



HUMAN REPRODUCTION

Making babies

Advances in genetics introduce new promise and perils into the business of being born

By Dov Greenbaum

In the 200 years since the genesis of Mary Shelley's *Frankenstein*, many have found the story to be a useful source of metaphors for rebuffing efforts to extend science beyond society's comfort zones.

Perhaps the clearest example is the widespread application of the "Franken" prefix as a tool to reflect a prevalent uneasiness with areas of science research that seem instinctively "wrong." However, perhaps a more apt metaphor can be found in the 1931 film adaptation's enraged mob. Here, seemingly, without second-guessing their sources, the townspeople set out to destroy the monster. Despite extraordinary advances in recent years, and substantial research supporting its safety and efficacy, there remain large and loud factions who not only are fearful of the use of genetic technologies in modern medicine but also actively campaign to prevent further advancements and applications.

Two authors have recently tried to enlighten readers on this topic: Paul S. Knoepfler, a prolific blogger and well-known stem cell researcher at the University of California, Davis, and Henry T. Greely, professor of law at Stanford University and director of the Center for Law and the Biosciences.

Knoepfler's *GMO Sapiens* is a down-to-earth introduction to the human use of new

GMO Sapiens
The Life-Changing
Science of Designer Babies
Paul Knoepfler
World Scientific, 2016.
282 pp.

**The End of Sex and
the Future of Human
Reproduction**
Henry T. Greely
Harvard University Press,
2016. 391 pp.



genetic technologies. An easy and enjoyable read, the book is targeted to an audience that has a general interest in, but perhaps a minimal understanding of, science. Knoepfler cautiously guides his reader through the emerging technologies that will allow humans to more easily alter our genetic codes. Throughout, he generously sprinkles personal anecdotes and interviews with many of the relevant personalities. In appreciation of his audience, Knoepfler provides only short and relatively simplified explanations of a number of complicated technological issues, including in vitro fertilization (IVF), stem cells, cloning, genetically modified organisms (GMOs), CRISPR, sex selection, and other technologies and their applications. He also addresses a number of relevant legal concerns, including, for example, the Genetic Information Nondiscrimination Act (GINA). Perhaps best summarizing his position, in the penultimate chapter, Knoepfler invites

Cutting-edge research and technological advances are ushering in a new era of human reproduction.

readers to imagine the promise of human genetic modification: "Totally new types of people could be made in such a fearless new world. It could be both wondrous and disastrous. I am inclined to believe it would be more disastrous, but it is thought-provoking and even fun to think about the possibilities from a strictly hypothetical perspective."

Readers looking for a more in-depth analysis of human genome modifications and reproductive technologies and their legal and ethical implications should strongly consider picking up Greely's *The End of Sex and the Future of Human Reproduction*. Whereas Knoepfler's book will make you look smart at your next cocktail party, Greely's will prepare you to attend a professional symposium on human reproduction or, alternatively, a legal conference on the relevant bioethics.

Greely's breezy first-person narrative belies the extraordinary depth and impressive quality of information provided, both scientific and legal. He does not dumb down the material; rather, he expects his audience to look up medical and legal terminology and jargon themselves, when necessary.

The End of Sex is organized into three distinct sections, punctuated by brief interludes that summarize the material covered and outline the goals of the next section. In "The Science," Greely describes the underlying advances in stem cell and genetics technology that will result in cheap, easy, and reliable alternatives to current technologies. "The Pathway" outlines Greely's speculation about the eventual outcomes of these technologies. One particular projection involves a reproduction technique that will allow for the relatively easy selection of a child's genetic attributes, an option Greely refers to as easy preimplantation genetic diagnosis or "easy PGD." In the book's third section, "The Implications," Greely provides a thorough analysis of the ethical, legal, and social implications of easy PGD. Here, he substantially tackles issues including safety, family relationships, fairness, justice, equality, coercion, enforcement, and implementation. He also engages with the visceral reactions that may play a significant role in guiding potential policies. Many of the tools Greely provides are also relevant in other bioethical questions.

Although both books have the potential to empower readers to make informed decisions about the implementation of advancements in genetics technologies, it is unlikely that either will convince the enraged mobs to put aside their pitchforks. At least the rest of us will be better informed.

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