

## What does the future hold? Reflections on the H G Wells anniversary

*By Professor Lord Martin Rees*

I'll start with a flashback to 1902. In that year the young HG Wells gave a celebrated lecture at the Royal Institution in London. He spoke mainly in visionary mode. "Humanity", he proclaimed, "has come some way, and the distance we have travelled gives us some earnest of the way we have to go. All the past is but the beginning of a beginning; all that the human mind has accomplished is but the dream before the awakening." His rather purple prose still resonates more than a hundred years later.

But Wells wasn't an optimist. He also highlighted the risk of global disaster: "It is impossible to show why certain things should not utterly destroy and end the human story .. and make all our efforts vain .... something from space, or pestilence, or some great disease of the atmosphere, some trailing cometary poison, some great emanation of vapour from the interior of the Earth, or new animals to prey on us, or some drug or wrecking madness in the mind of man".

Wells reflects the mix of optimism and anxiety – and of speculation and science – which I'll try to offer in this lecture. Were he writing today he would have been elated by our expanded vision of life and the cosmos -- but he'd have been even more anxious about the perils we might face.

The stakes are indeed getting higher: new science offers huge opportunities, but its consequences could jeopardise our survival. Many are concerned that it is 'running away' so fast that neither politicians nor the lay public can assimilate or cope with it. And humanity's ever heavier footprint on the Earth risks degrading our environment.

These will be my topics today.

I must start with a disclaimer – I'm an astronomer, but I'm not an astrologer.

A few years ago, I met a well-known Indian tycoon. Knowing I had the title Astronomer Royal, he asked 'Do you do the Queen's horoscopes?' I responded, with a straight face 'If she wanted one, I'm the person she'd ask'. He then seemed eager for my predictions. I told him that stocks would fluctuate, there'd be tensions in the Middle East, and so forth. He paid rapt attention to these 'insights'. But I then came clean. I revealed that I was just a scientist. He then lost interest in my predictions. And rightly so: scientists are rotten forecasters – almost as bad as economists.

Nor do politicians and lawyers have a sure touch. One rather surprising futurologist was Lord Birkenhead, crony of Churchill and Lord Chancellor in the 1920s. He wrote a book entitled 'The World in 2030'. He'd read Wells, Bernal and others– he envisaged babies incubated in flasks, flying cars and suchlike fantasies. In contrast, he foresaw social stagnation.

Here's a quote: "In 2030 women will still, by their wit and charms, inspire the most able men towards heights that they could never themselves achieve."

I'm going to make forecasts, but --- mindful of these precedents – very tentatively.

Twelve years ago I wrote a book which I entitled 'Our Final Century ?' My publisher deleted the question-mark. The American publishers changed the title to 'Our Final Hour'. (Americans seek instant gratification – and the converse).

My theme was this. Our Earth is 45 million centuries old. But this century is the first when one species – ours – can determine the biosphere's fate. I didn't think we'd wipe ourselves out. But I did think we'd be lucky to avoid devastating setbacks

And we've had one lucky escape already.

At any time in the Cold War era -- when armament levels escalated beyond all reason --- the superpowers could have stumbled towards armageddon through muddle and miscalculation. And the threat will always be with us

Nuclear weapons are based on 20<sup>th</sup> century science. Wells foresaw them in the 1930s – so did Churchill.

I'll focus later in my talk on 21<sup>st</sup> century sciences -- bio, cyber, and AI – which offer huge potential benefits but also expose us to novel vulnerabilities

But before that let's focus on the long-term threats that stem from humanity's ever-heavier collective 'footprint'.

Even without a crystal ball there are some forecasts one can confidently make.

For instance, the world will get more crowded.

Fifty years ago, world population was about 3 billion. It's now 7.3 billion. The birthrate in most countries has leveled off, but nonetheless it's expected to reach around 9 billion by 2050. That's because most people in the developing world are young. They are yet to have children, and they will live longer.

*The main growth is in East Asia, and it's there that the world's human and financial resources will become concentrated—ending 4 centuries of North Atlantic hegemony.*

*And in 2050, 70 percent of people will live in cities. Even by 2030 Lagos, San Paulo and Delhi will have populations above 30 million. To prevent megacities becoming turbulent dystopias will surely be a major challenge to governance.*

Population growth seems currently under-discussed --- almost a taboo subject -- maybe because it's tainted by association with eugenics in the 1920s and 30s, with Indian policies under Indira Gandhi, and more recently with China's hard-line one-child policy.

And the 1970s forecasts by the Club of Rome, Paul Erlich and others that there'd be mass starvation, have proved off the mark. Up till now, food production has more than kept pace – famines stem from wars or maldistribution, not overall shortage.

And indeed most experts would claim that 9 billion can be fed. The buzz-word is 'sustainably intensified' farming – low-till, water-conserving, and GM techniques --

plus better engineering.

Population trends beyond 2050 are harder to predict. Enhanced empowerment of women could reduce fertility rates where they're now highest – in parts of India and Sub-Saharan Africa.

But that's not guaranteed. There are now 7 births per woman in Niger, but when a survey asked what the optimum family size was, the answers averaged at nine! We may be as bad as Lord Birkenhead at predicting social trends. If families in Africa remain large by choice, then according to the UN that continent's population could double again by 2100, to 4 billion, thereby raising the global population to 11 billion. Nigeria alone would by then have as big a population as Europe and North America combined -- and almost half of all the world's children would be in Africa.

Optimists remind us that each extra mouth brings also two hands and a brain. But if there's real economic growth in Asia and Africa, each individual puts increasing pressure on environment and resources. There would need to be lifestyle changes. The world couldn't sustain even half its present population if everyone lived like today's Americans do today-- each using as much energy and eating as much beef.

Indeed there's a risk of triggering 'ecological shocks' that irreversibly impoverish the biosphere.

Some talk of a new geological era, the anthropocene, and a sixth great extinction. We're destroying the book of life before we've read it.

Biodiversity is a crucial component of human wellbeing. We're clearly harmed if fish stocks dwindle to extinction; there are plants in the rain forest whose gene pool might be useful to us. But for many environmentalists, preserving the richness of our biosphere has value in its own right, over and above what it means to us humans.

To quote the great ecologist E O Wilson 'mass extinction is the sin that future generations will least forgive us for'.

And there's a second firm prediction: our collective activities will change the climate. In contrast to population issues, climate change is certainly not under-discussed.

The projections are still imprecise – because, for instance, we don't know how cloud cover changes as the CO<sub>2</sub> warms the atmosphere. Nonetheless, there are two messages that most would agree on:

1. Regional disruptions to weather patterns within the next 20-30 years will aggravate pressures on food and water, and engender migration.
2. Under 'business as usual' scenarios we can't rule out, later in the century, really catastrophic warming, and tipping points triggering long-term trends like the melting of Greenland's icecap.

But even among those who accept the IPCC projections, there are divergent views on

policy – which stem from differences in ethics and economics.

Some economists, like Bjorn Lomborg's 'Copenhagen Consensus', apply the standard discount rate. They in effect write off what happens beyond 2050 and downplay the priority of addressing climate change today.

But if you care about those who'll live into the 22<sup>nd</sup> century then, as Harvard's Weissman argues, you'd deem it worth paying an insurance premium now, to protect future generations against the risk of crossing 'tipping points' and triggering runaway changes like the melting of Greenland's ice.

So, even those who agree there's a real risk of climate catastrophe a century hence, differ in how urgently they advocate action today. Their assessment depends on expectations of future growth, and optimism about technological fixes.

But, above all, it depends on an ethical issue – in optimizing people's life-chances, should we discriminate on grounds of date of birth?

(Incidentally, there's one policy context when an essentially zero discount rate is applied: radioactive waste disposal, where the depositories are required to prevent leakage for 10000 years – somewhat ironic when we can't plan the rest of energy policy even 30 years ahead)

*[Consider this analogy. Suppose astronomers had tracked an asteroid, and calculated that it would hit the Earth in 2080, 65 years from now – not with certainty, but with (say) 10 percent probability. Would we relax, saying that it's a problem that can be set on one side for 50 years – people will then be richer, and it may turn out then that it's going to miss the Earth anyway? I don't think we would. There would surely be a consensus that we should start straight away and do our damndest to find ways to deflect it, or mitigate its effects.]*

What will actually happen on the climate-policy front? The pledges made at the Paris conference are a positive step.

But even if they're honoured, CO2 concentrations will rise throughout the next 20 years.

By then, we'll have a longer timebase of data, and better modelling -- we'll know just how strong the feedback from water vapour and clouds actually is. If the so-called 'climate sensitivity' is low, we'll relax. But if it's large, and climate consequently seems on an irreversible trajectory into dangerous territory, there may then be a pressure for a 'plan B' -- being fatalistic about continuing dependence on fossil fuels, but combating their effects by geoengineering.

Geoengineering -- by for instance injecting dust into the stratosphere to block sunlight -- is feasible -- what is scary is that this might be within the resources of a single nation, or perhaps even a single corporation. But it would be a political nightmare: not all nations would want to adjust the thermostat the same way. Very elaborate climatic modelling would be needed in order to compute the regional impacts of an artificial intervention. (The only beneficiaries would be lawyers. They'd have a bonanza if nations could litigate over bad weather!).

Many still hope that the world can segue smoothly towards a low-carbon future. But politicians won't gain much resonance by advocating unwelcome lifestyle changes or a high carbon tax -- especially if the benefits are far away and decades into the future.

That's why a specially encouraging outcome of Paris was an initiative called 'Mission Innovation', where 20+ nations pledged to double their R and D into all forms of low-carbon energy. There's been a parallel pledge by Bill Gates and other private philanthropists.

This target is a modest one. Presently, only 2 percent of publicly funded R and D is devoted to these challenges. Why shouldn't the percentage be comparable to spending on medical or defence research?

The programme should include renewables, 4<sup>th</sup> generation nuclear fission, fusion, and the rest. And other technologies where parallel progress is crucial – especially energy storage and smart grids.

The faster these 'clean' technologies advance, the sooner will they become affordable by developing countries – where more generating capacity will be needed -- where the health of the poorest billions is jeopardized by smokey stoves burning wood or dung -- and where there would otherwise be pressure to build coal-fired power stations.

It would be hard to think of a more inspiring challenge for young engineers than devising clean energy systems for the world.

*Activists and experts by themselves can't generate or sustain political will. Only if their voice is amplified by a wide public and by the media, will long-term global causes rise high enough on the political agenda to compete with the immediate and the local.*

*Here, incidentally, the great religious faiths can be our allies. The Pope's Encyclical on environmental and climate, published in June 2015, was hugely welcome. The Catholic Church transcends normal political divides – there's no gainsaying its global reach, nor its durability and long-term vision, nor its focus on the world's poor. This Pope's message resonated in Latin America, Africa, and East Asia – and smoothed the path to the Paris consensus.*

Without applying new science the world can't provide food, and sustainable energy, for an expanding and more demanding population. Technology can be our salvation.

But many are anxious that we may not properly cope with the runaway advance in some technologies – bio, cyber and AI.

Let me expand on this.

Our world increasingly depends on elaborate networks: electric-power grids, GPS, international finance, globally-dispersed manufacturing, and so forth. Unless these networks are highly resilient, their benefits could be outweighed by catastrophic

(albeit rare) breakdowns that cascade globally -- real-world analogues of the 2008 financial crash. Cities would be paralysed without electricity – and supermarket shelves empty within days if supply chains were disrupted. Air travel can spread a pandemic worldwide within days. And social media can spread panic and rumour, and economic contagion, literally at the speed of light.

To guard against the downsides of such an interconnected world plainly requires international collaboration. (For instance, whether or not a pandemic gets global grip may hinge on how quickly a Vietnamese poultry farmer can report any strange sickness.)

Advances in microbiology -- diagnostics, vaccines and antibiotics -- offer prospects of containing pandemics. But the same research has controversial aspects. For instance, in 2012 a group in Wisconsin showed that it was surprisingly easy to make the influenza virus both more virulent and transmissible – to some, this was a scary portent of things to come. In 2014 the US federal government decided to cease funding these so-called ‘gain of function’ experiments

The new CRISPR technique for gene-editing is hugely promising, but there are ethical concerns raised by Chinese experiments on human embryos and by unintended consequences of ‘gene drive’ programmes intended to wipe out parasitic species.

Back in the 1970s, when DNA research began, there was a famous gathering in Asilomar where leading biologists agreed guidelines on what experiments should and shouldn't be done. This encouraging precedent, has triggered several meetings to discuss the more powerful new techniques in the same spirit. But today, 40 years after Asilomar, the research community is far more broadly international, and more influenced by commercial pressures.

Biotech involves small-scale dual use equipment. Indeed, biohacking is burgeoning even as a hobby and competitive game. I'd worry that whatever regulations are imposed, on prudential or ethical grounds, can't be enforced worldwide – any more than the drug laws can --- or the tax laws. Whatever can be done will be done by someone, somewhere. . Regulating the huge facilities in the nuclear arena is a doddle in comparison.

We know all too well that technical expertise doesn't guarantee balanced rationality. The global village will have its village idiots and they'll have global range. The rising empowerment of tech-savvy groups (or even individuals), by bio as well as cyber technology will pose an intractable challenge to governments and aggravate the tension between freedom, privacy and security.

Concerns about bioerror and bioterror are relatively near-term – within 10 or 15 years. What about 2050 and beyond?

We must keep our minds open, or at least ajar, to transformative advances that now seem science fiction. After all, today's smartphones and their ancillaries would have seemed magic just 20 years ago

On the bio front, the great physicist Freeman Dyson conjectures a time when children will be able to design and create new organisms just as routinely as his

generation played with chemistry sets. If it becomes possible to 'play God on a kitchen table' (as it were), our ecology (and even our species) may not long survive unscathed.

And what about another transformative technology: robotics and artificial intelligence (AI)?

There's been exciting progress in what's called generalized machine learning – Deep Mind (a small London company now bought up by Google) this year achieved a remarkable feat -- its computer has beaten the world champion in the game of 'Go'.

Of course it's 20 years since IBM's 'Deep Blue' beat Kasparov, the world chess champion. But Deep Blue was programmed in detail by expert players. In contrast, the Go-playing machine gained expertise by absorbing huge numbers of games and playing against itself. Its designers don't themselves know how the machine makes its cleverest moves.

Computers use 'brute force' methods. They learn to identify dogs, cats and human faces by 'crunching' through millions of images – not the way babies learn. They learn to translate by reading millions of pages of (for example) multilingual EU documents (they never get bored!).

But advances are patchy. Robots are still clumsier than a child in moving pieces on a real chessboard. They can't tie your shoelaces or cut your toenails. But sensor technologies are advancing apace.

The big question being debated is: Will this 'second machine age' be like earlier disruptive technologies – the car, for instance –and create as many jobs as it destroys? Or is it really different this time?

Machines won't just take over manual work (indeed plumbing and gardening will be among the hardest jobs to automate), but they will handle routine legal work (conveyancing and suchlike), investment decisions, medical diagnostics and even surgery.

[Can robots cope with emergencies? For instance, if an obstruction suddenly appears on a crowded highway, can Google's driverless car discriminate whether it's a paper bag, a dog or a child? The likely answer is that its judgement will never be perfect, but will be better than the average driver – machine errors will occur, but not as often as human error. But when accidents occur, they will create a legal minefield. Who should be held responsible – the 'driver', the owner, or the designer?]

The money 'earned' by robots could generate fortunes for an elite. But preserving a healthy society -- to avoid a bifurcation between Eloi and Morlocks --may then require massive redistribution to guarantee everyone a 'living wage'. And to create and upgrade public-service jobs where the human element is crucial and is now undervalued– carers for young and old, custodians, gardeners in public parks and so on.

This much is a real issue – not fantasy.

. But let's speculate further ahead.

Will robots ever be truly perceived as intelligent beings, to which (or to whom) we can relate — as portrayed in movies like *Her*, and *Ex Machina*?

If so, will we have obligations towards them? We worry if our fellow-humans, and even some animal species, can't fulfil their natural potential. Should we feel guilty if our robots are under-employed or bored?

What if a machine developed a mind of its own? Would it stay docile, or 'go rogue'? If it could infiltrate the internet — and the internet of things — it could manipulate the rest of the world. It may have goals utterly impassive to human wishes — or even treat humans as an encumbrance.

Some AI pundits take such scenarios seriously, and think the field already needs guidelines — just as biotech does. But others regard these concerns as premature — and worry less about artificial intelligence than about real stupidity.

Be that as it may, it's likely that society will be transformed by autonomous robots, even though the jury's out on whether they'll ever be more than 'idiot savants'.

[There's disagreement about the route towards human-level intelligence. Some think we should emulate nature, and reverse-engineer the human brain. Others say that's as misguided as designing flying machine by copying how birds flap their wings. (And philosophers debate whether "consciousness" is special to the wet, organic brains of humans, apes and dogs — so that robots, even if their intellects seem superhuman, will still lack self-awareness or inner life).]

The far-out futurist Ray Kurzweil, now working at Google, argues that once machines have surpassed human capabilities, they could themselves design and assemble a new generation of even more powerful ones — an intelligence explosion — the so called 'singularity'. He thinks that humans could transcend biology by merging with them. In old-style spiritualist parlance, they would 'go over to the other side'.

But he's anxious that this may not happen in his lifetime. So he wants his body frozen until this nirvana is reached. I was once interviewed by a group of 'cryonic' enthusiasts — based in California ---called the 'society for the abolition of involuntary death'. They will freeze your body, so that when immortality's on offer you can be resurrected or your brain downloaded.

I told them I'd rather end my days in an English churchyard than a Californian refrigerator.. They derided me as a 'deathist' — really old fashioned.

I was surprised to learn later that three academics in this country had gone in for cryonics. Two had paid the full whack; the third has taken the cut-price option of wanting just his head frozen. They were from Oxford, not from my university.

But of course research on ageing is being seriously prioritized. Will the benefits be incremental? Or is aging a 'disease' that can be cured? Dramatic life-extension would plainly be a real wild card in population projections, with huge social ramifications.

But it may happen, along with human enhancement in other forms.

And now a digression into my special interest – space. This is where robots surely have a future.

During this century the whole solar system will be explored by flotillas of miniaturized probes – far more advanced than ESA's Rosetta comet mission, and NASA's New Horizons, which transmitted amazing pictures from Pluto, 10,000 times further away than the moon. And later this century robotic fabricators may build vast lightweight structures floating in space (gossamer-thin radio reflectors or solar energy collectors, for instance).

Robotic advances will erode the practical case for human spaceflight. Nonetheless, I hope people will venture into deep space, though it will be as risk-seeking adventurers rather than for practical goals. The most promising developments are spearheaded by private companies. SpaceX, led by Elon Musk, who also makes Tesla electric cars, hopes soon to offer orbital flights to paying customers.

Wealthy adventurers are already signing up for a week-long trip round the far side of the Moon – voyaging further from Earth than anyone has been before. (I'm told they've sold a ticket for the second flight but not for the first flight.)

And the next step would be to Mars. If China wanted to mount an prestige project, they could go to Mars within 20 years. They might choose to do this. But it's unlikely that the Americans would repeat an Apollo-scale effort (which succeeded because, in the 1960s. NASA received more than 4 percent of the federal budget, as against 0.6 percent today.

So we should surely acclaim the private enterprise efforts in space – they can tolerate higher risks than a western government could impose on publicly-funded civilians, and thereby cut costs compared to NASA or ESA.

But they should be promoted as adventures or extreme sports -- the phrase 'space tourism' should be avoided. It lulls people into unrealistic confidence.

By 2100 courageous pioneers in the mould of (say) Sir Ranulph Feinnes -- or Felix Baumgartner, who broke the sound barrier in free fall from a high-altitude balloon -- may have established 'bases' independent from the Earth.

Musk himself (aged 45) says he wants to die on Mars – but not on impact. I'm skeptical, however, about his plan announced last month for a rapid buildup of the Martian population to a million plus. Nowhere in our Solar system offers an environment even as clement as the Antarctic or the top of Everest. It's a dangerous delusion to think that space offers an escape from Earth's problems. There's no 'Planet B'.

Indeed, space is an inherently hostile environment for humans. For that reason, even though genetic and cyborg technology may be regulated on Earth, we should surely wish the intrepid band of space pioneers – far beyond the range of Earthly regulation - - good luck in using all such techniques to adapt to alien conditions. This might be the first step towards divergence into a new species: the beginning of the post-human

era.

It may take just decades to develop human-level AI -- or it may take centuries. Be that as it may, it's but an instant compared to the cosmic future stretching ahead. So, by any definition of 'thinking', the amount and intensity that's done by organic human-type brains will be utterly swamped by the future cogitations of AI.

Is there life out there already? We know that there are no Martians – we're safe from Wells's 'war of the worlds'. Indeed there's nowhere in our solar system that harbours advanced life. However there may be freeze-dried bacteria on Mars. There may be creatures swimming under the Ice on Jupiter's moon Europa or Saturn's moon Enceladus.

But in the last decade we've learnt something that would surely have excited H G Wells. Perhaps the hottest current topic in astronomy is the realisation that many other stars -- perhaps even most of them -- are orbited by retinues of planets, like the Sun is .

We're specially interested in possible 'twins' of our Earth -- planets the same size as ours, on orbits with temperatures such that water neither boils nor stays frozen.

Some of these have been found – there are thought to be many millions in the Milky Way. The nearest star, Proxima centauri, has a planet around it on which water could exist.

Will there be life on them – maybe even intelligent life?

We still don't know the likelihood – we know too little about how life began on Earth to lay confident odds. What triggered the transition from complex molecules to entities that can metabolise and reproduce? It might have involved a fluke so rare that it happened only once in the entire Galaxy. On the other hand, this crucial transition might have been almost inevitable given the 'right' environment. We just don't know -- nor do we know if the DNA/RNA chemistry of terrestrial life is the only possibility, or just one chemical basis among many options that could be realized elsewhere

Moreover, even if simple life is widespread, we can't assess the odds that it evolves into a complex biosphere. And, even it did, it might anyway be unrecognizably different. I won't hold my breath, but SETI programmes -- looking for some transmission that's manifestly not natural --are a worthwhile gamble - because success in the search would carry the momentous message that concepts of logic and physics (if not consciousness) aren't limited to the hardware in human skulls.

I've agreed to chair an intensive search for radio and optical signals,-- a 10 years programme bankrolled by Yuri Milner, a Russian billionaire (better than a yacht or football team)

And, by the way, it's too anthropocentric to limit attention to Earth-like planets. Science fiction writers have other ideas -- balloon-like creatures floating in the dense atmospheres of Jupiter-like planets, swarms of intelligent insects, Etc. We should also

be mindful that seemingly artificial signals could come from super-intelligent (though not necessarily conscious) computers, created by a race of alien beings that had already died out. Indeed I think that's the most likely option.

Perhaps the cosmos teems with life, even complex life; on the other hand, our Earth could be unique among the billions of planets that surely exist. That would be depressing for the searchers. But it would allow us to be less cosmically modest – Earth, though tiny, could be the most complex and interesting entity in the entire Galaxy.

I'm often asked -- is there a special perspective that astronomers can offer to science and philosophy?

We view our home planet in a vast cosmic context. And in coming decades we'll know whether there's life out there, and how universal our physical laws actually are.

But, more significantly, astronomers can offer an awareness of an immense future. Let me explain

The stupendous timespans of the evolutionary past are now part of common culture (maybe not in Kentucky, or in parts of the Muslim world).

Our present biosphere is the outcome of more than four billion years of evolution,

But most people still somehow think we humans are necessarily the culmination of the evolutionary tree. That hardly seems credible to an astronomer, indeed we could be nearer the beginning than the end of emergent complexity

Our Sun formed 4.5 billion years ago, but it's got 6 billion more before the fuel runs out. It then flares up, engulfing the inner planets.

And the expanding universe will continue -- perhaps for ever -- destined to become ever colder, ever emptier. To quote Woody Allen, eternity is very long, especially towards the end.

Any creatures witnessing the Sun's demise 6 billion years hence won't be human -- they'll be as different from us as we are from a bug.

Posthuman evolution -- here on Earth and far beyond -- could be as prolonged as the Darwinian evolution that's led to us -- and even more wonderful.

Indeed, this evolution is even faster now -- machines may take over. We don't know whether the long term future lies with organic or silicon-based life.

And this was Wells's vision -- All the past is but the beginning of a beginning; all that the human mind has accomplished is but the dream before the awakening."

As I said, we can't foresee technology even a few decades ahead. Nor can we foresee how our scientific understanding will advance.

And that raises a question. Are there some things that we humans will never understand? Our brains haven't changed much for tens of thousands of years. They evolved to cope with life on the African Savannah, and with the everyday world. And it's rather astonishing that they've allowed us to understand the counterintuitive microworld of the quantum, and the vastness of the cosmos. But just as a chimpanzee

can't understand quantum theory, there may be aspects of reality that are beyond our grasp – and will perhaps have to await posthumans.

One of these things is time travel – what about Wells's Time Machine? Well, Einstein tells us that we can in principle 'fast forward' into the future. If we go at nearly the speed of light, or go very close to a black hole, our clocks go much slower than in the external world. But going back into the past is more problematic. It raises famous paradoxes – what happens if you kill your grandmother in her cradle, and so forth? Indeed I often fantasise about time travel. I'm trying to write a book – and getting on very slowly. But suppose I could go five years into the future, go to a library, take my book down from the shelves, read it, and then come back to the present and write it.

Fortunately, I've not time to venture further into science fiction. So let me close by focusing back closer to the here and now.

I've argued that even in a cosmic perspective -- a 'concertinered' timeline -- extending billions of years into the future, as well as into the past -- this century is special.

It's the first when one species, ours, can determine the future of the planet – when we could jump-start the transition to electronic intelligence, and spread beyond the Earth. Or -- to take a darker view – the century where our follies could foreclose this immense future potential.

We fret unduly about small risks – air crashes. carcinogens in food, low radiation doses, etc. But we're in denial about newly emergent threats that could be globally devastating. Some of these are environmental, others are the potential downsides of novel technologies.

It's a wise maxim that the unfamiliar is not the same as the improbable.

More should be done to assess, and then minimize, them.

Though we live under their shadow, there seems no scientific impediment to achieving a sustainable and secure world, where all enjoy a lifestyle better than those in the 'west' do today. We can be technological optimists – just as Wells was. But he was a political pessimist.

But the intractable politics and sociology -- the gap between potentialities and what actually happens -- engenders pessimism. Politicians look to their own voters – and the next election. Stockholders expect a pay-off in the short run. We downplay what's happening even now in far-away countries. And we discount too heavily the problems we'll leave for new generations. Without a broader perspective – without realizing that we're all on this crowded world together – governments won't properly prioritise projects that are long-term in a political perspectives, even if a mere instant in the history of our planet.

"Space-ship Earth" is hurtling through space. Its passengers are anxious and fractious. Their life-support system is vulnerable to disruption and break-downs. But there is too little planning too little horizon-scanning, too little awareness of

long-term risks.

Our pale blue dot is a special place

And we're its stewards in a special era.

And that's perhaps an apt closing thought to ponder, whether you're an astronomer or not.

And I give the final word to Wells: this century will be "a race between education and catastrophe"

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