Changing Planet: Past, Present, Future
Lecture 4 Climate Change: How Do We Know We re Not Wrong?

will be given by Dr. Andrew Knoll, Professor of Organismic and Evolutionary Biology at Harvard University; Dr. Naomi Oreskes, Professor of History and Science Studies at the University of California, San Diego; and Dr. Daniel Schrag, Professor of Earth and Planetary Sciences at Harvard University.

[DR. ORESKES:] So that's Protect Our Winters. I'd encourage all of you to check us out on the website protectourwinters.org. So Jeremy and Chris Davenport and Gretchen Bleiler and the other snowboarders and skiers in this organization are all seeing climate change happen in front of their eyes, but they're athletes, they're not scientists and they can't explain exactly what's happening. They can't explain why it's happening and for that we turn to science.

5. Science, politics, and the acknowledgement of rising CO2 (7:03)

So how do we know that the climate is changing? What is it that we've learned about this? Well, the fact is that scientists have known about climate change for a long time and our political leaders have known about it for a long time too. When Dave Keeling first started measuring carbon dioxide in 1957-'58-- Dave was a colleague of mine at the University of California, San Diego-- it just took a few years for him to conclude that indeed there was evidence that carbon dioxide was already increasing. And he and a group of other scientists wrote one of the earliest reports trying to explain why this might matter to the American people. And we know that that report was actually read in the White House under President Lyndon Johnson and in 1965 President Johnson said to Congress, "This generation has altered the composition of the atmosphere on a global scale through a steady increase in carbon dioxide from the burning of fossil fuels." So this is really very old news. Now it's not just Lyndon Johnson though. By 1979 the U.S. National Academy of Sciences had concluded that "a plethora of studies from diverse sources indicates a consensus that climate changes will result from man's combustion of fossil fuels and changes in land use." So by 1979 we knew that carbon dioxide was rising and scientists were trying to communicate that this rise in carbon dioxide was going to change the climate. By 1990, our first President Bush, President George H.W. Bush said, "We all know that human activities are changing the atmosphere in unexpected and unprecedented ways." And then in 2001 the IPCC: "Human activities are modifying the concentration of atmospheric constituents... that absorb or scatter radiant energy. Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations." And of course, the Keeling curve, CO2 rising and rising and rising. And then finally, most recently, the fourth assessment report of the IPCC 2007, as carbon dioxide was pushing above 380 towards 390 and even 400 parts per million: "There's very high confidence that the global average net effect of human activities since 1750 has been one of warming."

6. Many Americans remain unconvinced of climate change (9:18)

So what the history tells us is that, while Dave Keeling was tracking the steady rise in carbon dioxide, there was also a steady rise in the attempts by scientists to communicate to the American people and our leaders and the international community what was happening and why it mattered. And yet despite this 50 years of scientific research and 50 years of scientists trying to communicate to all of us about the issue, the American people remain confused

8. The origins of organized denialism (13:41)

So given this information, my colleague Erik Conway and I, who have worked on this together for about six years now, have suggested that there must be some additional explanation for why people have rejected climate science. And there are many reasons. It's not simply one thing. But our research has focused in particular on something we think is extremely important to understand. And that is the fact, the historical fact, that there has been, over the last 20 to 25 years in the United States, organized resistance to the scientific evidence: an organized attempt to challenge and cast doubt upon the scientific claims of people like Professor Schrag and Professor Knoll who you've just heard from. So in our research we asked the question. So where did this organized resistance come from, and through historical research we were able to track it back to its origins and discover that it actually had its origins in one particular place; a think tank here in Washington D.C. named the George C. Marshall Institute. This think tank was founded by three prominent American physicists shown here: Bill Nierenberg, Frederick Seitz, and Robert Jastrow; all of whom were highly distinguished, prominent physicists who had worked on Cold War weapons and rocketry programs. Bill Nierenberg had helped to build the atomic bomb, Frederick Seitz had helped to build the hydrogen bomb, and Robert Jastrow had helped to build the Apollo space program. Over 20 years these scientists challenged the scientific evidence on a host of issues, including stratospheric ozone depletion-- the ozone hole; the reality and the causes of acid rain and other forms of acid precipitation; and the harmful effects of tobacco.

9. The history of the Marshall Institute (15:26)

So you might ask the question, why would scientists challenge the work of their fellow scientists, and in particular, why would physicists challenge the work of climate scientists, and why would physicists defend tobacco? Well, the story begins with something that seemingly has nothing to do with climate change or tobacco or any of these issues-- the Strategic Defense Initiative. Now this, of course, is before any of you were born, but you may have heard of the Strategic Defense Initiative. It was sometimes also referred to as Star Wars, drawing on the name of the film of the same name, because it was based on the idea of weapons in space. This specific idea was to create a network of ground and space-based lasers that would defend the United States against incoming intercontinental ballistic missiles. That is to say, to defend us against a nuclear attack by the Soviet Union. Now it was a very controversial program, it was promoted and pushed by the Reagan administration in the early 1980s, but it was very controversial among scientists. The vast majority of American scientists criticized the program as being technologically unfeasible and politically destabilizing, because if you built a missile shield and you thought that you could protect yourself against a retaliatory attack then you might be tempted to launch a first strike. You might be tempted to say, let's take out those Soviet missiles because if they strike back, if that empire strikes back, they won't be able to hurt us because we have a missile shield. So a lot of scientists thought it was a bad idea because it might in fact tempt the United States to launch a first strike and start World War III. But some scientists, a very small minority, but some distinguished scientists defended SDI as necessary to protect the United States from the communist threat. And the three men who led that defense of SDI were Bill Nierenberg, Fred Seitz, and Robert Jastrow. They created the Marshall Institute for this purpose; to defend the Strategic Defense Initiative against the criticism of it by other scientists, other people in the scientific community. Now that was in the early 1980s, but in 1989 something surprising happened, something that not very many people anticipated: the Cold War ended. The Berlin Wall fell down and the Soviet Union broke apart, so the U.S. won the Cold War. So you might have thought that these men would be happy, that they would have retired to go play golf, because by now they were in their seventies and even early eighties, but they didn't retire. They kept on fighting and they took up a new cause. And the new cause was the continued defense of capitalism, of free-market capitalism, but not against the communist

that we may need to change the way we live, that the American way of life may need some adjustment. You've all heard about the Catholic Church, the trial of Galileo and the rejection of Galilean astronomy by the Catholic Church in the early modern period. The Catholic Church did not reject Galileo because they were having a vigorous open scientific debate with him about planetary orbits. They rejected Galileo's work because they did not like its implications, not because his science wasn't right or wasn't supported by ample evidence, but because the implications, because it implied, that the Catholic Church wasn't infallible. So let's stop there and take questions and then in the second half of the lecture I'll talk a little bit more about how we in fact judge the scientific evidence.

13. Q&A: Should scientists create public policy? (26:21)

So let's take questions here. Yes.

[STUDENT:] What's the scientist's responsibility then to create policies?

[DR. ORESKES:] Ah, well, that's a really great question. My view is it's not a scientist's responsibility to create policies. My view is that a scientist's responsibility to do science and to communicate it as best as they can, and then it's the job of politicians, people in positions of government and authority, and other forms of community leaders, to really think about what the policy responses should be. But those policy responses, as much as possible, should be based on a robust understanding of what the evidence tells us about what's happening in the world. But I think what the responsibility of scientists is, is that if a scientist does work that has social implications, then I do think the scientist has a responsibility to communicate that. So if we'd, say, go back to the period when people were first studying the harms of tobacco, if you were an epidemiologist or an oncologist, and you found data that showed that smoking was really harmful, and back in the 1950s, between 70 and 80% of the American people smoked, it seems to me at that point you have a moral and social obligation to say "Wow," you know, "70 to 80% of the American people have a habit that is deadly and that is going to quite likely take 10 to 20 years off their lives and hurt their families and their children." And so I think there's a social obligation for scientists to communicate that and to communicate it effectively, and I think a lot of scientists would say that there is some obligation to communicate up to some point. Well, actually, I take that back. I know a lot of scientists who will say that they don't have that obligation. They'll say it's just my job to do the science. I think if you do the science but you don't communicate it when it has social implications, then it's like that proverbial tree that falls in the forest where nobody hears. You've done all this good work but what is the value and the use of that work if people don't know it exists. So I think the communication piece is very important, but when it comes to the policy responses then I think other people need to step up to the plate an

[DR. ORESKES:] That's a really big question. Of course, that implicates what I said at the start of the talk about, it's not enough simply to throw information at people, right? And so there are a lot of people who study the question of science communication and what's effective, what works and what doesn't work, including some people in this room, and certainly people who work in museums, aquaria, people who are involved in informal science education know a lot about what tends to be effective and what isn't. So I do think the scientific community can benefit from working with people who are professionals in informal science education because, you know, as you've heard, climate change is a very complicated question. There are many aspects of the climate system that are still not well understood, but if you step back from that and you say "What does science...What does society need to know about this?" What are the key facts, the key things that we think are well understood: well, those are actually not that difficult to communicate. And so I, when I work with scientists I argue, when you're among yourselves you want to talk about what you don't know because you want to talk about the cutting edge, the research frontier, the exciting new stuff and that's great when you're with your friends. But when you talk to the public you need to step back from the cutting edge, the research frontier and talk about the things that you're pretty sure we know pretty well because that's where the policy needs to be built. We shouldn't be making policy based on, you know, things that are still kind of speculative and uncertain, but we can make policy based on the things we think we know pretty well. So we know tobacco kills people and so therefore we know it's reasonable to take steps to control tobacco use. And I think we can pretty much say that same about climate change.

15. How can the certainty of science be judged? (30:06)

So, climate change is a really big problem. You saw some of the evidence already about some of the kinds of implications, the fear of very substantial sea level rise that could drown major cities around the world, cost trillions of dollars in damage to infrastructure...effects on agriculture, drought, heat waves, wildfires, these are really big problems. These are things that will kill people, like tobacco. Arguably in some cases already have killed people. It's going to require big decisions, big investments, so I would argue that it is fair, it is appropriate for us to turn a critical eye to the science to try to make sure that we are confident that the science is robust and to do the best we can to the extent that is possible, to try to make sure that we're not wrong. So how do we do this? If you're a citizen, or a historian or philosopher of science, and you wanted to say "Well, look at the story we heard in the first lecture about how scientists changed their minds about continental drift, how do we know scientists won't change their mind about climate change?" How can we judge these claims to know whether or not they're robust? So philosophers of science have spent a lot of time thinking about these kinds of questions and they've argued that there are in methods were preferable. But one thing that almost everybody agrees on, whether you prefer induction, deduction, or some hybrid between, is that valid science is accomplished by using reliable methods. That is to say, by using methods that have stood the test of time. And the simple, most basic scientific method that goes back to Newton and beyond is observation. To make observations about the natural world and simply to report on what we see. And so in the case of climate science, one of the simplest basic observations we can make, which you've seen already, is that the temperature of the Earth has increased since the Industrial Revolution. That if we take temperature records from around the globe going back to the 1880s, which is the earliest period for which we have systematic and reliable records, we see that the temperature has risen. As Professor Schrag said, not exactly in a linear manner, there are ups and downs, some of those ups and downs may have been caused by other forms of pollution like coal dust, but overall the temperature has risen. That's a basic observation. Moreover in science we'd like to say, we generally do say, one observation is good, a hundred is better, a thousand is better than that, and it's especially good to have a lot of observations if some of them are completely independent, what scientists would call independent corroboration. So we re correlation is not the same

falls, and that tells us that the volcanic hypothesis is false. So if anybody tells you that the carbon dioxide in the atmosphere is coming from volcanoes, it's like I said in the video they're either confused, ignorant, or lying.

20. The process of peer review and the IPCC (39:44)

Now, here's the criteria that I like the best as a historian and sociologist, because at the end of the day, we don't have any way to prove that scientific theories are correct. We simply don't. We might like to but we don't. But one thing we can ask, one thing that's actually relatively easy for someone like me, as a historian and with some training in sociology of science as well, we can ask the simple question, have these claims passed peer review? That is to say, have they been judged by fellow scientists, have they been subjected to critical scrutiny by other experts in the field who understand the question, and have those other experts said "Yes, these are good data, this is robust evidence, this claim makes sense." And that process of critical scrutiny is what we call peer review. So let's talk a little bit about how peer review works. In science when researchers make claims they don't just tell their students, they write a paper, and they attempt to publish it in a peer-reviewed scientific journal. So we could imagine a claim, this is a ridiculous claim, I didn't come up with this-- imagine that toasters in space are heating the Earth. Okay, we know that's sort of silly, but let's just say for the sake of argument, some scientist or some would-be scientist made that claim. So, the scientist, or the person, the researcher, writes a paper and submits it to a journal. The editor of the journal then sends that paper to experts in the field. People who have expertise in this subject and understand it very well, typically two or three different people, and hopefully people who are not friends of the person who wrote the paper. So those experts scrutinize the paper. They ask themselves the question: is there sufficient evidence in this paper to support the claim? Is the evidence sufficiently well documented? Is it sufficiently well explained? Is it consistent? If the answers to those questions are "yes," it doesn't prove that the claim is correct, but it proves that the claim is at least reasonable for now, and the paper will likely be accepted for publication, and it goes into the body of peer-reviewed literature. But if the answer to one or more of those questions is "no," then the paper will be rejected. So in the case of the hypothesis of toasters in space, it would be rejected because there is no evidence to support the claim that the Earth is being heated by toasters in space. And indeed, one of the things that I found in my research is that, although many people have heard the claim that climate change is being driven by volcanoes, if you look in the peer-reviewed literature, you cannot find articles supporting that claim because in fact, the evidence doesn't support it. So many of these contrarian claims are not actually scientific claims. They're claims that come, as I've already said, from these non-scientific think tanks. Now in the case of climate change, though, we actually have an additional level of peer review and that's the organization called the IPCC, the Intergovernmental Panel on Climate Change. This is an organization consisting of thousands of scientists around the globe from 195 countries who, in their reports, subject the peer-reviewed scientific literature to what is in a sense a second round of peer review. It's a highly open process. It involves, as I've already said, thousands of scientists, and also people in the public and in NGOs and in environmental groups, and governments comment on the claims as well. As a historian of science, I would say that the IPCC represents a level of peer review and inclusivity that is unprecedented in the history of science. So the claims of climate scientists have been actually subjected to more scrutiny and more review than, say, any of the claims associated with plate tectonics.

21. How well do climate models perform? (43:30)

The final idea is a kind-of-complicated and subtle one, and it's the idea of performance. It's the idea that if our knowledge is correct it ought to be able to stand up in action. So I might say that I don't believe in gravity, and because I don't believe in gravity I'm going to jump out of a tenth story window. But that knowledge is not going to hold up very well in action when I hit the ground and fracture all of my bones, at best. So we can judge knowledge a little bit by how well it works when we're trying to do things with it. So in the case of climate science a lot of the judgments about the performance of climate science are tied up with climate models. And climate models are extremely complex, many of them involve millions of lines of computer code-- very difficult, if not impossible for any one person to really understand a climate model. So we can judge the model it, and how to think about what it means. So a few years back I did a review of the scientific literature, simply asking the question, if we look at the published peer-reviewed literature, how many of the papers in the peer-reviewed literature disagree with the claims that had been put in the IPCC reports, or the National Academy of Science's reports on this issue? What my students and I found was that 75% of the papers explicitly endorsed that position-- that anthropogenic climate change was underway and mostly caused by human activities. And the other 25% were actually about other things: mostly about paleoclimates--so, explaining stuff about paleoclimate variability-- or they were on instrumentation, technical aspects and essentially... or didn't take a position one way or the other. Of the papers that actually addressed the question of anthropogenic climate change, not one, not one of nearly a thousand papers published in peer-reviewed journals refuted the claim that climate change is happening and mostly caused by human activities, mostly caused by the increasing greenhouse gas concentrations over the last 50 years. So there is a consensus among scientists. There is a consensus about climate change.

24. The science is settled: Time to focus on what we should do (48:10)

The science is settled and it passes all of the tests that we can subject it to. The globe is warming, the climate is changing, it's because of the things that we do, and our debate should not be about whT1 n0ctulgeaushTe

California to reduce greenhouse gas emission, and part of that law is what's known as renewable portfolio standards. We're seeing businesses in California begin to adopt alternative opinion polls show that about 20 to 25% of the American people still don't believe that smoking cigarettes causes cancer. Well, oh well, you know? There's a point at which there might not be anything you can do about those people, and if they want to smoke, it is a free country, as long as they don't do it in my face, right? So I think that it's really important when you think about communication, not to worry about lost causes. Right? And from a political standpoint you don't need 100%,