RAJESH KASTURIRANGAN: My name is Rajesh Kasturirangan. I'm one of the co-founders of ClimateX, which is one of the co-sponsors of this event along with Fossil Free MIT and many, many other organizations on the MIT campus. We also have non-MIT people here, several of whom-- some of whom are MIT alums.

So Jeff Warren is one of our speakers. Britta Voss, who is on Skype over there is another speaker. And then we have Nathan Phillips and Audrey Schulman. So we have a really, really fantastic lineup.

But let me just explain what we are doing and why. So ClimateX-- the idea is to create an open climate learning platform for the whole world, but starting with the MIT community and then broadening that to the greater Boston area. So IAP, as some of you know, is the Independent Activities Period at MIT. And that's the time when we do all kinds of fun things. And there are many, many climate-related courses being offered, which we decided why not bring them under one umbrella and call it The Climate IAP.

So if you go to sites.google.com/cliap you will see all of the courses that are being organized. And so that's across the spectrum, everything from climate science, to policy, to energy negotiations in places like Mexico. So what we're doing here is to say how can citizens directly take action which is grounded in science?

And we have actually some fantastic speakers here today who have contributed to that in many different ways. Our first speaker, who will be introduced by Britta, will be Jeff Warren. And Jeff Warren is one of the founders of Public Lab, which does, you could say, community science around environmental questions, both building the hardware that allows you to sense environmental variables and the discussion and analysis that comes from collecting that data.

We have Nathan Phillips and Audrey Schulman, who have done some great work together on gas leaks in the greater Boston area. And those gas leaks will be the focus of not just this session, but also the next three. So we have three more sessions after this one.

There's one on the 23rd, which is a data hackathon. So we're going to take a dump of data from Audrey and Nathan, and we're going to do really fantastic things with it. And then, if you're really interested in seeing where these gas leaks are, we're going to go on a tour on the 30th across the Cambridge-Somerville area and do some gas sensing on our own.

And once that's done, we're going to come back on the 1st of February and say, how do we take this and make that work for us in the public interest, right? And so generally, I think the flow that we are trying to prototype here in these four sessions is that citizens can work with scientists and policymakers and others to directly take charge of the climate challenges that affect them wherever they are. And that by doing so, we can contribute to climate action, but climate action that's grounded in knowledge and not just pure advocacy.

So I think that's a really fantastic new opportunity that did not exist even a few years ago. So I'm really, really happy that we have a wonderful cast of speakers. I'm going to turn it over to Britta Voss to introduce today's session.

BRITTA VOSS: Great. All right. Thanks, Rajesh. Can everybody hear me?

RAJESH KASTURIRANGAN: Yes.

BRITTA VOSS: OK. So my name is Britta Voss. And I'm an MIT alum from 2014. So I just wanted to start off with a sort of a brief overview of our motivation and the idea behind Community Science.

And so we called this From Community Science to Community Action. And that really gets at sort of a larger motivation for this series of seminars-- of taking science and putting it to use for people. And it gets at the mission of MIT as an institution of using science for [INAUDIBLE].

I just want to start off really, really broad here and ask the question of what is science even for? Why do we have science? And my interpretation of this is that humans are naturally curious, and we want to understand the world around us.

And we also have needs. We need food and shelter and transportation. And so science has this double purpose for humanity. It feeds our curiosity, but it also helps us solve problems. And it gives us a process and a framework for addressing both of those issues.

And we all know that science is very important in modern society. It's pretty much everywhere you go, from your smartphones to social networking to the systems and the infrastructure to make modern life possible. And although we're all very aware of that, very few people have a direct relationship with science, either by doing it themselves in their day to day lives, or even the other people in their lives.

And so another motivation for this seminar series is that we're looking for an angle that will help us make science more relevant to people, make people care more about science, because it has a very important role in our society. And despite how important science is, we all know that science is often misused and mischaracterized at shockingly high levels of our leadership. When you see very prominent people making comments about scientifically false issues, and even to the point of someone like a US senator bringing a snowball to the floor of the Senate to prove that climate change is false. So there's obviously a lot that needs to be done to make society more aware of and informed about science.

And so how can community science address that? Community science is a way of making science speak for communities. So climate change is probably the best way, or the best example, of an area of science where community involvement is critical.

Because here, for example, you can see the effects of climate change on agriculture affect people's livelihoods. They affect the economy. And people who depend on agriculture, which is not just all of us, the food we eat, but people who make their livelihood off of farming, need to understand how climate change is affecting agricultural productivity from droughts and wildfires and all sorts of issues. And so science can help them with that if it is directly addressing their needs.

And then just a few more examples-- climate change is affecting water temperature in rivers which has effects on migratory fish populations that serve as important cultural and economic basis for Native American populations. Nuisance flooding in cities like Boston, and especially in South Florida, is becoming a big problem for quality of life and economic vitality in a lot of areas.

Communities in the Arctic are literally falling into the sea in some places because of thawing permafrost. And then, of course, in northern Alberta, you have tar sands mining that's wiping out the forests, and it's dumping lots of toxins into local rivers. And these toxins are going downstream and making first nations communities sick.

And so by producing independent science for those groups, you can help them fight back against these sorts of environmental threats. Communities living downwind of coal-fired power plants similarly are at serious risk of things like mercury contamination, articulate aerosols, and other negative health effects. And so if these communities have tools of science, they might be able to file lawsuits or come to their policy makers and say that they need a certain regulation or policy. And another good example, of course, is fracking, where the local communities, especially if there's wastewater injection going on, might be at risk for ground water contamination, irregular seismic activity, and lots of other environmental risks.

So the motivations for community science would be empowering communities by giving them ownership of their data and responding to their specific needs. And with respect to the scientists, it increases public awareness and interest in science, which is important to making sure that science is still a part of decision making and that science is supported long term. And also importantly, especially in the context of climate sciences, making sure that scientists have access to local knowledge that they might not otherwise be aware of.

But of course, there's also challenges. So just like with traditional science, community science needs to ensure the data is high quality and that it can be used for the purposes of the community that needs it. For instance, that it will hold up in a court of law. These projects need to have long term support.

So if you're looking at a long term monitoring program, it can be hard to make sure that that's financially viable over the long term. And then, the community's needs might change over time, if the environmental threats change, or if the make up of the community changes. And so research projects need to be able to respond to that.

And I'm sure Jeff can talk more about this-- just a few ideas about what can make community science successful. A few key factors are making data and methods open source so they're freely available and open for discussion. And similarly, open communication between the community members and the scientists themselves to make sure that everyone is working together and not for their own purposes. And probably the most important thing is making sure that the community is involved from the planning stages and not just brought in later on. And that's basically the key difference between community science and what's usually known as citizen science.

And finally, just in terms of the appeal of community science, it's important to encourage creativity, both from scientists and community members. And I think one of the really important aspects of community science is that it can be a synthesis of tools and ideas from different fields that might not happen naturally in traditional scientific enterprise. So just, finally, some examples-- there's probably many more out there.

But Public Lab, as Rajesh mentioned, you're going to hear from Jeff about it pretty soon. And then there's also the EarthWorks Community Empowerment Project, which gives these forward-looking infrared cameras to communities that want to monitor air balloons from local operations such as fracking. And then one I just learned about is Safecast, which is in response to the Fukushima nuclear meltdown, which is getting communities scientific tools for monitoring radiation contamination in their communities. So with that, I will turn it over to Jeff to tell you about some more specific tools for community science.

[APPLAUSE]

JEFF WARREN: You know, as Britta said-- thank you, Britta-- I'm one of the founders of Public Lab. There were seven founders. And I'll get into a little bit about where Public Lab came from. But I really wanted to talk about what makes Public Lab different, and what that has to do with some of the topics that we're going to dive into in this course.

I titled the talk Renegotiating Expertise. Because I think there's kind of this moment we're in now where people are beginning to be more aware of the mechanisms of expertise and where they are working and where they need improvement. And so I had some thoughts on this, and these are-- yeah, they're preliminary. So I'm eager for the discussion portion of the talk to just sort of dive into some of these questions.

And also, they're not necessarily right. But I'm going to put them out there. And I'm eager to hear your thoughts.

So Public Lab does what we call community science. And this involves supporting community knowledge production, which means creating bridges and shared spaces between formal expertise and community needs. So in the picture above, you can see a group that is on the Gowanus Canal in Brooklyn, which is a Superfund site. It's heavily contaminated with polyaromatic hydrocarbons and raw sewage.

I think somewhere in the order of 300 million gallons of raw sewage go into the canal every year. And that's actually part of how the New York sanitary system works. I don't think there are any current plans to change that. That's it, functioning properly.

But this picture is actually the day after Hurricane Sandy. And folks in the Brooklyn sort of chapter, or sort of local group of Public Lab-- Public Lab's an open community, so anyone can join-- went out in canoes, as they had done many times before in part of their monitoring of the cleanup, and took a bunch of remarkable images of lots of stuff having been washed into the canal as well as also some of the infrastructure that's been put in place, like these booms, to prevent pollution from entering the canal. This is next to what is now a Whole Foods. So this boom was actually added in response to previous monitoring by that group of the construction site.

And I think folks sometimes misunderstand what Public Lab is. Like a friend once told me that it's great that we're helping the public to understand science. And I think that is part of it. But that's really not the core function or the core purpose of Public Lab.

I think Public Lab is different because we focus a lot on the question of who above what. We're not necessarily teaching people about science exclusively. We're trying to negotiate a new relationship between science practice and the public, perhaps a more equitable or mutually beneficial relationship.

And that involves a lot of obviously big issues. But I think just through our work, and in trying to support communities facing pollution, the question of how our expertise works, how it functions, comes up a great deal. And that's something we've been sort of receptive to coming from communities we've worked with and tried to understand deeply.

These questions like who builds knowledge? Who is it for? Who asks the questions? And who understands the answers?

These are pretty deep questions. And I doubt we'd be able to unwrap them all in this session today. But they're pretty fundamental to some of the issues that we're going to talk about later.

I think what's key is that we're really trying not only to seek to make science findings accessible-- I think that is important-- but also, its methods, its tools, its structure of participation, and the depth of participation that people have in how science functions. This means both making more accessible on ramps to make it-- I won't necessarily say easier-- but I think accessible is a slightly different shade than easier. But it also means challenging what's possible in science practice by leveraging things like peer production, open source as Britta mentioned, and things like the maker community, which I think is changing our understanding of what technology development can do and how it can function.

So just for some concretes, you may have heard of Public Lab's balloon mapping project. This is our oldest project. And we developed this technique with a number of communities in the Gulf Coast to monitor the BP oil spill, to take aerial photographs in very high resolution of spill-affected sites before, during, and after the spill.

And basically, you just attach a camera to a balloon. I mean, it's easy to say it like that. But there's a lot of little things about it-- in how you connect things up with string and rubber bands, in how you archive the data and interpret it. And it really is this whole embodied research project in a community that is primarily made up of nonscientists or nonprofessional scientists, we'll say.

This is a good example. There's a group, two people in a canoe, again on the Gowanus Canal, this time in the middle of the winter. In the box-- and it's hard to see with the color on the projector, but this is a large plume of raw sewage that's on the Canal. As I mentioned, this happens all the time. So people who live there are really familiar with when and where it happens, how often, and what volumes. And they've structured their research project based on their understanding, their deep knowledge of this particular site.

And one thing that they discovered-- oh, it's not in this picture-- later slide-- teaser. So we also focus on making your own tools. Now I wouldn't say this is a prerequisite or an absolutely necessary portion of our work. But it has been a really important part of it.

We've managed to engage pretty large numbers of people in constructing tools and experimental setups. For example, paper craft spectrometers-- optical range spectrometers built around a webcam, and doing comparative work using different sample preparations, and in some cases, ultraviolet light to induce fluorescence. And so this is just a graph of how many people have actually built and uploaded data using a spectrometer that they built themselves.

This graph is, I think, the past 52 weeks. But overall, almost 10,000 people, which I think is an interesting project for us. So all in all, people come to PublicLab.org, they post their work to share it with others, but also to ask for help. These people might be scientists. Many of them are. But they're just as likely to be educators, to be hobbyists. And the group we're most interested in serving are those community groups who experience environmental problems firsthand.

So I guess it's a big question. Why do it yourself? Why go beyond simply dissemination of science knowledge to the public? And I think there's a bunch of different reasons to this. But this is sort of the crux.

In some ways, it's because experts, I think, often have a pretty narrow conception of where the public could become involved. For example, public dissemination of science is part of most federal grants. There's some portion of it where you have to communicate your findings. This is an area that people, I think, are making good progress on.

But involvement in the design of experiments, in the formulation of research questions, in the interpretation and application of those findings to real world scenarios-- those are often considered outside the scope, sometimes even of science practitioners, but certainly outside the scope of a partnership with a community group facing a challenge or a problem. Of course, I think with the do it yourself kits and so forth, the cost barrier is definitely a factor for us. It's hard to get more people involved in performing science, doing science, and understanding science-- any of those-- unless there's cheaper instrumentation. This is not true for all fields, but it's certainly true for some.

But I think really to answer this question more thoroughly, I think we need to take a few steps back and try to better understand how shared knowledge is produced-- the key word there being shared knowledge, not just knowledge that's held by scientists, but knowledge that is commonly held, which I hope is the goal-- and how expertise works. So a depressing slide, I know. But this is *The New York Times'* up shots sort of meta poll of polls. So they're listing all of the projections of the outcome of the November 8th election. Obviously, the data didn't fit the outcome.

But I do think it's an interesting case. In part because it has a lot to do with-- in my eyes, it has a lot to do with how expertise is represented today and how it's communicated. How are our projections or predictions made? This isn't representative of that many forms of science, but I think it's a relevant data point. And specifically, why and when people trust these kinds of projections-- and I'm not necessarily calling these wrong. I think there's something really-- I'll get into this in a moment, sorry.

So data and its interpretation increasingly drives decision making in our society. And this is something that happens a little bit outside of the scope of what we typically understand as science practice, but it is an important ramification. And I just want to suggest this. I think you can see how this might become a problem, not in itself, but where it displaces, where it happens at the cost of a more discursive mode of debate in a democracy.

And I really am not saying that we should use democracy to do science. What I'm saying is that there is a relationship between the two that we need to better understand. And I think this could present challenges not only because of possible biases-- I mean, there's clear problems with science being paid for in certain spheres as well as ideological issues and their relationship with science in Congress as was mentioned earlier.

But I think also it has to do with some of the areas that Public Lab is focusing on, which may be the most objective parts of science-- the selection of problems and questions to pursue, and of course, the application of science is findings. These are sometimes outside the scope, please.

AUDIENCE: I don't want to derail us but--

JEFF WARREN: No, please.

AUDIENCE: Did you say that data and its interpretation increasingly drives decision making in our society? I think there's a common belief that, sadly, opposite is now true.

JEFF WARREN: Oh, timescales-- I mean, the last 200 or 300 years.

[LAUGHTER]

JEFF WARREN: Sorry. Very-- yeah.

AUDIENCE: But there's-- I mean, one of the reasons I'm here is because I have great concern that we've lost this notion of truth and falsehood in public discourse.

JEFF WARREN: Absolutely. I desperately want to talk about that. I'm being a little round about, so I apologize. Yeah. So I mean, as you said, it's concerning when people lose trust. This is a graph of the 48 hours surrounding the election, and the projections of the election's outcome. And it's a really depressing graph to look at for me.

I found it really interesting. This is *The New York Times* upshot. But I found it very interesting the language that fivethirtyeight.com used, and a lot of other data driven analysts are increasingly using, to tune how they communicate certainty.

And this is something where, in the days following the election, you heard some analysts talking about, well, we said it was 70 something percent or whatever. And that's not-- that's actually not very certain. You know, there's something hidden in that or something that needs to be unwrapped about the communication of certainty. And I think it's a real challenge. I don't know that people have answers to this, but it's something I'm interested in.

I know they sometimes would say things, like, more probable than making a field goal. That didn't help me, because I don't know anything about football. But they're trying to communicate what the graphs mean.

You know, it's easy to just look and see all blue dots. But it's a very different thing to understand what the ramifications are for how reality plays out. And then, of course, yeah-- this is the big thing. That sort of scenario plays out on a lot of other narratives, right?

Adjacent displays and communications of data-- many of you may have seen this Bloomberg thing. It's very interactive, extremely data dense. Like, there's so many studies and so many data points that have been summarized and metasummarized to create something which communicates, I think, very effectively about warming trends. If you haven't used it, go and play with it. It's really, really interesting.

And so, you sort of have to ask why isn't it persuasive to everybody, you know? Because it's pretty good. And I think it's easy to demonize experts for not being good communicators when things go wrong. I think a lot of complex knowledge is communicated in pretty rich and pretty interactive ways. It's not just learn this by rote, you know?

AUDIENCE: Is that the name of the tool, compare and contrast?

JEFF WARREN: It's Bloomberg.com What's Warming the World? And I think it's pretty great. So I think, yeah, with such a wealth of data and such persuasive communication of that data, with all the tools we have today, what is-- or is-- something broken about expertise? And I think that, in some cases, people are very much afraid that there is something broken, maybe not about all expertise, but about some portions. You have a thought?

AUDIENCE: --comment again. I don't think expertise is broken. But I think there's a feeling among experts that no one has the patience or wherewithal to listen.

JEFF WARREN: Yeah.

AUDIENCE: And when you add that to the conflation And obfuscation of fact by people who really are pure advocates, and kind of have-- whatever the interest may be, whether it's to show up to their party, whether it's to curry favor for any position--

JEFF WARREN: Funding. [LAUGHS] Yeah.

AUDIENCE: --that seems to have overwhelmed the voice of reason and fact-- it's just my opinion.

JEFF WARREN: I agree with that. I think the way that I'm using the term expertise here is potentially trying to understand it in a wider scope. Which is to say expertise could be defined as a body of knowledge which is contained or known or collected. But what I mean, broke-- when I'm using the term here, I'm talking about it as a set of relationships as well.

AUDIENCE: [INAUDIBLE].

JEFF WARREN: Expertise-- yeah. And relationships with experts-- and who are experts, how are they identified, how do we trust what they say? How do we, if we are experts, communicate in a trustful manner to people. There's a whole set of issues.

AUDIENCE: The scientific method was supposed to be the solution to that. But I think everyone's just too--

JEFF WARREN: Well, let's not give up on it yet.

AUDIENCE: But we can't push a button [INAUDIBLE].

JEFF WARREN: Yeah. It's true.

AUDIENCE: --wayside. Forgive me. I'll [INAUDIBLE].

JEFF WARREN: No, no, no, please. And thank you, no. I'm glad you're engaging. Because it's something I think about a great deal and have thought about, especially recently.

So Harry Collins is not popular in all fields. But he does do a very close and careful examination of different kinds of expertise. And I think it's a very interesting thing to think about what distinguishes different kinds of expertise.

And one in particular that he talks about is meta expertise. And it's the ability to distinguish expertises, the ability to compare and to choose an expert among several who are purporting to be experts. And he says, you know, and I think this is a persuasive point of his, that it's a particularly difficult one, but it's one which many people are called upon to have.

It's one that is often based on long term reputation. It's based on, in some cases, relationships, personal relationships, and it can sometimes be affected by a different kind of expertise, which he calls-- I think he calls it downward discrimination expertise, which is essentially the ignoring of one expert because you perceive a different expert to be of a greater authority. So I don't know about every observation he's made. But I do appreciate the taxonomy he's created and the attempt to understand what are the mechanisms that allow expertise to occur in our society.

And I think the question for Public Lab and for some of us is what do we do about the widening gap? Because although there is a tendency to think that the ability to question expertise is driving a wedge, the democratization of knowledge production is an assault on expertise. But I actually think maybe it's like there's a few other dimensions to that. And although I'm not going to say that's not true in some ways, I think that there are other ways we can think about it as well.

So what Public Lab tries to do is to focus on problem definition. So this is the earliest stage in the sort of sequence that might encompass scientific inquiry. And staying close to real world problems-- Britta mentioned communicating with people as early as possible, building products in collaboration with groups that face problems, engaging them in the problem selection in the formulation of questions, and in some cases, in research design.

There are specific expertises and capacities to formulate an experiment. But those may be, in some cases, the places where it's most likely that you would learn something from a group that has deep understanding of a particular problem, first hand knowledge. So I'm really interested in that potential, and in, really, collaborating as much in asking questions as in answering them.

But what are the sources of mistrust? I think there are many, but I'm going to try to dig into a few of them. I think one of them is limited ability to evaluate or test. So this affects, perhaps, climate science more than almost any other type of science, although I guess the LHC is another example. But how can people evaluate empirically what climate science is saying?

It's not very possible. You can observationally do it in some cases. But understanding that in a context is difficult. And I mention this one mainly because it underlies a lot of what we do at Public Lab. Public Lab's not primarily interested or not primarily engaged in climate research. We're primarily engaged in pollution research.

But we take it as a powerful thing to be able to empirically verify something. And that's why we're focused on low cost tools and democratization of the technologies. But this is linked in climate to the following-- when processes are too big to see feedback loop personally. When you go and you do something, it's one of the longest feedback loops that we are confronted with in research.

But yeah, oh, sorry. I already mentioned this. But basically, we do focus on testability at Public Lab on the question-- can you also build this? Do you also get the same result?

And this is a picture of one of our spectrometer prototypes. Someone literally, like, tweeted a picture and a link to plans. And someone else built one and tweeted that they had, as close as possible, reproduced this.

Harry Collins talks a lot about the infinite regress. What's the-- anyway, whatever-- I'll get back to it later.

AUDIENCE: Sorry. Is that name Harry Collins?

JEFF WARREN: Harry Collins? Yeah. Yeah. I'll talk a little more about him later, too. I should probably start moving a little faster. A couple of others-- environmental issues affect someone else.

I think this is one where it's not just about-- I think there's many sides to that one. It's a tough one. But I think increasingly people are understating environmental problems as ones which affect people. That's a major step forward. I think the environmental movement had been very closely associated with conservation, and I think conservation is great.

But I do think it is important for people to recognize that there are justice issues at stake with communities that are facing pollution and don't have a way to respond to it, or sometimes, even, to understand it. But increasingly, pollution is affecting everybody, and the climate is affecting everybody. And I think this is an opportunity for common cause.

The other one is one that affects poor communities perhaps more than others. And that's that they have very limited ability to respond, and in many cases, to question. And therefore, they already have the experience of having been lied to and hurt by industries, and sometimes by the scientists that those industries employ. I know this is a difficult one for all of us.

But I think that if you talk to communities who face pollution firsthand, this is a very common experience. And it's unfortunate. Harry Collins actually mentions that he feels that the fact that we are upset when we see that there has been an exchange of money which has influenced the findings of a research project-- we are upset because we know that that's wrong. Because there's something essential and fundamental about science which is being broken when that happens-- so complex, but interesting.

So OK, so what can I do as a scientist or a technologist? These aren't the same thing, but the question might be relevant to both. Tough-- we're going to try to get into this. I have some ideas, four broad ideas.

This is an article which I found very interesting. It recaps a lot of ideas which Public Lab has championed over the last six years. But it also shows how difficult it is to have an articulate conversation about these things, because it is very complex. The subtitle is maybe more important-- *experts need to listen to the public.*

I went into the comments, all right? I know that's not always a productive place to find things. But for once, I actually thought it was really, really educational. Yeah. So I'll just read it.

"No, scientists need to do science, not run a PR campaign and become marketing experts. They aren't trained to do that. And it's silly to expect them to.

What the rest of us need to do is invest in the school system"-- well, that's interesting-- what the rest of us-- so this gentleman does not identify as a scientist-- --"is invest in the school system that we've basically let rot in many places so that our citizenry has knowledge of the scientific method beyond the third grade level. If they understand what science is and what it has accomplished, then they'll appreciate its value. It's the job of the public schools to teach this, not career scientists."

There's almost too much in that statement for me to peel apart. But we'll try to get to some of these questions as we go. And I'm not putting it up here because I think this person is completely wrong. I'm putting it up here because it's a series of statements that have some value.

I think that it is overlooking other things, but the next two are even better. "This boils down to wanting scientists to basically add some responsibilities to the number of things they have to do already, yet it doesn't seem to dangle much in the way of tangible money for that extra work." True-- TLDR-- less science, more photo ops. I think that wasn't a helpful comment. But

I think it's reductive in a way that is helpful for us as we're looking at this problem.

So educate yourself. That's what the first commenter is saying. But actually, I want to say it to everybody, including scientists and technologists. I think it's really important.

Because we tend to think, and we're taught science, often, in the public schools somewhat historically. Where did it come from? How long has it been around? Why does it work this way? And how did it develop into what it is today?

I mean science studies-- MIT has a great department of science, technology, and society. You know, basically, I think it's important not to be naive about this. Understand how the field works empirically as well as theoretically. As in, you know, how do we aspire for it to work versus empirically, how can we measure it to be working or not or in what ways, who it's benefited and how it developed over time.

This is one thing that I really respect folks like Harry Collins for trying to understand, apart from the different ways that people have actually come up with to understand it. I mean, Harry Collins is just one perspective. Part of this, I think, is vocabulary.

And just about this particular topic that Public Lab is engaged in, you might have seen three different phrases. You'd come across these three phrases to describe closely related ideas. Public Lab uses community science. It's a term that we've helped to define. In part, we've used it because there's actually two definitions of citizen science, which are competing and quite confusing.

There's the 1995, Alan Irwin's definition of citizen science. Rick Bonney describes it as a methodology for engaging a large group of people outside of science practice in performing data collection. For example, doing bird counts, submitting data, being an extension of science's ability to interrogate the world.

And this is a very powerful thing that I think that Public Lab uses as well. But actually, I think Public Lab is perhaps more inspired by the older definition of citizen science by Irwin. And Irwin described the work of HIV activists in the '90s and earlier who included AIDS patients, and who were involved in drug trials in early AIDS treatments.

And they organized. They protested. They did die ins at the National Institutes of Health. And ultimately, they gained what-- and again, I'm over reference term by Collins-- interactional expertise, which is that they could read and debate papers and peer-reviewed research.

They could challenge the structure of drug trials, and they successfully did so, persuading those who ran the trials to modify how they worked. And in some cases, they did so in an extremely disruptive way to the researchers. Which is to say they sometimes exchanged the drugs they were given in order to intentionally mix placebos with nonplacebos because they found it to be unethical to do double blind research on people who are suffering.

So it's a complicated story, many sides, many, many important aspects of this. But what happened was not that scientists, per se, decided to include people in their research, but that they were persuaded to do so. And they eventually did so, some of them, voluntarily. And collaborated with activists, in some cases, in order to recruit for new trials.

So there were constructive collaborations that led out of this sequence of events. And it's a fascinating history. It's a fascinating set of new organizations or new relationships between people who did not originally have almost any kind of expertise besides the immediate expertise of being a victim or a patient and people who had expertise of the kind that we are more familiar with.

So OK, fascinating, and difficult to distinguish the two now that the terminology has been overwritten. So Harry Collins-- also Sandra Harding, another controversial figure, but one who I really appreciate. She wrote *Whose Science and Whose Knowledge?* And she talks about the relationship of feminist epistemology with scientific research.

And she just has so much to say. It's amazing. But one thing that I really appreciated was her focus on the selection of problematics, the choosing of scientific questions as an area which, well, as she was writing in the '80s, was understudied, she felt. So she has a lot to say about that.

Harry Collins has a book-- *Are We All Scientific Experts Now?* Spoiler alert, no. [LAUGHS] Definitively, he says no. And I'm persuaded by a lot of what he says, but not by all of it.

Collins also did a really interesting sort of retrospective of this set of studies from after the Chernobyl disaster. He wrote a piece in the early 2000s looking over that work called *The Science of the Lambs.* He's part of a group of scholars who are very punny.

But he looked at how the studies of radiation's effects on sheep in Cumbria and other parts of the UK. He worked with Trevor Pinch as well. Basically, it's, like, it's complicated. But he looked at how researchers trying to map out and quantify radiation did and did not succeed in working with farmers and building bridges between the farmers' knowledge of water flow, of exposure, of site conditions, and the farming practices, and their own expertise to rich conclusions. Tough one, but a really interesting read, and a fairly short one?

So Sandra Harding, as I mentioned, who asked the questions which science attempts to answer-- I think it's a really important one. I don't know. I mean, I know, but got to dig into that.

So OK, some tough ones here. The possibility that scientists' practice today does have blind spots, and specifically when it comes to other forms of knowledge production. Not to say it's not interested, but there are new forms of knowledge- well, new-ish forms of knowledge production emerging.

And I really want to be clear. I'm absolutely not saying we should try to recognize climate denial. No. That's not the kind of blind spot I'm talking about. [LAUGHING] I think that's really part of a parallel discussion about the influence of money in politics and science. And it's one I'm not even going to try to broach necessarily in this session.

I'm talking about the lived experience of those who suffer from environmental problems. And to some degree, this sort of humble recognition of our own limits and unknowns. And especially on questions, critical questions of environmental harm.

So number two-- in terms of-- I wanted to tell the story of this picture. That's a sunken boat, so ignore it. This is-- I wrote it over with letters, oops.

But there's a darker thing here, right? And that's actually melted ice as water came out of a pipe on the side of this canal. And that wasn't on the original engineering surveys. And it wasn't in the EPA's data on this site.

But it's an active inflow. There's water and whatever else coming out of it, off of a construction site. And it's just a good example. There's a group who lives there. They go by that site every day.

And they can do kinds of observations. This is data collection in a way. But they did it not because they were contributing to science in a sort of a noble way, but because they're engaged in the problem, you know?

And they're critically monitoring this site. They're watchdogging this site. And they're trying to hold the abutters, the construction sites, and the potential polluters-- they're trying to hold their feet to the flame. They're not objective.

But they were able to submit data, including this photograph and others, that updated the understanding of the site and influenced the cleanup. OK, interesting, and specifically, it's easy to take for granted when you're speaking with your colleagues where your expertise comes from, what kind of certainty you're communicating. And this is something that, you know, when people read the so-called climate gate e-mails, insider talk is structured in a certain way. It's hard. It's not designed to communicate to all audiences.

But when you are communicating with people, especially outside of the group that you work with immediately, how do people know where your expertise comes from? I mean, you know, I think titles, degrees, credentials help here. But they're not the whole story.

And there's this really interesting sidebar. The Quechua language group in Peru has this fascinating quality. Which is that it has a suffix which indicates the source of your knowledge. So you can say the same thing and indicate grammatically whether you heard it from someone else, whether you experienced it firsthand, and several other forms of empirical context.

And I often wish that I did a better job at that. Full disclosure, in terms of communicating how you get your expertise, I'm not a scholar of science studies. Although I'm a fan of it, as you can tell. I also have no formal science training. I just have some thoughts.

I think interactional expertise is what Collins talks about, the ability to speak the language of science, which is on the way to being able to perform at science, to actually do science. It's hard to develop. He notes that AIDS activists were able to do so with a lot of hard work.

He also ran this interesting experiment, hard to know what to make of it. But where he did a quiz along with a number of gravitational wave researchers, and then showed the answers, his answers-- he studied the community for over a decade. But he doesn't do gravitational wave science. And actually, I think, seven out of nine of a panel were unable to distinguish his answers from those of practicing gravitational wave scientists.

And that wasn't to say that he thinks it's easy. He did this for decades. He worked with these folks for decades to acquire that level of interactional expertise.

But what he's trying to say is that there is a fine line of distinction between be able to communicate and critique and interact with people in a field of expertise versus being able to design and perform experiments. And I don't think it's a matter of dumbing things down when we talk about inviting other people into work. I think, as the commenter said, that scientists aren't necessarily the best at communicating knowledge. But that doesn't mean that they're off the hook necessarily or that the burden is on, exclusively, everyone else. I think that there has to be some teamwork here.

I'm going to move forward, because I think we're running out of time here.

[TAPS PODIUM]

I did want to say-- let's see, OK. I know that we often talk about mass communication and so forth. But when outsider groups are more able to challenge expertise, we're living in an interesting time. I think there are positive and negative ramifications of this.

I think that the limitations of science practice, that capacity, budgets, some of the things these commenters very clearly articulated, the fact that science isn't suited for every problem we have on Earth, you know? It's not the end all, and it cannot contain all knowledge. But I do think that there are alliances that may be formed.

I mentioned the maker community, the hacker community. But also, environmental justice groups who have worked for decades to do science, but to do it to answer questions about threats to their own health, to find relationships between knowledge production and justice, social justice, and who have been doing their own monitoring and watch dogging, often with very good relationships with the researchers who choose to work with them.

Yeah, again, I think you can look at groups who use aerial photography as Public Lab does or Google Street View to investigate pollution issues. There are more empirical means at our disposal today. And I wanted to mention, sort of wrapping things up here, that Public Lab's participating in the Environmental Data Governance Initiative. So Public Lab began as an effort to create an independent record of the BP spill, a separate data set.

But with the transition happening, the presidential transition, EDGI is an effort to download and archive EPA data before the transition potentially cuts off access or destroys data, as actually has happened in previous presidential transitions. It's sort of a breakneck effort that's been put together over the past 10 weeks to literally, like, scrape and download everything that the government has online currently. Anyway, I mostly-- you know, I don't have any where near all the answers here.

But I'm trying to ask hard questions and propose ways forward. I really am trying to find places to build bridges and to build alliances and not walls. And I think that getting closer to people personally, getting to know people personally who are outside of your particular circle, is really powerful. To learn what people know, what they need, even if you don't always agree, and primarily to not assume that information flows only one direction.

So OK, I'll put the hardest question up. Is bad science, like science that doesn't serve the public, or that is misleading, is it science gone wrong or is it science as usual? Is there something fundamental about the way that we're doing science today that needs to be reformed in some way, or are there a number of bad actors who are taking advantage of science? And really, those are sort of two sides of the same coin. I mean, in the sense that if there are bad actors, we could reform science to try to stop them.

And Collins says that-- well, I mentioned this sort of idea of when we abhor-- when there are bad actors, when we can recognize when it is going wrong. And then, really, these are things that I'm sure people have thought about. But you know, is science more inclusive as a profession? Is it more inclusive in its conclusions? And I guess is the broader direction of science, and specifically, its questions more than its answers, simply what we make of it?

And I'm very clear in that distinction. Because I don't mean that its answers are what we make of it. But I do mean that we can choose to pursue inquiry in different directions. And we can choose to structure what we ask, even if we can't choose to structure what we find out. Thank you.

[APPLAUSE]

AUDIENCE: I've been involved with data collection in numerous ways that have been citizen called for. One was with lead in the soil, and the other was monitoring the river out here. But now I see a really, really important area for citizens in our communities in having the skill to, you might say, cross examine the experts, especially around infrastructure projects. And I'm thinking of the gas projects in Massachusetts, where there've been a lot of hearings and the scientists, or I would say, the utility representatives have a lot of expertise.

JEFF WARREN: Yeah.

AUDIENCE: And so there you have a great deal of information on their part. And then you have these limited opportunities for citizens to raise their hand, like, wait a minute, aren't we getting too overdependent on gas. And what we don't have is equivalent ability to question the basis for how do you make decisions about these things and being able to influence the decisions that are made. So I see a gap there with whatever community ability we can -- We need help in that vein.

JEFF WARREN: Yeah. There's certainly an asymmetry to it. And it's very difficult to have-- I mean, for example, self-reporting is a common mechanism in terms of regulations for producing knowledge about emissions or about potential pollution. But self-reporting is not blind, you know? It's telling people what you did.

And often, like in Louisiana, a lot of, say, smokestack emissions are based on estimates. They're not even actually based on empirical measurements that you perform yourself as an operator of a gas facility or a refinery. So it's very alarming, because the standard of evidence is almost meaningless.

It's like, I think we probably, maybe, emitted this much lead last night. We're next to a community, like a residential community. So it's very troubling.

I mean, part of this is asymmetry is cost as well as expertise. And I think the equipment to measure gas, if it's cheaper, it makes a lot of this easier. But it's not the whole equation, for sure.

One example I wanted to share actually that I forgot was-- so a lot of the community groups we've worked with in places affected by oil and gas will grab sample measurements. So they take a bucket, and they use a vacuum, and they suck air into a gas bag inside the bucket. And then they mail that entire bucket to a lab to get a certified test done of analysis of the contents.

And what is nice about this is that it allows these community groups to choose, based on their deep knowledge of the patterns-- like, do the facilities typically emit at night? Do they emit at certain times, certain days of the week? Are there signals? Like, is there a flare up that you see, or is there an alarm, stuff like that that enables them to structure when they take the samples in order to sort of, like, catch the emission at the right moment.

What's nice about it also is that it's a standardized test. So they can send it to different labs.

They're sort of, in a sense, made it a service that these labs provide, as opposed to the people collecting the sample being the service part of it.

So it's sort of inverting that in a nice way. And the thing that was really remarkable to me is that several of these communities that we've spoken with and worked with will actually not trust labs-- one of them didn't trust in state labs. And one of them just doesn't trust a lot of labs in general, because they feel that there may be some of these labs do work for and accept money from oil and gas companies.

And so what they did, which was really remarkable to me, is they faked samples. They made positive and negative control samples. And then they sent those to labs at a cost of hundreds of dollars per sample, in order to test the labs. And only after confirming that these labs would correctly report different levels of preprepared positive and negative samples, did they then use that lab for their own real sampling.

And you can imagine that if community groups are already under resourced and find it difficult to marshal their resources to do testing at all, it's not trivial to spend all that money to establish trust. But I thought it was a really interesting example of science being done on scientists, you know? And I think it's a positive-- it's actually a positive thing, you know?