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Remaking Eden: How Genetic

Engineering and Cloning will

Transform The American Family.

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Prologue

A Glimpse of Things to Come

DATELINE BOSTON: JUNE 1, 2010

Sometime in the not-so-distant future, you may visit the maternity ward at a major university hospital to see the newborn child or grandchild of a close friend. The new mother, let's call her Barbara, seems very much at peace with the world, sitting in a chair quietly nursing her baby, Max. Her labor was—in the parlance of her doctor—"uneventful," and she is looking forward to raising her first child. You decide to make pleasant conversation by asking Barbara whether she knew in advance that her baby was going to be a boy. In your mind, it seems like a perfectly reasonable question since doctors have long given prospective parents the option of learning the sex of their child-to-be many months before the predicted date of birth. But Barbara seems taken aback by the question. "Of course I knew that Max would be a boy," she tells you. "My husband Dan and I chose him from the embryos we made. And when I'm ready to go through this again, I'll choose a girl to be my second child. An older son and a younger daughter—a perfect family."

Now, it's your turn to be taken aback. "You made a conscious choice to have a boy rather than a girl?" you ask.

"Absolutely!" Barbara answers. "And while I was at it, I made sure that Max wouldn't turn out to be fat like my brother Tom or addicted to alcohol like Dan's sister Karen. It's not that I'm personally biased or anything," Barbara continues defensively. "I just wanted to make sure that Max would have the greatest chance for achieving success. Being overweight or alcoholic would clearly be a handicap."

You look down in wonderment at the little baby boy destined to be moderate in both size and drinking habits.

Max has fallen asleep in Barbara's arms, and she places him gently in his bassinet. He wears a contented smile, which evokes a similar smile from his mother. Barbara feels the urge to stretch her legs and asks whether you'd like to meet some of the new friends she's made during her brief stay at the hospital. You nod, and the two of you walk into the room next door where a thirty-five-year old woman named Cheryl is resting after giving birth to a nine-pound baby girl named Rebecca.

Barbara introduces you to Cheryl as well as a second woman named Madelaine, who stands by the bed holding Cheryl's hand. Little Rebecca is lying under the gaze of both Cheryl and Madelaine. "She really does look like both of her mothers, doesn't she?" Barbara asks you.

Now you're really confused. You glance at Barbara and whisper, "Both mothers?"

Barbara takes you aside to explain. "Yes. You see Cheryl and Madelaine have been living together for eight years. They got married in Hawaii soon after it became legal there, and like most married couples, they wanted to bring a child into the world with a combination of both of their bloodlines. With the reproductive technologies available today, they were able to fulfill their dreams."

You look across the room at the happy little nuclear family—Cheryl, Madelaine, and baby Rebecca—and wonder how the hospital plans to fill out the birth certificate.

DATELINE SEATTLE: MARCH 15, 2050

You are now forty years older and much wiser to the ways of the modern world. Once again, you journey forth to the maternity ward. This time, it's your own granddaughter Melissa who is in labor. Melissa is determined to experience natural childbirth and has refused all offers of anesthetics or painkillers. But she needs something to lift her spirits so that she can continue on through the waves of pain. "Let me see her pictures again," she implores her husband Curtis as the latest contraction sweeps through her body. Curtis picks the photo album off the table and opens it to face his wife. She looks up at the computer-generated picture of a five-year-old girl with wavy brown hair, hazel eyes, and a round face. Curtis turns the page, and Melissa gazes at an older version of the same child: a smiling sixteen-year-old who is 5 feet, 5 inches tall with a pretty face. Melissa smiles back at the future picture of her yet-to-be-born child and braces for another contraction.

There is something unseen in the picture of their child-to-be that provides even greater comfort to Melissa and Curtis. It is the submicroscopic piece of DNA—an extra gene—that will be present in every cell of her body. This special gene will provide her with lifelong resistance to infection by the virus that causes AIDS, a virus that has evolved to be ever more virulent since its explosion across the landscape of humanity seventy years earlier. After years of research by thousands of scientists, no cure for the awful disease has been found, and the only absolute protection comes from the insertion of a resistance gene into the single-cell embryo within twenty-four hours after conception. Ensnared in its chromosomal home, the AIDS resistance gene will be copied over and over again into every one of the trillions of cells that make up the human body, each of which will have its own personal barrier to infection by the AIDS-causing virus HIV. Melissa and Curtis feel lucky indeed to have the financial wherewithal needed to endow all of their

children with this protective agent. Other, less well-off American families cannot afford this luxury.

Outside Melissa's room, Jennifer, another expectant mother, is anxiously pacing the hall. She has just arrived at the hospital and her contractions are still far apart. But, unlike Melissa, Jennifer has no need for a computer printout to show her what her child-to-be will look like as a young girl or teenager. She already has thousands of pictures that show her future daughter's likeness, and they're all real, not virtual. For the fetus inside Jennifer is her identical twin sister—her clone—who will be born thirty-six years after she and Jennifer were both conceived within the same single-cell embryo. As Jennifer's daughter grows up, she will constantly behold a glimpse of the future simply by looking at her mother's photo album and her mother.

DATELINE U.S.A.: MAY 15, 2350

It is now three hundred years later and although you are long since gone, a number of your great-great-great-great-great-great-great-great-grandchildren are now alive, mostly unbeknownst to one another. The United States of America still exists, but it is a different place from the one familiar to you. The most striking difference is that the extreme polarization of society that began during the 1980s has now reached its logical conclusion, with all people belonging to one of two classes. The people of one class are referred to as *Naturals*, while those in the second class are called the *Gene-enriched* or simply the *GenRich*.

These new classes of society cut across what used to be traditional racial and ethnic lines. In fact, so much mixing has occurred during the last three hundred years that sharp divisions according to race—black versus white versus Asian—no longer exist. Instead, the American populace has finally become the racial melting pot that earlier leaders had long hoped for. The skin color of Americans comes in all shades from African brown to Scandinavian pink, and traditional Asian facial features

are present to a greater or lesser extent in a large percentage of Americans as well.

But while racial differences have mostly disappeared, another difference has emerged that is sharp and easily defined. It is the difference between those who are genetically enhanced and those who are not. The GenRich—who account for 10 percent of the American population—all carry synthetic genes. Genes that were created in the laboratory and did not exist within the human species until twenty-first century reproductive geneticists began to put them there. The GenRich are a modern-day hereditary class of genetic aristocrats.

Some of the synthetic genes carried by present-day members of the GenRich class were already carried by their parents. These genes were transmitted to today's GenRich the old-fashioned way, from parent to child through sperm or egg. But other synthetic genes are new to the present generation. These were placed into GenRich embryos through the application of genetic engineering techniques shortly after conception.

The GenRich class is anything but homogeneous. There are many types of GenRich families, and many subtypes within each type. For example, there are GenRich athletes who can trace their descent back to professional sports players from the twenty-first century. One subtype of GenRich athlete is the GenRich football player, and a sub-subtype is the GenRich running back. Embryo selection techniques have been used to make sure that a GenRich running back has received all of the natural genes that made his unenhanced foundation ancestor excel at the position. But in addition, at each generation beyond the foundation ancestor, sophisticated genetic enhancements have accumulated so that the modern-day GenRich running back can perform in a way not conceivable for any unenhanced Natural. Of course, all professional baseball, football, and basketball players are special GenRich subtypes. After three hundred years of selection and enhancement, these GenRich individuals all have athletic skills that are clearly "nonhuman" in the traditional sense. It would be impossible for any Natural to compete.

Another GenRich type is the GenRich scientist. Many of the synthetic genes carried by the GenRich scientist are the same as those carried by all other members of the GenRich class, including some that enhance a variety of physical and mental attributes, as well as others that provide resistance to all known forms of human disease. But in addition, the present-day GenRich scientist has accumulated a set of particular synthetic genes that work together with his "natural" heritage to produce an enhanced scientific mind. Although the GenRich scientist may appear to be different from the GenRich athlete, both GenRich types have evolved by a similar process. The foundation ancestor for the modern GenRich scientist was a bright twenty-first-century scientist whose children were the first to be selected and enhanced to increase their chances of becoming even brighter scientists who could produce even more brilliant children. There are numerous other GenRich types including GenRich businessmen, GenRich musicians, GenRich artists, and even GenRich intellectual generalists who all evolved in the same way.

Not all present-day GenRich individuals can trace their foundation ancestors back to the twenty-first century, when genetic enhancement was first perfected. During the twenty-second and even the twenty-third centuries, some Natural families garnered the financial wherewithal required to place their children into the GenRich class. But with the passage of time, the genetic distance between Naturals and the GenRich has become greater and greater, and now there is little movement up from the Natural to GenRich class. It seems fair to say that society is on the verge of reaching the final point of complete polarization.

All aspects of the economy, the media, the entertainment industry, and the knowledge industry are controlled by members of the GenRich class. GenRich parents can afford to send their children to private schools rich in the resources required for them to take advantage of their enhanced genetic potential. In contrast, Naturals work as low-paid service providers or as laborers, and their children go to public schools. But twenty-fourth-century public schools have little in common with their

predecessors from the twentieth century. Funds for public education have declined steadily since the beginning of the twenty-first century, and now Natural children are only taught the basic skills they need to perform the kinds of tasks they'll encounter in the jobs available to members of their class.

There is still some intermarriage as well as sexual intermingling between a few GenRich individuals and Naturals. But, as one might imagine, GenRich parents put intense pressure on their children not to dilute their expensive genetic endowment in this way. And as time passes, the mixing of the classes will become less and less frequent for reasons of both environment and genetics.

The environmental reason is clear enough: GenRich and Natural children grow up and live in segregated social worlds where there is little chance for contact between them. The genetic reason, however, was unanticipated.

It is obvious to everyone that with each generation of enhancement, the genetic distance separating the GenRich and Naturals is growing larger and larger. But a startling consequence of the expanding genetic distance has just come to light. In a nationwide survey of the few interclass GenRich-Natural couples that could be identified, sociologists have discovered an astounding 90 percent level of infertility. Reproductive geneticists have examined these couples and come to the conclusion that the infertility is caused primarily by an incompatibility between the genetic makeup of each member.

Evolutionary biologists have long observed instances in which otherwise fertile individuals taken from two separate populations prove infertile when mated to each other. And they tell the sociologists and the reproductive geneticists what is going on: the process of species separation between the GenRich and Naturals has already begun. Together, the sociologists, the reproductive geneticists, and the evolutionary biologists are willing to make the following prediction: If the accumulation of genetic knowledge and advances in genetic enhancement technology continue at the present rate, then by the end of the third

millennium, the GenRich class and the Natural class will become the GenRich humans and the Natural humans—entirely separate species with no ability to cross-breed, and with as much romantic interest in each other as a current human would have for a chimpanzee.

DATELINE PRINCETON, NEW JERSEY: THE PRESENT

Are these outrageous scenarios the stuff of science fiction? Did they spring from the minds of Hollywood screenwriters? No. The scenarios described under the first two datelines emerge directly from scientific understanding and technologies that are already available today. The scientific framework for the last scenario is based on straightforward extrapolations from our current knowledge base. Furthermore, if biomedical advances continue to occur at the same rate as they do now, the practices described are likely to be feasible long before we reach my conservatively chosen datelines. Whether they are used or not will come down to politics.

It's time to take stock of the current state of science and technology in the fields of reproduction and genetics and to ask, in the broadest terms possible, what the future may hold. Most people are aware of the impact that reproductive technology has already had in the area of fertility treatment. The first "test tube baby"—Louise Brown—is already eighteen years old, and the acronym for in vitro fertilization—IVF—is commonly used by laypeople. The cloning of human beings has become a real possibility as well, although many are still confused about what the technology can and cannot do. Advances in genetic research have also been in the limelight, with the almost weekly identification of new genes implicated in diseases like cystic fibrosis and breast cancer, or personality traits like novelty-seeking and anxiety.

What has yet to catch the attention of the public at large,

however, is the incredible power that emerges when current technologies in reproductive biology and genetics are brought together in the form of *reprogenetics*. With reprogenetics, parents could gain complete control over their genetic destiny, with the ability to guide and enhance the characteristics of their children, and their children's children as well. But even as reprogenetics makes dreams come true, like all of the most powerful technologies invented by humankind, it may also generate nightmares of a kind not previously imagined.

Of course, just because a technology becomes feasible does not mean that it will be used. Or does it? Society, acting through government intervention, could outlaw any one or all of the reprogenetic practices that I have described. Isn't the *nonuse* of nuclear weapons for the purpose of mass destruction over the last half century an example of how governments can control technology?

There are two big differences between the use of nuclear technology and reprogenetic technology. These differences lie in the resources and money needed to practice each. The most crucial resources required to build a nuclear weapon—large reactors and enriched sources of uranium or plutonium—are tightly controlled by the government itself. The resources required to practice reprogenetics—precision medical tools, small laboratory equipment, and simple chemicals—are all available for sale, without restriction, to anyone with the money to pay for them. The cost of developing a nuclear weapon is billions of dollars. In contrast, a reprogenetics clinic could easily be run on the scale of a small business anywhere in the world. Thus, even if restrictions on the use of reprogenetics are imposed in one country or another, those intent on delivering and receiving these services will not be restrained. But on what grounds can we argue that they should be restrained?

In response to this question, many people point to the chilling novel *Brave New World* written by Aldous Huxley in 1931. It is the story of a future worldwide political state that exerts complete control over human reproduction and human nature

as well. In this brave new world, the state uses fetal hatcheries to breed each child into a predetermined intellectual class that ranges from alpha at the top to epsilon at the bottom. Individual members of each class are predestined to fit into specific roles in a soulless utopia where marriage and parenthood are prevented and promiscuous sexual activity is strongly encouraged, where universal immunity to diseases has been achieved, and where an all-enveloping state propaganda machine and mood-altering drugs make all content with their positions in life.

While Huxley guessed right about the power we would gain over the process of reproduction, I think he was dead wrong when it came to predicting *who* would use the power and for what purposes. What Huxley failed to understand, or refused to accept, was the driving force behind baby-making. It is individuals and couples who want to reproduce themselves in their own images. It is individuals and couples who want their children to be happy and successful. And it is individuals and couples—like Barbara and Dan and Cheryl and Madelaine and Melissa and Curtis and Jennifer, *not governments*—who will seize control of these new technologies. They will use some to reach otherwise unattainable reproductive goals and others to help their children achieve health, happiness, and success. And it is in pursuit of this last goal that the combined actions of many individuals, operating over many generations, could perhaps give rise to a polarized humanity more horrific than Huxley's imagined Brave New World.

There are those who will argue that parents don't have the right to control the characteristics of their children-to-be in the way I describe. But American society, in particular, accepts the rights of parents to control every other aspect of their children's lives from the time they are born until they reach adulthood. If one accepts the parental prerogative after birth, it is hard to argue against it before birth, if no harm is caused to the children who emerge.

Many think that it is inherently unfair for some people to have access to technologies that can provide advantages while

others, less well-off, are forced to depend on chance alone. I would agree. It is inherently unfair. But once again, American society adheres to the principle that personal liberty and personal fortune are the primary determinants of what individuals are allowed and able to do. Anyone who accepts the right of affluent parents to provide their children with an expensive private school education cannot use "unfairness" as a reason for rejecting the use of reprogenetic technologies.

Indeed, in a society that values individual freedom above all else, it is hard to find any legitimate basis for restricting the use of reprogenetics. And therein lies the dilemma. For while each individual use of the technology can be viewed in the light of personal reproductive choice—with no ability to change society at large—together they could have dramatic, unintended, long-term consequences.

As the technologies of reproduction and genetics have become ever more powerful over the last decade, most practicing scientists and physicians have been loathe to speculate about where it may all lead. One reason for reluctance is the fear of getting it wrong. It really is impossible to predict with certainty which future technological advances will proceed on time and which will encounter unexpected roadblocks. This means that like Huxley's vision of a fetal hatchery, some of the ideas proposed here may ultimately be technically impossible or exceedingly difficult to implement. On the other hand, there are sure to be technological breakthroughs that no one can imagine now, just as Huxley was unable to imagine genetic engineering, or cloning from adult cells, in 1931.

There is a second reason why fertility specialists, in particular, are reluctant to speculate about the kinds of future scenarios that I describe here. It's called politics. In a climate where abortion clinics are on the alert for terrorist attacks, and where the religious right rails against any interference with the "natural process" of conception, IVF providers see no reason to call attention to themselves through descriptions of reproductive and genetic manipulations that are sure to provoke outrage.

The British journal *Nature* is one of the two most important science journals in the world (the other being the American journal *Science*). It is published weekly and is read by all types of scientists from biologists to physicists to medical researchers. No one would ever consider it to be radical or sensationalist in any way. On March 7, 1996, *Nature* published an article that described a method for cloning unlimited numbers of sheep from a single fertilized egg, with further implications for improving methods of genetic engineering. It took another week before the ramifications of this isolated breakthrough sank in for the editors. On March 14, 1996, they wrote an impassioned editorial saying in part: "That the growing power of molecular genetics confronts us with future prospects of being able to *change the nature of our species* [my emphasis] is a fact that seldom appears to be addressed in depth. Scientific knowledge may not yet permit detailed understanding, but the possibilities are clear enough. This gives rise to issues that in the end will have to be related to people within the social and ethical environments in which they live. . . . And the agenda is set by mankind as a whole, not by the subset involved in the science."

They are right that the agenda will not be set by scientists, who wield little power in a free society, despite their sense of self-importance. But it's utterly naive to think that "mankind as a whole"—unable to reach consensus on so many other societal issues—will have any effect whatsoever. Instead, in the near future, power will lie in the marketplace, and the agenda is sure to be set by individuals and couples who will act on behalf of themselves and their children.

In the pages that follow, I will explain how remarkable advances in science and technology force us to reconsider long-held notions of parenthood, childhood, and the meaning of life itself. I will show you how technological advances, in particular, provide individuals and couples of all kinds with options for reproducing in ways that were previously unimaginable. And I will present imagined futures—alternatively nightmarish and

dreamy—in which people use reprogenetics to assume control over the destiny of humankind.

Throughout, I will explore the ethical arguments that have been raised against the use of this technology. In most instances, I will attribute opposition to conscious or subconscious fears of treading in "God's domain." Indeed, I will argue that nearly all of the objections raised by bioethicists and others ring hollow with one exception not often considered. The power of reprogenetics is so great that if left to the market, those families and groups *not* able to afford it could become severely disadvantaged.

Will a global marketplace based on individual freedom and competition among people and countries reign supreme in the centuries and millennia to come? If so, a severed humanity may very well be its ultimate legacy.

But what is the alternative? So long as sovereign states prevail, international borders can do nothing to halt the passage of cells and genes carried deep within a woman's body. Only a single world state could control the use of reprogenetics, providing it in measured amounts to all its citizens. From our vantage point at the beginning of the third millennium, such a Huxleyan world seems much more securely in the realm of fiction than even the most fantastical scenarios imagined in this book. Nevertheless, the future of humankind is a thousand times longer than its past and impossible to foresee.

Of one thing, I have no doubt. The growing use of reprogenetics is inevitable. For better *and* worse, a new age is upon us—an age in which we as humans will gain the ability to *change the nature of our species*.