

The Big Questions: Is interfering with genes ethical?

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Nicky Campbell (NC): Today on The Big Questions - the building blocks of life. Should we meddle with them to create designer babies, cure diseases, enhance human beings, or interfere in the natural world?

NC: Good morning. I'm Nicky Campbell. Welcome to the Big Questions. Today we're back at the Harris Academy in Peckham, South London, to debate one very big question: Is interfering with genes ethical? Welcome, everybody, to The Big Questions.

NC: Now. Until recently, you could only suspect you were at risk of developing a disease or life-changing condition if someone in your family had already suffered from it. Today, anyone can find out about the genes that make up their DNA by sending off a test tube of spit to one of the many companies who offer a testing service for a modest fee.

NC: Now, to some, knowledge is power. They may be able to make changes that might reduce their risks. Others say it's better not to know - why face a death sentence if nothing can be done about it?

NC: But now doctors are beginning to change the odds. Gene therapy may one day help the sufferers of previously incurable diseases, and gene editing is already helping carriers of damaging conditions to have healthy babies.

NC: Of course, if you can change things for humans, you can also change things across the natural world - crops, insects, birds and animals. The possibilities unfolding are powerful. But, like that Pandora's box, they may also unleash unexpected problems, and pose moral quandaries, too.

NC: So we have assembled a highly distinguished front row of scientists, bioethicists, environmentalists, campaigners, religious thinkers, embryologists and lawyers to debate the challenges posed by this new frontier of science.

And you can join in, too, on Twitter, or online, by logging onto bbc.co.uk/thebigquestions. Follow the link to the online discussion. Lots of encouragement and contributions from our excellent audience here in South London. Welcome, everybody.

NC: Such a fascinating and enthralling subject, this. Doctor Silvia Camporesi, Director of Bioethics, Kings College, London. Silvia, hello.

Silvia Camporesi (SC; Director, Bioethics and Society, Kings College London): Hello, thanks for having me.

NC: It's a great pleasure. I mean, it's a terrifying area for some...

SC: Not terrifying.

NC: You're very excited about it?

SC: I'm very excited, of course. I don't think we should hype up the claims of scientists, but I think, personally, it's very exciting. I am a bioethicist with a background in biotechnology. So I think looking at the field of gene therapy from the early 80s up to now, this is revolutionary technology. And gene therapy, the problem has always been the off-target effects. So when

we were trying to change a particular sequence in the DNA, we were not really able to change that one and we would have changes in other parts of the genome.

SC: And with CRISPR genome editing, that is a game changer. So we have very fewer, or none off target defects. And it works in any cell with a nucleus, that's a eukaryote cell. So human cells, animal cells, plants, and when we talk about human application, it's really going to be gene therapy.

NC: I want to ask you about that. The world's our genetically modified oyster, basically, isn't it?

Looking ahead.

NC: Now, at the moment, current rules only allow scientists to use embryos up to 14 days after fertilisation. Now, I know you would like to extend that, because you're talking about the time that we could have full-term pregnancies, one day. What do you call it? Ectogenesis, is that...

SC: Yes, ectogenesis is a term that was coined in 1924, almost 100 years ago, by British evolutionary biologist Haldane. It really means the growth of a human embryo, so a foetus, outside of a woman's body. When we talk about 14 days, I think there needs to be some distinction made, because most of the application of CRISPR genome editing are not going to be on the embryos, they are going to be on the somatic cells, the adult cells. But when we talk about the embryo...

NC: A somatic cell is a cell which doesn't have any inheritable...

SC: Yeah, somatic cells are cells from our skin. Anything that is not a germ cell, sperm cell, or eggs, really. So when we're talking about the 14 days, I think that the elephant in the room in the discussion is really ectogenics, because if we were able to culture an embryo in vitro for longer, we would be able to experiment with a culture in an embryo and foetus outside of the woman's body. I have always been fascinated with a future, which, unfortunately, I don't think is going to happen in my own lifetime, in which we would have reproduction decoupled from biology, and finally achieve gender equality.

NC: How would that achieve gender equality?

SC: Because I don't think gender equality is ever going to be achieved if we have women tied to biology and pregnancy. And having to carry the...

NC: So pregnancy would be outwith the woman's body?

SC: Yeah, externalised. Increasingly we see reproduction and pregnancy being externalised in different contexts with IVF and surrogacy, but if you look at... I mean, these are debates that are not new. In 1969, there was a wonderful book by Ursula McGuinness, some of you may remember it, *The Left Hand Of Darkness*, in a future in which there is no sexual dimorphism, men and women, and both... Basically, there is one gender. And they can... Men and women, can carry to term babies. And I think, that's of course just my personal opinion, that we are never going to achieve gender equality until we have reproduction decoupled, so, from biology. That's why I think this is one of the debates that is not really much to discuss when we talk about the 14 days. We always talk about, "Oh, we are curing infertility", this is the mantra.

NC: EXHALES SHARPLY

SC: But there are other topics that are important.

Trevor Stammers (TS; Centre for Bioethics and Emerging Technologies): I wonder about...

NC: What about that, hey? I knew this was going to be interesting.

TS: I wonder about...

NC: Trevor?

TS: I wonder about equality, too.

NC: Well, what do you think about what you heard there: what was it? Decoupling women from biology and social inequality by having full-term pregnancy outside the body?

TS: I think we need to be very careful before we decouple ourselves from what may constitute an intrinsic part of our humanity.

APPLAUSE

TS: I can see how... I can see how ectogenesis may be able to save babies that currently die because they are born preterm, but I think that our human development is such that the... the nurturing, the closeness, the fact that that is the way in which human beings come into being, in their mother's womb, I think that trying to escape from that element of human nature may have adverse consequences, as well as saving premature children. So...

NC: What would those adverse consequences be?

TS: Well... I think that for one thing, the... One of the interesting questions about ectogenesis. ...

NC: You don't have to go through pregnancy, you don't know what it's like!

TS: No, I don't. And I know that women do. But one of the arguments that is commonly made for having abortions is that a woman has a right over her own body. And if ectogenesis were to become the norm, the circumstances, as I know from being a general practitioner for nearly 30 years, the circumstances that often lead to an abortion, the fella's gone off, or whatever, those are still going to be relevant to, surely, turning off the ectogenesis machine, or killing the infant.

I think we treat antenatal life trivially now.

Virginia Bolton (VB; Clinical Embryologist, British Fertility Society): No, that's not...

NC: Virginia wants to come in now.

TS: We'll still do so then.

NC: Virginia?

VB: I just feel a little uncomfortable that the debate has jumped, taken a quantum leap so far into the future.

NC: It's not my fault!

LAUGHTER

VB: when... I'm not apportioning blame in any sense.

NC: Pull us back.

VB: I think that perhaps it would be more constructive if we talked about reality, about things that are immediate. The ethical issues that we're confronting with the science that we are able to do today, rather than projecting so far into the future that we're talking about hypothetical situations which have no relevance to the present day.

NC: Although the notion of taking it beyond 14 days, the embryo at 11+ days after fertilisation, is quite interesting, pushing that particular limit, because there are very strict rules on that, aren't there?

VB: Yes, there are indeed.

NC: Properly?

VB: Those rules were put in place a long time ago, when the Act was passed, The Human Fertilisation And Embryology Act was passed in 1990. And that was following an enormous amount of public debate, public consultation, the Warnock Commission's report to the government, on what would be acceptable...

NC: Sorry.

VB: A line needed to be drawn.

NC: I'm so sorry, Virginia. I'm staying with you, but a little bit of explanation for our viewers. Why 14 days, was that when this little streak of blood appears?

VB: This is exactly what I was about to say. The line had to be drawn because public opinion was so concerned, and so suspicious of what might be possible about the slippery slope that we might be embarking upon, that everybody recognised we needed to reassure the general public.

We need to tell everybody there isn't crazy scientists in white coats in basements wanting to do insane things with embryos, and tinker with them. What we want to do is responsible science, responsible research. So where is a reasonable limit that we can draw that would enable us to carry out research, and to advance our knowledge, and advance our understanding, that we can say, this is a defined time, there's something specific that happens at 14 days that we can say, this is the point at which, beyond which, it's not acceptable to do...

NC: That was 27 years ago. That was a long time ago.

VB: The line was drawn at the point when a primitive streak appears in the embryo, and that is the last point at which twinning can occur, so this was taken to be a tangible moment in development that people could identify with, and say this is the point at which personhood, perhaps, if you choose to use that term, or if that makes you feel comfortable... So it was really creating a moment, or defining a moment that people could identify with and say, "OK, this is the point beyond which it is a human being".

NC: Has the time come, 27 years on, given our knowledge now, compared with then, has the time come to push it beyond 14 days?

VB: To revisit the decision that was made then?

Jonathan Montgomery (JM; Former Chair, Nuffield Council on Bioethics): Absolutely.

NC: Jonathan?

JM: It's definitely time to ask for a decision again, that 14 days are a pretty flaky biological line.

We don't really know what happens at 14 days, because we haven't been able to observe things that far. We have a big gap between about 14 days, and about 28 days, when we can begin to learn things from miscarriages, where we just don't really know about the foetal development.

And the case to be made, and I think the case still has to be made, is that there's enough promise of us learning things that will be useful, reasonably soon, about particularly, I think, the causes of miscarriages.

NC: And eliminating certain diseases as well?

JM: Well, it's too early. I think the 14-day question is not yet about eliminating diseases. It's about understanding embryology. Hopefully, it might lead on to some of those more clinical applications later, but at this stage, the question is, do we think it's good enough? Is it important enough to know those things to go back to the public and parliament, and say, "Is this the time to move?" So I don't think the case is yet made that we should move, but it's definitely time to ask the question.

NC: David King, director of Human Genetics Alert. Presumably there's an alert to you on what we're hearing here. Is it time to revisit this and look again at whether we should go beyond 14 days?

David King (DK, Human Genetics Alert): I'm not convinced by that. What I see, having watched the way the scientific community operates from...as a, kind of... pundit and commentator for the last 30 years, is they're very good at, you know, coming up with very nice sounding and reasonable sounding explanations about why we should always, you know, just move beyond this particular thing, then the next thing, and the next thing,...

NC: That's progress, scientific progress.

DK: Unfortunately, what some people call scientific progress, other people call a slippery slope.

And those slippery slopes, unfortunately, are very real things.

NC: Are they bad, slippery slopes?

DK: They can be. They can be very bad. I'll give you an example which will relate very much to this question of genetically engineering human beings. There are lots of people now saying, "Oh, it's fine, we can just use it for, you know, for treating single gene diseases. We won't use it for all those things that are labelled enhancement, about making children, you know, stronger, more athletic, taller, more beautiful and all that. They think that we can cross the line to do single gene diseases, but not doing enhancements. That's an example, we know already, with drugs, with surgery, that these techniques which developed for the very best purpose...

NC: David, this is like splitting the atom!

DK: Yes, and look what came of that!

NC: Good things came of it as well, though, didn't they?

DK: And a lot of extremely bad things came of it. We've been living for the last 80 years under the threat of nuclear annihilation...

SC: Just because there are bad politicians...

DK: Scientists always want to say, "Oh, no, no, it's not us, it's the bad politicians". Excuse me. But it's scientists who always push, push, push. And they've always got to...

NC: But Science is discovering means of progress. It's discovering new techniques. The fact that those techniques are misused and abused by some people, if... otherwise, you're saying, "put a stop, call a halt to science". We can't do that. Ruth, come in here.

DK: I'm not saying that at all, I'm sorry.

NC: Hang on, let's get Ruth's response.

Ruth Stirton (RS; Healthcare Law and Ethics, Sussex University): The thing about the slippery slope argument rhetoric is it's rhetoric. We talk about the inevitable slip down the slope...

DK: It's reality, I see it happen everyday...

RS: No, it's not. It's been 27 years since the 14-day rule was set and we haven't gone on any further because we have a very strong regulatory framework which stops people going further.

TS: And because you couldn't culture the cells for more than 14 days. But now you can, so I would suggest that's also part of the mix.

RS: But because the science has changed, is it not also time to revisit the regulatory framework? If the 14-day rule is really as flaky as it sounds. And it was picked because we needed a line to make our regulatory framework work, and it is arbitrary. And you can make the argument about any point in, from conception to birth, any line is arbitrary. So why have we fixed on 14 days when, actually, we can learn things that are incredibly valuable if we carry on a little bit longer?

APPLAUSE

NC: Let me talk to you, Jonathan. What about the eradication of diseases? The use of that particular technology when it comes to the exciting new world, the frightening new world, the brave new world, whatever you call it, where are we going with that?

JM: Well, I think we shouldn't think this is just about gene editing.

I'd like to talk about gene editing now!

JM: So, the question is not just about the technique. The question is about, is the purpose, the purpose which you can sign up to...

NC: You're reading my mind.

JM: And, secondly, is there anything about using this technique which is more or less dangerous, more or less likely to succeed than others? So, the discussion about somatic and germline therapies is a way of thinking about, it might be less risky...

NC: Germline is when it is heritable.

JM: ..So, less risky to do something that won't be inherited than is inherited. But we do lots of things that have impact on our children. We choose how to educate them. We immunise them. We try and do things to try and have impact, we think are good impacts. So we should ask ourselves, first of all, whether or not the most effective way of eradicating a disease is to do something relatively untried.

NC: Or a disability?

JM: Well... disabilities, there's lots of discussions about the way we can define...

NC: We're about to have it!...

LAUGHTER

JM: the way we define those, too. So, if you're talking about enhancement, they were talking about, I wear contact lenses, I'm enhancing my poor sight. I have a poor memory, I make notes of things so I can deal with it. We don't think those things change identity. They help me be the person I am. The challenge around the disability debate is that some of the things we talk about about disabilities are in that category of short-sightedness or poor memory. Others are in the category that we think is about our identity as people. So, we should talk about things like Down's Syndrome, where people have identities that they associate with being a particular type of life, things that they particularly like. And if we're saying we don't want people like that, then I think that is something to be concerned about. But if what we're doing is helping other people live fuller lives...

NC: Is it an either/or?

JM: ...No, it's a continuum. There's a range of things that are there. But our first responsibility, and this would be my response to Silvia's point, I think, is to try and sort out why our society is an inhospitable place for people with differences, and editing genes is not a very efficient way of doing that.

NC: Yeah. I mean,

SC: I agree 100% with...

APPLAUSE

SC: ...I agree 100% with Jonathan's points, there are many other ways in which we influence future generations, ways that are much more irreversible than potentially editing the genome.

So there is nothing special about the way in which editing of the genome with genetic tools puts in a different category than education, or environmental changes to our planet.

NC: But it is being able to eradicate as much as we can, diseases and, by inference, disability.

Is it a desirable direction of travel?

JM: I don't think that's a fair inference. Yes. Eradicating disease and dealing with disability, they sometimes overlap, but they are not the same thing. So, if we were talking about the possibility of genome editing, being able to rid the world of HIV, we'd have the same sort of debate as we have about polio...

NC: Cystic fibrosis, for example?

SC: I know where you are trying to push me, about the threshold.

NC: I know, I know!

SC; But I think they are difficult questions. My personal opinion is that individuals should have a choice whether to use a particular technology if it's available or not. We are making a decision about their children, that is part of reproductive freedom, that's my opinion.

NC: I will be with you, Laura. Rabbi Laura wants to come in. But, Jackie, can I ask you a question? I mean, you're deaf, it's part of who you are, obviously. What are the dangers here of undervaluing difference and sending the message to people that they don't matter?

Jacky Leach Scully (JLS; Policy, Ethics and Life Sciences, Newcastle University): I think there's a very real danger, particularly in terms of policy and regulation. Individual decisions people make about reproductive selection or, potentially, in the future, about gene editing within their own lives and their own families are individual decisions, and one can't really judge them. You can't really interpret what they mean to anybody outside that family. But when we do have a national policy, a set of regulations, a set of laws, which enable intervention into the lives of some people and not others in order to shape how they appear in the world, whether they have a disability or not, then I think that does run the real risk of sending out some kind of message to the general public that we want particular kinds of people in our society, and we don't want others.

JLS: Now, that might be in fact the truth, that there are certain kinds of people, certain kinds of embodiments, disabilities, diseases, whatever, which any humane person would think, this is not a flourishing life, this is not a way that anybody would want to live. But my concern with a lot of this is that sometimes the technology offers us a very easy answer, an apparently easy intervention, so that we stop thinking about some of the boundaries, about other ways in which we can help disabled people have flourishing lives. We stop thinking about whether in fact something is a disability because of the way somebody's body is, or whether it's a disability because of the way society is, or because of people's attitudes, and so on.

APPLAUSE

NC: Steven?

Steven Storey (SS; had stem cell treatment for MS): Nicky.

NC: How are you doing?

SS: Top of the world.

NC: A lot better than you were, right?

SS: Always.

NC: Tell us the story.

SS: So, I have multiple sclerosis. I was...The headline, I was diagnosed in 2013, my condition deteriorated phenomenally quickly - prior to that I used to do lots of triathlons and long-distance mountain marathon things. Within nine months I was permanently in a wheelchair, and within 18 months I was completely paralysed. Not just unable to stand and

walk, but completely bedbound. Having to be hoisted out of bed, fed with a spoon, washed, cleaned, toileted within 18 months. Which to lots of people would seem a pretty tragic and horrendous place to be. And just in response to what you were just saying a moment ago, I, not for one moment through any of that journey felt any sadness or upset about the place I was in. I was embracing the journey that I was on and relishing every moment of it. I've never been paralysed before, and that was a great moment to experience that, the challenges that brings. And the people that you can communicate with and connect with, and the love and joy that they give you and, equally, the love and joy that you can put out into the world, at whatever point in that spectrum you are, is... I can't think of the right adjective to use, but incredibly valuable.

NC: Life affirming.

SS: Completely life affirming. And I think it's something that... I'm concerned, through the conversation we are having, that gets...undervalued. I don't feel any stronger. I'm now still a wheelchair user.

NC: Tell us about your treatment.

SS: OK. So, at that point when I was completely paralysed, I was introduced by the two professors in Sheffield, Professor Sharrack and Professor Snowden. Sheffield and Chicago are leading some pioneering stem cell treatment. And this is an autologous stem cell treatment, so the beauty of it is it's using my own stem cells to heal my own body.

NC: Right.

So, it's not using any gene editing, so there's no issue with my body rejecting the stem cells. It's using my own stem cells to heal my own body. In essence, they harvest my stem cells, they wipe out the whole of your immune system to zero, so you're in reverse-barrier isolation for a month, so you don't get a cold, because you've got no immune system, which could be tragic and terminal. They then introduce back your own stem cells, and those stem cells go through a process of rebuilding you a brand-new immune system. And effectively, it's like when you have a computer, and your computer crashes, and how do you fix it? You turn it off and you turn it back on again. And that's exactly what they did. It's rebooting your immune system back to a point that it worked, and from being completely paralysed with no sensation, no muscle activity at all, within nine days of having my stem cells back, within nine days, I started. . . I was able, consciously, not through a spasm or a twitch, I was consciously able to twitch a toe. Move it through my own thought.

NC: What was that moment like?

SS: Words can't describe. It was...At that moment, it felt that... Actually, at that moment, it's a point called the day zero, when you get to the point when you have your stem cells back, and that moment it felt like that was the first part of my life, day zero was now going to be the next chapter in my life, and it was...staggering.

NC: How would you feel now if that had been, and how would you have felt then going through that treatment, if they had been somebody else's stem cells? Or stem cells from somewhere else, not you?

SS: That's where my... Lack of comfort with it comes from. Prior to conception, I understand there's a much bigger hurdle to jump. Even post conception, and where I am now as a human going through my journey in life, I still have an issue with stem cell...The stem cells that I had were non-manipulated stem cells, they were just my pure stem cells. If they were manipulated stem cells, I would have an issue.

NC: OK. Brilliant. Purely because...

SS: A final thing I would say...

APPLAUSE

NC: I want to ask you... Get your heads around this, please. Why would you have had an issue?

SS: Purely because of the law of unintended consequences. Not understanding the long-term implications of editing those stem cells, or those genes, or my DNA. The way I view it is very much that with something like insulin, insulin is created by gene editing, with bacteria, and it creates insulin, which you then use if you're diabetic. It's then a process that your body uses to get you through that journey. Right. For me, that is not something that's changing your DNA. That insulin is just fuel. It's basically food. Right. And the way I describe it... The final question I'll say Nicky, is the way I described it to myself at the time was that, if I eat a chicken... If I eat a chicken sandwich, that doesn't make me a chicken. Mm. It's food. If I have gene editing, that could make me closer to being a chicken.

NC: Fascinating. Thank you.

APPLAUSE

NC: Ruth.

RS: Yeah.

NC: I'm going to chuck you the ball.

RS: Yeah.

NC: Where do we draw the line here? Would you have objections if those stem cells had come from elsewhere? Would you draw a moral line?

RS: I think the thing about Stephen's story that really struck me was that if we weren't doing the scientific research, we wouldn't have been able to give you your own stem cells. I'm actually... I know Basil quite well. It doesn't surprise me at all that it was him that was involved.

NC: Yeah. These doctors, they all know each other.

SS: And John Snowdon, let's just put a word in for John Snowdon as well.

NC: Yep. So, we need to do the research.

RS: We need to do the research. We need to find these things out, because, otherwise, Stephen would have been stuck, paralysed, unable to move, and perhaps may not have had the same positive view.

TS: But Stephen was cured with his own stem cells...

RS: Yeah.

TS: ..and I have no moral objection...

RS: Yeah.

NC: OK, wait, wait. Where would your moral objection come in?

TS: But they would come in with the use of embryonic stem cells.

And I think that that...

NC: from a foetus.

From a foetus or an embryo. Right.

Because I would view that as being destructive research on a member of our own species. And it's quite interesting that, at the beginning, when legalisation for stem cell therapy was being mooted, embryonic stem cells were touted as being the sort of crock of gold at the end of the rainbow.

I don't think there is still any, is there, confirmed therapy that's come from the use of embryonic stem cells, and all of the therapies have still come from adult stem cells.

NC: Ruth, come back on that. Stem cells from another member of our own species...

RS: Yeah. I really think that this discussion of embryos as something... Embryos are special, I'll absolutely concede that, but when we talk about them in this way, we're talking about them in relation to their potential. Embryos that are being researched on have no potential, at the moment, to get beyond 14 days.

NC: Yeah.

RS: There is no... There's no person there. It's a collection of cells, and it...

NC: There's a religious divide here. There is...

RS: Yeah.

NC: Trevor comes from a faith point.

RS: Yeah.

JM: I don't think that's true, the religion side.

Laura Janner-Klausner (LJK; Senior Rabbi, Reformed Judaism): Actually, religion's very...

NC; Well, yeah, yeah, so, Rabbi Laura, yeah. I mean, Trevor, your views are informed by your faith.

TS: They are informed by my faith, and I mean, for a Christian, Jesus Christ is the most important person in the universe and, in fact, we believe he created the universe. And millions of people celebrate his birth every year. And before that birth, he was an embryo. And so, obviously, aside from my convictions as a human being, even if I were an atheist, I would have real concerns about experimentation on one of my own species.

THEY TALK OVER EACH OTHER

NC: Rabbi Laura, in a second. Wait, Rabbi Laura in a second. A quick response from Ruth on that.

RS: We do experimentation on members of our own species all the time.

APPLAUSE

RS: All the time.

TS: Not for non-therapeutic benefit. This is totally of no benefit to the embryo. No, no.

RS: There is a huge amount of non-therapeutic research done on human beings, all over the world, all of the time. Yeah.

JM: I would draw a distinction between therapeutic...

No, Rabbi Laura has not spoken yet.

LAUGHTER

LJK: It's quite unusual!

NC: Rabbi Laura, as somebody who does not celebrate the birth of Jesus Christ.

LJK: No, and I wanted to say, it does say that Jesus gave his life so that others could live, so that's interesting.

NC: Rabbi Laura, Rabbi Laura, right.

APPLAUSE

OK. Yeah.

TS: But it was his choice, and he gave his consent.

LJK: I don't think he had a choice to be crucified.

NC: Theology! Theology! You've got an -ology!

TS: He claimed...

LJK: Yeah, well...

NC: OK, right. Let me ask you. Rabbi Laura, Rabbi Laura. Right, let's get back to the Scriptures, if we will. The people who wrote the Scriptures. They did not know about this stuff.

LJK: It might not have been people who wrote the Scriptures, by the way.

NC: But it might have been, but it might not have been.

LJK: Yes.

NC: OK, we've been there before.

LJK: (Laughing) Yes, we have been there before!

NC: They... OK, the people who read the Scriptures didn't know about, not know about this stuff, they would never have conceived that we would be getting to where we're getting now. It's not in the rule book.

LJK: So, what is in the rule book, from the point of view of Jews, is a very permissive attitude to this, that we are partners with God in developing people and making health better. When we talk about genetics or stem cells, I call that medicine. And it is a wonderful thing, and it enables us to live longer, and when we talk about disability, we also haven't mentioned the "pain" word. How much pain and humiliation it can be for people who don't have the possibility... So, when you talked about your stem cell, which is absolutely fantastic. One of my closest friends is going through the same thing at the moment and I speak to her every day, and she is coming back to life, and the only thing I can think of is, thank God that we have the capacity to work together to move the boundaries forward.

APPLAUSE

LJK: Where's your question?

NC: Hmm. No, no. You've just completely floored me.

LJK: Thanks.

NC: As ever. So, I think...

JM: Can I just say...

NC: Go on.

JM: If I was drawing on the Christian tradition, I would take the parable of the good steward, and the person who sits tight and does nothing with the resources is cast into outer darkness. So, I think our religious responsibility is to try and make the most of what we can.

NC: To save lives.

LJK: Absolutely.

JM: So, I think there's a difference between therapeutic benefit, which we can't yet establish, and therapeutic intent, which is what we're trying to achieve.

NC: Let's see what the audience think about this. We've got some... some really engaged expressions, and we've got some quizzical faces as well. One of which is mine. Yeah, what would you like to say?

Audience 1: I have to agree with the Rabbi, and I wish all religious people would look on science and medicine in the same way. It is for the benefit of humans.

APPLAUSE

NC: There are some more hands up. Yeah, the lady there in the black, yeah.

Audience 2: I'm from the Sikh faith, and in our faith, we believe in leaving our hair and our body intact, the way that we are born. I think it's a slippery slope, because what I'm seeing is, we haven't had treatment for cancer and many other illnesses, we've had medicine, and

now we're talking about genetic engineering. I'm just thinking whether we're going to create even more problems for ourselves from the side effects of medicine and genetic engineering and all these new things that are coming out, rather than just staying the way nature intended us to stay.

NC: How nature, what... Ah, how nature intended. There's an interesting phrase, Rabbi Laura.

LJK: How do we know that? How do we know...? I believe that we are continually made, wired, to grow and be curious and try and fix things and try and grow things, and that's how I believe nature intended us, to leave the Garden of Eden to move to the next age, to continually grow. You talked about having contact lenses. I don't think that's the right analogy. I think it's about laser treatment. Can you actually change the way that we are so we can see the world better? And I would say that is how, from my point of view, God intended it.

NC: I'm going to come in a second to somebody who wants to see a much better... Well, we all want to see a much better world...

Yes. ...it's the transhumanist angle on things. Keith. We haven't heard from you yet.

NC: Actually, what an interesting and vexing and perplexing area this is. And it's interesting hearing the different perspectives of the Jewish faith, as expressed by Rabbi Laura, and the Christian faith as expressed by Doctor Stammers. Where are you on this?

Keith Fox (KF; Faraday Institute for Science and Religion): There's a variety of opinion even within the Christian faith, so I understand a lot of what Trevor has said.

NC: Yeah.

KF: I have less reservations about the use of stem cells than he would have. I am concerned about the origin of those stem cells. If they come from aborted fetuses, then I think there is an issue to be asked about.

NC: Tell me more about that issue, the issue you have with that?

KF: Well, it touches, actually, the issue of abortion. If the stem cell has come from something that's cultured in the laboratory, under culture conditions, then it is actually remote from the possibility of being an individual. If it's come from a foetus that happens to be aborted, you've had to give a life in order to be able to save a life. But I would say, within the Christian tradition, there's always been that emphasis on healing, on care for the disadvantaged, which is the other side of that as well, and this is, if you like, if used properly, is another form of healing. That's very dependent on our knowledge of the science and the technology. It has to be applied properly and sensitively, with full debate within that, but if used properly, it's a healing. But there is a fine line between a healing process and enhancement that starts to ask questions about, who are we? What do we...? How do we care for those who are disabled or disadvantaged? What is it that makes me, me? And that's far more than just the DNA that I'm made of.

NC: Mm. Transhumanism. What is it?

David Wood (DW; Transhumanist Party UK): Transhumanism says that what we have inherited from nature, or from our evolution, is far from being the end point, and even a desirable end point. What does nature want for us? Well, nature serves up disease and decay and death and all kinds of destitution and problems. And thank goodness humans

have had the intelligence and the culture and, indeed, often the guidance from religious leaders, and other cultural leaders, to try and progress out of that natural state.

NC: How do we do that?

DW: Well, we can take advantage of what science and technology is putting at our disposal. We have to do it wisely. Of course there are risks, of course we've got to be careful.

NC: Can we genetically manipulate ourselves to be more creative, more intelligent, nicer? Less xenophobic, less racist? Do you believe that can happen?

DW: I think these things are all possible.

NC: How?

DW: I'm not saying that the genes are the only way to enhance us, but as we understand genes more fully - and we're still at a comparatively early stage of how all the connections fit together - there may well be things we can do with our genes to improve aspects of our nature. Some people say, "Oh, it's too complicated, you'll never get a single gene that has a single impact, all these things work in great combinations." Well, frankly, people said for a long time you couldn't have a genetic manipulation that would extend lifespan, because there were hundreds of genes affecting lifespan. Then a few decades ago, people found single genetic modifications in fairly simple organisms, worms, that extended their life two-fold.

And then another modification more recently, a single genetic modification extended their life ten-fold. So I think we should keep an open mind as to what's possible.

NC: Mm.

DW: In terms of the attitude towards what the religious holy books say, I think there's...

NC: OK

DW: There's... The rule book, as it were, can be read in two ways, often...

NC: It can be read in many ways. Allow me to move on to... I'll come back to you, that was interesting. Let me move on to genetically modified crops, if I may. Tony Juniper, environmentalist, what's your problem with GMO? We have very strict regulations in this country about GMO.

Tony Juniper (TJ; Environmentalist & Writer, formerly with Friends of the Earth): We do. My principal skepticism around genetically modified crops is the extent to which they're not actually addressing the main problems that face agriculture at the beginning of the 21st century. We have major problems of soil damage going on across the world, caused by intensive agriculture. We have the impacts of climate change being caused by the build-up of greenhouse gases in the atmosphere, and we have farmers who are not trained to be able to use the land in sustainable ways. All of these things are not going to be amenable to being addressed by the silver bullet of...

NC: So, is this the way to feed the world? This isn't the way to feed the world.

TJ: No, it's not the way to feed the world. And if you look at some of the rhetoric that was there in the late 1990s, from some of the big GMO companies, about how we were going to lift up food production to feed everybody, you look at the crops that we actually have developed, they are mostly herbicide tolerant and insect resistant crops, that are mostly

being used to supply grain for factory farming, for pigs, chickens and cattle, and being used for biofuels. And at the same time as we've invested an enormous amount of effort into these technologies, we're finding that they're beginning to wear out. So, 20 years ago when I worked at Friends of the Earth, we said, down the road, very likely, these transgenic crops that are being used with herbicide, very powerful herbicides, they're not going to work, because nature's very flexible and the weeds will evolve resistance to the herbicides. That's exactly what's happened. We have superweeds now growing in landscapes in North America. We're putting more and more pesticides on, causing more soil damage, and damage to microbes and creatures in the ground. What we need to do is to understand that agriculture is part of a set of natural functioning ecosystems, and we have to protect, preserve and enhance those, rather than chucking more and more technology at it, which experience shows us is actually making things worse as we go along. And, actually, on this thing about food security, and whether we've got enough food in the world, there was some research published recently, telling us that if we didn't go down the factory farming route so forcefully, we've got enough food to feed about 14 billion people. This is not about feeding people, it's about patenting genes in order for very powerful agrochemical companies to make much more money. That's what it's all about.

APPLAUSE

NC: And your point about ecosystems is...

A WOMAN INTERRUPTS

NC: One second, please. I'll come to you in a second, I was just going to stay with Tony. Your point about ecosystems is really interesting, because we are yet in the foothills of understanding...

TJ: Yes.

NC: ...how those ecosystems work.

TJ: Exactly.

NC: We see that we're in the midst of the sixth great extinction...

TJ: Yes.

NC: ..of wonderful animals.

TJ: Yes.

NC: But, you know, do you think this is a kind of madness that we've been gripped by? Because you can understand people's motivations on this, apart from the big companies. But you've got to understand, people think, "Well, this could be a way, actually, to deliver food to a lot of people."

TJ: That may be the stated motivation, but if you look at what's going on on the ground, and the plight faced, especially by poor farmers in tropical countries, remote from markets, it's not an absence of GMO technologies that they are wanting for. They need somewhere to be able to dry their cocoa beans and coffee beans, somewhere to be able to store them and some way of getting them to market. These are the kinds of problems they face. They don't know enough about how to maintain soil health, and the fertility of the ground is going down. They could be getting assistance to be helping with that. And so it just seems to me that by

looking so strongly towards the GMO route, towards global sustainable agriculture, we're looking in the wrong direction.

NC: But there could be positives to it. People talk about...

TJ: Yeah, well...

NC: ...malaria. Mosquitoes and malaria, and having mosquito...

TJ: Yes, but...

NC: Malaria-free mosquitoes.

TJ: That's not an agricultural technology. We're not going to eat the mosquitoes, I wouldn't have thought. You'd need an awful lot of them to make a decent meal.

NC: Birds eat mosquitoes.

TJ: Well, exactly. And so if you start going down these kinds of routes without understanding the full set of implications, especially when you're doing it with things that are in nature, I think there's a completely different set of questions around lab-based technologies being developed for human betterment, compared to those that are being released into the environment. And one of the things that we... (in response to unheard audience member) No, it's not. You don't release...

NC: So, lady there, you're quite animated. What are you...?

Audience 3: Yeah. I mean, I completely agree with what Tony Juniper's saying, but where I think I might come onto disagreeing with him, is I don't think that there's a huge difference between mucking about with things we don't understand, when they're out in the field, and when they're in human beings.

NC: We've moved on from that just slightly...

Audience 3: No, no, but it's extremely important. I mean, you started this programme by the woman saying...

NC: Ecosystems, yeah.

Audience 3: ...you know, saying about, well, human, you know... we'll only have sexual equality, gender equality, when babies are born completely outside the body. Well, you know, I'm a lifelong feminist, and I think this is complete rubbish. And the reason that I think it's complete rubbish is because whenever you look at any particular thing that has happened, you know, that's scientific interventions - I'm not anti-science, but I am against this kind of idea that, somehow, the way you solve these problems is by introducing necessarily scientific solutions, instead of human solutions. So, why don't we have a society where men do 50% of the childcare, and 50% of the domestic work?

NC: Well, that's another debate.

Audience 3: That would be...

NC: That's another debate.

Audience 3: No, but...

NC: Yeah, that's another debate.

Audience 3: That would be a lot more use. It wouldn't be destroying...

NC: It's one we've had before and one we'll no doubt have again. I'd like to move on to...

DW: There's a point that's very pertinent here... If you think about contraception. Contraception was...

NC: No, no, please! I like that power.

DW: Contraception was a technology...

NC: No, I want to move onto xenotransplantation. It's very important that we do that, and I will give you a chance to come back.

DW: Thank you.

NC: With the scientific knowledge that we have of the possibilities of xenotransplantation - this is growing organs in pigs - Ruth, I mean, obviously there are... Nobody would for a second suggest that we use self-aware animals like the great apes for this. There's a massive debate around pigs now, you know, for ethical reasons. But you think there are some very exciting possibilities here, that are actually animal friendly.

RS: Yeah. Well, if you could...

NC: You were telling me earlier on.

RS: I was.

NC: Create animals without brains.

RS: If you were to use xenotransplantation to create animals without brains, then you can grow organs which could be transplanted into humans. We would solve the organ crisis, the organ shortage.

SC: But I think there are other ways to solve the organ shortage. I mean, on this point, I'm usually pro-science, and that's always exciting, but I think there are other ways...

NC: Can I hear from Ruth?

SC: Yeah. Sorry.

NC: Do you ever get the feeling you've lost control? Ruth.

RS: So, the no brains, because there would be no pain, no consciousness, so you'd be farming organs. And using...animal, animal material to do it.

NC: Animals without sentience?

RS: Animals without sentience, without consciousness, without feeling.

NC: This would be interesting, Rabbi Laura, because you might be able to move to a situation that you could have animal experiments, that I think everybody wants to move away

from, without actually using animals with sentience, or using stem cells. There'd be quite exciting possibilities here in terms of animal welfare.

LJK: So, with all of these, my question is one of dignity, and doing what you said, reasonable. So, I don't know the medical answer because I'm a rabbi, and I really don't know what I'm talking about from the point of view of science. I can only try and bring some moral, religious prism, through which to see this. So, I wonder what gives more dignity? When you talked about GM crops, my question is not whether it works or not, but what is the social justice issue underneath it? The question is food poverty. What drives food poverty? What drives pain? And you can start like that with the overriding questions, and then you move forward with dignity, in order to enhance all life, gently, slowly and reasonably.

NC: Yeah.

TJ: Yes. When it comes to food poverty, you know, in the world today, it's low incomes and political instability that are the problem. Not the absence of someone genetically modifying soya beans, or whatever else it happens to be.

NC: Are you excited by the possibility of maybe having...

APPLAUSE

NC: As a man, as a man who cares about the environment, as a man who really deeply cares about animals, are you excited by the possibility of having, for example, experiments that do not abuse animals?

TJ: Yes, the animal welfare side of this is huge on the xenotransplantation side. I've not studied this idea of going to animals that don't have a central nervous system. But I think as we, especially if we can deal with the in-built inequality of all this, this is elite medicine we're talking about here at the moment. And if it does get to scale, then we're going to need an awful lot of organs to be able to cope with demand. And at that point, you know, do you want massive factory farms full of animals that are being used to grow human organs, or would you like to find some other way of doing that?

NC: Synthetic

SC: There are other ways.

NC: Well, hang on - yes, go on.

VB: Can I draw the discussion back to the use of stem cells? Because an area of stem cell work that people haven't discussed here today is the use of such material as an alternative to animal testing, so you could use stem cells and test drugs. You could use stem cells to test nutrition. Stem cells could be used instead of animal testing.

NC: I mean, that sounds like progress, doesn't it?

VB: I can't think of anyone in this room who would think that's a bad thing.

NC: Yeah.

APPLAUSE

NC: Jonathan. I haven't heard from you for a while.

JM: So, I think we're mixing up time frames.

NC: Well, we've only got an hour, we've got to do that!

If we're asking what are the priorities... We're looking ahead.

We're looking at what the possibilities...

Our priorities now, I completely agree, GM crops not a priority now, there are things we can do much more efficiently to deal with things. I think I would take the same on the xenotransplant of organs.

Yeah.

JM: But we also need to be investing in understanding the future. So, a small amount of exploration of those things.

I think the biggest worry I have about the anxieties that we express sometimes in this country about GM crops, and also possibly about gene editing, is it won't stop it happening, it will drive it out of proper scientific endeavour. So our big advantage here is that we can regulate well so that we learn and make sure that we find what happens. This is not yet about doing things at scale, and we have the prudential question, would we ever want to do it at scale? Not if there are better alternatives. But it's quite right we put a bit of effort into finding out.

NC: David. We're regulating but, of course, in other parts of the world, they might not be regulating quite so stringently.

DK: Indeed, and we saw this very recently with the three-parent IVF business, that the very first thing that happened was... Yes, you know, long regulatory process in this country, I may say, actually, I think the regulatory process in this country is rubbish, actually. But leave that aside. I'll give you a...

DW: That's a very strange viewpoint.

DK: I will give you, I can give you a list of examples as long as your arm that the regulator in this country is basically an approval facilitator, not a regulator. Anyway.

DW: It's taken a long, long time to reach its conclusions.

DK: The key point, though, is that as soon as that technology, you know, got to the point where it was feasible... So, one scientist took it and went to Mexico and he said specifically, we're doing this because there's no regulations. And then another set of scientists in the Ukraine immediately went not to the mitochondrial diseases that it was supposed to be for, but for the mainstream IVF market. Why did they do that? Very simple. That's where the money is to be made. And that, coming back to the genetic engineering issue, is the real problem. What genetic engineering of human beings can do that other technologies can't is this so-called enhancement thing, and that is where the market will be.

NC: David, the enhancement thing?

DW: Yes, I'm in favour of enhancement. Yes! I think it's been very important throughout history that we have enhanced ourselves, that people moved away from a situation in which most women were pregnant most of their time to raising up children. And they have the ability...

DK: I think we saw in the 21st century where that politics...

THEY TALK OVER EACH OTHER

DW: We haven't seen proper enhancement. We need a thoughtful debate, not dominated by medieval philosophies. We need a thoughtful debate on what the possibilities are. And we can do much better as humans. We can free ourselves of some of our bigotry and prejudices...

DK: And that is what it is.

DW: We can free ourselves from our stupidity...

DK: That is what they thought of in the United States...

NC: We can stop arguing! I see a future.

APPLAUSE

NC: Are you excited by... A lot of people pay a lot of good money for this. Jackie, I'll come to you in a second, I see you want to come in. A lot of people pay a lot of good money for this, cryogenics, having their bodies frozen.

DW: Yeah.

NC: Are you excited by that?

DW: I think we're going to look back in just a few decades at the present situation and we're going to be horrified at our current bad practice. which is when people die, but their brains basically are still in good shape, what do we do? We put them in the ground, they get eaten by worms, or we incinerate them. Whereas we could preserve them, and with future technology, we'll be able to reanimate them. And we will be horrified, as I say. The same way as we are horrified of many of the things of the past. Now, I'm hearing a lot of future shock in the audience.

Our first instincts often on these things mislead us. We say "yuck". For example, the first time there was talk about having a heart transplant, people said "Oh, yuck, that's a horrible "thing, that's Frankenstein."

NC: So you think this will happen? Some people can't afford the full body to be frozen, they're just having their heads frozen. Some people are paying the money to have their whole body frozen.

DW: Yes.

NC: Would you go with the head or the whole body?

DW: Well, I think I would go for the whole body. But the key thing is to bring the price down, so that it's much more widely affordable. It's very expensive at the moment? It's expensive...

NC: Why would you want to come back, though?

DW: Well, I believe in life. If somebody has an accident, and they have a heart attack and they fall down you don't say, 'Well, that's the end of their life, too bad'. And if their loved one says, "Let's reanimate them", we don't say, "You're selfish for wanting them to live on". So

cryonics is about giving somebody a chance to have more life. It's about giving their loved ones a chance to continue their experience with them.

NC: I've.. I want to take a photograph of you three. Right, now, your expressions are... I wish I had my phone! I wish I had my phone. Victoria, yeah.

VB: Bring the price down? That is absolutely ridiculous. It's about making it even a feasible reality. Charging people for something that is a complete fantasy is outrageous.

DW: There needs to be some cost, because there is quite a difficult procedure to put people into a state of deanimation.

VB: So difficult that it can't be done. No, but...

DW; Hang on... You're an embryologist, you know that we can freeze small embryos.

VB: An embryo that's a tenth of a millimetre in diameter. That's right. We don't do that very well.

DW: Well, but then the next scale is up from some organs. We have frozen some worms, we've trained them in memory.

NC: You look like you have your doubts about this. Rabbi Laura. Rabbi Laura. Do you have your doubts about this?

LJK: Yes. Absolutely. I do. Right. Once someone has died, and I think it is death, you honour them by burying them properly with as much dignity as possible. And also, in this situation, the element of choice is totally taken away. You may say it in advance, but when you're bringing someone back... For me, which is great, I have a massive red line here.

NC: Do you?

APPLAUSE

DW: Would you allow people the choice to say they would like to be brought back in various circumstances?

LJK: But when you say the people, the only thing I can think about is first of all, choice over life and death.

DW: Yes.

LJK: And secondly, who has the dosh? Who has the money to buy into this rather perverse system?

DW: It's not a perverse system, and it can be afforded by a relatively modest life insurance premium.

LAUGHTER

NC: Wait a minute...

DW: It comes to the...

LJK: That is not persuading me, life insurance premiums!

NC: In the time left, the future. Jackie, may I ask you about the future? Where is all this tech... I mean, we've just heard some, some people might say it's fanciful, it's science fiction. Others might say, "Well, we just don't know what's going to happen." Who would have predicted where we would be now, even 25 years ago? Where do you think we're heading with this? Because human beings being human beings, it will be misused, it will be abused, but it will also be no doubt leading to some wonderful breakthroughs.

JLS: I think what we see if we look back in biomedical history and history of technological innovation in general, is that things that were perhaps overhyped, that we have talked about as transforming the future and transforming human beings, have tended not to work out like that.

They work out reasonably well, they don't sometimes produce the goods that they've touted to, and they also often introduce problems that we've not actually anticipated. And if you look back on something like IVF, for example, lots and lots of discussion about what these children might be like when they grow up. Not much discussion about that now, because they turned out to be pretty much like any other kind of children. Some of the issues that did arise around IVF were unanticipated. So, in a sense, in order to address the problems, you have to go forward cautiously, because your guestimates about what those problems might be in the future, may well turn out to be wrong. I think one of the issues, though, is that we do tend to have these very polarised debates. I mean, they're great fun to have...

NC: Tell me about it!

JLS: People shouting at each other here.

NC: Yeah.

JLS: But in real life, things are never as clearly delineated as that. And to set up a situation where these debates of pro and anti, in real life, is problematic. We need to be able to bring in the general public, and a lot of the voices that are not usually heard in these sorts of highly, sometimes highly technical debates, so that we get a really full picture of people's opinion.

NC: What I will say... I think we have, obviously we have some interesting views and we have... which is quite good, because it concentrates people's minds on where we're going. But I think we have a lot of fantastic nuance here as well, if I may say so. Stephen, your life has been transformed.

SS: It has, it has.

NC: You want as many people's lives to be transformed as possible.

SS: I do. There's one very simple point of qualification, or clarification I need to make. This treatment I've been having is not a cure. There's lots of people watching this programme who have got severe, serious conditions. The treatment is not yet a cure, we don't know what the long-term outcome's going to be, so I really wanted to make that point very clearly. It's been wonderful for me, but, you know, that's the journey. Where the...what the future holds, who knows? Every day's an adventure.

APPLAUSE

NC: Is there anything that absolutely terrifies you about what's going... I know you're nodding, David. You're really pretty scared, aren't you?

DK: I am. Because it's... You know, David over there used the phrase "future shock". Actually, we've had past shock. For the first half of the 20th century, there was a massive movement called eugenics, which people associate mostly with the Nazis, but actually it was dominated by doctors and scientists who meant very well. They saw it as a form of humanitarianism. They thought that we'd get rid of all the disabled people, and that would be to their benefit. It was a form of humanitarianism.

NC: Ruth... That's, in the time available... Ruth, eugenics.

DK: ..that's what we're seeing now.

RS: Absolutely, I absolutely agree. But we learnt from it. And we've got really strong regulatory frameworks which are going to stop it happening again.

APPLAUSE

NC: We've got to learn, haven't we?

SC: Well, I think it goes back to the point about science and politics. So, I actually don't think that eugenics were the scientists just going ahead, it was the policies that were being devised. Policies of sterilisation, including in Scandinavia and the US, it was never the scientists, it is always the politicians. So when we talk about the nuclear... This is again, if we have bad politicians, doesn't mean we should not go ahead. Slippery slope, could bring us wonderful things. Even though, as I said, I could be cautious. I think when we talk about organ transplant or GMO crops, there are non-medical, non-technical solutions to these problems. And we have example of countries where the option is to give organs, and they work. So maybe before creating...

NC: Do you know what, we started this wonderfully interesting debate with you, Sylvia.

SC: About coffee.

NC: And you have book-ended it for us. which is great. Thank you all very much, indeed. Thank you for taking part.

APPLAUSE

NC: As always, the debates will continue on Twitter and online. That's it for this series. We'll be back in January 2018. Thank you for watching. For now, goodbye from everyone here in London and have a great Sunday.

APPLAUSE