Climate Crisis, Designer Babies and Pandemics

Challenging the Techno Utopianism of the Genetically Engineered Age

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Moderator: Pat Thomas, author and environmental campaigner

Discussants:

Bill McKibben, founder of 350.org and author of many books, including *The End of Nature* and *Falter: Has the Human Game Begun to Play Itself Out?*

Stuart Newman, Professor of Cell biology and Anatomy at New York Medical College in Valhalla, and co-author of *Biotech Juggernaut*

Marsha Darling, Professor of History and Interdisciplinary Studies at Adelphi University, with a focus on race and gender issues around emerging genetic biotechnologies

This transcript has been lightly edited.

PT: Joining the dots between the multiple challenges that we face, challenges that could seem at face value unrelated, is never easy; the natural human inclination is to break big problems down into component parts and pick one. And yet it is impossible to separate climate change from human health and social justice and race and gender issues and poverty and power hierarchies.

Bill, in *Falter*, you make the point that climate change is here, it's happening. And when we propose solutions like genetic engineering or artificial intelligence or even flying humanity to another planet, we're not really facing up to the problem at all and could be making it worse. I wonder if you could say a bit more about what made you link these particular issues together.

BM: Absolutely. This is a really important conversation. 2020 does feel like a year when all these crises came together at once, and we began to understand what we're facing. But if we're going to go through this much trauma, we might as well at least get a few insights from that. And one of those insights, I think, has something to do with questions around social solidarity. You know, I grew up in the shadow of the Reagan years, politically, and in your case the Thatcher years.

Ronald Reagan's favorite laugh line always was "the nine scariest words in the English language are 'I'm from the government and I'm here to help'." But it turns out those aren't the scariest words, the scariest words are things like 'we've run out of ventilators' or 'the hillside behind the house is on fire and we have to evacuate'. And these are not problems that yield themselves to market solutions, they're problems that demand we figure out how to work together.

And working together is also the precisely opposite paradigm to the idea that the way out of our dilemma is to engineer our children's lives that they're so intelligent or perfect or some such that they don't ever have any need for cooperation. We live together on a planet, and learning to acknowledge that together has got to be the ground zero for useful work on these crises that we face. Leaving behind that hyper individualism is going to be paramount for any work on these issues. That's why, if you forced me at gunpoint to explain why there might be some hope that emerges from 2020, it's merely that that message might begin to sink in a little bit.

PT: Marsha, in some nations we're seeing a big push for new reproductive and genetic biotechnologies that are potentially very undermining to women's reproductive rights. What are some of the social justice issues around these, and would you also touch a little bit on Bill's hyper-individualism theme there?

MD: Okay so, for a very long time now, certainly for as long as the genetics genie has come out of the bottle, there has been a process underway that should really concern us. And that is that the governance mechanism by which we focus on values, and decide what our values are, and then apply those values to how we use and instruct the genetic genie, how to behave, and what to do and what not to do — for a very long time that governance mechanism is actually behind the technology. So the acceleration of the technology is out in front of our boundary making.

And I don't mean our individual or civil society boundary making. I happen to think the values that are being discussed at the level of civil society are really quite sound —serious questions about germline engineering; questions about bodily integrity for women; the process of using women's biological functions as a kind of laboratory for how to pursue lifting those processes into a lab, replicating them, and then applying them to a generation of future children.

So that's what I mean by the genetics genie is out of the bottle. That in and of itself is not a cause for alarm, I would argue. The issue is: The genetic genie is out of the bottle, what are we going to do about that? What are we going to do with it? What boundaries do we set? What values do we apply?

Now in terms of something that Bill has just brought up, this focus on individualism and the process of moving careers and profits into the marketplace as a way of privatizing them and owning them, let me say for a very long time I have been very concerned and even resistant to the notion that the public trust, our Commons, our public Commons, can be privatized, can be owned, can be moved away from the public trust where it belongs. And so, as someone who teaches, one of my deep concerns is, how do I have conversations with the young, by which I encourage them to take responsibility for stewardship around caring about the environment, caring about boundaries, values and not simply being lured and seduced into this idea that all technology represents progress. So, much of that is to say, not stick the genetic genie back in the bottle — that's impossible, that's not going to happen. But here and now, those of us who are adults and older

adults, or young adults, what are our responsibilities around setting boundaries around that technology, particularly to protect vulnerable populations, women and women's reproductive agency. It simply isn't the case that women have had, for a very long period of time, the right to have some sense of self-determination about our bodies. And even now, it is under challenge in the courts here in the United States. Issues that we thought — Roe v Wade — issues that women thought were settled, and I don't pretend to speak for all women, but I do speak in this moment for a progressive view of how to bring technology together with governance and regulation.

PT: It's a really interesting point about new technology and limits and boundaries. I think that is a real core issue and I know, Stuart, it's something that you have been looking at too. A good portion of your book is devoted to human genetic engineering — the twins in China, who were at least theoretically supposed to be engineered to be resistant to HIV, and most recently, you and I have had discussions about germline manipulation and gain of function and this idea of making children resistant to coronavirus, which is superficially interesting but what are the real problems with this approach?

SN: Well, I think the main problem is that, and I just want to pick up on what Bill and Marsha have been saying, that we're looking at very complex systems and biological systems, and the idea of engineering them is a misconception because you can only engineer something that you understand the principles of, and as scientists we don't really fully understand how biological systems — organisms — work so the idea of kind of plugging in genes and hoping for the best is something that can be quite disastrous. Just looking at all these issues, as a scientist, what's struck me is that a lot of technology that we're seeking to apply and a lot of social devices are in response to bad technologies and bad ideas in the past.

In the past, the extraction of fossil fuels was seen as the height of science and technology. This was somebody's clever idea and, and then it became a whole industry's clever idea about how to run the world and how to supply energy and we're just meeting the consequences of that. And in fact, going back even further, the plantation system was looked at as somebody's great idea about how to grow cotton — grow crops — and we're living with the consequences of that.

And then there are responses, you know, the environment heats up. So let's apply a technological solution: Of course, air conditioning is going to solve that problem. And then the plantation system starts not delivering the way people want it, so let's introduce the cotton gin, let's do the triangle trade. Basically, it's one bad technology heaped on another bad technology and civilization bears the consequences of this. What happens is that something that starts out as a marginal technology then is partly successful, at least for some people, and then there are basically vested interests in enforcing it.

People fight to enforce fracking and fight to enforce using fossil fuels, and people fight to enforce the slave system — we had the Civil War about it. So it leads to social disasters, as well as technological disasters. And with biology and with genetic engineering, we're poised to do the same thing, we're poised to engineer individuals and ecosystems, and it's going to lead to disasters. I mean, just look at the newspapers and now people are talking about it, that there are viruses, not only in humans but running rampant through animals so somebody came up with the idea of coming up with a virus that immunizes them — spread a disease to fight a disease.

We haven't done a lot of these things, we haven't put them into place, we haven't put germline modification in any large scale into place, and we can decide based on all of the disasters of the past, not to do it, because it's really a bad idea.

PT: It strikes me listening to all of you that there are a couple of important subtexts here. I'm just going back to genetic engineering and away from all the other technologies that haven't quite gone right. The first is the notion of genetic determinism, that is, the idea that all life's problems begin in the genome. And of course, framing and approaching our problems that way automatically changes the way we frame solutions as well. The second I think is more Victorian than futuristic and it's this idea that we have bad genes. And if we can get rid of those bad genes, then humanity can be good but, of course, the looming issue there is even if it were true, who gets to choose which genes and which traits are bad and which ones are good. I wonder if any of you have anything to say on that.

BM: Well, Donald Trump was in Minnesota two nights ago and gave a big speech about what good genes people have in Minnesota. He went on and on and on to his big crowd about what good genes they have. It didn't take a whole lot of subtext to try and figure out what he was saying there, I think. Of course, that we're even having discussions like that in 2020 is crazy. One would have thought that if anything had happened over the last 50 years we might move past that, but clearly not. And so we need to reiterate, at the beginning, the ground rules. Once again, we're all people.

I hope that some of the truly tragic events of this summer may have helped bring that home, bring home not only our connection, but the fact that the lines of vulnerability run in the same direction, everywhere. So, the most famous quote of 2020 came tragically from George Floyd. As he was being murdered, he said I can't breathe. And you can't really breathe because there's a cop kneeling on your neck, because your community is stifled by police brutality, but you also can't breathe because the same communities are far more likely to host, say, coal-fired power plants. Asthma rates are three times as high among black Americans as white Americans, it doesn't have the slightest thing to do with genetic disposition to asthma, it has to do with where the hell you live.

We can't breathe because there's so much wildfire smoke in the air across the western US. They're telling you to shelter in your house and keep the windows shut so none of that outside air can enter in. There's not an individual cure for that, there's only the hard work of defeating climate change.

The iron law of climate change is, the people that did the least to cause it suffered first and hardest. And that's basically true with just about everything else, including COVID, too. So again, if 2020 has given us any gift at all it's a kind of X-ray of our society, to demonstrate where the fractures are. That may be a metaphor that I'm a little over comfortable with, but I think it's a powerful reminder of just what we've learned over the past year.

MD: I wanted to pick up on your allusion to eugenics. Some ideas become very seductive for even very smart, well-educated people, but it simply is not true that the eugenics movement was this fringe element of people that just were misguided and misinformed. It had everything to do with selling the idea that, first, there are bad genes. Particularly after Galton frames and names it in the late 19th century, he comes up with the Greek word *eugenics*, meaning the pursuit of good

genes. It is very easy to sell many people on the idea — it was, and I'm not so sure we're past that now — that there are bad genes, and that there's a technology to fix the bad genes. Of course, eugenics didn't so much offer a new technology. The eugenics movement offered the idea that those people with bad genes would be restricted from being able to reproduce.

But still, as I said, there are a lot of people across the political spectrum — ideological spectrum — in different countries around the world, with this idea that there's something in relation to biological determinism, there's something in nature that needs to be either eliminated, restrained, or with a technological fix, fixed — have the technology fix it. So, I mean, I know that there are elements of the eugenics movement that after the Nuremberg Trials moved into taking up places in the new genetics field. I won't get into that now but it certainly does speak to the ongoing seduction if you will the attraction of being able to fix bad genes,

PT: Is part of the seduction that it sounds really simple, Stuart? I mean, you know that it's not simple but to some people this is a quick fix, it's a little edit, and then we can fix everything.

SN: Right. That's the seductive part of it but it's based on bad scientific theory so it's not just bad technologies that are all around us, but a lot of science is really combating, not just confronting nature directly and finding out about it, but it's really dispelling bad ideas, bad scientific ideas, of the past. Eugenics and genetic determinism grew up around classes of people that had an interest in defining themselves as better than other people. In fact, slavery was being abolished in England before the United States, and then just alongside the end of slavery was this new ideology.

Galton, as Marsha mentioned, was one of the founders of a new ideology that tried to place in nature the idea that that people in the upper classes were somehow superior to people in the lower classes. Whether their status in society was as slaves or workers, the people on top were better biologically. And then, as genetics became more of a science, this idea of genetic determinism took hold, not only in society but in biology itself. So biologists, for a long time, acted and wrote as if organisms were run by little computer programs that were based on the genes. And since we know how to reprogram computers, we can reprogram the genome.

But what we're finding out more and more is that genes don't always act the same way in different individuals. So the same gene can act quite differently in two different people. And certainly we learned a lot about genes from looking at non-human species, and it's even a bigger jump there. The genes may act one way, a given gene may act one way in one species and people say, Oh, that's the way it happens in humans, we can't experiment on humans but that's the way it happens. But when we change that gene in the human, we're finding out in human populations that people who have genetic variants that should kill them, are perfectly healthy, and vice versa: Genes that seem to be normal are harmful in some people that happen to have other genes that are incompatible with them. So we don't even know what genes do in in one species. So, the idea of changing them, and the idea of explaining differences between individual people based on genes is ridiculous.

PT: You mentioned something there about computers and human beings and I was interested to read — it's been in the news for a while now — the Gates Foundation sort of touting the idea that we can inject our blood with nanobots, which will alter our DNA and therefore make us healthier

and better human beings. And this kind of solution, this kind of creating these transhumans, you know it does view people as extensions of computer software. It's a very prominent theme, within genetic engineering, even with food — genetically engineering our food and using food as just an extension of a computer program as well.

SN: Right. And it's going to become more and more industrialized. There are going to be attempts, as in the Chinese case with the twins, to modify human embryos, but people are quickly realizing that this is such a chancy thing that they're shifting to another strategy, which is to use people's body cells, the cells of somebody's skin or other obtainable parts and turning them into stem cells, and then you can turn those stem cells into eggs and sperm. And then you can create an unlimited number of basically clonal individuals from the same parents.

Or you could even turn your own cells into both sperm and egg and have yourself replicated many times and then choose the ones that are genetically engineered to your satisfaction. So, it becomes a kind of an industrialization of human reproduction. It's really in the cards. In fact, a Dean of Harvard Business School recently wrote an Op-ed in the *New York Times* touting this as an idea for infertile people and same-sex couples to have children, to just do it on kind of an industrial basis.

PT: Marsha, what do you think about that, from a rights perspective? What are the rights of the progeny of these technologies?

MD: Well, there's the process of adults entering the marketplace to purchase technologies to fulfil their sense of adult agency. That's different — and I think we have to remember that that's different — from the notion of intergenerational concern for what we pass on to children in the future.

Now, I tend to call this intergenerational justice, and I think a few other people have also used that term. Of course, "justice" gives it a much more legalistic root if you will, grounding, but it still goes to the issue of separating adult agency now, and once again we're talking about people with deep pockets. We're not talking about a widely available option for many different kinds of people, or many different social classes, we're talking about, as Stuart just mentioned, the images that the well-to-do have of themselves and other agencies.

So that's one issue. But another issue is, what are our conversations about our boundaries and responsibilities to the children who are to be? Is it simply about our level of agency now, what we want, is it just our ego extension now? And I think this does touch on Stuart's concern about what happens when there are errors. Who will take responsibility? The child to be will be responsible. Looking over that, looking over their shoulder, it will have been the adult agency that created the situation.

That's not to say that there are always errors and there will always be errors. But in this brave new world, you know, to quote somebody who's used that title before, where are our values? And what kinds of critical conversations about fairness and limits, if you will? I mean I find myself in some conferences using that term, and people start to shudder. Well, why should we be pulling back from the notion of limits?

SN: I'd like to pick up on the intergenerational points that Marsha raises. There are actually prospectively good uses for genetic technologies if somebody is very ill, if an existing person is very ill. Sometimes there are no cures for what they have and genetics may present cures, because in an adult, or a child, it's usually one organ that's compromised and you can modify the genes in that organ.

When you start talking about genetically engineering people that don't yet exist — that's what's called germline modification — it's prospective. And this is not a pressing point because you don't have anybody who is sick. You have just somebody who might be sick if they're allowed to come into existence, and you want to stop that. It's basically a problem that is not a real problem, it's just something that is possible to do scientifically. There are business models accumulating around it and people say, "Well, why don't we try it? It might give people options to have children that they wouldn't have based on their own genetics." And it becomes a kind of a consumer desirability that is not really a social problem.

There's that side of it, and then there's also this question of deception in selling these things, for example, as you probably know, Pat, in England. There's a technique for producing people prospectively by mixing parts of eggs of two different women. It's been called mitochondrial transfer, at least that's the way it's been presented to the public. It was approved in Great Britain, it went up through Parliament, and as Tina Stevens and I show in our book *Biotech Juggernaut*, it was based on a misrepresentation of the technique, because it wasn't mitochondrial transfer at all. It was taking the nucleus of the egg of one woman and transferring it into an egg of another woman so it was nuclear transfer.

The nuclei have most of the genes of the person, about 22,000 genes. The mitochondria have just a few dozen genes, and it was sold as mitochondrial transfer because it was more palatable and it seemed less dangerous. But in fact, it was dangerous, and it was nonetheless approved, based on misrepresentation, not only by advocates from the commercial side but scientists themselves, who allowed the misrepresentations to go forward, because there was an interest in applying this clever fix to a problem that is not. It's a problem if a child is born with these genes, but the child doesn't need to be born with them.

BM: I just want to go back a little bit and see what comes from organizing and movement-building terms. One of the things that Stuart said is really important.

When one confronts this possibility of a future of genetically modified human beings, we're lucky in that there is a fairly obvious line in the sand to draw, under the germ line. And that's not always the case and one of the things that has made the fight around climate change so hard was that for quite a while we had no real idea of how much was too much carbon and so one and that was sort of the work of groups like 350 dot org, to try and draw a line and say this far and no further.

The other thing that makes it possible at this point is that there isn't yet in existence the enormous industry that's making huge amounts of money from doing this. There's a prospective industry that thinks it might make some serious money. And one of the problems is that that industry is concentrated in and around Silicon Valley, and it has tight connections to some of the richest and most powerful people on earth, people at places like Google, but it isn't yet in existence. We're not talking about the same kind of problems as when we deal with climate change, of having

to deal with the fact that millions of people make their living in the fossil fuel industry or that there's a huge dedicated infrastructure that's in all our homes that needs to be changed or anything like that. For once we actually have a potential crisis that we understood far enough in advance to be able to say, let's just don't go there and we can cross this one thing off our list. It's not like we don't have a lot of other things to worry about, as a society; this would be one road down which we would not have to go.

And it's been good to see some of the world's scientific societies and things, stepping up a little bit. I was kind of interested to see if this ham-fisted attempt by this Chinese doctor to produce these babies last year seems to have resulted in at least a few scientists that maybe we're not really in a place to do this yet and we should back off some and that struck me as a good sign.

SN: I'd just point out that the framing of that is very important. As Bill points out, there are scientists that are kind of expressing caution about it. But the cautions are kind of peculiar. The main technique, CRISPR, that's used to genetically engineer organisms is not entirely accurate. So very often the question is what let's wait until we can make it more accurate and then do it. But there are very few people talking about the complexities of the organisms that make them inherently not capable of being engineered because you can make the technique of changing the DNA as accurate as perfect as possible, and you still have this problem of complexity.

BM: That's why we're glad we have you to sort of make the broader case.

SN: And then there's the framing of accessibility so very often. There was a letter in *Science* by a whole bunch of people that were concerned about this calling for public discussion, but another aspect of the framing that's very prominent is, let's make sure it's available to everybody and it's not applied in a discriminatory fashion. But if something is a wrong thing to do, you don't necessarily want to make it available to everybody. It might just be a wrongheaded thing, as I believe it is, to go about doing it. People might be satisfied that the government will step in and make it available and probably make it available to poor people first, maybe to do the experimental phase, but really the idea of accessibility of something that's a bad idea is not a good framing.

PT: Do any of you think that this framing attacks what it is to be human, I'm thinking particularly, Marsha, of your comments on limits and boundaries and I have to echo you that the work that we've done over here on limits and boundaries around genetic technologies makes people very uncomfortable. The idea that there should be limits really gets people's blood boiling and yet human beings are inherently limited. We have limits, we have boundaries, we work within them. We have planetary boundaries and we should be working within those too and yet we continually try to break them and we do that in the name of innovation: the rhetoric is, we're facing big challenges and we need to innovate. I wonder if any of you can speak to the difference between thinking critically about technology, as opposed to dismissing it entirely, because that seems to be part of the problem..

MD: So how do we have a real honest conversation about hubris? Because that's what it is. That's what I think we have to be on guard for, not whether or not we need or can move forward to use technologies to really benefit humankind. And for me, there are a couple of important markers: One

important marker is, we now have some of the power that nature has to reproduce itself, send it forward to build itself. The difference is that nature isn't in it for profit, and some of our activity is.

That's not to say do nothing about the technologies we have. It is to say, for me at least, let's have an honest conversation about a couple of major things. One, what is the role of pride, ego, hubris in our decisions? Two, to what extent have we channeled millions of dollars of public funds into private endeavors, but not asked those successful endeavors to return that seed capital to the public fund to make those funds available for new innovations?

Because then what happens is that part of what drives people is this notion that I have to get something, use it, keep it and keep it all for myself — not, I have to use what's in a public commons or public trust, or public kitty, use it to fund innovation, but then be sure to give something back at least, at the very least, what I received from the public good. Give that back. Give those resources back to make that capital available for other entrepreneurs, other scientists, other people with good ideas.

So you see how that, over time, encourages a level of selfishness, that is laced with what I (for want of another term) call hubris. And we do have a choice, we do have choices about intervening in the conversations we have with one another, and the choices and decisions we make about these issues. It's not somehow beyond us to do that. And sometimes some of our actions speak to almost the sense of the inevitability of selfishness and egotism.

SN: There's a real good case in point that illustrates these issues. In 2004, there was a ballot initiative in California, Proposition 71, that called for $3 billion to be spent on making embryonic stem cells. The Federal government in the US had banned making embryonic stem cells from human embryos, so California decided to go it on its own. And they promised that this technology would be used to cure all sorts of diseases, and would return huge amounts of money that were publicly spent to the public coffers because companies would be started and everything.

The people who were promoting this bill tried to get an injunction against critics on the ballot who used the word embryo in describing the embryonic stem cells, they said they're not really embryos, they're somatic cell nuclear transfer products — they used some kind of verbiage — but they lost. They lost the ability to prevent people from describing those embryos but they won the initiative.

They spent the money, and they wound up barely using that technique at all, that the whole program was devised around. It started the California Institute for Regenerative Medicine, they funded a lot of projects using other technologies which became more useful but barely used the technology that it was founded for and returned no money to the public coffers, and now they're coming back again and asking for $7 billion, I think, to keep on doing it.

PT: Bill did you want to jump in there.

BM: Just to kind of broaden the discussion a little bit. I really want to go back to Marsha's powerful discussion around hubris. Look, the idea that there's something either right or wrong about technology and solving that question will help you solve a problem is one. There are technologies that exist to make our impact on the world around us bigger and technologies that exist to make our impact on the world around us smaller.

For instance, I think the most important thing that governments can be doing at the moment is figuring out how to build solar panels as fast as ever they could. Because if we can roll them out in sufficient numbers, we can staunch some of the flow of carbon into the atmosphere and reduce the temperature at which the planet finally equilibrates, high though that will almost surely be. That's a technology of human humility at some level, it makes us smaller in our impact on others.

And it's exactly the opposite of, say, germline genetic engineering, which is profoundly a technology of human arrogance. The idea that, say, our parents are well equipped to genetically program their children and that will work out great is belied by everything we know about ourselves, our desires our inclinations, our sense of the world. These are cases where we should figure out how to reduce our size. Again, there's good news here in that this is one of these cases, I think, where we may find, as we have in the climate movement, that there'll be a lot of people of faith, for instance, who understand this predicament in those terms and will be willing to think about it in powerful ways.

As usual, the problem is that there are a small number of people who can make a great deal of money from things, and under our current setup, that's all that we need to go ahead with them. We've got to become serious about stopping the ability of small numbers of people with lots of money to do whatever they want, because it's getting us in all kinds of trouble.

PT: So that sort of provokes what was going around in my head as the next question, and I would frame it by saying, you know, pharmaceutical drugs are studied specifically for adverse effects and there are ethics committees that you have to jump through, and some would argue that maybe they're not studied enough but at least they are studied. Technology when it is released into society is not necessarily studied for its adverse effects. It doesn't have to prove its benefit, it's not necessarily subject to ethical inquiry. So I guess my question is, does that need to be built into some official regulatory process? And a second part of that question is, how can the social movements that we talked about earlier redirect things in that way?

SN: Well, as far as germline genetic engineering, it's impossible to do it that way, because, basically, it's an experiment that takes a generation or two to see if it worked or not. So, it would be really infeasible. If we started along that path to have committees scrutinizing it, it would be cross-generational committees that would have to see whether children that were genetically engineered to cure this disease or that disease or affect this change didn't have side effects and adverse effects as they aged and so on. So, this is a real example of a technology that is just not a good idea to embark upon. But with regard to other things of course you're right, that if something is introduced, and it can be introduced provisionally, it should definitely be scrutinized the way introducing a medication is scrutinized, for sure.

PT: Well, at the moment the scrutiny is the laboratory science, and what we're hearing today, what this group is saying, is there's more than the laboratory science, there is the ethics, there are the social effects, there are the longer-term effects. It strikes me as really very odd that technology which so profoundly affects our lives, how we view ourselves, our humanity is not even scrutinized at all before being released into the world.

BM: I listen to scientists when they talk about this, When I've done interviews with lots of scientists working on this, I'm impressed by two things: One, they always say, we do it because it's cool. The big money guys are looking at the big money, but a lot of the bench scientists are like, this is what we do. It's interesting and fascinating and we're pushing ahead and finding things out and whatever.

But the other thing they always say is, I very much hope that people are not leaving it up to us to solve the ethical problems around this, because we're not equipped to do that, we don't know how to do that. And, you know, in other areas, we understand that. We don't expect people who know how to design nuclear missiles to decide whether or not dropping them on a particular city or dropping them at all is a good idea or not. And the fact that someone's put out CRISPR doesn't give them any particular insight into whether or not it's a good idea to use it in these applications or not.

This is, I gotta say, also true in too many ways, too often, of this caste of people called bioethicists, whose work often consists of saying, this somewhat resembles something else that we've done in the past, so go ahead and do it.

These are questions that are completely possible for human beings to answer themselves and as a society. Human beings' naive understanding of how this works or what we should do is often far sounder than people who are deeply immersed in the science. If you ask normal people, is it a good idea to have designer babies, they say for the most part, no it's not a good idea because they know a lot about societies, they know a lot about babies, and they know a lot about love. And those are the things that you need to understand these questions, not a kind of PhD level education in genetics. That's useful if you actually want to do the work, but it doesn't help you, it doesn't give you special insight into what the work is about, or what we should do with it. So I think this is a place where we'd be well advised to have this discussion as widely and broadly as possible, and without attendant deference to expert opinion here, because there are no experts in that sense.

MD: Let me share a bit about social movements. There's a lot of energy out here for social movements on the environment or for justice, racial ethnic rights, immigrant rights. Part of what's really obstructing things right now is this movement by those in positions of power away from government-run society, to a corporate-run society. Recently I looked at the composition of who's serving in our Congress, what are their passions or their backgrounds. And there's a real emphasis on deep pockets putting people in positions of decision-making — money putting people in the Congress.

So, we have to begin to address some of these. Maybe through voting, maybe through more sophisticated use of social media, but there's no shortage of energy in social movements to really address, and in some instances, redirect some of the emphasis of some of the movements, or the uses of technology, some of the choices and decision-making. But at the moment, we have a federal infrastructure that is not very supportive of social engagement by and large, and certainly not very much at all supportive or welcoming of social-justice movements and social movements, so we have to change that.

We have an election coming up. It isn't just the White House that we should be focused on. We should also be concerned about who's making the laws, who's spending the public money, who's making choices and decisions about the direction of the useful — a number of things are popping in my head. So right, there's work, there's serious work to be done and I'm thinking of the

rollbacks at the level of the EPA bill. There's energy, and we have to make a better way for that energy to be translated up through government, so the different choices and decisions can be deliberated on and decided on and put into place.

PT: We're coming very close to our hour now, I wanted to ask each of you a final question, and I'll frame it this way: A million years ago when I was editing a magazine called *The Ecologist*, I circulated a list of questions to my staff that I hoped that they would consider when they were confronted with a new technology. They looked at it from ecological and social and practical and political and aesthetic and all sorts of different perspectives and of course, few technologies stand up to all of these things, but I wondered, in our last moments, if each of you could give some advice to our viewers today about critical thinking when it comes to technology, when you're faced with a new whiz bang technology that just sounds like it's going to change the world. What are the key questions that you think people should ask to try and make sense of it?

BM: I was just gonna say, I mean, the first thing obviously is to look and see if it causes more problems than it solves. Very often, that's the case, but the even deeper question is just to ask yourself first, whether there's actually a real problem it's trying to solve anyway. I mean, the problem that human genetic engineering is trying to solve is people aren't good enough. But that's not a problem. People are good enough. We're completely capable of doing all kinds of things. We don't do them because we live in unjust social structures, we don't look out for each other, we're responding to a bad series of cues, we have compromised history, on and on and on.

But we can overcome those things, we're capable of doing it. We're quite remarkable. So that would be the very first advice: Make sure that the thing that you're solving is actually a problem, not just a kind of opportunity for making money, which is a very different thing. The fact that you might have to forego something that would make somebody money is not a problem. It's often it turns out to be a great virtue in and of itself.

MD: And if I can say a few words about precaution. Not too long ago, I mean not even a century ago, some decades ago, always before us there was this idea that any maverick technology, innovation, should be able to establish that it will do no harm. And that was called the precautionary principle. Now, it is still important and vital in many places in our thinking and our behavior in the science community — and in other places as well — but it has now run up against this rush for branding technologies, this rush to make profits as Bill was saying, this rush to hurry up and enter the marketplace with something.

For those of us living here in the States, I don't watch that much television, but I've seen a few ads where a drug is promoted in an ad to solve a problem. And then if you listen carefully by the end of the commercial, it lists no less than five other things that can happen to you, if you take this drug. And those other things are pretty serious, enough so that when I listen to what it's meant to intervene in, barring if you're allergic to it, and then I listened to all of the, but here are the other things that can happen to you, I'm like, shut up!

So that backs me back up to precaution. How are we looking at novel maverick technologies or protocols and asking, do we know it doesn't do harm? And when it comes to genetic technologies, experimenting on mice and animals, even primates, is not the same as experimenting

on humans. If I can leave one message, to what extent do we revitalize a precautionary principle? Know this up to as far as we can ascertain, we know we have tested it, we know this will do no harm —precaution as a way to protect consumers, and precaution as a way to protect real humans. So that's what I would leave things with. Thank you.

SN: I would end by saying that science itself is a kind of differentiated enterprise. Just because something involves genes doesn't mean it's scientific. I think that informed people very often, kind of pit the scientific world against the anti-science world but it's much more complicated than that. Within science there are divisions. The idea of genetic determinism seemed to be the height of science for many years, and now it's dissolving. And so people who are trying to evaluate a new technology should look at the debates within the scientific community that may kind of question and pitch that technology because it's not as if anything that is genetically engineered is going to be better than when it's not genetically engineered. I mean, people understand that, but they also have to understand that genes are not what runs everything in an organism and modifying genes is not the only way to improve things.

PT: I'm just in awe of the breadth of this conversation today and I wish we could carry on for much longer. I think there's some tremendous food for thought there about the way that we approach technologies, and in particular the power of our hierarchies behind these technologies and how often we as individuals get left out of them. I just thank you so much, all of you for joining us today. It's been a real pleasure to speak to you all and I hope we can maybe have a part two sometime.