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Bioethics, CRISPR, & Our Children Redesigned
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This fall, I will be facilitating a six-session class on Tuesday evenings here at UUCF on Bioethics. This sermon is a preview of some of the contemporary issues we will be covering such as the **revolutionary new genome-editing technology CRISPR**. As many of you likely know, I'm not talking about "crisper" with an "e"—like a refrigerator drawer for keeping your lettuce fresh. I mean the all-capitalized acronyms CRISPR, an abbreviation for Clustered Regularly Interspaced Short Palindromic Repeats. (That clears it up, right?! No worries. More clarity forthcoming.) Other major themes of the class will be Research on Humans, Reproductive Technologies, Genetic Choices, Dividing Up Health Care Resources, and Ethics for Medical Professionals. Then, in November, there will be a second Sunday service on the topic of bioethics, which will incorporate some of the insights from the class.

Regarding the relevancy of this topic, consider these headlines in *The New York Times* from just the past six weeks—breaking news that I had no idea would be the case when I originally planned this sermon. The first headline is from July 27: **"In U.S. First, Scientists Edit Genes of Human Embryos."** It says "In U.S. First" because Chinese scientists were the first to experiment with this breakthrough two years ago in mid-2015 (xix). That highlights a crucial factor in bioethical debates: not only *should* something be tried, but also, what happens if others move forward and we do not? The headline continues, "Scientists Edit Genes of Human Embryos," but it is important to add that "the embryos were not allowed to develop for more than a few days and were never intended to be implanted into a womb." In other words, we are

currently holding ourselves back. Perhaps rightly so, but it depends on whom you ask. (We can talk about it. Sign up for the class!)

The second headline is from August 30: **"F.D.A. Approves First Gene-Altering Leukemia Treatment, Costing $475,000."** A week ago from this past Wednesday, the U.S. Food and Drug Administration "approved the first-ever treatment that genetically alters a patient's own cells to fight cancer, a milestone that is expected to transform treatment in the coming years." This particular treatment is for an especially aggressive type of leukemia, but many similar gene therapies are in the pipeline. The half million dollar price tag is because a single-dose must be tailored for each individual, which can make the treatment both effective and expensive. "The first child to receive the therapy was Emily Whitehead, who was 6 and near death from leukemia in 2012 when she was treated…. Now 12, she has been free of leukemia for more than five years." Such possibilities open a whole new world beyond today's typical regimen of "surgery, radiation, and chemotherapy" (175).

A helpful guide to this cutting-edge world of possibilities is a book titled **A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution** by Jennifer Doudna and Samuel Sternberg (Houghton Mifflin Harcourt, 2017). To name one among her many appointments, Doudna is a professor in the Chemistry and the Molecular and Cell Biology Departments at the University of California, Berkeley. Sternberg is a fellow researcher and doctoral-level biochemist.

While I mainly want to focus on the technology and its potential implications, I can't resist sharing the story that first launched Dr. Doudna on a trajectory toward become an expert on genome engineering. **When she was twelve, she returned home from school to find on her bed a "tattered copy of James Watson's *The Double Helix*"**:

> My dad would occasionally pick up books for me at used bookstores to see if they sparked any interest. Thinking this book was a detective novel —which it was!—I set it aside for some weeks before diving into its pages one rainy Saturday afternoon…. I felt the first tugs of interest that would eventually guide me onto a similar path. (10)

I love that story. I find it fascinating to trace the difficult-to-predict sparks that can grow into a lifelong passion. And that passion for discovery, ignited by reading about the mid-twentieth-century discovery of DNA's molecular structure, led to the innovation of CRISPR.

But perhaps appropriately for an invention whose full implications are far from clear, neither of these scientists set out to turn biotechnology and bioethics on their respective heads. Rather, their intention was to research "the way that bacteria defend themselves against viral infection." In so doing, they **stumbled backward into the "workings of an incredible molecular machine that could slice apart viral DNA with exquisite precision.** The utility of this same machine to perform DNA manipulations in other kinds of cells, including human cells, was immediately clear" (xvii).

It is at this point that bioethicists diverge. In politics, the saying goes that, "One person's terrorist is another person's freedom fighter." Likewise, in bioethics, **one person's sacrilege is another person's sacred responsibility** (xviii):

> Some people view any form of genetic manipulation as heinous, a perverse violation of the sacred laws of nature and the dignity of life. Others see the genome simply as software—something we can fix, clean, update, and upgrade—and argue that leaving humans beings at the mercy of faulty genetics is not only irrational, but immoral. Considerations like these have led some to call for an outright ban on editing the genomes of unborn humans, and others to call for scientists to forge ahead without restraint.

One side argues that we must beware the "Law of Unintended Consequences." The other side urges that, "Someday we may consider it unethical *not* to use germline editing to alleviate human suffering" (xix).

Speculation aside, let me tell you about what has *already happened*—because a few newspaper headlines notwithstanding, it seems evident that **scientific research is significantly outpacing public awareness of bioethical breakthroughs** (200-201):

- Scientists have harnessed CRISPR to generate a genetically enhanced version of the beagle, creating dogs with Schwarzenegger-like super-muscular physiques by making single-letter DNA changes to a gene that controls muscle formation.

- In another case, by inactivating a gene in the pig genome that responds to growth hormone, researchers have created micro-pigs, swine no bigger than large cats, which can be sold as pets….
- Meanwhile in the plant world…gene-editing experiments have produced disease-resistant rice, tomatoes that ripen more slowly, and soybeans with healthier polyunsaturated fat content….by fine-tuned genetic upgrades involving changes to just a few letters of the organism's own DNA….
- In recent experiments, CRISPR has been used to "humanize" the DNA of pigs, giving rise to hopes that these animals might someday serve as organ donors for humans….
- In laboratory-grown human cells, this new gene-editing technology was used to correct the mutations responsible for cystic fibrosis and sickle cell disease, among many other disorders. (xiv-xv)

So much more is quickly becoming possible—or is already possible—that we're not yet sure, collectively, whether it's a good idea to try. Some of you will recall the tale of Prometheus: "the deity in Greek mythology who was the creator of humanity and its greatest benefactor, who stole fire from Mount Olympus and gave it to humankind." With CRISPR, we are playing with fire with great potential for promise and peril.

The best metaphor I've seen for how CRISPR works—for those of us who don't have a doctorate in biochemistry—is that **CRISPR is kind of like a "designer molecular Swiss army knife"** which can "home in on specific twenty-letter DNA sequences and cut apart both strands of the double helix" (101).

The real rub for bioethics arises because **CRISPR can alter not only *somatic* cells (throughout the body of individuals), but also *germline* cells, whose traits can be inherited by future generations** (158). All of a sudden, we humans—ourselves products of the evolutionary process—have the power to micromanage the evolutionary process itself:

> Should we begin editing genes in unborn children to lower their lifetime risk of heart disease, Alzheimer's, diabetes, or cancer? What about endowing unborn children with beneficial traits, like greater strength and increased cognitive

abilities, or changing physical traits, like eye and hair color? (xvi)

These are questions of genetics that do not even touch the coming augmentations that will be possible through artificial intelligence, nanotechnology, and other forms of bioenhancement, all of which I'll delve into more deeply in both our class this fall and in part two of this sermon in November.

For now, as some context for how rapidly these changes are happening, let's turn the clock back almost forty years:

- In **1978, Louise Brown is born, the world's first 'test-tube baby'**…proving that human procreation could be reduced to simple laboratory procedures: the mixing of purified eggs and sperm in a petri dish, the fostering of a zygote as it grew into a multicellular embryo, and the implantation of that embryo in the female womb. *In vitro* fertilization, or IVF.
- Around that time, **in the 1980s, scientists were content to edit individual genes at efficiencies that were just fractions of a percent"** (100). In other words, *not* very efficient at all.
- Then, a little less than 30 years ago **in 1990, headlines broke about scientists teaming up around the world to sequence the human genome**.
- And **in 1996, the world witnessed the birth of Dolly the sheep, "the first successful cloning of a mammal"** (191).
- And we now know that less than twenty years ago, **"In 2001, after herculean efforts and at a cost of more than three billion dollars, the first draft" of the Human Genome Project was completed** (14-15). By then, scientists were able to edit individual genes at efficiencies of low-single-digit percentages. (Still not every efficient.)
- But in just the past few years **with CRISPR, gene editing is now "so powerful and multifaceted that it is often referred to"—not as gene editing—but as "genome *engineering*"** (100).

To give you a further example of the power that CRISPR holds, we humans could potentially choose to wield this new technology to either make mosquitos less dangerous or to make the mosquito extinct. Why would we want to do that? It's not about having a few less annoying misquote bites:

> The mosquito [arguably] causes [as much or] more human suffering than any other creature on earth. Mosquito-borne diseases—malaria, dengue virus, West Nile virus, yellow fever virus, Chikungunya virus, Zika virus, and many others — have an annual death toll in excess of one million. CRISPR-based gene drives might be the best weapon we have against this pervasive threat. (152-153)

And here's the even more head-spinning twist: **If we were to regret making mosquitos extinct, we could potentially bring them back, *Jurassic Park*-style,** in the same way that CRISPR could allow us to bring back from extinction the Wooly Mammoth and other species (118-119). Cue: #LawOfUnintendedConsequences!

None of this is an exaggeration. There really are earth-shattering consequences at stake. Indeed, the U.S. Senate Armed Services Committee in its Worldwide Threat Assessment has classified

> **genome editing as one of the six weapons of mass destruction and proliferation that nation-states might try to develop, at great risk to America.** (The others were Russian cruise missiles, Syrian and Iraqi chemical weapons, and the nuclear programs of Iran, China, and North Korea.) (217)

There is indeed much to be wrestled with about the implications of forthcoming biotechnology. But we already live in a world in which CRISPR has made "the human genome as easily manipulable as that of a bacterium" (187). For almost all the related bioethical questions, **the issue is not only "if," but *what* and *when* and *how* and by *whom***?(188). To quote the late Marshall Nirenberg, who shared the Nobel Prize in 1968 for "breaking the genetic code": "[Humanity's] [power to shape [it's] own destiny can be used wisely or unwisely, for the betterment or detriment of [humankind]" (189). The choice is ours.

I'm tempted to re-preach my sermon from a few month ago about Eugenics. But the truth is that twenty-first century bioethics is more complicated than merely rejecting twentieth-century eugenics, which in most cases was racist and repugnant. For a more twenty-first century perspective, consider the view of Charles Sabine, who lives with Huntington's Disease: **"Anyone who has to actually face the reality of one of these diseases is not going to have a remote compunction about thinking that there is any moral issue at all."** You may disagree. But

there are people who feel strongly about pursuing the power of these new biotechnologies.

And for better or worse, we likely do not have the luxury of indecision. As the historian Howard Zinn liked to say, **"You can't stay neutral on a moving train."** We can decline to explore the bioethical frontiers, but other nations are already going ahead. As we wrestle with these and other forthcoming bioethical dilemmas, I will remind you of Pope Francis's message to Tim Cook, CEO of Apple, which Nancy shared earlier during our Spoken Meditation: "Never has humanity had such power over itself. Yet nothing ensures it will be used wisely." Cook's related insight for those MIT graduates is also crucial:

> Technology is capable of doing great things. But it doesn't *want* to do great things. It doesn't *want* anything. That part takes all of us. It takes our values, and our commitment, our love, our belief that all of us are interconnected, our decency, our kindness.

The frontiers of biotechnology are both fascinating and frightening. As guidance, our UU tradition advises us to keep in mind our 4th Principle: **"A free and *responsible* search for truth and meaning."** None of us knows what the future will bring, but I am grateful to be part of this congregation and the larger UU movement that cares deeply about both spirituality *and* science. Here at the beginning of my sixth year as your minister, I am grateful to be on this journey with all of you.