has often been defined as the social organization of "the facts of life," as a social arrangement modeled after and attentive to genealogical, biogenetic connection. Recent anthropological reconsiderations, however, have reoutfitted kinship as a concept that refers to

how people make sense of social connection in general; kinship may make reference to biogenetics, but may also implicate political, class, caste, racialized, sexualized, and religious affiliations (see, for example, Stack 1974; Geertz and Geertz 1975; Yanagisako and Collier 1987; Weston 1991). Contemporary practices of genetic engineering, new reproductive technology, and information science force still further changes in accountings of kinship, especially since "biology" still haunts the landscape of relatedness (see, this volume, Thompson; Franklin). In *Modest_Witness@Second_Millennium.Female Man©_Meets_OncoMouse™*, Haraway provides some useful remappings of this mutated terrain. She argues that kin are "tied to each other by the passage of bodily substance" (1997, 22), but notes that where the passage of bodily substance once referred exclusively to the flow of blood or genes down generations, it now enfolds multiple kinds of connections between such entities as humans, transgenic organisms, and machines. OncoMouse™, the transgenic rodent that reliably develops breast cancer, is kin, is sister, to the human females with whom she shares a particular kind of tumor-producing gene. As Haraway observes, "Transgenic creatures, which carry genes from 'unrelated' organisms, simultaneously fit into well-established taxonomic and evolutionary discourses and also blast widely understood senses of natural limit. What was distant and unrelated becomes intimate" (56). And in an era when genes have become information, transgenic creatures are also kin to other sorts of text-based creations, like the various genome projects' databases, which provide information enabling new sorts of organisms to be intellectually and corporeally conceived.

As information becomes a conduit for thinking kin connection, it enters into confluence and interference with the concept of "substance." Janet Carsten (this volume) points out that substance—a word that has referred to that which anchors "natural" relatedness in U.S. kinship—is a notoriously ambiguous term. It "accommodates a remarkable range of indigenous meanings, including bodily matter, essence, and content in opposition to form, as well as differences in degrees of mutability and fluidity" (Carsten, this volume). In so doing, substance oscillates between essence and corporeal matter, and sometimes seems to mean both. When substance is filtered through the lens of information, this oscillation is intensified. Information has historically had two primary meanings. The first is simply a quantitative measure of the complexity of a linear code or message and has nothing to do with what the code or message means. How *much* information is there? The second, associated with computer programming, attaches to the concept of instruction or program, for which meaning is of the utmost concern (see Keller 1995). Information, then, like substance, sometimes refers to abstract form and sometimes to content.[4] But information also overflows substance because what it can contain as content or meaning is so ambiguous—information can be "about" anything (Oyama 1985), which is one reason it can connect entities such as humans, transgenic mice, and digital organisms.

Carsten says that she is "more interested in what substance *does* than what it *is*." I have the same curiosity about information. I think that what information *does* when it becomes a kind of shared substance is to both solidify and disturb the neatness of lineage. Kinship in the age of informatically enabled transubstantiation is no longer only or so cleanly about family trees or roots.[5] Transgenic tomatoes containing genes from flounders are a sign that lines of kinship are becoming rhizomatic—webbing together in new formations that not only ramify but rejoin and connect in recursive ways. Under the sign of information, we get hybrids of the natural and artificial, the organic and technological, and the fictional and factual. Chimerical creatures like OncoMouse™ and the FlavrSvr tomato become possible, the spawn of technologies of genetics and informatics. In this regime, the stability of such concepts as lineage, paternity, or racial purity is decidedly at risk. Though it has a hypertext format, Bailey's Family Ancestral Album is tailored to patrilineal tales and would be hard-pressed to contain all the new sorts of connection that informatics makes possible.

What else about information might destabilize tales of patrilineal inheritance, even against the apparent efforts of some Artificial Life scientists to download such stories into the future? What else does information *do*? Because it also carries the meaning of "instruction" or "code," it resonates with "code for conduct" as well—the item that in Schneiderian kinship theory at least, is often contrasted with substance. While substance refers to natural connection, code refers to relationships by law. "Blood relations" materialize in Euro-American kinship when substance and code are conjoined by heterosexual intercourse and the legitimating institution of marriage. When information replaces blood as that which ties substance and code together, different sorts of relationships become thinkable. To begin with, the close connection between kinship and gender that post-Schneiderian theory assumes (see Yanagisako and Collier 1987) becomes unfastened—extending the unbraiding of sex, gender, and reproduction highlighted in recent discussions of new reproductive technologies as well as lesbian and gay kinships (see,

for example, Strathern 1992b; Weston 1991; Hayden 1995). Because information as a substance is less sexualized than blood or genes as it is differently embodied/materialized (Franklin 1995), the kinship it underwrites may have quite different implications for gender. Mothers, fathers, women, and men may morph, mix, and meet new sorts of kinship agencies and entities—like multinationals with legal rights and interests in patented genes or transgenic creatures. Novel sorts of corporate bodies could attain the status of "in-laws," as witnessed by the government of Iceland's recent decision to sell the rights to its national genome—the genetic sequence data of its citizenry—to a private pharmaceutical company that hopes to "mine" it for useful therapeutic information. In a world where genomes are for sale, the claims of so-called mothers and fathers to their children are being renegotiated.

The presence of law and capital on the scene should signal that property persists as an important player in kinship. What Johann Jakob Bachofen, Lewis Henry Morgan, and Friedrich Engels saw as a crucial ingredient in the consolidation of patrilineality and patriarchy now points away from systems of consanguinity toward corporate affinities. Charles Darwin argued that "natural classification" must follow and reflect genealogical history, the history of the transmission of hereditary properties in ramifying family lineages ([1859] 1964, 411–34). These days, mapping the socionatural terrain of "life" requires knowing who owns what. In Haraway's terms, we are witnessing a transition from a concern with natural kinds to a concern with brands—generic marks, new sorts of genres, genders, typologies, and typographies of kinship categories. The Motorola corporation now offers "DigitalDNA™," an embedded microchip that "breathes life into products, from simple things such as a coffeemaker to complex things like a computer" (Motorola 1998). DigitalDNA™, suffused with the public relations and protocols of Artificial Life technology, naturalizes the commodity fetishism that allows corporations and their customers to see products as the animate entities that struggle to exist in the Darwinian marketplace.

KINSHIP IN HYPERTEXT 3

Haraway has contended that hybrid creations like OncoMouse™ are kinds of tricksters—vampires polluting "the lineage of nature itself—transforming nature into its binary opposite, culture" (1997, 60), and she maintains that the currency that enables this transformation, this exchange of logics, is

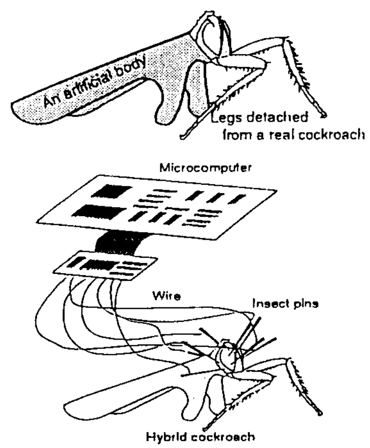

FIG. 4.5 A hybrid cockroach robot from Hirofumi Miura, Takashi Yasuda, Yayoi Kubo Fujisawa, Yoshihiko Kuwana, Shoji Takeuchi, and Isao Shimoyama, "Insect-Model Based Microrobot," in *Artificial Life V*, ed. Christopher G. Langton and Katsunori Shimohara (Cambridge: MIT Press, 1997), fig. 7. Reprinted by permission.

information. Information is the stuff that allows some scientists to contemplate splicing carbon-based life-forms to silicon-based computer systems, to think of making not only transgenic organisms but what I would call "transinformatic" creatures—like the hybrid cockroach robot reproduced in figure 4.5, created by Artificial Life researcher Hirofumi Miura and his Tokyo team (1997). This creation—a compound of paper body, insect legs, and microcomputer—is an artificial life-form that is neither virtual nor transgenic, nor more bizarrely, living or dead.[6] Mixing signals from nature and culture, it is the result of a new sort of AI: Alchemical Informatics, not Artificial Intelligence. The kinship that this artificial insect has with other things in the world looks more like hypertext than genealogy. Its kinship network extends into a worldwide web of computer science, biology, and capital. Asking after its "parents" lands one in a net of techno-scientific relationships, none of which can be reduced to the traditional descent categories of Euro-American kinship.

Paul Edwards has characterized hypertext as a mode of connection that relentlessly brings together elements from widely different and sometimes contradictory domains. According to Edwards, "Hypertext is fundamentally unstable, open for constant revision" (1994, 232). A never finished set of connections between an often heterogeneous set of entities, it demands ever-mutating reading practices. In the techno-scientific worlds of Artificial Life, tales of fathering are linked to a net of beliefs about monogenetic creation, progress, purity, and genius. But because these stories are told in the tongue of

information—a language capable of making surprising connections between radically different orders of things—they are ever in danger of dissolving. Kinship, in the age of Artificial Life, threatens and promises to run away into the rhizomatic world of hyperactive hypertext—a world that may be difficult to contain within the frames of masculine monogenesis and patrilineality.

I think some sense may be made of this proliferation of connection and definition by returning to the concept of kinship within anthropology. Artificial Life and anthropology are both enmeshed in modernity's vexed project of self-examination and self-critique, and both are in transformation as their most paradigmatic objects of investigation—life and kinship—are under stress as coherent categories. Life occupies the same position in Artificial Life as kinship has in anthropology. Artificial Life assumes that the category of life can be universalized to both carbon and silicon creations, but this ignores that life is not only a contingent fact of the history of biology on earth but also, as Michel Foucault taught in *The Order of Things* (1966), a contingent category of the history of natural philosophy. Life only emerged as a force or principle unifying living things because of formalist commitments in taxonomy. Similarly, traditional anthropology assumed that kinship was a universal formation connecting the order of nature to the order of culture, but failed to recognize the cultural specificity of social and symbolic valuations of genealogy and blood. All this is not to say that biologists or anthropologists should discard life or kinship as categories. Rather, it must be recognized that these terms have histories that inform any possible attempts to redefine them. The denaturalization of kinship available through the logic of information is a challenge to take up the work of articulating relationships in ways that accent shared responsibility and risk, not just shared substance.

NOTES

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1 An affirmation that, as Mary Bouquet (this volume) might remind us, is reinforced by the display of the family photo, a kind of technologically materialized substance that helps make kinship ties "real." When people put baby photos on-line, often on their

"home page," they assert and even advertise what they believe their kin connections to be.

2 Note, too, that while Ray's image of his body as compost for "life" acknowledges matter as crucial for vitality, this matter is primarily coded as dead stuff in need of recycling.

3 This sort of Artificial Life practice contrasts with the fashioning of patented lab animals in which stopping the evolutionary process and holding reproduction constant is the goal (see Haraway 1997; Franklin, this volume).

4 Strathern (1998) has argued that Euro-Americans believe that information about biogenetic relationships is identical to those relationships themselves, and Bouquet (this volume) has shown how artifacts such as family photos can act as informational substances that solidify normative notions of family.

5 It should be noted, of course, that "blood" was never a completely neat way of signaling genealogical flows; blood can run in pathways that cut across the grain of lineal relations (see Weston, this volume).

6 Informatics is also responsible for blurring this boundary between life and death in other domains, especially as it becomes technologically possible to mine and revive the genes of organisms long dead. Of course, Euro-American kinship has long been predicated on symbolically linking the living to the dead, as Gillian Feeley-Harnik (this volume) argues in her astonishing account of the ways Lewis Henry Morgan's theories of consanguinity were inspired by his desire to communicate with and feel connected to his prematurely departed daughters. Morgan's obsession with railroads may have emerged in part from his regret that he could not come sooner to his dying daughters' sides; train tracks, laid alongside the North American rivers that Morgan compared to the channels of blood linking human families, could be crucial technologies in kinship networks. Many decades later, telephone lines—first set alongside these same railroad tracks—would become the conduits for which information theory would be developed (helping predict the communication capacity of these filaments), and would themselves become pathways for reinforcing old and new kinship relations (telephones were also early technologies through which the living tried to contact the dead [see Ronell 1989]).

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RELATIVE VALUES

Reconfiguring Kinship Studies

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