

**A decade ago climate experts were deeply worried. Now they are terrified - Tim Flannery**

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New solar powered agriculture and industrial processes are being developed. And South Australia has become a world leader as it takes up renewable energy. But with coral reefs dying before our eyes and climate changing everywhere fast, there isn't a moment to lose.

Robyn Williams: One of the things that often came up when I first met Tim, it was at the Australian Museum 40 years ago, something like that, I was on the board, he was a young mammalogist, which means officer commanding mammals, and he was beginning to write because of course his first degree was in literature and the arts. It's always good to mix the subjects. And then came his famous book *The Future Eaters*. And one thing that comes out of the uninformed mouths of some of his critics occasionally, what is a mammalogist doing writing about weather and the future? And the point in *The Future Eaters*, or one of the big ones, was that to understand the nature of Australia you've got to understand the oscillation, the El Niño and La Niña, the ways in which heating and cooling happens so dramatically and harshly in this incredible wide brown land. And so naturally in understanding all these animals and plants you had, if you are Tim, to start with weather and climate and that sort of understanding, and the rest kind of developed.

And so for the first part of today, he will brief us for about 15 minutes or so on the latest ideas about climate change. And then we will have a chat about it. So Tim, please.

Tim Flannery: Thanks so much, Robyn, for that great introduction. Look, I'm very, very pleased to be here today, in large part because I'm here in Adelaide, in South Australia, and this state is leading not only the nation but the world in many ways as we address climate change.

Having lived here for seven years, I know that things aren't easy, nothing is easy when we start undertaking these great transitions. There are political impediments, there are economic impediments, there is every other thing that you want to deal with. And sometimes it feels like you're not making sufficient progress. But from the outside, South Australia looks like it has been going at light speed towards a future that we all want to get to.

When I came here in 1999 there wasn't a single windfarm in South Australia. I think the first one was built in 2003. Today on many occasions wind is producing 50% of your electricity and is a major export, and that is really only the beginning. In this state, you have also developed a new means of agriculture, the first I would say really fundamentally new breakthrough in agriculture probably since irrigation thousands of years ago. And that is occurring at Sundrop Farms near Port Augusta where 10% of Australia's truss tomato crop is being grown without using a drop of fresh water or any soil, it's all hydroponics and the power of the Sun. So what South Australia has showed is that the future of agriculture for crops like tomatoes is really in places that have abundant sunlight and access to seawater. It's an amazing feat, creating 200 full-time jobs in agriculture. That in itself is a rarity. But also you can see producing these tomatoes with so little waste that it is going to be the future of some crop growing, like tomatoes.

You have also just in the last few months put in the world's largest grid connected battery, lithium ion battery. Amazing to see that happen, just fantastic. So again, congratulations. You are about, in this state, to lead the charge into the hydrogen economy. Plans were announced today for a hydrogen superhub at Crystal Brook, and you already have plans afoot to build a 15-megawatt hydrogen plant at Port Lincoln, which will be providing...my guess would be 10% to 20% of Australia's nitrogenous fertilisers, from the wind, from the sun. How incredible is that. Today we make nitrogenous fertilisers through using fossil fuels, things like gas. You are pioneering a new way in this state to do that. And as the hydrogen economy builds a head of steam, you will be contributing disproportionately to storage, to transport and the decarbonisation of transport, and to gas substitution. So we are not going to be as heavily dependent on fossil fuels for those purposes as we were in the past.

So I just want to take my hat off to you guys, you are showing us all how to do it. If the rest of the world was doing what you're doing, we would have the biggest part of the climate problem on a very long way towards being solved, and that being the electricity generation sector, with big inroads happening elsewhere. But the problem we have is that the world is way, way behind you here in South Australia. I guess that's good news for you because you're going to be building new industries, training brilliant people who will go off and do what you're doing now in other parts of the world. It is fantastic for South Australia but sad for the rest of the world.

Just how far behind we are is shown by the raw figures that dictate the extent of climate change. On 4 March, 2018, CO<sub>2</sub> concentrations in the atmosphere were just the tiniest shade below 410 parts per million. That is way, way up on when I wrote *The Weather Makers* years ago. The concentration of CO<sub>2</sub> is rising at an unprecedented rate. And the rate at which the warming that has been driven by that CO<sub>2</sub> is increasing is about 100 times faster than any other period recorded in geological history. So we are facing the beginnings of what will become very severe problems in coming decades unless we pull out all stops now.

Despite the signing of the Paris Agreement, we haven't done as much globally as we should. For three years, between 2014 and 2016, emissions of CO<sub>2</sub> and other greenhouse gases from human sources had stabilised, so there had been no increase. I was really optimistic we were going to turn things around. But 2017, we saw an increase of 3.5%, partly because America was dead in the water, not decreasing as it had up to that point, and partly because there was a very dry year in China which minimised hydroelectricity, along with a very strong economic stimulus package that increased Chinese emissions by 3.5%.

Now, these might be transient problems, but if you look at Australia and what we are doing here and extrapolate to many other parts of the world, you can see that we have enormous challenges that we don't have the energetic approach to, regulation and politics that we need to overcome this problem.

As all of this is happening, we are entering what I would call the acute stage of the climate problem. Up until now we have seen climate impacts, some of them have been spectacular, but we haven't seen mass systemic change yet of the scale which is almost certainly to come. And how can I say that it is almost certainly going to come? It's because the greenhouse gases that will drive that change are already in the atmosphere. We have already put them in, they will be accumulating heat close to the Earth's surface for several decades to come, and what that means is that the 2020s will be worse than the teens, the 2030s will be worse than the 2020s. Maybe by the 2040s if we really start pulling a finger out now we can start improving things. But we will face two decades of change now, even if we do our utmost. We've just missed the chance to get in early and solve the problem.

And if I could just say, Robyn, you'd remember the Rio Earth Summit in 1992. If we'd have started then, we would have had the easiest trajectory to solving this problem. We missed the chance. If we'd started after the Copenhagen meeting we would have had a pretty good chance at avoiding the worst of climate change. But leaving it to 2015 and still as of 2018 not acting as strongly as we need to, we are really up against it, we are entering the acute phase of the problem.

By 2030 we will have passed through this acute phase and we will be in a phase, if we do nothing, which will really be a future where it will be very hard to alter the outcomes. If we leave it another decade, the greenhouse gas burden will have built up so much that no matter what we do it is going to be very difficult to reduce the impacts.

As it is now, in this acute phase of the problem, we not only have to cut emissions as hard and fast as we can from all human sources, but we also have to build carbon negative technologies that will get gas out of the air in an attempt to minimise the future impacts. As it is now, there's a moderately good chance that even if we never omitted another kilogram of CO<sub>2</sub> we would still reach 1.5 degrees of warming. By 2030 that's going to be an inevitability, and probably 2 degrees of warming will be an inevitability. So that is a scenario that we've got to act now in order to avoid.

When you look at the cost of runaway climate change you can see how severe they will be. A fair case can be mounted now that the Barrier Reef has suffered terminal or near terminal damage. We've had back-to-back bleaching events in the last several years. There was never a bleaching event recorded before 1976. It takes coral a decade or more to recover. So as these bleaching events get more frequent, closer together, the coral has less time to recover and the reef will slowly vanish. So what happens if the reef is mostly dead in a decade or so from now? We lose all that biodiversity, we lose our tourism, we'll lose our fisheries, and we will have increasing damage on the Queensland coast because the great barrier that always protected that coast from storm events will be gone. So the costs will simply escalate.

If we look to the planet's north in the Arctic we can see the melting of those icecaps. You probably read in March that temperatures at the pole in the dead of winter, the North Pole, were above freezing, and stayed above freezing for a number of days in what climate scientists said was an unprecedented event. So those

Arctic ecosystems with their walrus and narwhale and polar bears, it's hard to see them surviving if we continue on our present trajectory. There's a lot at stake but there is a lot that can be done.

And before I finish, I just want to point to a few opportunities that are directly relevant here to South Australia. As I said earlier, you guys have done so much, you've created a decarbonised electricity grid by and large. You are really now powering down the hydrogen economy line, you've invented new forms of agriculture, all fantastic and absolutely necessary, but there are some big opportunities that are yet to be grasped, and one of the largest of them all is an opportunity for a carbon negative technology that South Australia is uniquely positioned to take up. And that opportunity concerns seaweed.

You know that seaweed grows 30 to 60 times faster than land-based plants, it grows very, very fast. It likes cold nutrient-rich water, you guys have got a lot of that. And we found out, just in publications done over the last 8 to 12 months, that in fact a lot of seaweed is sequestered in the deep ocean, so the carbon in that seaweed gets into the deep ocean and that carbon doesn't resurface over timescales that are meaningful...in terms of climate change. So if we can grow seaweed in areas where we can get some of the crop into the deep ocean, we are on a winner. We can sequester lots and lots of CO2.

South Australia not only has the cold water to grow seaweed, it has a marine typography that is uniquely suited to sequestration. Most of the seaweed that gets into the deep oceans seems to get there through submarine canyons. There are about 660 submarine canyons identified around the planet, and one of the largest and deepest is right here off Kangaroo Island, a 4 km deep submarine canyon, that is like a superhighway for taking seaweed, if you want, into the deep ocean and out of the system, along with all of the carbon that's in that seaweed.

You also have a fantastic technical expertise here in marine engineering, the tuna industry, the offshore aquaculture industry has shown us how we can build durable structures to grow fish in the Southern Ocean. So you've got the two things that are really required to make a difference. What you need now is the investment I think to capitalise on that.

Can you imagine a marine permaculture system operating off Kangaroo Island, which is producing not only seaweed but high-quality marine protein for export to Asia, which is utilising some of that seaweed crop while some of it is being sequestered in the deep ocean.

In the US over the last budget cycle, which was President Trump's first budget I hate to say but I must say, two very important tax credits were given for the sequestration of carbon. One was a \$50 a ton tax credit for the geological sequestration of carbon. That could mean the disposal of seaweed into the deep ocean because it's on a geological timescale in terms of storage. The other was a \$35 a ton tax credit for the profitable use of sequestered carbon. And again, that marine permaculture is front and centre for those sort of tax credits. They are the sort of incentives we need at the state government or federal government level to start building new industries that will not only help feed the world but will help sequester carbon at the gigaton scale eventually.

So I just say to you all, you are in the ringside seat. You people and your vote has never been more important. You've led the way for the rest of Australia and much of the world, and yet the opportunities are there to do much more. Could I just beg you, talk to your politicians about what they are going to offer in terms of climate change. What we do now and over the next four years will have a disproportionate impact.

Robyn Williams: This is The Science Show at WOMADelaide, with Dr Tim Flannery.

One thing that I really do not understand, because many people smear the sort of thing you've been saying as leftist or greenie, implying you are anti-capitalist. Yet surely what we are talking about are the new technologies, the new ways you can invest, the entrepreneurial opportunities of the future instead of 19th century old-fashioned technology.

Tim Flannery: Yes, that's right. I've often found, you know, if you can't win an argument with facts, you try to win it by slandering people and that's what they're trying to do, or use words that are meaningless. But tell that to Elon Musk, that's what I say to people. Of course this is the future, young people recognise it, they are already making good money in new industries in this way. The politics of this whole thing is bizarre beyond reckoning.

Robyn Williams: But why aren't people investing in what seems to be a fair bet? I could list you so many technologies that could make a difference, some of them that are taking off you have. Why don't you have people jumping in with money instead of investing in the old-fashioned stuff that is likely to plunge?

Tim Flannery: Part of the reason is just uncertainty. Markets don't like regulatory uncertainty, and one way of holding back that investment is just by creating an uncertain regulatory environment.

Robyn Williams: But did you see Four Corners? It was a whole program with no politicians but only businesspeople and they are all saying similar things to you.

Tim Flannery: Yes, well...

Robyn Williams: The business people are acting already in many areas in ways that are completely straightforward and concerned and getting on with it.

Tim Flannery: Look, if you can do it in South Australia, you can do it in many other parts of the world, there is no doubt about that. But it is that regulatory uncertainty. I remember I came to South Australia in 1999, I lived here for seven years, and I saw the beginnings really of a consistent state government approach to investment in things like wind and solar, and it's taken a long time to build, as of course it should, but that consistency has been hugely important I think in this state. And where we have got governments that chop and change policy or come up with crazy stuff one week and then ditch it and something else the next, it's very hard for markets to invest in that sort of circumstance.

Robyn Williams: How do you grow kelp, which is the seaweed you're talking about, on a scale that will make a difference, and why isn't it just growing anyway?

Tim Flannery: Aha, well, that's a great question. The reason it isn't growing everywhere, particularly in the deep ocean, is that there is no nutrients in the top 300 metres of the ocean, that's the photic zone, so they have all been used up. So kelp needs both sunlight and nutrients. So the question is really how do you get the nutrients to the kelp?

There's a brand-new seaweed farm by a group called Marine Permaculture who have come out of Woods Hole, as you probably know, on the east coast of the USA. They have already built a 100-metre array. It will be deployed in the Indian Ocean over the next four months or so, and it uses renewable energy, so wave energy and solar, to pump water up 300 metres to the kelp farm which sits 25 metres below the surface and will irrigate the kelp with that cold nutrient-rich water, and they will grow more than just kelp on that farm, they are growing a whole lot of high-quality marine sources.

Robyn Williams: But can you do it on a scale that will make a difference to our weather?

Tim Flannery: Absolutely you could, yes. I mean, much better than growing trees in the sense that if you try to do it with trees, we've got limited land area and trees grow so much slower than kelp, so you've got a much better chance. And the best estimates that I and others have on this is by 2050 you could be doing four gigatonnes of carbon a year, so 15 gigatonnes of CO<sub>2</sub> in round figures. So that's a big, big contribution.

Robyn Williams: And in the film and in fact in your book as well as the film you showed that there are various products, food indeed, that you can make with kelp.

Tim Flannery: You can make amazing food, medication, paper, structural materials, lots and lots of stuff, plastics, it's endless what has been done in Asia with this stuff. So you could sequester some there. But the key is I think having a carbon price that lets you sequester some of that kelp in the deep ocean because then that is absolutely out of the system.

Robyn Williams: I mentioned the heads of academies of the Commonwealth are going to make an announcement, it's to do with climate again. These are Venki Ramakrishnan who is the president of the Royal Society of London...by the way, where did Venki Ramakrishnan, the first Indian to head the Royal Society, where did he go to school?

Tim Flannery: I'd only be guessing, but I'd say Eton, lots of Indians go...or am I wrong?

Robyn Williams: Unley Primary School.

Tim Flannery: Really? Wow, that's fantastic, Robyn, that's amazing.

Robyn Williams: You've had the Four Corners, you've had the statement that I've just been broadcasting on The Science Show which is the assessment in America of the impact of climate, and my feeling is that 2018 is different. Things have taken off, people are beginning to take it much more seriously than they did before, as if the evidence has reached a tipping point and people are convinced. Do you agree?

Tim Flannery: I hope you're right. Look, it really has to be. When you talk to the experts in the fields, they were deeply concerned a decade ago, now they are terrified because they can see these are the last moments really, this next decade, where we will have any control over the system, so we have to make those deep cuts starting now. And in a sense I think that's why we are getting such a big push-back from the traditional industries as well, they see this as their last gasp as well.

Robyn Williams: Even BHP the other day has pulled out of its alliance with the coal people, the Minerals Council of Australia, and the world, even BHP.

Tim Flannery: Yes, that's a big thing.

Robyn Williams: I want to ask you a few detailed questions about some of the technologies. For instance, critics of some of the wind turbines are saying they are becoming more and more expensive and their building is using as much in the way of energy and carbon and suchlike as if you went for other systems. What do you think about that argument?

Tim Flannery: The facts on the ground, they are pointing in exactly the opposite direction. Do we buy more cars as they become more expensive for the same model? No, you don't. Look at GE as one example, they have just announced a 12 megawatt offshore wind turbine. Can you imagine that? I mean, today an 8 megawatt wind turbine is huge. 12 megawatts is going to be the next one, and they are going to be offshore and they are cheaper than ever. So the price of wind energy is going down, the price of solar is going down even more spectacularly, and the price of storage is decreasing. So we can see in the electricity sector...I think no one will ever build another coal-fired power plant in Australia and shouldn't be building them anywhere else.

Robyn Williams: And this bit of news is for our friends the bats in the trees up there and the birds that are flying past, something I picked up in Texas when I was attending the AAAS meeting, that's the American Association for the Advancement of Science, what they have developed is a kind of echo screen which you put up near a wind turbine that reflects sound, and when birds are flying...I don't know about the bats, I'll have to ask them later...is they are often just looking down, they are not looking ahead to where they are flying in the sky. And so what they are doing when they are going 'tweet, tweet' or making whatever noises they are up there, is waiting for some sort of feedback. And if you put a plate up next to the turbine, it reflects the sound, the bird goes, oh shit, and they look up and they avoid the turbine. So the technology, however simple now, is there.

Tim Flannery: Yes, absolutely. And look, they are just at the first innovations of many I think that will cascade down the production chain. So plastics now, obviously the world is choking on the damn stuff. But in future we will be able to use biological materials for plastics or direct air capture of CO<sub>2</sub> for degradable plastics or plastic substitutes. So there's a big opportunity in that area. I mean, it would be nice to do without them altogether and just use banana leaves, maybe one day we will, but at the moment that's not there.

Carbon fibre is the other huge area. There was this breakthrough two years ago in the USA where people have been able to create carbon fibre from atmospheric CO<sub>2</sub> directly, at a cost, they say, competitive with current production methods. So once carbon fibre gets cheap enough, who is going to want to use aluminium or steel for many purposes? Using the problem, atmospheric CO<sub>2</sub>, to outcompete sources of pollution is really smart stuff. So once we start moving that way we will really I think start having a significant impact.

Robyn Williams: I want to ask you about sequestration, which you mentioned in terms of seaweeds, kelp, but just a mention of something I picked up in Caltech two weeks ago, and if you meet someone from Caltech they've got at least one Nobel Prize, it's just outrageous how clever they are. And this professor of chemistry was telling me about something, an enzyme called carbonic anhydrase, which is keeping you alive at the moment because when you breathe out your CO<sub>2</sub> leaves your system, dissolved, and comes out of your lungs and you breathe it out, and the system is working like that all the time. If you reverse the process and you want to get CO<sub>2</sub> into water, then you add the enzyme and it goes 500 times faster than it might do in ordinary systems in nature. So the idea that they are talking about is to scale it up so that you can get a factory system. There are a number of ways in which you can get that negative carbon you are talking about absorbing CO<sub>2</sub>. Now, if you can do it 500 times faster, that should be really good fun, as long as someone, again, invests. What sort of things have you seen around the place for sequestration, apart from the carbon fibres you're talking about? Is there much going on?

Tim Flannery: I worked with Siemens for a number of years and they are looking at exactly that technology, so you dissolve CO<sub>2</sub> in water, run a weak electrical current through it and you can create the building blocks for a whole lot of materials that are useful in many industrial processes, and substitute for fossil fuels, so that's just one small example of that. We can grind up silicate rocks, they are rich, there are many silicate rocks around the planet. And as they decompose they absorb atmospheric CO<sub>2</sub>.

I've got a friend who is a glaciologist, a geologist working in Greenland, and he said as the glaciers recede there are gigatonnes of rock flour being exposed, and they have silicates rocks in them. So if you want to, for example, use them as a soil amendment where they will absorb CO<sub>2</sub>, or in the oceans to absorb CO<sub>2</sub> out of the ocean water, you can transport them at relatively low costs.

There is another group of people talking about capturing CO<sub>2</sub> over the Antarctic icecap as dry ice, so chill the air a few tens of degrees, let the dry ice fall as slow and bury it in the icecap. These are possibilities. But as

time goes on we will see more and more of these. Which ones are going to be the winners I don't know, but I have a strong feeling seaweed is going to play a role in this. It's already a \$12 billion a year industry. We understand it very well. We now know how it is sequestered. And I think that that is going to be a race very quickly to unlock the potential of that material.

Robyn Williams: What about the development of the coastline? I've mentioned in this forum and various other places the role of seagrasses which absorb 100 times, 40 to 100 times more CO<sub>2</sub> than tropical rainforests. Bloody seagrasses! So if you preserve the coastline and what's under the water and you develop it in a way that enhances what's around, according to Jane Lubchenco who is the former head of what they call NOAA, the oceanic and atmospheric organisation under Obama, you will increase the creation of wealth by 30%. So you don't shut down industry by preserving nature, you increase it by enhancing what's going on there, as you said, tourism and suchlike. Seagrasses, who'd have thought!

Tim Flannery: I know, it's amazing. Whatever it is beneath the waves there is hidden to our view, so we don't appreciate it as much as we should. And often, as you say, people degrade seagrass for no good reason whatever. But this state is very fortunate, you've got a really forward-looking organisation called SARDI here which does a lot in the marine environment. And I think with those new values and new appreciations, and particularly the value of sequestered carbon, we can see huge opportunities in that area. It's interesting that we are so land-based, we don't look under the oceans, and yet it's 72% of the planet. And the systems really are different there, they work at a different scale and in a different way.

Robyn Williams: Before I ask for questions, a couple of personal ones to you. Do you get put off by being attacked for the 100th time in the papers?

Tim Flannery: God, I've got the skin of a rhinoceros by now I think. It's like a game of rugby, we've got possession of the ball, we are running for the try line, we've made some steps forward, and every bugger on the other team is going to be using every tactic, legal and illegal, to trip you up before you get there. So we've just got to keep pushing on. Don't worry about them, just watch the ball and watch the game.

Robyn Williams: So you don't lose it now and then?

Tim Flannery: In private perhaps but not in public.

Robyn Williams: And why do you think it's coming from certain forces? Can you guess?

Tim Flannery: Look, old men don't like losing power. I'm sorry, I'm an old man myself, but it's what it comes down to, Robyn, I'm afraid.

Robyn Williams: You've just turned 60, that's nothing. I'm bloody Methuselah, look at me!

Tim Flannery: In any case, it is there. Being able to depose Prime Ministers is where you get your thrills if you are a multibillionaire, for some people in the world today. Other people do good things with their money. But people don't like change and if you've done very well under the old system, you'll like change even less. And there's a lot of ego there as well. People who built the world as we know it through extracting fossil fuels or whatever, their ego is all tied up in that old world. And so of course they are not going to like change.

Robyn Williams: Sure. We've been talking mainly about the Anglo countries. What about the rest of the world? Are there places where people are really getting on with it and showing some great success?

Tim Flannery: Yes, sure. Europe has done some astonishing things. I mean, they were the early pioneers and they still continue to do great things, and some of the innovation companies in Europe are doing a lot. China of course now is the big runaway success. And because they are not very rich in fossil fuels they've understood that they can use manufacturing to create energy, that is a huge breakthrough. So China is now going for broke with this sort of stuff.

And I think we will be surprised at the speed of the transition in some areas. So electric vehicles is a good example. So much is happening in China, and yet it's hidden from our view really because it's such a different sort of place. But when they start manufacturing these things by the hundreds of thousands or millions and start exporting, that's when we will see the difference, it will come at us I think like a big wave, whereas at the moment Tesla, they are struggling to do a few thousand a month I think, but the Chinese will do it by the hundreds of thousands.

Robyn Williams: Well, of course you know that Martin Green and the University of New South Wales has held the world record for solar of the silicon type for a long time, and one of his ex-students, Zhengrong Shi, became the first billionaire in private industry in China. And he's doing well. But one wonders why it is that we have to have that kind of industry going from Australia as an idea and exploit it in China as an industry.

Tim Flannery: The University of New South Wales deserves some sort of Darwin award because at the same time they did all of that they also sold the patents to a solar hot water system which is now the most widely deployed solar hot water system in the world. There are billions of units out there. They sold the patents for \$160,000 to a Chinese company, sold them, didn't even reserve 1% or a 10th of 1%, the university would have been like Harvard if they had done that, but jeez...and of course it was John Howard that shut down the solar stuff, because coal is the future, why should we worry about solar?

Robyn Williams: And the same thing was going for the other kind of solar that is just heating the water.

Tim Flannery: There are so many different ways of harnessing the Sun's energy. One of the really interesting ones is the solar thermal technology where you can concentrate the sunlight, so you've got, say, 1,000°C, and with that very high quality heat you can do lots and lots of things in terms of industrial processes or desalinisation or whatever, but you can also store it. And I think that those solar thermal technologies, and again South Australia has promised I think to build the largest solar thermal plant in the country in the next couple of years at Port Augusta. They will be transformational.

Could I just say, Robyn, I remember being here a couple of years ago when there was a group of young people working for 350.org who did a walk to Port Augusta in support of that solar thermal power plant being built. And we never give them credit, these young people, for walking 400 km and putting the heat on the state government for doing it, but they really deserve a round of applause.

Robyn Williams: One there in the middle?

Question: Thank you, it's been fantastic. I just would like some words for my 11-year-old daughter who is listening.

Tim Flannery: What's her name? Harper. Look, Harper, we stuffed up pretty badly, I'm sorry. Some of us have done our best, but we are going to have some rough times ahead. I think you'll still have a great quality of life here in South Australia but we will see impacts on our biodiversity that we'd rather not have seen. But for your generation and people a bit older than you, there are huge opportunities in this. Whatever you study at school, you could be part of a great new transformational enterprise, whether it's communication, the arts or the sciences, we are going to need so many diverse skills as we transition into this new economic model. Just keep your eye open for that. Do as much as you can. And I think we can avoid the worst of climate change still, if we act promptly.

Robyn Williams: One thing I'll add to that is I broadcast a program last Sunday which involved in fact a student at the University of New South Wales working with schoolkids, 14, 15, 16 years old, who are in connection with the space station. They weren't waiting to graduate or grow up, they were doing it now. Kids can do it now, don't wait.

Question: Just back to the doom and gloom for a minute. You said that they were going to be at least two decades of things happening, whatever we do. What I'd like to know is are there any potential benefits from climate change and climate warming? We know about the change in weather and the big events and the floods and the flooding of the low-lying areas, but is it possible that there will be enough moisture generated to, say, start greening parts of the Sahara or other parts of Africa? Because I'm a little bit unclear about the actual fact of climate change being totally negative.

Tim Flannery: Sure. Look, the science around that is very complex because the sort of world that we are headed for at the moment is a world, under the Paris Agreement, about 3 degrees warmer than current. So the last time the world was that warm was about 5 million years ago, and we can look at the fossils from that time and we see that in fact the world did have more rainfall back then, and there were many other differences and probably more productivity, but there wasn't the Arctic habitats and a lot of the alpine environments we have now and so forth.

You might think that, well, as we get towards that world we will have more rainfall, and that's unfortunately not true because the speed of the change also has a big impact. And one very good example of this is the withdrawal of rainfall from southern Australia, which we've seen for the last few decades. If it was just a linear matter of going back to the Pliocene of 3 million years ago, we would have a Nullarbor Plain with big forests on it now instead of less rainfall. But what's happening is that the very rapid rate of warming is causing some distortions in the way the climate system works. And so while that warming persists at this rate, that southern rainfall zone will continue moving south.

So it's a really complex question. And the way I view it is really that climate change is not a destination but a process, and for people who rely on stability during this period of rapid change, there are going to be challenges. I guess conceivably there might be some benefits, maybe less frost in the northern hemisphere wheat areas or plant growing areas, but for every one of those there's going to be a lot of negative events as well. So it's a complex science and I just reflect I guess the scientific consensus that there are going to be lots and lots of negatives and very few positives.

Question: Hi. You've spoken a lot about South Australia being involved in a lot of innovative projects to do with moving towards battling climate change and that sort of thing, but we are also at the moment dealing with a lot of contrasting projects like the exploration of oil and gas in our Great Australian Bight. I wanted to know, one, what your opinion on projects in coastal areas like that in terms of what you said about growing kelp forests and that sort of stuff, and if you think for the next few years there is going to be this battle between very contrasting projects, people trying to move forward and people trying to keep us in the same place, or if you think that at the moment it's kind of a last-ditch effort for these kind of industry type projects?

Tim Flannery: My gut feeling is it's a last-ditch effort. So if we look at exploration for oil and gas in the gulf, in the Great Australian Bight, my guess is that there'd be a number of years of exploration there and then a number of years of development before you get any return on your \$1 billion-plus investment, so you might be looking a decade out. And if I was looking at that and looking at South Australia, well, the hydrogen economy is coming along pretty quickly, electric vehicles are coming along pretty quickly, is my oil really going to be worth recovering a decade from now, or my gas? And I guess the old dinosaur industries are making a bet that it is. My gut feeling is that's wrong.

Let's just pick apart hydrogen. As I said, 97% of the world's nitrogenous fertilisers are made from natural gas at the moment, but right here in South Australia you are developing a plant that is going to be making them from wind and solar electricity, amazing stuff, cost competitively. So that is a huge step. And the hydrogen that will be generated as well, you can shandy that into the gas pipelines I think on the order of 15%, without deleterious effects. So again, you are lessening the demand for gas.

As we start getting into the technologies that Robyn talked about with the means of capturing CO<sub>2</sub>, you start developing cost-effective opportunities for substituting a lot more of the uses of fossil fuel we have. So we are in a period of great transitional change, and I reckon it's a bit like a dinosaur, you know, it has been shot in the head but the tail is still kind of moving, it takes a while for the signal to get down. Let's hope that's right. Of the more pressure we can put on these projects for delay in fact will be better because I think five years from now it will be evident to everyone where we stand.

Robyn Williams: I'll give you one more example. Imagine that we are sitting in a very posh room and we are getting a bit cold because we are in northern Europe and we happen to be sitting on Louis Quatorze's furniture, it's made of wood and we think, oh yes, let's chop it up and put it in the fire. Here you've got the basis in oil and coal of chemical industries to do all sorts of things, and you mentioned fertiliser, drugs, you name it, all sorts of things you could do with them. Burning them?! (laughs)

Tim Flannery: Yes, exactly, well...

Question: Tim, I'm one of a couple of early childhood educators sitting here today, committed to actually breaking down these very difficult concepts to the understanding of four- and five-year-olds, and I know I speak on behalf of both of us that we strongly believe that if we actually educate these young people and they go on with this in their education for the future, that there is hope for us all. I guess my question is do we have time to wait for these four- and five-year-olds who then can have these ideals instilled in them from now through to the future, do we have time to wait for that?

Tim Flannery: No, no we don't, we have to be the Colossuses that hold up the sky for those kids, to give them time to grow, and then fulfil their part of that process, because we are not going to solve the problem over our generation, but unless we perform superbly this next decade, they won't have the opportunity to the full to do what they can to address the problem. Look, for me, four-year-olds and five-year olds are the most precious resource we have. To keep their imagination alive and give them a sense of optimism are the most important things, and a sense of confidence really at that age, because they are the ones who will go on and take full advantage of some of these opportunities like seaweed farming or carbon-negative technologies.

Our job now is to cut emissions I think and start creating those opportunities because they are not going to be mature for several decades at the scale we want. It's like wind and solar, it took four decades to grow to where they are today. Well, these new carbon negative technologies are probably going to develop along similar timelines, just because it takes a long time to grow those industries. But it is, it's all about for me imagination, possibility, confidence, love, all of those things, you know it better than I do.

Question: Hi Tim. You've been talking a lot about carbon in the atmosphere and we are measuring that quite accurately. I'm more worried about carbon absorption in the oceans and whether or not we've already pushed the oceans over its balance or whether or not it has a chance to recover.

Tim Flannery: It's a great question. And one of the biggest concerns that climate scientists have now is the weakening carbon sinks of our planet. So the ocean is the most important carbon sink, but in every year that goes on it's less able to absorb the CO<sub>2</sub> to the same extent. So that is a really massive issue and it's one of the things that just makes the problem so much worse. So when you look at the conventional accounting as to whether we are committed to 1.5 degrees or 2 degrees, if you factor that in it makes it more likely we are



committed to 2 degrees than 1.5 degrees. It's a big concern but it's nothing we can turn around quickly. We have to attack the problem at source, which are the emissions, and then start building those new approaches that will take some CO2 out fast, like seaweed. Seaweed can do a lot.

Robyn Williams: One thing I'd add to that actually is the process I mentioned before of the enzyme and putting the CO2 into the ocean to be absorbed, it produces bicarbonate which, as you know, when you've got an upset tummy, is an antacid, so what you're doing is reducing the acid effect. Whether you can do so on the scale that makes a difference, who knows, but at least it's going in the right direction.

Question: Yes, Tim, I'm wondering about soil carbon and the issue of, dare I say it, weeds. In Brazil they are using eucalypt a lot because it sequesters carbon. It grows quickly, they can put it back into the soil, it sequesters carbon. In this country it doesn't matter where you go, if you go into the suburbs, if you go into rural landscapes, if you go into national parks, you'll get a lot of herbicides used because there is an image of weeds as being a negative connotation. Where do you stand on the hybridisation of landscapes, i.e. permaculture, how do you feel about just allowing weeds to heal the landscape?

Tim Flannery: Let's just take it at that fundamental carbon level first. All of that stuff is potentially sequestered carbon. There are ways you can deal with weeds that don't involve glyphosate and that sort of thing. I think we use way, way too many herbicides and pesticides. And if you look at insect abundance (you've probably covered this, Robyn) in places like Europe where it's well documented, we've had catastrophic declines of insects which strike at the heart of those terrestrial ecosystems. So I do think we need a new approach.

It's interesting, a weed is just a plant out of place, and so in Europe, ragwort, which is native, is considered a terrible weed, and great efforts are made to remove it. I'm not enough of an ecological expert in those places to know, but I do think you can create a balance that allows for a diverse ecosystem to persist with some of those new elements in it.

Robyn Williams: In the Mediterranean you'll see lantana in pots as a plant you keep in your garden instead of razor wire that you want to get rid of, it's most extraordinary. What about biochar? That was quite fashionable 10 years ago.

Tim Flannery: It was, and there are still people using biochar, various processes.

Robyn Williams: That's where you burn something and make it into a kind of carbon that you add to the soil.

Tim Flannery: You partially burn it, you char it and pyrolyse it. The difficulty with all of the terrestrial approaches is one of scale. So getting to a gigatonne scale, because we are 50 gigatonnes of CO2 in the atmosphere, it getting a gigatonne out using any terrestrial approach is challenging, just because the land surface is so limited. So the example I gave earlier of what would we need to do in terms of tree planting to withdraw five gigatonnes of CO2? It is pretty much cover North America in forest in round figures.

Robyn Williams: Not a bad idea actually. Who's next?

Question: My name is Anna, I'm from Queensland. I'm not an expert in this area at all, I've got solar panels, I try and make good choices, I look at policies before I vote, that kind of thing, but what would be the one thing that you would advise that we action on that would make a difference moving forward?

Robyn Williams: Actually, if you're coming from Queensland, may I refer you to...you know, I read the Economist all the time, and last week in one of the articles it said Queensland, the buzz saw capital of the world, where chopping down the trees is worse than in Brazil. It's unbelievable. It's happening now!

Tim Flannery: Can I just point to one very specific thing? And there's lots you could do as an individual, but just one thing Queensland could do. Queensland has some of the most progressive laws in the country concerning run-off from fish farms, from aquaculture. They allow zero run-off of nitrogen and phosphorus, and that has led to a total breakthrough in terms of water treatment. So there are new water treatment plants on aquaculture farms in Queensland that lead to zero run-off. But human sewage farms, human waste farms up and down the coast run off vast amounts of pollution because they are not regulated. Other forms of agriculture still have huge run-off.

So as a Queenslander, if you could extend that law from just fish farms to all waste, you would make a huge difference in terms of helping the Great Barrier Reef with run-off. But you would also...because those farms use seaweed as the active ingredient to get the nutrients out of the water, you create a major new material which can be used for fertiliser or making biochar or whatever else. And there's lots and lots of it. I know that might seem off the wall, it's kind of a weird one, but it's an opportunity that Queensland has sort of half grasped.

Question: I'm in year 12 at the moment, and for my research project I'm looking at the ways in which we can reduce our carbon footprint. And so leading up to that question I've been looking at why we need to...the

negative impacts we are having on the Earth or causing, and I was just wondering, what would you say are the biggest factors contributing to climate change?

Robyn Williams: Well, there's one. May I just mention there's a book out in 2017 by Paul Hawken. There are 200 different examples of ways in which you can make a difference in various areas we've discussed, and it gives an assessment of the impact and what happens when you put them all together. So Paul Hawken's book, which I presume you've seen, has got it all in it. It's a big book, but lots of colour and a couple of pages for each.

Question: When you're talking about the impasse at the top, the power grab that we see going on at the moment from the characters, political characters such as Trump and Putin, they are very widespread, a lot of them are less visible, they are behind these big fossil fuel companies, chemical companies, and you talk about character traits such as narcissism, ego, power grabbing. It kind of brings to mind for me this kind of predatory nature, which is a bit like...it draws a parallel with a recent phenomenon of #MeToo. In a way I think there's a huge need to expose these people, even though they may say that they are elected, I still think there's a level of exposure that needs to happen. So do you think we need a kind of social media grab that goes out on the lines of #EarthToo or whatever it is, ideas welcome, to say this is no longer acceptable, this is persistent violation, when will it stop? Thank you.

Tim Flannery: I've been waiting for it, I've been really hoping we'd get onto that. The #MeToo, that whole phenomenon looked to me to be so powerful and it seems to have reached a stop and it needs something else to revitalise it because the sexual predation of those people is just one...as important as it is, just one form of predation on the rest of society. And I think about unless we act to protect our own interests, they will remain in power. We need to act in concert in a way that goes beyond voting because that representation system is broken, to something else I think. So I agree with you.

Robyn Williams: One last question please.

Question: I'm an exchange student from Switzerland, I'm currently in year 12 here, and I'm doing a research project as well. For my research project I am having a closer look on artificial reefs, and therefore I was wondering if you think if it would be increased number of artificial reefs, if it would have a positive impact?

Tim Flannery: I think it very much depends on where they are and what grows on them. To get permanent sequestration of carbon we need to get the carbon into the deep ocean, so they need to be somewhere...or whatever it is that we use to capture that carbon needs to be somewhere near marine canyons. So I guess, look, it may have an impact around the margins, but if we want large-scale sequestration it very much depends on that location.

I think we've got time, this poor fellow, he has been waiting forever, could someone hand him a microphone?

Question: It actually relates back to the political question. Have you got any suggestions for how we can actually change this political system so that we move on faster, because the mainstream media support them and they are corporate backed. How do we escape this system?

Tim Flannery: In 10 seconds, I think what we've got to do is have people of good standing in the community, like yourself sir I hope, stand for elections, stand for elections, say I'll only stand for three years, I've only got one item on the agenda which is to make sure that every piece of legislation that is passed and actioned has to go through a citizen jury. So we pay people for their time, people chosen at random who can make the decisions. So parliament becomes really the agenda setting thing.

Robyn Williams: Would you please thank Tim Flannery?

[Applause]

Tim was at WOMADelaide. His latest books are Atmosphere of Hope, and Sunlight and Seaweed.

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