Bioscience frontiers: The Good, the Bad, and the Incredible[1]

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1. Introduction

I have worked on ethical, legal, and social issues arising from advances in the biosciences for over a third of a century. During that time, I have seen some ideas that were good, some that were bad, and some that were impossible to believe (as well as a few that were ugly). Over that time, the good have gotten better, the bad worse, and the incredible even more fantastical. I want to open this issue of *BioLaw Journal* by talking briefly about those categories today, as we move into the second quarter of the twenty-first century.

But first I want to start with something unequivocally good – the anniversary of *BioLaw Journal*. It is quite an accomplishment to create a good scholarly journal and a greater one to keep it running well for over a decade. I know. Its first issue was published in May 2014; meanwhile, on February 4, 2014, the *Journal of Law and the Biosciences*[2] published its first article, an early part of its March 2014 issue[3]. Professors Glenn Cohen of Harvard, Nita Farahany of Duke, and I have co-edited that journal from its inception – I know just how hard it is to keep a journal going. So, my hearty and sincere congratulations to all those involved in *BioLaw Journal*!

But now let's delve into the broader world of biosciences and the good, the bad, and the incredible.

2. The Good

At the highest level, advances in the biosciences can do two things that are, almost always, good: it can relieve suffering and it can advance knowledge.

The suffering we most often think about is human suffering. Bioscience research is usually aimed at improving human health, directly or, by research that might involve such "non-human things" as cell lines, microscopic worms, fruit flies, and rodents, but provide help in solving human problems. Such research does not always succeed; decades of work and, literally, hundreds of billions of dollars of research on Alzheimer disease have yet to make more than a possible, but uncertain, dent in this awful condition. In fact, the research usually doesn't succeed. Biology, and hence medicine, are complex and most ideas, no matter how good they seem, do not work. But some do.

Throughout the world, and not just in the rich countries, life expectancy has shot up in during my lifetime – which is long, but not *that* long. In Europe, it has gone from about 62 years in 1950 to about 82 years now. And those years are, on average, better, with most people in better health and condition. Look at photographs of your grandparents and great grandparents: 70 really is the new 50.

Some might argue that this is not an altogether good thing. Suffering, it is said, is essential to a good human life. It can lead to great good, in a person and in a society. And I concede this is true – sometimes a period of suffering can make someone a better person, or, perhaps, a country a better place. Sometimes. But we know that

[1] With apologies (and respect) to Sergio Leone, *Il buono, il brutto, il cattivo* (Produzioni Europee Associati, 1996).

[2] https://academic.oup.com/jlb.

[3] R. Dresser, *Public Preferences and the Challenge to Genetic Research Policy*, in *Journal of Law and Biosciences,* 1, 1, 2014, 52, https://doi.org/10.1093/jlb/lst001.

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suffering *always* leads and involves suffering, and that almost everyone wants to avoid suffering. Of course, those who believe suffering is crucial can take heart – bioscience will never eliminate all suffering, whether it comes from diseases, from nature, or from other people. But it can reduce it.

In addition, though, research leads to new knowledge. Knowledge can often be very useful because it can be applied to concrete ends, of making people, other organisms, or the world better. In the mid-2000s, Professor Francisco Mojica in Spain, working on odd DNA and RNA patterns in microbes, realized that they were a way the microbes fought off viruses. He discovered, and along with Ruud Jansen, named it "clustered regularly interspaced short palindromic repeats" – CRISPR. 12 years later Jennifer Doudna and Emanuelle Charpentier figured out how humans could use it as an incredibly valuable tool, but they wouldn't have done that without the basic research of Mojica, motivated by his curiosity.

Still, although perhaps it is a failure of my imagination, I find it impossible to see concrete benefits to our increased knowledge about some kinds of knowledge. What benefits do we gain from knowing about planets circling other stars, about the movements of continents over the 4.55 billion years of Earth, about the increasingly complex history and genealogy of humanity, or about newly deciphered, badly burnt, manuscripts of Roman literature from Pompeii. And yet, to me, knowing them is a good. And for the people who uncover them, solving those puzzles is good. It makes me, and them, happy, and it makes some other (but not all) people happy.

Of course, some research needs to be examined carefully in advance to decide whether it comes with risks that make pursuing it too dangerous. Or would use resources that not only *could*, but most likely *would* be used for better ends. A great deal of bioscience research will pass those tests; it will probably have to be justified, politically, for its chances of relieving suffering, but, in the likely event it does not relieve suffering, it will contribute to knowledge. That does not require a "breakthrough" or even a success: negative results, if done rigorously, also tell us something about the biology, if only about what it is not.

Similarly to suffering, some might worry that we will be too successful and all questions will be answered, leaving the world a dull place. I don't think we have to worry about this. I recently heard a good simile: knowledge is like a balloon. The amount of knowledge is the air inside the balloon; research makes more of it. As a result, the balloon expands and the surface area of its skin gets bigger. But scientific questions seem to be like the skin of the balloon; the more we know, the more questions we have.

But what more specific good things can we expect from bioscience in the near future?

Today, we have more promising routes to fight suffering. Consider just four areas: diseased organs, genetic diseases, reproduction, and brains. We can now save people who need new organs with transplants, but there aren't enough donated organs and the procedures are difficult to do with results that can be hard to live with. But we are discovering new ways to repair or protect organs, from gene therapy to small molecule drugs. We are finding new ways to preserve organs, inside and outside the body. We are building machines to replace organs. We are learning how to use modified pig organs to keep people alive. And we are (slowly, so far) learning how to build new organs for people from their own skin cells, transmuted first into induced pluripotent stem cells and then into heart or kidney or liver cells, and ultimately organs.

Will all of these methods work, or, at least, work well enough to be used? Almost certainly not. Which ones will work? I wish I knew. But I am confident that in the next few decades, several of them will be available.

Meanwhile, we now know about roughly 6,000 powerfully genetic diseases, as well as some genetic variations that increase (or lower) the carrier's risk of more common diseases, like colon cancer or Alzheimer disease. What can we do now? We can do basic gene therapy – replacing the dangerous genetic sequence with the normal sequence. And over a dozen such therapies have been approved. We can try to fix the genetic issue in other ways, like turning back on a form of the gene that was used by fetuses but not in living people. We can try treating people with RNA to turn genes on or off to treat the disease. We can select embryos or fetuses based on their risks of genetic disease. And we could do – as one unethical scientist already has done – edit human embryos to change their disease risks.[4]

But alternatives that do not directly involve DNA or RNA exist, too. Cystic fibrosis, a nasty disease found in about one birth in 2,000 in the U.S. and Europe, can now be effectively treated for 90 percent of those with the disease – not with gene therapy (though that is also in the works) but with a combination of three traditional small molecule drugs, which make the genetically misshapen protein responsible for the disease work properly.

Human reproduction is also very likely to change. In vitro fertilization (IVF) is now over 45 years old, but it still works less than half the time, and it is expensive, uncomfortable, and somewhat risky even if it does work. We should be able to make it more effective. That may require more and better research into human embryos and their development in order to understand why it succeeds or fails, but research with both "real" human embryos and "embryo models," not made from eggs and sperm and, perhaps, not able to become a baby. Or we are likely to extend IVF to new kinds of infertility. One major advance will probably be "in vitro gametogenesis," making sperm or eggs from skin cells.[5] Why would we do that? To help people who want to have genetic children but who lack (useful) sperm or eggs achieve their dreams. Or maybe we could make eggs from a man's skin cells or sperm from a woman's. Why would we want to do that? Ask aspiring gay or lesbian parents.

Or, within a few decades, we may be able to make babies entirely outside of people, using mechanical substitutes for uteruses or, more likely, from uteruses made from skin cells or donated from cadavers or "surgical waste" but kept alive outside the body.[6] Would this be good? For people who cannot bear a pregnancy, perhaps because of a congenital or disease-related reason, perhaps because they were born male, it could offer an alternative to surrogacy or a uterus transplant.

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[4] The scientist is named He Jiankui; the first two of his three "CRISPR'd" babies were born in October 2018, the third the next summer. See H.T. GREELY, *CRISPR People: The Science and Ethics of Editing People*, Cambridge, Massachusetts, 2021 (Italian edition*: Bambini Geneticamente Modificati? La tecnica CRISPR: scienza ed etica dell'editing umano,* Milano, 2023).

[5] See H.T. GREELY, *The End of Sex and the Future of Human Reproduction*, Cambridge, Massachusetts, 2016.

[6] Research using donated uteruses was done, in Italy, in 1988. It kept the uterus alive for over 50 hours and, on transferring three "leftover" IVF embryos to it, saw one of them appear to begin to implant. C. BULLETTI, et al., *Early Human Pregnancy in Vitro Utilizing an Artificially Perfused* Uterus, in *Fertility and Sterility*, 49, 1988, 991. But the research proved so controversial that it was abandoned. C. BULLETTI, et al., *The Artificial Womb*, in *Annals of the New York Academy of Sciences*, 1221, 2011, 124-128, https://doi.org/10.1111/j.1749-6632.2011.05999.x.

The most complex organ – arguably, the most complicated "object" we know of in the universe, is the human brain. It also should be on the edge of great advances. Drug treatments may be part of it, but recording and stimulating technologies will play a major role. Things like functional magnetic resonance imaging already have expanded our knowledge of how the brain works (and doesn't) enormously. Implanted electrodes are allowing paralyzed patients to "move things" with their brains, whether cursors on a computer screen or prosthetic limbs. Non-invasive approaches, such as electrical, magnetic, or ultrasound stimulation, should allow us first to understand, and then to treat or prevent, some of the greatest sources of human misery: depression, schizophrenia, Alzheimer disease, and other mental illnesses and neurological conditions.

All of these wondrous treatments are plausible. Will they all come to pass? Almost certainly not. But some will, at least if we continue to support appropriate research. And we cannot know which will work unless we try them.

3. The Bad

But all technologies can be used for good or for evil. Commercial jets can ferry people across oceans and continents; they can also be used to destroy skyscrapers filled with thousands of people. Bioscience technologies are no different. Whether good or bad depends on how they are used. But, particularly with these technologies, which cut so close to the essences of who we are, it also depends on what you think is bad.

In my personal ethics, I worry most about safety, honesty, and liberty. Others may worry about dehumanizing or unnatural effects of technologies. I do not, but I don't think the other perspectives are "wrong" – just different. How should we resolve those differences? The way we resolve other strong differences of opinion, through our laws and our cultures.

But, to focus on what I think is wrong, consider first safety. If technologies are widely used before they are shown to be reasonably safe, I think that is bad. And it is especially bad if people who didn't make knowing choices get hurt. If I choose a risky experimental approach to try to treat a hopeless and fatal of mine, at least I will have a choice. But sick people often aren't in the best position to make choices – they are often frightened and in pain, conditions that can keep them from understanding and evaluating their situations. If we make such a choice for, say, an embryo, it had no chance to choose; the same is true of children or incompetent adults. Often they have family we can (largely) trust to act in their interests, but not always. I believe we need good evidence that health interventions are reasonably safe – not perfectly safe, an unattainable standard, but safe given the circumstances – before letting them be used.

Plus, alas, sometimes advances could be used for the very purpose of causing harm. CRISPR makes cures easier. It also makes biological warfare easier. Better understanding and interventions into the brain make treatments better; it could also provide "improved" methods of torture.

As to honesty, "quacks" have always been with us, people selling treatments that will not do good, and may well do harm, to sick people, or those who love them. Sometimes they may sincerely believe in what they are doing (and their profits are merely a nice side effect). But sometimes they are lying to desperate people solely to improve their profits. To me this kind of dishonesty requires that Dante be brought back to life to create a new, lower, 10^{th} circle of hell. But other dishonesty is also reprehensible, especially dishonesty in science, which not only makes false

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claims to benefit the liar, but can mislead and misdirect future research.

Then there is liberty. If reproductive technologies are used coercively, to force parents to choose things or not to choose things for their future children, that's bad. If genetic technologies are used to discriminate against people, that's bad. If brain technologies are used not just to cure serious mental illnesses but to impose outside, involuntary control over people, that's bad. (And we should remember that psychiatric hospitals and treatments have been used by tyrannical regimes against dissidents, because, after all, one would have to be insane to dislike the current government.)

The technologies are rarely, if ever, "good" or "bad" in themselves. Their normative position depends on how we use them. And that means on how we regulate them, not only through laws but also through research funding, clinical reimbursement, and cultural approval or disapproval.

4. The Incredible

Much in science, like much in modern societies, suffers from "hype," short for hyperbole and meaning exaggeration. Dramatic claims attract attention. For researchers, that can mean fame, grant money, tenure, and other good things. For universities, it can mean prestige or donations. For companies, it can be funding, through private or public markets, and ultimately sales. And for the media, it leads to readers or, at least, clicks, and hence money.

Bioscience is far from immune to hype; indeed, quite the contrary. But if something seems too good to be true, it usually is. Some of the "hottest" in the biosciences that are currently discussed seem to me to be "too good to be true," to be, quite literally, incredible…incapable of being believed. To end this essay I want to comment on two in particular that I think should truly not be credited: the fully "Neuralinked" brain and human immortality.

To say that Elon Musk is many things seems a great understatement, especially given the last few months in the United States. But, whatever else he has done, he has transformed several industries, from electric vehicles to lithium-ion battery storage to space flight. One of his most discussed ideas, along with colonizing Mars, is manifest in his company, Neuralink.[7] Its goal is to allow for the safe, easy, and effective insertion of thousands of electrodes into the brains of living people. Some of those involved are focusing on using these as a better form of brain computer interface (BCI) for treating various diseases and conditions, such as paralysis, amyotrophic lateral sclerosis (known in the United Kingdom as motor neurone disease), or locked in syndrome. Musk's goals, though, seem to go far beyond that, to a system where human brains are seamlessly linked, at a very high rate, into computer systems, enabling them to communicate near instantly with the internet or other people.

BCI work has been moving forward over the last two decades, with some small but real successes. But the barriers to Musk's full dream make

[7] Neuralink, https://neuralink.com. See Wikipedia, *Neuralink*, https://en.wikipedia.org/wiki/Neuralink; A. Regalado, *With Neuralink, Elon Musk Promises Human-to-Human Telepathy. Don't Believe It*, in *MIT Technology Review,* April 22, 2017, https://www.technologyreview.com/2017/04/22/242999/with-neuralink-elon-musk-promises-human-to-human-telepathy-dont-believe-it/; C. Naysmith, *Elon Musk's Neuralink Aims for a Future of 'Superhuman' Vision and Telepathy—But First, It Will Tackle Blindness and Paralysis*, in *Barchart*, September 10, 2024, https://www.nasdaq.com/articles/elon-musks-neuralink-aims-future-superhuman-vision-and-telepathy-first-it-will-tackle.

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colonizing Mars look easy. The human brain has about 89 billion neurons that act through about 10 trillion connections, called synapses. Another roughly 1 trillion "other cells", grouped together as glia and previously widely dismissed as "support staff", also turn out to be important to brain function. Those cells, neurons and glia, are constantly doing things, including making and breaking connections and releasing and capturing chemicals. Technical problems of connecting electrodes safely and permanently with the brain are vast, but even more difficult is the problem of understanding what things in the brain mean.

BCIs are here and will get better, at helping seriously impaired people function better. As fully linked in plug ins to healthy brains, they seem to me to, at best, farther away than the lives of anyone who has yet been born.

But, of course, that could be a long time if you believe the peddlers of the second incredible advance: human immortality or, more modestly, radically extended life spans. Some enthusiasts have proclaimed that the first immortal human has already been born. By the time he (and this does seem to be a male-dominated field of discussion) is 90, we'll have ways to extend lives to 150. At 140, we'll be able to take him to 200. By the time he is 200, a thousand years will be feasible… and so on.

Neuralink is one, relatively inexpensive, part of the dreams of one billionaire. Immortality, or, at least living for several hundred years, has been a dream for millennia. Most recently, it has attracted much attention, and funding, from billionaires, and others. The most prominent scientific exponent of this idea is Aubrey de Grey,[8] who as early as 2013 argued that the first person to live to 150 had very likely already been born.[9] Reaching 150 might be conceivable in a century or so, for one person in ten million, but it is stretch. Only one person has ever been documented to make it to 120 years of age; as of April 7, 2025, the 50 documented oldest people in the world (from among over 8 billion people) range from 112 to 116 years old. (Forty-nine of them are women; the only man is number 38, at 112 years old.)[10] But things fall apart. So many body parts and functions are necessary to survival; to keep them all working (or to replace them all with machines or transplants) well enough to allow survival is, to me, incredible. And, of course, even if the body is kept alive, the most mysterious organ is the brain; keeping that not only alive but healthy adds even greater difficulty. What would a 1000 year life span be like if the last 900 years were spent with Alzheimer disease?

Some computer-oriented people have taken a different approach. We won't be immortal in our bodies, but in computers, or, nowadays, in "the cloud."[11] Kurzweil's initial idea was to program a computer to simulate a living person's brain, in such detail that all of that person's memories and personality would be captured. This would require an ability to record the present state of those 90 billion neurons and 10 trillion synapses in great detail, as well as to project their millisecond by millisecond changes. Of course, if Neuralink worked maybe one could just use the connection to upload your brain. But it won't.

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[8] See Wikipedia, Aubrey de Grey, https://en.wikipedia.org/wiki/Aubrey_de_Grey.

[9] J. NOSTA, *the First Person to Live to 150 Has Already Been Born—Revisited!*, in *Forbes*, February 3, 2013, https://www.forbes.com/sites/johnnosta/2013/02/03/the-first-person-to-live-to-150-has-already-been-born-revisited/.

[10] Wikipedia, *List of Oldest Living People*, https://en.wikipedia.org/wiki/List_of_oldest_living_people.

[11] This idea became popular 20 years ago through R. KURZWEIL's book, *The Singularity Is Near*, New York, 2005.

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It is hard, if not impossible, to "prove" a negative. And I'm certainly willing to admit that these might be plausible, several hundred years in the future (if our civilization or a technologically sophisticated descendant civilization exists). But not soon.

I could, of course, be wrong about that. Maybe fully internet linked human brains and human immortality are right around the next corner, along with faster than light human travel, perpetual motion machines, and complete world peace. But I doubt it. Do not invest in incredible bioscience, certainly not in money but even in time and scholarship. I try to keep my work to things that seem to me plausible within, say, a 50 year span. Not certain or even necessarily probable, but plausible. A legal analysis of 1000 year life spans or of brain to brain telepathy could be great… as science fiction. But, as scholarship, to me, it seems a waste of our most precious resources, our brains and, even more, our time.

5. Conclusion

This is a wonderful era to be alive and to be working in this field. The science is amazing, complex, and hugely important. But the law, and the ethics, and the culture, and the politics are, in many ways, more important – and more complex.

What's important is not what *might* be done but what does get done and how. And that is where we – as authors, as scholars, as teachers, as speakers, as journal editors – play our role. It's an important role, I think it's a noble role, but, for me, I must confess, the best thing is that filling it is a lot of fun. And fun is good!

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