

The future of making babies

We will soon be able to determine our children's personalities, as well as their gender and health, says **Gregory Stock**. Indeed, it might be considered reckless not to

When people ponder the challenges that technology will pose in the generations ahead, they typically think of global warming or globalization. Such issues, however, pale beside the question of how we will change ourselves using advancing technology in the life sciences. The idea that humans might one day transform their biology seems strange and disturbing – if not downright preposterous – but genetics and biology are at our core and as we begin to understand and adjust them, we are changing ourselves.

Two unprecedented revolutions are under way today. The first is the silicon revolution. Here, we are breathing into inert sand – the silicon at our feet – a complexity that rivals life itself. The second is the biotechnology revolution. As we plumb the workings of life to untangle our very substance, we are beginning to manipulate its underlying processes and take control of our evolutionary future. Our science has slammed evolution into “fast forward”, and no one can say where we will end up.

The power of genetics

The poster child of biotechnology is the human genome project. Our genes are not our destiny, but they carry tremendous information about who we are. Between a quarter and three-quarters of the variation in most traits across the human population can be explained by genetics.

Widespread and inexpensive personal genetic testing will arrive during the next decade. It will push medicine towards more preventive and personalized interventions. One example would be a screen against a predisposition to plaque-formation in at-risk adults and early use of drugs to counter that risk. This will be challenging because we will have to decide who pays for such procedures and how many should be covered – in short, how we ration the burgeoning possibilities for medical care. This, however, is just the beginning. As we come to understand the constellations of genes that influence our identities, potentials, vulnerabilities and temperaments, we will want to use this knowledge to improve our children.

Changes in human reproduction in the decades ahead will give people three primary

ways of choosing their child's genes. These germinal choice technologies range from reproductive cloning – which, despite the controversy it provokes, is highly conservative – to germline engineering, which embodies the radical possibility of conscious human design. None is distant, and each is already used in rudimentary form with livestock, lab animals or humans.

Cloning brings nothing novel into being. It merely attempts to copy a previous genetic constitution. The procedure is technically difficult, of dubious safety and without broad appeal. Despite this, it has provoked legislation and inflamed passions, because cloning is a symbol of the coming insertion of sophisticated technology into human reproduction. Unlike in vitro fertilization (IVF), cloning creates an outcome unachievable by biology alone: the birth of a delayed identical twin.

Given recent research progress on embryonic stem cells, which involves similar nuclear transfer and embryo-manipulation technology, a human clone is likely to be born within a decade. The event won't be as momentous in scientific terms as the inevitable media hullabaloo would suggest. A delayed twin may be strange, but such a birth will hardly threaten civilization. Moreover, a clinical procedure that is very expensive and difficult – as this will be – will not come into widespread use very soon. A quarter of a century after the arrival of IVF, which promised to fill a deep void in the lives of millions of childless couples, IVF accounts for just 1% of live births in America and Britain, where the technique is most widespread. Furthermore, the desire to clone oneself is surely far less popular

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and passionate than the longing of a couple to bring their own offspring into the world.

Germline engineering, the most potent germinal choice technology, sits at the other pole of emerging possibilities, because it embodies direct embryo design: enhancement and novelty, not duplication. Germline engineering is even more distant and technically-challenging than cloning, but a basic outline of how it might be safely effected in humans through artificial chromosome technology has already been described.

Genetic screening

Between these two extremes – cloning and germline engineering – lies a more immediate and profound challenge: pre-implantation genetic diagnosis. This is already broadly used in a rudimentary form and significant refinements are under way. The major enabling developments required for advanced diagnosis of this sort are breakthroughs in oocyte (egg) handling, which will enable many eggs to be fertilized; completion of genomic population studies, which will link genes to various traits; and comprehensive genomic testing of single cells, which will allow embryos to be screened routinely.

All are straightforward extensions of current research, so advanced pre-implantation diagnosis could emerge in full force in the next generation. Moreover, embryo screening will be almost impossible to control. It will be easy to do – and not just in the developed world – but in thousands of labs all over the world. People will want it. Moreover, it cannot be detected after the fact. Of course, there are national bans of pre-implantation genetic screening and there will be more. However, these merely raise the price of the procedure, drive it underground, shift it to more hospitable environments and reserve it for the wealthy. In short, advanced embryonic screening will soon be with us.

Reproduction, future-style

The logistics of reproduction will soon shift to a process that starts when a young woman freezes and cryogenically banks large numbers of immature oocytes collected by ovarian biopsy. Later, when she has a partner and wants children, she will thaw, mature and fertilize these eggs, screen the resultant embryos using advanced diagnostics, and implant those that she and her partner choose. Moreover, the focus of embryo screening is likely to shift from protecting against genetic disease to avoiding vulnerabilities like manic-depression and choosing non-disease attributes such as personality, temperament and appearance. The users of such screening will shift from the infertile, who will initially see it as an adjunct to IVF, to the wealthy, who wish to avoid the uncertainties of traditional reproduction, to just about everyone else.

Let's imagine that scientific progress and public policy combine to make meaningful enhancement technologies widely available, relatively commonplace and largely under the control of individual parents. This is not far-fetched. Lab-mediated conception using genetic testing may one day seem no more foreign than medically-assisted birth does today. Parents will want to do what they think is best for



Not as much fun as the old way

their children. Indeed, even those uninterested in enhancement may come to see it as reckless and primitive to conceive a child without prior genetic testing.

As particular attributes are boosted or diminished in children, their predispositions will come to reflect their parents' philosophies and attitudes. Children will also come to manifest the cultural ethos and values that influence their parents. Consider gender. Many couples would choose different attributes for boys and girls. Germline choice technology would, therefore, translate cultural attitudes about gender into the biology of children. If a society believes that women are, or should be, more empathetic and supportive, and boys more aggressive and independent, then that's how they will turn out, regardless of whether that is how they are now. If, on the other hand, society believes that such gender distinctions do not, or should not, exist, they will diminish if they are present.

Even aspects of personal identity that are specific to a particular culture at a particular time could become embedded in biology to deepen the differences among human populations. Cultures value education, athletics, intelligence, calmness, obedience, curiosity and other personality traits quite differently. To the extent that genes influence these variations, germinal choice technology might reinforce and heighten them, particularly if the biological predispositions that elicit these cultural patterns engender selection of the same predispositions.

Who are we?

One certainty about germinal choice technology and the other emerging possibilities of biotechnology is that, no matter how much debate and discussion takes place, no consensus about them will emerge. These possibilities speak too directly to our vision of the human future, our notions of who we are and who we will become. They touch us too deeply. Our perceptions of them depend too much on religion, philosophy, culture and politics. To some, this is the invasion of the inhuman and we are heading towards disaster by violating the most sacred aspects of our humanity. To others, this is our flowering, enabling us to transcend our biology in ways that other generations could barely dream of.

In light of this, it is worth thinking about what the various critics of germinal choice and other technologies of the biotech revolution are most afraid of. They are not particularly concerned that these technologies will fail or prove unsafe. No, the real worry is that these technologies will succeed, and succeed so gloriously that they create seductive possibilities that we can't resist. Then we will have to face our real fears.

Our fears

Our first fear is that we will abuse these technologies. Of course we will. We abuse every technology. This, however, does not mean that we should stop.

Our second fear is of the philosophical implications. Will these technologies change our sense of who we are? Yes, they will. However, our great grandparents would probably find our world jarring too. As to our great grandchildren, they may well think that a world where people care so little about their children that they leave conception to a random meeting of sperm and egg is a primitive one indeed.

A third fear is that we will be forced to make difficult choices. And we will. Coming choices about the beginning of life are going to be excruciating. It is not easy to decide which embryo to implant and which to discard. Humanity is leaving its childhood and moving into its adolescence. The time has come for us to accept the responsibility that comes with our new powers. The next frontier is not space, it is our own selves. Do we really want to pull back and relinquish the exploration to braver souls in other regions of the world? **GA**



CV GREGORY STOCK

Gregory Stock is director of the Program on Medicine, Technology and Society at the School of Public Health at the University of California, Los Angeles. He is chief executive of Signum Biosciences.