Interview with Dr. Lonnie Thompson

Interview conducted by John Hooton on Wednesday, March 29, 2017 at 9:00 AM.

This interview was transcribed by John Hooton. The text has been edited for clarification and in some cases brevity, but the vast majority of the words do not derive from the spoken word. Verbal fillers have been removed. The interview's words are represented in bold whereas Dr. Thompson's words are represented as plain text.

Alright, first and foremost, what is it like to have your own Wikipedia page?

I don't really think about it that much. I think in life it's a matter of finding out what you're really passionate about, concentrate on doing that, and everything else develops around it. So, I guess it's good to have one [laughs], so people know who you are or they can find out who are. Certainly was not an objective.

Just a happy little benefit.

Yeah, just a benefit along the way, yes.

So, I know what it is you study, more or less, as best a history major can, but I know a couple people, just off the top of my head, that often read Frozen Fridays and they don't know much about the Byrd Polar Research Center if anything, how would you describe what you do and what you study to someone who wouldn't know, just in your own words?

I'd say, first and foremost, we study glaciers. It's very much a team effort and we've been very lucky to have great teams of people. We've now conducted sixty-two expeditions in sixteen countries in addition to Antarctica and Greenland to look at the history of climate recorded in ice. Glaciers are wonderful recorders in that every year, if you're high enough, cold enough, or in high latitudes where it's cold enough, you get an annual layer of snow deposited. You can measure that layer through measurements of isotopes of oxygen and hydrogen that tells us the temperature of the past so you can actually see the seasonal cycle in these areas. You can look at the annual variations in things like dust. Every dry season, if you're in the tropics, you get a layer of dust. You can measure the thickness of those dust layers through time and you can reconstruct precipitation, another very important part of variables in climate systems.

Literally anything in the atmosphere is recorded in the ice and that's including the atmosphere itself. In the little bubbles (capsules) in the ice is capsules of the atmosphere of the past so we can extract the gasses from those bubbles so we can measure carbon dioxide, methane, and nitrous oxide; all the greenhouse gasses we're concerned about today. We can look at how natural variation has changed through time. That record now goes back over eight hundred

thousand years. You can actually put today's variation into a time perspective and that's critical for understanding climate and environmental change.

But glaciers also respond to climate change. They're indicators. If it gets warmer or drier, the glaciers will retreat. When it's colder or wetter, they advance. So in some ways they're a visual recorder of how the system is changing. I believe and it's not just because I've spent a lifetime studying them, I believe they're the best archive we have of the past because not only do they record the climate history, they also record the forcings of climate. Natural variations and things like volcanic activity through the tephra and the sulfate that come from those are recorded in those layers. We can look at how the sun has varied, cosmogonic nuclides that are formed in the upper stratosphere and get deposited with the annual snow that falls on these glaciers. So they record so many variables and they're the richest recorder that we have on the planet. Unfortunately in today's world, those recorders are disappearing because the Earth is getting warmer.

I know you do a lot of travel and studying. I know the Byrd Center prides itself on having ice cores from various places. You said you've been to Greenland, where else have your studies taken you?

Well we have drilled the ice fields of Kilimanjaro in Africa, the highest tropical mountain in Africa. We've drilled the ice fields down in through the Andes of Peru, Bolivia, and Ecuador. The highest tropical mountain on Earth is Huascarán. It's one of our drill sites in the Andes in Peru. We've drilled in places where people don't even know there's a glacier. For example, in Papua, Indonesia in what used to be called New Guinea, in the middle of a tropical rain forest, there's a glacier, very difficult to get to and that glacier is disappearing very rapidly in today's world but we were able to drill there in 2010.

A lot of what we do is like a salvage mission to capture the history in the ice before it disappears. China, Tibet: we went into that part of the world right after relations were normalized between the U.S. and China. We've now been working there for thirty-three years and drilling in the Himalayas and across the Tibetan plateau. We just completed a project in 2015 in the far western Kunlun Mountains where we expect to have the oldest ice archive outside of the Polar Regions recovered on earth. We don't know yet how old it is, but it might actually be the oldest ice on earth. That's the beauty of what we do: we go to places where no one has gone before and in those areas you are almost guaranteed to find something new and exciting when you start reading that record.

Obviously, one might not expect to find a glacier in the tropics. How does that happen?

Well, it was one of our biggest issues even getting started in the lower latitudes. When I was a graduate student at what was then the Institute of Polar Studies here at Ohio State, there was a fellow, John Mercer, who was a geographer and he had made these atlases of the glaciers of the world (northern hemisphere, southern hemisphere) and he had these boxes of aerial photos. In

one of those boxes we found this Quelccaya Ice Cap in the Andes of Peru. This was back in the mid-seventies. Our initial concept was very simple: they were drilling in Antarctica at Byrd Station and in Greenland at Camp Century and the idea was can we connect the climate history from Antarctica to Greenland through something in between in the tropics. But when we went to National Science Foundation, to Polar Programs, which was the only place that funded ice core research, the program manager listened to us and he looked at me and he said, "You know Lonnie, that's sounds very interesting but you know I can't fund it because it's not north of the Arctic circle or south of the Antarctic Circle." There was no agency to fund that type of research.

I was at Byrd Station in Antarctica in 1973/74 and in February I got a telex from the program manager saying that he had funded all of his real science projects and that he had seven thousand dollars left. What could we do on that tropical glacier for seven thousand dollars? I telexed back and said, "We can get there".

The following summer we made our first trip to the Quelccaya Ice Cap. It turned out to be a fantastic place: very remote, very difficult to get to. None of the logistics that had been developed for the Polar Regions would allow you to drill in these remote, high mountain regions. There had to be an engineering part of this to develop new drills, so we developed the first solar powered ice core drill to drill that icecap because the drills from Antarctica were a two day journey by horse from the nearest road. There was no way you could get one of those heavy drills from Antarctica or the generators from Antarctica to power it. Really, if you would look at it, it wouldn't have looked like a good business model [laughs].

There wasn't even an agency to fund that type of research but the science, if you think about it, the things that really impact climate on this Earth come out of the tropics, things like El Niños, things like the monsoons that affect so many billions of people on the planet. If you think of forcings, if you have a major eruption of a volcano in Alaska, it will impact the Arctic part of the globe, or if you're down in South America in Argentina or Chile and there's an eruption it will impact Antarctica, but if you want to impact the climate of the Earth, you put it in the tropics. If it erupts in Indonesia, it will impact both hemispheres and you will see the impacts of that in the climate record. The tropics make up between thirty degrees north and thirty degrees south, fifty percent of the surface area of the planet because we live on a sphere, and about seventy percent of the seven point three billion people on the planet live in the tropics, so it's a place where we need to understand both natural and human driven changes. It's part of a big system. We need those polar cores but we need to connect the system.

But you did receive some skepticism from the beginning.

Oh, absolutely. I am a firm believer that it doesn't matter what area you're in, you've got to be willing to put in ten thousand hours (that's about eight years of your life) and I've put in about eight and a half years trying to figure out how to drill the Quelccaya Ice Cap in the Andes of Peru. But yeah, there was a lot of skepticism the first time we tried to drill. Being young and

naive, we just brought a drill from Antarctica and its power system. We made a contract with the Peruvian air force for a Bell 212 twin engine helicopter. No airport up there, we had to fly it thirteen hours to get it up to the area. We had to bring in fuel by boxcar on a train. We staged out of the back of a hotel in this little town of Sicuani. But at nineteen thousand feet this helicopter just falls. There's no way we'd get near the surface.

Of course, the first time we tried we failed, but the second time, for all the research we do, we have to write a proposal and it has to be reviewed by your colleagues. The second time, we tested some solar panels. This is back in early 1980s and technology in the solar energy was just in its infancy. Not even the National Science Foundation thought that we could use solar power to drill this ice field. The fact was that when you get up to nineteen/twenty thousand feet, the panels perform twenty-thirty percent above manufacturers' specs. That's why they use them on space stations: there's no atmosphere to absorb the radiation. You're right up there!

The proposal to build the drill to use solar power had to be reviewed. One of the reviewers was one of the pioneers of the ice core industry in the Polar Regions, that was Willi Dansgaard, and he sent me a copy of the review he sent to the National Science Foundation which was very short and simply said the Quelccaya Ice Cap is too high for human beings and the technology did not exist to drill it.

Fortunately, there was a program manager who had just gotten his Ph.D. studying monsoons in India and South America. He said, "Willi might be right but we won't know unless we try" and so we developed a drill. We tested it on a parking garage here on campus. We put the panels up on the roof, we put the drill over the side, we brought in blocks of ice and it seemed to work.

Two weeks before leaving on that expedition in 1983 I passed the M.B.A. exam to get into the Fisher School of Business because I figured that if we failed, I wouldn't be a glaciologist because that would have been two failures. I really respected Willi Dansgaard. I had met him many times at meetings and he was one of the pioneers. But also I learned a lesson there and the important lesson was that when we actually drilled using solar power, we drilled not one but two cores to bedrock. One set of samples we sent to Willi Dansgaard's lab in Denmark. He analyzed them and he was so excited. It was such a phenomenal result and he became one of our greatest supporters of why we should drill mountain regions.

How did that eight and a half year process between the concept and actually being able to accomplish it is what launched all of our work in the low latitudes. It takes a special team. There's not a lot of competition because most people do not want to work in twenty-two, twenty-three thousand feet. It's tough. There's not very much oxygen. There are places very difficult to get into, very hard to drill and get the ice cores out while keeping them frozen. A lot of effort. And then, if you're working in a place like Tibet, you need these permits to get in and be allowed to drill there and to take the cores back to your lab. We drilled in Tanzania, Kilimanjaro in Africa which is a national park, a World Heritage Site. We had twenty-four permits we had to get in

order to drill. A lot of time and effort goes into just getting the ability to try. Then there's all kinds of issues with things that could go wrong, why this could be a real big failure.

But, if you like working with other people and other cultures (which I do), going in and trying to figure out a place where there is no logistics, where most people haven't even heard of an ice core, how do you make it happen? I'm really impressed by, once people understand what you're trying to do, how they will really try and help you succeed in that effort. Our programs are very much international. They require a great team of people here at Ohio State, but they also require a great team of people in the country where we are working in order to make all of this work.

How you ever encountered in troubles with people in other countries, be it a government official that's being difficult or any less-than-legal groups?

Oh, yes. It comes with the territory. When we were drilling in New Guinea, we had all our official papers from the Indonesian government but the drilling team was attacked by a one hundred and fifty Amungme people. At the base of the mountain, there are four tribes and they're at war with each other. There're spears and there're arrows. Fortunately, we were drilling up in the clouds so they couldn't find us. Then they went to break into the freezer, into Tembagapura, where we were storing the ice cores. The company we were working with got word they were going to break in, so the company took the cores and moved them to another freezer down on the coast. When they broke in there was nothing in there.

Then I get this call from the head of the mining operation and he asks me to come down and talk to these Amungme people. There are one hundred and fifty Amungme in a room and the security guards are around. I start to talk and explain to them who we are and what we're doing and, when I am about twenty minutes into the lecture, they all stood up and they screamed.

I looked at the translator and the security guards say, "It's okay, they always do that before they go to war" [laughs] I thought "Oh, okay…"

But I come to find out that in their religion, the arms and legs of their god are the mountains and the valleys. The glacier is the head of their god and, in their words, we were drilling into the skull of their god to steal their memories. I told them, "that is exactly what we're doing." I also told them that "the day will come very soon, in a matter of years, when the only part of your god's memories will be in a freezer in Ohio State University."

There was a big discussion between the elders of the tribe and the younger people. The elders said "No, the glaciers will always be there. They are part of our tradition." The younger people said, "Have you been to the glaciers recently? Have you seen what's happening to them? They're disappearing." In the end, we were given permission to finish our project, take the ice cores, and go home.

Afterward we had this meeting and I asked the head of the mining company and said, “I came a year early. I always come a year early to give lectures to let people know what we’re doing and ask for their help. Why didn’t we meet with these people?” He said, “Well, it’s simple. There are four tribes and they are at war with each other. You make one friend, you make three enemies. They would not have given you permission, so it was better to do it and ask forgiveness.” [Laughs]

So every project has its own unique story about how you actually get the project done. It doesn’t matter whether you’re in New Guinea or you’re in the Andes of Bolivia. The local people when we went to drill Sajama, the highest mountain in Bolivia…you have all your official documentation but it’s always a challenge. Bolivia was particularly a challenge. I think they’ve been a nation for forty years, or something like that. They’ve probably had about thirty-five governments. So you get your permits the previous year, as we did, but when we actually arrived, two weeks earlier the government had changed. All of our permits were not good even though we had six tons of equipment at the airport.

Dealing with changing landscapes is a real factor in what we do. Frankly, there are times when windows are open, you get into certain parts of the world and other times you cannot. You have to wait until the window is open so you can get in and do your thing, get the ice, and get out. Every country is different.

Even in Bolivia, once we got permission from the government to go out and drill, there was a tribe the Aymara tribe that live in a village at the base of the ice field and when we had to meet with the, the whole community was there and there was a medicine woman who was very dead-set against us drilling. She said that we would anger the gods. In their religion the gods live on the mountaintops in the glaciers. And what are we going to do? Drill through it! She said the glacier will split and the climate will change. There’ll be starvation in the village.

There was this huge discussion and after we presented the last thing, the mayor of the town asked me if they decided not to give me permission, would I take all my people and all my equipment and go away. I said, “Yes. If every mountain had a village that was protecting it for whatever reason, we wouldn’t have many of the environmental problem we have today.”

In the end, they decided to give us permission if we did three things: Donate five hundred dollars to the local library (I looked around at mud huts and I didn’t know where it was, but yes we could do that). Hire local village people for the logistics, moving things (we had planned to do that anyway).

The third one was that “You will participate in an ancient sacrifice to the gods of Sajama, asking forgiveness for what you are about to do. I said, “Okay…what are we sacrificing?” It turned out to be a white alpaca and I said “Okay, that’s what happens to alpaca anyway, so we can do this.”

There was a ceremony set up and the whole village came out, all of our drill team. The alpaca is blindfolded and they have two priests that ask forgiveness and they cut the throat of the alpaca, catch it in a cup and sprinkle it in the ground with their prayers. Then the animal is cut in half. The head of the village and the head of expedition (me), the heart is roasted in the fire and we split it. Then the animal is split between the drill team and the village. That's how you get permission to do what you want to do.

So, the fact is, no matter where you get your degree, no one trains you to make this really happen in the real world. I always figure that we are the outsiders, this is their culture. It is not for me or our team to judge, but on the other hand we need their support in order to make the expeditions succeed. After that we had great support. We could not have done it without the village people. There is a reoccurring theme: glaciers are holy places. It doesn't matter if it's the Himalayas with the Tibetans or in the Andes in South America or over in New Guinea. They are sacred places where the gods live. I feel very fortunate at the time we came along that we are able to get these archives because in all cases now they are disappearing.

In some places where we've drilled thirteen, fifteen years ago, those places are gone. The only archives are out here in the Byrd Polar and Climate Research Center. In many ways, timing is so important. It doesn't matter what field you're in. Back when I studied, no one went into glaciology because there were only two professors in all the United States, so where were you going to get a job to get trained as a glaciologist? But, it just turned out that at the same time, the Earth was warming up. People start recognizing that the ice is disappearing, the sea level is rising, and we have a major problem. It was just five years ago that the University of Michigan hired five glaciologists all at once. You never know when you start as a young person that you're in a period of human history and what that allows you to do are forces much bigger than any one individual. There is a lot of serendipity in that. You have to be at the right place at the right time and things take off.

So, you've eaten the heart of an alpaca, you've talked down an angry tribe on the brink of war, drilled into the mind of a god, dealt with turbulent revolutionary governments and you've endured high altitudes. Why? Aren't there other, easier ways to study climate? Like, can't you study clouds?

[Laughs] I think about that sometimes. Every time we write a proposal to do a project, initially you're worried about "Okay, will it get funded?" Then it gets funded and you're excited for about an hour. Then you realize… "Oh, I've got to do this. Oh my god" [laughs] There is absolutely no way when you write a proposal that you could actually anticipate what you're going to encounter until you actually get there. So, to me, part of it is the challenge. Not knowing and having a team that is versatile enough that when everything falls apart, you can still make it happen. You need a good team of people with different talents. We've been in places where the drill is stuck in customs and we have to build a drill in the country where we are. If you have the right people on your time, this can be done.

I would say that the human race, not just me, but the human race has a mad gene. [Laughs] You think about it, all the Polynesians that settled the islands of the Pacific, how many of them went out and never came back? Yet they still went out. Now we're developing our space program and going out to Mars. Well, chances are, there are going to be problems. People aren't going to make it. But yet, that will not stop the human race from proceeding. Life and advancement has always been a function of risk and reward. I think that we forget that about human nature, but sometimes I think about those families that settled this country in a covered wagon. You put your whole family in a horse or oxen driven wagon and you would head west into Indian country, snakes, bears, everything and some of them don't make it. But others do and they set the way forward. Especially for science. It's always been that you've got to have people that want to push the envelope. If you push the envelope, there will be risk associated with that fact. If you don't take the risk, you don't make the breakthroughs. It's always a matter of balancing these two things. I think that probably at the end of the day, it's probably a defective gene. [Laughs]

So that's why you do it? You have a defective gene that makes you want to push the envelope?

I think it's a characteristic in human beings that has been with us for a very long time. It has served us well in the big scheme of things. Now, whether it serves us going forward, now you have to think that we have been as a species quite successful. There are seven point three billion of us and the number continues to rise. But, there is probably a limit. To me, this is one thing that gives me hope for the future is that as a race we are very innovative. We can find solutions to problems once we realize they are true problems. I would say that this is where we are with climate change. This is a large number of people, not the majority, but a large number of people who are currently in control will argue that this is not a problem. But this is a problem. This is physics and chemistry. Human beings are such that if there is any hope that if you do not have to deal with a problem, you don't. But when your backs to the wall and you have no other choice, we're pretty good about coming together and finding a solution. On the issue of Climate Change, the beauty of it is that we caused it. If we caused it, we can fix it. If we weren't causing it, then we wouldn't be able to fix it. To me it's a matter of when we actually decide to do that.

What would you say to someone who denies the existence of Climate Change, or considers it to be something that is happening naturally, something not caused by mankind that has happened in the past and will happen again?

First of all, I'd tell them that you're absolutely right. Climate on this planet has changed through time. Yes, it has changed. There have been times when there has been no glaciers on this planet. Sublevels have been a hundred and twenty meters higher. The geography of the planet was different. Our time is different only in that there are seven point three billion people. We settled this planet in sailing ships so we built the cities and infrastructure on the coast. As climate warms and the sea level rises again, all that infrastructure is suddenly at risk. People will find it much more difficult to migrate inland because they've invested in all this stuff in the coastal areas. A

lot of it is self-inflicted by us and of course we have huge companies that insure all that stuff we've built that is now at risk. But all of that will not the sea level from rising.

All of this is chemistry and physics. Facts for matter. Glaciers will melt and will continue to melt. Sea levels will rise. People will increasingly be adversely be affected by that change. Yes, it's changed in the past, but the difference now is us. We will all be impacted. It's not going away. It doesn't matter who's president, or at least who is not president. No matter what I believe, it's fact. I would say that I understand skeptics of climate change. If I worked for ExxonMobil and there was some way you could argue the quality of life on Earth has been changed by fossil fuels, that all the things that we are able to do with mechanized things that reduce the workload of human beings is fueled by fossil fuels, I'd argue it. But no one ever believed in the early days that we would be able to tap all this oil and gas and coal and that all the carbon that nature had archived millions of years ago would suddenly be pulled to the surface and thrown into the atmosphere. We've known for over two hundred years that if you increase carbon dioxide, the temperature of the planet will rise. This is physics. Carbon dioxide is rising and the temperature of the planet is rising. This is not worth the change caused by technology.

I could have sympathy because initially, a lot of things we do in life are good. If we do them too much, then there's an adverse effect that comes. What's happening now is that there are so many of us depending on fossil fuels that we are now seeing the adverse side of that advancement.

Four and a half years ago I was diagnosed with congestive heart failure. But fifteen years earlier, I had been diagnosed with exercise induced asthma. For years I had been running these expeditions and oh yeah, it was difficult to breath at twenty-two, twenty-three feet and, with time, you're only getting older. When it came down to a choice between believing if it was asthma or congestive heart failure, I went with the asthma. I told the doctor that he didn't know what he was talking about because I had climbed the highest mountains on Earth. "The old heart was doing just fine, thank you very much!"

For two years I fought the idea that I had congestive heart failure because if I had put on my medical that I had congestive heart failure, I would not receive medical clearance to do what I do. I didn't want to believe that. But at the end of the day, I was drilling in the Alps and one day I could not walk from my tent to the drill site. I couldn't breathe. I ended up coming back. I was in the hospital for four months. I initially had a heart pump and I had a turbine put in the old heart which meant that for six months I operated on a computer. I had a drive line coming out of my side that drove the turbine. It was in my old heart and I wore a battery pack that powered the computer. At night I would plug into the wall. That was my key to life for six months. Fortunately, while I was on the heart transplant list, in May of 2012 I got a heart transplant and in 2015, drilling in the Western Kunluns, set a world record for a heart transplant patient drilling at 22 k feet. So, I just want to say there's a bad gene. [Laughs].

The way that it relates to climate change is that it really does not matter what you wish for, you hope for, because at the end of the day it only matters what is. If you deal with what is, you can actually make life better than it was before. But you have to come to grips with the fact that you have to deal with it. So it is with climate change. It is just a matter of time because it will continue to worsen, the cost will continue to increase and as the human race we will deal with it because we won't have any choice. So I kind of understand where these people are coming from, but on the other hand, it doesn't matter! [Laughs] It's physics and chemistry.

So, climate change is more than just rising tides. Could you describe what might happen?

Well, I think it's happening and I think it's bad in a way and good in a way. As a species, we are "here and now". We are not very good at planning for the future and climate change is something that is going to happen fifty years from now, a hundred years from now. We are more concerned about what is going to happen today, tomorrow, maybe next week.

With the climate changes that are already under way, you can talk to the mayor of Miami. He has no qualms that the sea level is rising. High-tide comes up through the streets, comes back up through the city. That's going to increase on all coastal towns throughout the world. And that's nothing. The extreme events, the major hurricanes, typhoons…all you have to do is look at the last five years and the number of super-storms and the number of destructions. People that keep track of these are the big insurance companies, insurance companies that insure insurance companies. Nationwide, downtown, has records going back to 1980 of losses due to floods, droughts, storm damage, and these are increasing faster than carbon dioxide in the atmosphere.

There's a cost to climate change and we are paying that cost. Everyone who is paying insurance is paying that cost because what insurance does is distribute risk. But if you're paying more for damage on coastal cities even though you live in Ohio, your insurance premium will go up because insurance companies are in the business to make money. So we all pay the price and right now it's just that the companies that are causing the problem are not paying the costs of the problem. As long as they can get away with that, then we will continue to pay.

But these things will catch up. We will have no choice. Even in this country now, seventy percent of Americans believe that climate change is a real issue and that it's a problem. At what stage in a democracy does this become so overwhelming to our representatives in Washington, that's hard to say but I'd say that time is coming, that it's close. There will be a real change. Every four years we get a chance to vote and give our opinions. It doesn't matter where we are. Everyone in power should realize that they have to make the right choices, otherwise they are likely to pay a price for it. The system works, it's just up and down. You have to look at the longer term, just like climate.

So many people get weather and climate get mixed up. You get an extreme winter and the number of emails I get in February that say, "It's cold outside! It's cold outside! Where's Global Warming? Where's Global Warming?" They aren't looking at the world! When it's cold here,

it's cold somewhere else. This is the variability that is in the system, You've got to have a thirty year average of that variability to have climate. It's that trend that we have to keep our eyes on. I would say that so it is with our political system.

I grew up in West Virginia, so I know how important a pay check was to coal miners at the end of the week for their families. But I also know that the maximum number of coal miners were employed in 1924. The maximum amount of coal production in Virginia was in 2002. The number of miners has been decreasing since 1924 and they will continue to decrease. The problems in the coal industry have very little to do with the Environmental Protection Agency and everything to do with how cheap natural gas is. That's an economic driver and you can't legislate that back into existence. It's sad, but when someone goes down to lecture in West Virginia and you have standing room only. People who want to hear. I tell young people, "The future is in solar, it's in wind, it's in engineering jobs, better paying jobs, safer jobs and it will come." That's the beauty of this country. This country goes along because of local and regional governments. This is where people and the government actually interact. The changes are very basic and they are occurring all over. There will be blips, but they won't stop the change.

You seem very optimistic.

You think about the human condition and you go back to the 1800s in London or Paris, on Wednesday, all the excrement from humans was thrown out the window into the street. There was a whole industry about collecting that and turning it into fertilizer and putting it on the fields to grow crops. People noticed that the number of people dying in the cities was increasing and they tied it to this problem. You can image the mayor of London saying, "Okay, we understand we have a problem here. We have decided that we are going to dig up the streets and put in a sewer system to collect this. Oh, and if you're a landlord, you going to have to put in a special room in the apartments and you'll have to put in plumbing for all this." You can imaging the pushback that came at that time. But it didn't stop it. The change came anyway.

It's the same with fuel. If you go back in this country, the big fuel was wood cutting for fireplaces and when Benjamin Franklin came along with the Franklin Stove, which was much more compact and much more efficient, the fireplace industry had all these ads about how that heat was bad for your health and the fireplace was much better. But anyone who's ever stood in front of a fireplace when it's cold, one side is burning up and the other side is freezing. There's no sense in that argument, but they were trying to protect their industry. But it did not stop the change. The change will come. It's the same with alternative energy. The human race didn't leave the Stone Age because we ran out of stone. We found a better way and I think we know what that better way is now. It will come, regardless of who is in charge.

Do you think that if humanity has a change of heart and does everything it can for climate change right now, do you think we have a chance?

Oh yes. I think that the technology is there. If we wanted to, and this is where the old and the new are in conflict, we can increase the mileage of out vehicles to 50 miles to a gallon. This can happen overnight. The technology is there, we have electric cars. We just need to have a new source for the electricity to charge those cars. These changes can come very rapidly.

Still, in the meantime, does the current administration's efforts and the general lack of political will to change frustrate you? I know that you've been outspoken about climate change for a long while and that you actually worked with former Vice President Al Gore on *An Inconvenient Truth*.

We also worked with Senator McCain with the insurance companies because the insurance companies know what's going on. It frustrates me because the evidence is so overwhelming. The only way these people have made an inroad is that they are trying to move away from facts. But facts do matter. They really do matter when it comes to anything that is proven by chemistry and physics. How far will they be able to go? I have great faith in our forefathers who set up this country. We've got a president, a congress, a department of justice and these things will not change overnight. If I was the current administration, I would be very afraid of a major climate impact occurring under my watch while I have taken a very strong stance against this thing and issue. It can come back and bite you.

Anyone who's been in politics realizes that a month is an eternity. I have to feel that the pendulum has gone very far to the right, but it will come back. How much damage can be done in the short-term? Well, it's probably the only time in my life that I think bureaucracy will work to our benefit. [Laughs]

My greatest concern is for young people; people who are just starting their careers. I've had people ask me, "Is there going to be a future in my area of research?" My feeling has always been that you go with the facts and the facts always win. Yes, there will be a future. It may be a rough spell here, but I believe that every time there is something bad here, there is something good on the other side that counteracts it. It is important that people speak out. Science is not going to change. You may be cover it up, hide it, try not to monitor it, but it is not going away. Change will come. It's an interesting time that we are living in. It will be interesting to see how it plays out. For me, I've got my forty year pin here. I've been with Ohio State for forty years. I've been through times when the government's been shut down for nine months. It's stressful for anyone who is working in the area. But at the end of the day, the facts do matter. You just stick to the facts.

But what about the alternative facts? [Chuckles]

They will be short lived. I do think about this. The fact is the human race has gone through two dark ages where people revert to myths, to magic, but it never lasts. I've seen the Cultural

Revolution. I've been to China after their Cultural Revolution. There was an uprising of all the peasants and all the professors were sent out to work in pepper fields in far western China, practically starved to death and the country went down. In every country, gross domestic product is directly related to how much support that country gives to science and technology. This is where new ideas come from that keep a country strong. So, are we going to go through a cultural revolution is this country, are we going to try to go backwards? I think you can do it in a system like they had in China, but it is harder to do in a democracy. Last week I was lecturing in Alberta, Canada, and there was a reporter who came to talk to me afterwards. He asked me, "Is the time when other nations need to step up and support climate science instead of the U.S.?" They may have to. They may have to. But I believe that the science will go on because it always has. There are good times and bad times, but in the end it is absolutely essential for the wellbeing of the country that we deal with facts.

I'm teaching a paleoclimate class and I asked the students where they thought the climate would be in 2040 and I was discouraged. Young people should be the ones who are optimistic about the future and that they can change the world. But no, they were really concerned about where we are headed. I think that is not good because, when you get to my age you can get pessimistic, because you've seen a lot. [Chuckles] But when you're young, you need to think you can change the world. Because you can. You've got to believe it.