THIS TRANSCRIPT IS ISSUED ON THE UNDERSTANDING THAT IT IS TAKEN FROM A LIVE PROGRAMME AS IT WAS BROADCAST. THE NATURE OF LIVE BROADCASTING MEANS THAT NEITHER THE BBC NOR THE PARTICIPANTS IN THE PROGRAMME CAN GUARANTEE THE ACCURACY OF THE INFORMATION HERE.

REITH LECTURES 2010: SCIENTIFIC HORIZONS

Presenter: Martin Rees

Lecture 2: Surviving the Century

TRANSMISSION: 8th JUNE 2010 RADIO 4

SUE LAWLEY: Hello and welcome to Wales. We're at the National Museum Cardiff for the second in this year's series of BBC Reith Lectures. We have an audience of scholars, students, experts and commentators from fields such as astronomy, physics, earthquake engineering, oceanic studies, and many more.

The series is called 'Scientific Horizons' and our lecturer is Martin Rees, Master of Trinity Cambridge, Astronomer Royal, and President of the Royal Society. He's exploring the role of science in today's world. As a cosmologist, he has an awareness of the immense scale of the future and the threats to our existence. He believes science can provide solutions to many of them, but are we capable of implementing those solutions? 'We are stewards of the world at a very special time', he says. 'Man has the future in his hands.' Ladies and gentlemen, please welcome the BBC Reith Lecturer 2010: Professor Martin Rees.

(APPLAUSE)

SUE LAWLEY: Martin, you are in fact almost Welsh, aren't you?

MARTIN REES: Well almost. I'm afraid I can't really say I'm Welsh. I grew up in a village near Ludlow, which is just one mile the other side of the border. So I'm really a Shropshire lad, but I come to Wales whenever there's a chance; and one of the bonuses of being the Reith Lecturer is the chance to come to Cardiff today.

SUE LAWLEY: But hence your full title: Lord Rees of Ludlow. You're not very keen on titles, are you? Do you hate being called Lord Rees?

MARTIN REES: Well I think it does sound a bit pompous, doesn't it, but one uses it to impress public officials, etcetera. (LAUGHTER) But I don't feel it's the kind of thing to use all the time.

SUE LAWLEY: You quite like Professor. Your parents ran a school, didn't they? Were they scientists of any kind, or were they journalists?

MARTIN REES: *(over)* No, they weren't. They were both teachers. But my mother was a primary school teacher and my father had a degree in English.

SUE LAWLEY: And did they spot very early on that young Martin had a natural bent for physics or astronomy or science in general?

MARTIN REES: They didn't. I didn't really have that early bent particularly. I was interested in numbers and nature. But I have to say that when I went to secondary school, I really did science because I was bad at languages. (LAUGHTER)

SUE LAWLEY: So you became an astronomer by chance, did you?

MARTIN REES: By chance. I went to university; I did mathematics and

physics. And then when I was 21, I wanted to do a PhD, and then I decided I would do something in applying what I'd learned to astronomy. And I was very lucky in that that was a time, in the 1960s, when the subject was opening up: the first evidence for the Big Bang, first evidence for black holes, etcetera. And so I was quite lucky because if you go into a subject when things are happening fast, you don't have to be cleverer than the old guys because everyone is starting at the beginning.

SUE LAWLEY: That's very good rationalisation for a very successful career. Professor Rees, let me invite you to deliver your second lecture on Scientific Horizons. This one's called 'Surviving the Century'.

(APPLAUSE)

MARTIN REES: As an astronomer, I often get mistaken for an astrologer, but I cast no horoscopes and I've got no crystal ball. And in fact scientific forecasters have a dismal record. When Alexander Graham Bell invented the telephone, he enthused that: 'some day every town in America will have one'. (LAUGHTER) And the great physicist Lord Rutherford averred in 1937 that: 'nuclear energy was moonshine'. And Thomas Watson, Founder of IBM, said: 'I think there is a world market for maybe five computers'. (LAUGHTER) And one of my predecessors as Astronomer Royal said: space travel was 'utter bilge'. So I won't add to this inglorious roll call. I'm going to focus on a key question: how can our scientific capabilities be deployed to ease the tensions we'll confront in the coming decades?

Our lives today are moulded by three innovations that gestated in the 1950s, but whose pervasive impact wasn't then foreseen. Indeed forecasters generally underestimate long-term changes even when they overplay short-term ones.

It was in 1958 that Kilby and Noyce built the first integrated circuit. This was the precursor of today's ubiquitous silicon chip - perhaps the most transformative invention of the last century. It has spawned the worldwide reach of mobile phones and internet, promoting economic growth while itself being sparing of energy and resources.

In the same decade Watson and Crick discovered the bedrock structure of heredity: the double helix. This launched the profound science of molecular biology whose main impact still lies ahead.

And there's a third technology: space. It's just over 50 years since the launch of Sputnik, and that event led President Kennedy to inaugurate the Apollo programme to land men on the moon. Kennedy's prime motive was of course superpower rivalry. Cynics could deride it as a stunt. But it was an astonishing technical triumph, and it had an inspirational legacy too: distant images of Earth, its delicate biosphere of clouds, lands and oceans contrasting with a sterile moonscape where the astronauts left their footprints have ever since the 1960s been iconic for environmentalists.

But of course there was always a dark side to space. Rockets were primarily developed to carry nuclear weapons, and those weapons were themselves the outcome of the World War II Manhattan Project which inaugurated the nuclear age.

We lived throughout the Cold War under a threat that could have shattered the entire fabric of civilisation. The risk of global nuclear annihilation, involving tens of thousands of bombs, is thankfully now in abeyance. But it hasn't gone for good. We can't rule out by mid-century a global political realignment leading to a standoff between new superpowers that could be handled less well, or less luckily, than the Cuba missile crisis was. And the

risk that smaller nuclear arsenals proliferate and are used in a regional context even by terrorists is higher than it ever was.

I'll suggest in this lecture that we shall confront new threats that may be even harder to control than nuclear weapons. But the response should certainly not be 'to go slow' on science. On the contrary. What's needed is greater urgency in advancing knowledge and a redirection of our priorities in applying it.

In looking several decades ahead, there's one trend we can predict with confidence: there'll be more people on the Earth. Fifty years ago the world population was below 3 billion. It's more than doubled since then - to 6.8 billion today - and it's projected to reach about 9 billion by 2050, and the growth is mainly in the developing world. But nearly half the world's people live in countries where fertility has fallen below replacement level, and this so-called demographic transition is a consequence of declining infant mortality, availability of contraceptive advice, women's education and so forth. But numbers are still rising fast in India, whose population is projected to overtake China's and could exceed 1.5 billion by 2050. And they're rising fast also in Africa. It's worth quoting some more numbers here. A hundred years ago Ethiopia's population was 5 million. It's now about 80 million, and it'll almost double again by 2050. And Sudan and Uganda will more than double by mid-century, and its consequent pressure on the water resources of the Nile Basin. And there could be a billion more people in Africa in 2050 than there are today.

Most of those who are alive today are under 25. That's why a continuing population rise until mid-century seems almost inevitable. But the trends beyond 2050 will depend on what people now in their teens and 20s decide about the number and spacing of their children. But in Africa about 200 million women are denied such a choice. Enhancing the life chances of Africa's poorest people by providing clean water, primary education and

other basics should be a humanitarian imperative; and it would achieve throughout the continent the demographic transition that has occurred elsewhere. Failure would be a failure of governance - the resources required are modest - and it would be a tragedy of continental proportions, which would also trigger massive migratory pressures.
To feed Africa's present and future population, modern farming techniques must be used to enhance productivity, but without degrading the soil or ecology. And water shortages, perhaps aggravated by climate change, must be addressed. To produce a kilogram of vegetables with present methods takes 2,000 litres of water. A kilogram of beef takes 15,000 litres. Can we specify an optimum population for the world? I don't think we can. That's because we can't confidently conceive what people's lifestyles - diet, travel patterns and energy needs - will be beyond 2050.

The world couldn't sustain anywhere near its present population if everyone lived like present day Americans. On the other hand, more than 10 billion people could live sustainably, with a high quality of life, if all adopted a vegetarian diet, travelling little but interacting just via super internet and virtual reality.

I've highlighted though the fast rise in global population because it is deemed by some a taboo subject, tainted by association with eugenics in the 20s and 30s, with Indian policies under Indira Gandhi, and more recently with China's effective but hardline one-child policy.

But two messages, in particular, should surely be proclaimed more widely. First, enhanced education and empowerment of women within this decade - surely a benign priority in itself - would reduce fertility rates in the poorest nations and could thereby reduce the projected world population beyond 2050 by as much as a billion people. Second, a higher population would aggravate all pressures on resources - especially if the developed world

(where most of the growth would be) narrows its gap with the developing world in its per capita consumption.

Another firm prediction about the post-2050 world is that, as well as being more crowded, it'll be warmer. By how much is a matter of continuing research. The greater the warming, the greater the risk of trimming, for instance, gradual melting of Greenland's ice cap or the release from the Tundra of methane, which would lead to further warming. And that's the motive for attempts to reduce global consumption of fossil fuels.

The declared political goal has been to halve global carbon dioxide emissions by the year 2050. This corresponds to a ration of 2 tonnes of carbon dioxide per year, each person on the planet. For comparison, the current US level is 20 tonnes per person per year; European figures about 10; the Chinese level's already 1.5; and the Indian is 1.5. In cutting these emissions, the richer countries must take the lead without stifling economic growth in the developing world where emissions in the short-term are bound to rise.

Success in halving global carbon emissions would be a momentous achievement - one where all nations acted together in the interests of a future beyond the normal political horizon. The meagre progress in Copenhagen last December didn't instil optimism. On the other hand - odd though this may sound - the political response to the financial crisis may offer encouragement. Who would have thought two years ago that the financial system would have been so transformed that big banks were nationalised? Likewise we need coordinated, outside-the-box action to avoid serious risk of a long-term energy crisis.

The world spends more than 5 trillion dollars a year on energy and its infrastructure. There's a glaring contrast here with health and medicine where worldwide R&D expenditures are much, much higher. The clean energy

challenge deserves a priority and commitment akin to the Manhattan Project or the Apollo moon landing.

It's sometimes said fatalistically that the UK's stance on all this is of marginal import because our carbon emissions are only 1 or 2 percent of the problem. But we have leverage in two respects. First politically. We've earned international influence because of the UK government's leadership ever since the Gleneagles G8 Summit, and because we've already enshrined in our Climate Change Act a commitment to cut our own emissions by 80 percent over the next 40 years. Second, we have the expertise to spearhead some of the technologies needed for a low carbon economy. We need to keep our lights on to ensure energy security for ourselves, but beyond that imperative it's in our interest not to fall behind the Chinese in developing clean energy technologies that the world will need.

In wave and tidal energy, for instance, the UK could lead. We have the geography - capes round our coast with fast-flowing tidal currents - and we have marine technology from North Sea oil and gas. And since I'm speaking in Cardiff, I should highlight the Severn barrage scheme as well.

What about biofuels? There's been ambivalence because they compete for land use for food growing and forests, but in the long-run GM techniques may lead to novel developments: bugs that break down cellulose or marine algae that convert solar energy directly into fuel.

Another need is for improved energy storage. In the US Steve Chu, the Nobel Prize-winning physicist whom President Obama appointed as Energy Secretary, has given priority to improving batteries - for electric cars and to complement unsteady power sources such as sun and wind and tides.

What's the role of nuclear power? I'd myself favour the UK having a

replacement generation of nuclear power stations - and boosted R&D into 'fourth generation' reactors and into nuclear fusion. But one can't be relaxed about a worldwide expansion of nuclear power unless internationally regulated fuel banks are established to provide enriched uranium and remove and store the waste. Otherwise there's too much risk of weapon proliferation.

I think an attractive long-term option for Europe is solar energy: huge collectors - most maybe in North Africa - generating power that's distributed via a continent-wide smart grid. Achieving this would require vision, commitment and public-private investment on the same scale as the building of Europe's railways in the 19th century.
Some pessimists argue that the transition to a low carbon economy won't happen fast enough, and that the international community should, as a fallback, contemplate a 'plan b' - being fatalistic about the rise in carbon dioxide, but combating the warming it induces by, for instance, putting reflecting aerosols in the upper atmosphere or even vast sunshades in space.

The political problems of such geo-engineering may be overwhelming: not all nations would want to turn down the thermostat equally, and there could be unintended side effects. An alternative geo-engineering approach would be direct extraction of carbon from the atmosphere. This approach would be more acceptable politically. But it seems to me right at least to study geo-engineering, to clarify which options make sense and which don't; to explore the governance issues they raise and perhaps damp down undue optimism about a technical quick-fix of our climate.

Energy security, food supplies and climate change are the prime long-term threats without enemies that confront us - all aggravated by rising populations. But there are others. For instance, rapid changes in land use may jeopardise whole eco systems.

There have been five great extinctions in the geological past. Human actions are causing a sixth. The current extinction rate is a hundred, even a thousand times higher than normal. We're destroying the book of life before we've read it. And biodiversity - manifested in forests, coral reefs, deep oceans and all Earth's other eco systems - is often proclaimed as a crucial component of human well-being. And it is: we're clearly harmed if fish stocks dwindle to extinction; there are plants whose gene pool might be useful to us; and massive destruction of the rainforests could accelerate global warming.

But there's an ethical issue here. For some environmentalists, these instrumental - and anthropocentric - arguments aren't the only compelling ones. For them, preserving the riches of our biosphere has value in its own right, over and above what it means to us humans.
So far today I've talked about threats we're collectively imposing on the environment, but I'd like now briefly to highlight a new type of vulnerability, stemming from fast developing technologies.

Almost all innovations entail new risks: in the early days of steam, people died when poorly designed boilers exploded. But something has changed. Most of the old risks that humans caused were localised - if a boiler explodes, it's horrible but there's a limit to just how horrible. But there are new hazards whose consequences could be so widespread that even a tiny probability is disquieting. We're all precariously dependent on elaborate networks: electricity grids, air traffic control, international finance, just-in-time delivery and so forth. It's crucial to ensure maximum resilience of all such systems. And there could be other vulnerabilities. It's becoming feasible, for instance, to stitch together long strands of DNA and thereby construct from scratch the blueprint of an organism. This offers huge potential for medicine and agriculture. But there are risks. Already the genome for some viruses - polio, Spanish flu and SARS - have been synthesised. Expertise in such techniques will become widespread, posing a manifest risk of bio-error or bio-terror.

And we're kidding ourselves if we think that those with technical expertise will all be balanced and rational. Expertise can be allied with fanaticism - not just the traditional fundamentalism that we're so mindful of today, but that exemplified by some New Age cults: extreme eco freaks; violent animal rights campaigners, and the like.

And there will be individual weirdoes with the mindset of those who now unleash computer viruses - the mindset of an arsonist. The global village will have its village idiot.

In a future era of vast individual empowerment where even one malign act could be too many, how could we be safeguarded? Maybe our society will shift towards having more intrusion and less privacy. Indeed the rash abandon with which people put their intimate details on Facebook and our acquiescence in ubiquitous CCTV suggest that such a shift would meet surprisingly little resistance. Or will there be pressures to constrain diversity and individualism?

This lecture has focused on some potential downsides of the 21st century. But despite all that, I am actually an optimist - at least a techno-optimist. There seems no scientific impediment to achieving a sustainable world beyond 2050 where the developing countries have narrowed the gap with the developed, and all benefit from further scientific advances that could have as great and benign an impact as information technology and medical advances have had in the last decade.

It's the politics and the sociology that pose the deepest concerns. Will richer countries realise that it's in their self-interest for the developing world to prosper, sharing fully in the benefits of globalisation? Can nations sustain effective but non-repressive governance in the face of threats from small

groups with high-tech expertise? And, above all, can our institutions prioritise projects which are long-term in political perspective even if a mere instant in the history of our planet?

And I'll conclude with a cosmic vignette. Suppose some aliens had been watching our planet from afar for its entire history. What would they have seen? Over nearly all that immense time, 45 million centuries, Earth's appearance would have altered very gradually. Continents drifted; the ice cover waxed and waned; successive species emerged, evolved and became extinct.

But in just a tiny sliver of the Earth's history, the last one millionth part, patterns of vegetation altered at an accelerating rate. This signalled the growing impact of humans and the advent of agriculture.

Then, in just one century, came other changes. The amount of carbon dioxide in the air began to rise anomalously fast. The planet became an intense submitter of radio waves - the output from TV, cellphones and radar transmissions. And something else unprecedented happened: small projectiles, launched from the planet's surface, escaped the biosphere completely. Some were propelled into orbits around the Earth; some journeyed to the moon and planets.

If they understood astrophysics, the aliens could predict that the biosphere would face doom in a few billion years when our sun flares up and dies. But could they have predicted this sudden fever less than halfway through the Earth's life? And if they continued to keep watch, what might these hypothetical aliens witness in the next hundred years in this unique century? Will a final spasm be followed by silence? Or will the planet itself stabilise?

And will some of the objects launched from the Earth spawn new oases of life elsewhere?

Well the answer depends on how the challenges I've addressed today can be met. 21st century science, optimally applied, could offer immense benefits to the developing and the developed world, but it will present new threats. To confront these successfully, and to avoid foreclosing humanity's long-term potential, should be our aspiration for the coming decades. Thank you very much.

(APPLAUSE)

SUE LAWLEY: Thank you very much indeed. And now to questions from the floor here in the National Museum Cardiff where we have an audience of academics and experts and students and laypeople. I've seen lots of questions being handed in during the course of the lecture, so I know there are plenty. I'm going to call for a question first from Peter Harper who's Head of Research at the Centre for Alternative Technology here in Wales. And I think you focus on the changes people can make to their everyday lives, such as organic farming or environmentally friendly ways of running their homes - yes?

PETER HARPER: Indeed, but that's not what I would like to ask Professor Rees. You've mentioned several times the need for re-prioritising our work, but that means doing some things less perhaps. Do you think that some of the more fun stuff, we should do less of? I'm thinking of things like the moons of Saturn, the origins of humanity, even the mighty Higgs boson. Perhaps it's time to stop doing that stuff or defer it until the 22nd century. Isn't it time for all hands on deck?

SUE LAWLEY: You might just have to tell us what the mighty Higgs boson is

before we go any further.

MARTIN REES: It would take too long to explain that.

SUE LAWLEY: But it's actually what the Large Hadron Collider is up to.

MARTIN REES: It's what … The big machine in Geneva is looking for it - yes, yes

SUE LAWLEY: Exactly.

MARTIN REES: Well I think I would disagree because the amount spent in actual pure research is only a tenth of what's spent in the development stage. And I think if we look back in the past, we have found that the research that's paid off has been the unpredictable part, and I think it's in the development and the applications that we need to make the choices. And obviously I think we need to spend more on the developed countries; and in terms of energy research, I think we could afford to multiply the amount spent on energy R&D by a factor of 5 or 10 very easily.

SUE LAWLEY: Do you accept that, Peter Harper?
PETER HARPER: Yes. *(laughs)* look, the Large Hadron Collider has cost quite a lot of money and there's thousands and thousands of scientists there. I'd love to see them working on energy research. Why aren't they?

SUE LAWLEY: That's the point, isn't it?

MARTIN REES: Yes.

SUE LAWLEY: I mean do we actually need what the Large Hadron Collider is doing, or could that money be put to your solar panels in the Sahara Desert

and actually get some electricity created?

MARTIN REES: Yes. Well I think there are lots of people who could help with the solar energy, but I think there are other ways I would get them rather than from the Hadron Collider. I think there are many other types of activity which are lower priority than fundamental research.

SUE LAWLEY: You mentioned medical research and I'm going to bring in Nick Thomas, Dr Nick Thomas. He's principal scientist at one of the world's biggest medical technology companies, and he doesn't get as much research funding as he thinks he ought to. I suspect you're not alone. (LAUGHTER)

DR NICK THOMAS: That's possible.

MARTIN REES: Yes.

DR NICK THOMAS: The question I'd like to ask. You touched on the disproportionality between funding of energy and healthcare. Currently I've read that the funding rate levels in energy are about 1 to 10 percent of those in healthcare. So, first of all, do you believe there's a fundamental need to readdress the way science is funded? And if so, do we have to accept a compromise in individual survival if we reduce healthcare spending to the greater good for global survival?

MARTIN REES: Again I don't think we need to have that trade off. I mean I think the deficiency in the energy R&D is to be blamed on the large utility companies. Tom Friedman in his book says that the American energy companies spend less on R&D than the American pet food industry does, and that seems an imbalance. So I think what is wrong is that the big companies ought to be investing from the huge turnover they have. Pharmaceutical companies - as you know better than me - invest about 20 percent, don't they,

in R&D; in the energy utilities, it's less than 1 percent. And I think of course investment in a new energy system is very long-term, and probably it needs some sort of financial incentives which don't exist at the moment.

SUE LAWLEY: I'm going to call someone who's handed in a question here. Jackie Mulville?

JACKIE MULVILLE: Yes, my question is: is the survival of the maximum number of humans worth the environmental cost?

MARTIN REES: Well as a human being myself, I think that the future of humans is specially important. But it should not be at the cost of all the rest of the biosphere, and that's why I think we do have to ensure that we don't ravage the biosphere in the way that is happening now and would happen even more if population rises and we don't change our methods. We can envisage a situation where with modern technology the world population, even the projected world population, could survive without despoiling the ecology.

SUE LAWLEY: Okay, I'm going to call in Dr Simon Jones who's a principal lecturer in geography at the University of Glamorgan, and he's an expert in the management of coastal zones, which you mentioned.

DR SIMON JONES: Thank you, Sue. Martin, you made great play on the need for energy security during your lecture - alluding, amongst other things, to the proposed Severn barrage. Would you agree that such proposals are cumulatively perhaps examples of destruction of the biosphere that inevitably will lead to human extinction? Are our chances with these things 50/50?

MARTIN REES: Well I think if we are to get our energy by non-fossil fuels,

then there's a limited number of options, isn't there? There's tidal, there's wind, or there's nuclear, and all of them have some environmental negative effects and I think we just have to make the choice of which of those three we prefer and also of how much energy we want to use per capita in order to provide the sort of lifestyle that we want. Any option is going to have some environmental effects and it would not be for me to decide whether you should go for the Severn barrage or for more wind farms.

SUE LAWLEY: You don't have a view on the Severn barrage? You sounded as if you …

MARTIN REES: My instinct is to be in favour of it because it's true it would have an environmental impact, but in the long-run it's not obvious to me that the environmental consequences would be negative; and compared to the huge area of wind farms you would need to provide the same amount of energy, I would have thought that the Severn barrage was something to be considered very seriously.

SUE LAWLEY: We should explain that it would be a 10 mile wide barrage, I think, running from somewhere just south of where we are sitting now, from the south of Cardiff, across to Western-super-Mare. And then, because there's this huge tidal rise, a tremendous amount of electricity could be created if it were held back and let through, yes? Right, what do you think of it?

DR SIMON JONES: I think I'd probably defer to the wisdom of my grandmother in the first place: that you never appreciate something fully until it's gone.

SUE LAWLEY: I see on the front row here we have Rhodri Morgan, the former first Minister for Wales, what about a comment on the Severn Barrage?

RHODRI MORGAN: Yes, well I did want to pick Sir Martin up, I think he referred to the incoming Energy Secretary in the USA, Stephen Chu deciding to concentrate a lot of US research effort on batteries so that, in effect, you'll be able to store electricity because that would be enormously helpful to counteract the intermittency of renewable sources that you've described as 'unsteady' but actually, tidal – it may be intermittent, but it's not unsteady, you can predict it for thousands of years in advance. So , you know coalitions are all the rage at the moment, (laughter) but do you think the most significant coalition, in the long term, would not be the one launched in the Rose Garden of 10 Downing Street, just recently, but the coalition of Professor Chu's giant banks of energy –storing batteries and the Severn Barrage belonging to Wales and the West of England?

MARTIN REES: well, I'd agree with that. The other point I'd make is that if you do things on a full European scale, then, of course, the fluctuations in wind and sun are smoothed over so the larger the scale over which your grid can transmit power, then the easier it is to get by with renewables.

SUE LAWLEY: You mentioned weirdoes and village idiots in the global village. Let me go to Professor Rod Dubrow-Marshall. (LAUGHTER) Oh that was unfortunate, wasn't it? Rod Dubrow-Marshall is a social psychologist and his work focuses on how we can prevent such people unleashing their bio-terror on the planet. Your question, if you will? Sorry about that.

PROFESSOR ROD DUBROW-MARSHALL: Yes, hopefully not a weird question. Do you think our ultimate survival actually depends on the pooling of knowledge across science, the social sciences and humanities?

SUE LAWLEY: Are you suggesting knowledge isn't pooled at the moment?

PROFESSOR ROD DUBROW-MARSHALL: Well in universities of course

we have the traditional barriers between the sciences and the social sciences and the humanities and the arts, and of course across those barriers resources flow perhaps in different rates. But my question is: for us to survive, does it not have to break down completely in order for knowledge to be pooled to the maximum?

MARTIN REES: I think yes because technical scientific knowledge by itself is clearly not sufficient. We have to know what people want, what their preferences are. Clearly that involves social studies, and we want a humane public that is steeped in the humanities as well - if possible. So I think we do want a broadly educated public.

SUE LAWLEY: The professor raised the point about bio-terror, but I believe you've suggested in the past, Martin, that the cause of our demise is more likely to be error than terror?

MARTIN REES: I think there is a risk of error, unintended consequences of some of these things, but I think …

SUE LAWLEY: So it's the idiot scientists, not the village idiot?

MARTIN REES: Well not idiot scientists, but there are of course risks of some process going wrong - whether it's an oil spill in the Atlantic or anything like that. And of course as science gets more powerful, then the downside of errors gets greater.

SUE LAWLEY: But you've also said that in your view we only have a 50/50 chance of surviving the century.

MARTIN REES: Well I didn't quite say that. I said that I think …

SUE LAWLEY: Well you wrote a book called 'Our Final Century'.

MARTIN REES: Well yes, and what it said was … (LAUGHTER) Yes and what it said was that I thought there was a 50 percent chance of a setback to civilisation as bad as a nuclear war, or some consequence of 21st century technology equally serious. I think the chance of us being wiped out is very small.

SUE LAWLEY: I'm going to call Jenny Hainsworth-Lamb.

JENNY HAINSWORTH-LAMB: Hi there. I feel that we're fed politically motivated, one-sided scientific opinions. Making informed decisions about the environment is difficult. To empower ordinary people to change, do you agree that it's the responsibility of the scientific community to ensure that facts and balanced arguments are delivered in plain English?

MARTIN REES: Certainly it should be possible, in my opinion, to make the essence of science accessible to people in plain English. The technical details involve mathematics and formulae, etcetera, but the essence I think can be explained in plain English to the extent that is needed by a citizen to make an informed decision.

SUE LAWLEY: You grow your own vegetables, don't you?

JENNY HAINSWORTH-LAMB: I grow my own vegetables and I also, because I do an awful lot of driving in my professional career - I decided to keep bees to try and balance out the effect I was having on the environment. So I hope I'm making a contribution one way or another.

SUE LAWLEY: But essentially what you seem to be suggesting, Martin, was that you know if we all became vegetarian and went on virtual holidays,

everything would be fine.

MARTIN REES: Well that was a caricature. I wasn't suggesting that. I was just …

SUE LAWLEY: Oh I quite like the idea.

MARTIN REES: Well I was just saying that there are two extremes. One extreme is present day Americans; and the other extreme would be not travelling at all and living in virtual reality and just eating rice. I'm not advocating either of those extremes

SUE LAWLEY: I'm going to call Nick Pidgeon, Professor of Environmental Psychology at Cardiff University. You're currently investigating public attitudes towards climate change and energy resources.

NICK PIDGEON: Yes, thank you Martin. Your analysis points to the inescapable fact, in my view, that combating climate change will require a revolution in technology, in politics, and in our lifestyles on a scale not seen since the Second World War. Are the public and politicians ready for the scale of change that will be required here? And, additionally, are there dangers for scientists when they act as advocates for such change?

MARTIN REES: Well I think if scientists advocate a sort of bare bones approach that's going to involve drastic life changes, they won't get much resonance. But my view on this whole topic is that the way the problem will be solved will be by obviously first tackling ways in which we can actually save money - by using energy more efficiently, insulating buildings better, etcetera. Then we want to incentivise the development of new clean technologies and hope to end up when it is in fact no more expensive than fossil fuels. And so that will enable the transition to happen without there

being any hardship involved.

SUE LAWLEY: But the thrust of the question, as I understood it, is can you take the politicians with you? Are they listening enough?

MARTIN REES: Yes. Well I think the politicians would obviously resonate with what I've just said because they realise it's hard to get the public to make a change which imposes inconvenience or hardship on them. But I genuinely believe that in the long-run we can meet these targets of reducing our dependence on fossil fuels by moving to other sources of energy which we can develop in the next 10 or 20 years. But what is very important is to prioritise the development of those new energy sources - be they wind, tides or solar or nuclear.

SUE LAWLEY: And you mentioned that President Obama is now listening to environmentalists in a way in which his predecessor wasn't. What about our new Prime Minister? Do you feel you're going to be pushing at an open door there?

MARTIN REES: I don't want to make political statements, but I think the auguries are positive so far and I think we should pay tribute to the last government for what it achieved in this area.

SUE LAWLEY: Our thanks to you all. We have to end it there. Thank you very much indeed. Next week we'll be broadcasting from Martin's professional home - the Royal Society in London, where he's been President for the past 5 years: a place where since its foundation, in 1660, great minds have gathered to discuss the important scientific issues of the day. The title of his third lecture is tantalising. It's called 'What We'll Never Know: Journey into the Known Unknown with us - or is it the Unknown Unknown - at the same time next week. For now, from Cardiff, our thanks to Martin Rees and goodbye.

(APPLAUSE)