President's Council of Advisors on Science and Technology (PCAST)
Public Meeting Transcript
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Welcome from PCAST Co-Chairs

>>John Holdren: Could I invite people to take their seats. We are almost on schedule but it's a minute or two past nine. It is a pleasure as always to welcome the members of PCAST, the President's Council of Advisors on Science and Technology, the members of the OSTP staff who have joined us and who work in close collaboration with PCAST. Pleasure to welcome as well the members of the wider science, technology, and policy community who have joined us here and those who are joining us on the web cast. It has been and as it has been throughout this administration, an interesting and exciting time for science and technology policy. We have a new President's budget for FY 16 which will be coming out soon with some important implications for science and technology. Science and technology did quite well in the omnibus passed by Congress recently for FY 15. That was not entirely uniformly well but on the whole, science and technology came out well. As anyone who reads the newspapers know there's a very wide array of compelling issues, challenges and opportunities in the science and technology space facing the nation, facing the world. We're going to have the opportunity to talk about one of the most challenging and complex of those intersections among science, technology, and policy in just a minute but before we do that, Eric, do you have any opening comments?

>>Eric Lander: No, I just want to welcome PCAST and thank everybody for the tremendous amount of work that continues to go on here, and welcome everybody joining us on the web.

International Environmental Developments (Lima; US-China Announcement)

>>John Holdren: Good, let's move right into our first major topic of the morning which is international environmental developments, with some particular emphasis on climate change policy. We're delighted to have with us Dr. Kelly Sims Gallagher who is Senior Policy Adviser in OSTP, with a focus on these energy and climate matters and most importantly, for the purpose of this morning's discussion, the interaction with China on climate policy and energy policy.

Kelly is on leave from her position as Associate Professor of Energy and Environmental policy at the Fletcher school at Tufts University where she also directs the Center for International Environment and Resource Policy. We have as well Dr. RICHARD DUKE, the Deputy Director for Climate Policy in the Domestic Policy Council, and also, an Associate Director in the Council on Environmental Quality. He is what we call dual-hatted. I should mention that Kelly also works actively with the Office of the Special Envoy on Climate Change, Todd Stern. So the members of PCAST have more details about the bios of both of them in their packets. I will mention that RICHARD DUKE, prior to his current position was Deputy Assistant Secretary for Climate Policy at the U.S. Department of Energy. We have a couple of

very experienced folks in this space and I have to say that both Dr. Gallagher and Dr. Duke were extremely important players behind the scenes in the activity leading up to the announcement by President Obama and President Shee on the joint announcement of the two country's respective targets for greenhouse gas emissions reductions post 2020, so it's great to have both of you with us.

I think you're aware that our usual format is to have relatively brief presentations so that there's time for discussion with the members of PCAST, and this session is scheduled to go until 10 o'clock. So Kelly and Rick, I don't know how you're arranging it but please proceed.

>> Kelly Gallagher: Okay, thank you very much! It's a pleasure to be back. I last spoke with PCAST in May, 2014, so it's great to see you all again. Rick and I have a plan. This is our agenda. We're going to start by reviewing the goals and outcomes of the U.S.-China joint announcement, and then I will speak briefly about Lima which was the conference of parties of the UN Framework Convention on Climate Change which took place in December of last year, and what happened there. And then I will turn it over to Rick who is going to talk about transparency mechanisms in the UNFCCC, and then provide a summary of a presentation he gave in Lima essentially on US progress towards reducing greenhouse gas emissions, and then we'll go to the discussion. That's the plan.

We thought we would just take it chronologically and so it all began with the U.S. /China joint announcement on climate and clean energy and I would say that our goals going into this dialogue with the Chinese were basically two. First, we wanted to try to inject momentum into the UNFCCC process because in December of this upcoming this year, we're in 2015 now. In December of this year we will all be convening, the entire world will be convening to try again to reach a global agreement, a protocol or other legal instrument as they say in the negotiations in Paris.

So we wanted to try and get excitement about this process moving again. That was a major goal. Second, we hoped to achieve a standalone agreement by the two largest emitters and the two largest investors in clean energy technology that can be used as an ongoing mechanism, and I'm happy to report we were able to achieve both of those goals. I think an unexpected outcome was that we had a bit of a breakthrough on an issue called CBDR, common but differentiated responsibilities and I'll come back to that in a minute.

The specific outcomes that were announced in the joint agreement on November 12th, included statement of our post 2020 targets. So for the United States and this is what Rick is going to talk about in some detail later, the United States is committed to reducing its emissions 26 to 28 percent below 2005 levels by 2025, and China committed to peak its emissions around 2030 and to achieve 20 percent of its primary energy from non-fossil sources also around 2030, and both countries committed, and it is in the agreement, to increase ambition over time. We hope these are minimum goals, and that we might be able to achieve even more then is stated in the agreement.

Less reported, but I think just as important, we committed to strengthen our policy dialogue going forward and there were also a number of clean energy components to the agreement. First is that we agreed to extend for another five years, the U.S./ China Clean Energy Research Center which is the mechanism that the Obama administration established in the first term with China to do energy R D and D, collaboratively with the Chinese. There are

three existing tracks, buildings, advanced coal and I'm blanking on the third. Oh, electric vehicles, and we added a fourth track in this agreement on the energy, water and access. In addition, there were two major announcements on carbon capture and storage. The two countries have agreed to do a demonstration project on enhanced water recovery which means injecting CO2 and trying to recover water. The first project in that regard will be physically based in China. There's an intention to also look for a site here in the United States. And then second of all, there will be a demonstration project that's a pure storage project. A long term CO2 storage project that will be based physically in China and be heavily instrumented, and will be open to other countries as well, but led by the United States and China, and will also be a public, private partnership. So we'll be looking to private firms and academics to join us in this long term project. This is a very significant step forward because the Chinese have never agreed to do a long term storage project. They have always been focused on capture and utilization, so we think this is a big achievement.

There's also a new cities initiative which has two components. One is a city level summit where we can share best practices on city level policy on climate change and clean energy and also, a more technical track which is on research, development, and demonstration on smart infrastructure for urbanization.

We agreed to keep discussions moving on HFCs and also agreed to a green goods trade mission that will take place this upcoming April. So now let me turn to Lima because just a couple of weeks later after this agreement, you know, the entire world convened for the international negotiations and this was the 20th conference of parties, otherwise known as Top 20. We did reach an official outcome although, it was a little worrying for a while that we might not actually get to a final agreement out of Lima. The formal agreement is called the Lima Call to Action. And also, a draft text was released called Elements for Draft Negotiating Text. If you go on the UFCCC website, you can download both of them. The draft negotiating text is supposed to be narrowed. Right now, it's 38 pages. Very long and at each - - for each topic, there's multiple options listed under each topic so it's a very complex, difficult text, at the time as of right now but as of May, the Lima call for action requires that a pared down negotiating text shall be ready that will then be negotiated. When we think about this from a U.S. perspective, and here I'm looking at this middle box, we really came into this negotiation in a leadership position for the first time in many, many years and that was exciting and almost fun for us. Those of us who were there, to be there and really be proud of where the United States stands and we are in that position in part because of the good work that the Obama administration has done so far to get the U.S. House in order through the climate action plan and all of the policies that have set us on course as Rick will explain in a bit to meet our 2020 target and also, because of the U.S./ China joint announcement which was perceived as a real breakthrough in the international negotiations. Another sort of indicator of the fact that the U.S. is in this leadership position is that Dan Reifsnyder who is the Deputy Assistant Secretary of State for Environment, was elected by acclamation to be the co-chair of the ad hoc working group on the Durbin Platform for Advanced Action, otherwise known as the ADP and that's the working group that will be developing that negotiating text. So it's great that we have a U.S. co-chair on the negotiating text.

In terms of the U.S. goals for COP20, I think they were pretty simple. We wanted to keep everything on track for the Paris agreement and not have a derailment that sort of made it

impossible to proceed with the current plans, and second of all, we really wanted to try and make sure that the intended nationally determined contributions by parties were scoped out and that they were scoped out in such a way that they were transparent, detailed, and submitted early. And so these INDCs are the commitments, the individual commitments of each party for the Paris agreement. So every country is going to have something that looks different. Every country is likely to have different types of commitments and one of the reasons why the US/ China joint announcement was perceived so well is it kind of embodied how different INDCs could be acceptable. So the Chinese commitment looks very different than ours. There is peaking and a commitment of non-fossil energy. Ours was a more traditional emissions reduction commitment, but both of them are like, both of our commitments will be submitted as part of our INDCs but there was a huge amount of controversy about the scope of the INDCs and whether financial commitments from the industrialized country should be considered part of the INDCs. Whether adaptation is one of the areas that should be considered part of the INDCs or not. Looking forward on the road to Paris, we're hoping to see many other countries submitting their I NDCs in the next couple of months. It did say that ideally in the LIMA they should be submitted by the end of the first quarter of 2015. We will be trying to refine that elements text. One thing that did not go well in the Lima negotiations were the discussions about technology transfer. There was an effort by the developing countries to have an explicit linkage between the green climate fund and the technology mechanism, and continued push by India for a compulsory licensing, and making freely available technology for developing countries and the negotiations were so difficult they resulted in a non-text, in other words, no agreement. That was pushed off to Lima and so that's an important issue we have to address between now and then. Climate finance was sort of a good news, bad news story.

From our point of view, it was a good news story because United States has committed $3 billion to the green climate fund, and that's another reason why we were perceived in the leadership position, but many developing countries feel like the total that's been collected, which is about $10 billion is insufficient so far. And then in the common but differentiated responsibilities, this is kind of the code word for the fire wall that's existed between industrialized countries and developing countries, and the commitments that are required by each. One of the things that was a great breakthrough is that the U.S. China agreement was considered to embody breakthrough in CBDR because there were differentiated commitments. China had different kinds of commitments from the United States, and that was remarked upon repeatedly, over and over, by negotiators around the world that we had found a way through this very difficult issue. It remains to be contentious topic and will be the main, I suspect, the main challenge in Paris.

There's much more to say but I don't want to take up all of the time so I am going to turn it over to Rick to talk about the multilateral assessment process which was one of our goals in Lima.

>>Richard Duke: Thanks Kelly and good morning everyone. I want to start with an explanation on why transparency in the United Nations Framework Convention for Climate Change is such a priority for the Administration and why the State Department and the overall administration have been focused on transparency mechanisms as core to the whole process.

In effect, we believe that only through frequent reporting, clarity around pledges and comparability around pledges, and opportunities to challenge each other, will we have the sunlight that is needed to ensure we are all making and delivering against serious commitments to reduce emissions and otherwise address climate change.

That's why the transparency piece of the puzzle has been central for us. That's why we're very excited about the progress that has been made in the negotiations in securing commitments from all major economies to put forward clear pledges in these nationally determined contributions that Kelly has been referencing, and then to report on them and to review one another time.

We had been enthusiastic participants in the process we have helped to shape. I will give you a sense of that in the negotiations context here on this slide. Going back to the Copenhagen and Cancun meetings of the UNFCCC, some of the core architecture where transparency was put in place. It included reporting requirements every two years where countries need to put forward explanations on how they're doing against their existing commitment, and then there's also this multilateral assessment process which I had the privilege to represent the United States for in Lima, in which each country sits in the hot seat and takes, presents on what they're doing and then takes questions from all of the other parties to the convention.

In my case, the session lasted for an hour and a half plus. I had, I believe 14 questions in my first round of questions and then quite a bit more dialogue after that, both in the session and in the hallways in Lima. We think that's an extraordinarily important part of the overall UNFCCC process and it's off to a very good start in Lima and through the bi-annual reports that the countries have started to put forward.

Just a word about those biannual reports. The United States put forward their first ever bi- annual report in January of last year but I think it's worth underscoring, we took the extra step of putting our draft bi-annual report out for public comment before we finalized it. So in September 2013, we had a draft out in the Federal Register and took public comment and responded to the comments before we went to a final report last January. We intend to do that in the second biannual report, take the extra step for additional transparency through public comment.

And then shortly on the Lima transparency outcomes, they essentially affirmed this set of mutually agreed transparency mechanisms where countries put forward their nationally determined contributions, and through this process, what bi-annual reports and multilateral assessments, and some other more technical details as well.

Let me now turn to what is happening in the U.S. context on acting on climate. So for us, it's important to start with the original climate action plan from the second term. So of course the President came out in his inaugural address in the beginning of the second term speaking very forcefully about climate change, and shortly thereafter, put forward a climate action plan that weaves together three dimensions we think are synergistic and all of which are essential to acting comprehensively on this important challenge.

First, cutting our emissions and I'll mainly give you a sense on how we're doing on that aspect of the climate action plan. The second is to make sure we have the adaptation measures in place, and that we're preparing for climate impacts, which is, I'm sure you have heard from Dr. Holdren and have talked about many times, are already, in many cases,

unfortunately unavoidable, and lastly we need to lead internationally on what is a fundamentally a global challenge and requires a global effort.

This slide presents a snapshot of where we have been historically on emissions, where we thought we were headed when the President took office, in the dotted line, increasing roughly along the trend indefinitely in terms of emissions. And then our two goals for emissions reduction. And importantly, in 2009, and then more formally in Cancun in 2010, the President put forward a goal to reduce US emissions, economy wide net greenhouse gas emissions, net of land sector syncs, in the range of 17 percent below 2005 levels by 2020. So that's the first inflection point you see on the green dotted line. And now with the joint announcement with China, the President has put forward a second critical goal to reduce emissions further and at a faster pace, to 26 to 28% below 2005 levels by 2025 as Kelly has noted. That speaks, importantly to the acceleration of ambition over time that Kelly referenced and that was built in to the joint announcement with China, and again we are seeking to model the kind of response that we expect from other major economies worldwide in moving at a quickening pace and with serious and comprehensive effort to drive down emissions in the U.S. economy.

Just a word on the process to develop the 2025 goal. I want to just note that we have spent a great deal of time involving all of the relative agencies in a deep analytic effort to identify and incorporate all of the kinds of measures we can believe will be brought to bear in order to drive down emissions on this time horizon, and we feel that a 2025 goal for the United States, is an important way to maintain and accelerate comprehensive pressure for action. So we feel that pressure every day. We work hard in our agency every day to drive down our emissions, to hit both of these goals, and let me give you a sense on how we're doing on some of those actions.

So first, we are taking a comprehensive approach. We look across all of the different sectors, all of the different greenhouse gases. We pay attention to land sector, carbon fluxes, or I should say, terrestrial carbon fluxes which are very important in the U.S. context. Something on the order of 14 percent of our greenhouse gas emissions are offset by our carbon syncs annually, and so it's important that we over time enhance measurement of those carbon fluxes, and we also do everything we can to bolster those carbon syncs over time and we're very actively working on that challenge.

In addition, sector by sector, we're taking the measures that will cost effectively drive down emissions in each of these sectors and the power sector, of course, through the EPA's Clean Power Plan, and through appliance standards and through doubling renewable energy in the first term and setting a goal to double it again. Transport sector moves centrally through fuel economy standards and then each of these other sectors each have its own set of measures that we're implementing under existing legal obligations and authorities.

Let me give you a little bit more detail, and I'll be brief so we can leave plenty of time for discussion but a little more detail on the clean energy side and I'll speak briefly to the efficiency side and other sectors. On the clean energy side, the Environmental Protection Agency's Clean Power Plan is the most important mechanism, but by no means the only mechanism. When the President put forward the Climate Action Plan in June of 2013, it was accompanied by effectively an executive order, a presidential memorandum that laid out a plan for EPA to deliver the Clean Power Plan and you can see the times there for the proposal and then the final rule in

that is all tracking towards what will be an incredibly important part of the overall efforts to address climate change, and in this case, by engaging states to put in place measures that will continue to accelerate movement towards low carbon sources in the power sector, renewables, energy efficiency, nuclear and all of the others.

It's just worth noting again, we have actually doubled electricity generation from solar and wind, renewable electricity, and we're headed towards trying to hit another doubling by 2020 of the new renewables, of course, hydro being more stable.

I want to note just that there's quite a bit of ongoing R & D work, much of which got a real shot in the arm through the recovery investment from $80 billion in funding for these kinds of technologies and we're starting to see extraordinary progress on some of the key clean energy technologies, and we think that's tremendously important both for the U.S. and globally to continue to accelerate action on emissions reductions. So a quick example of that would be the solar effort that the Department of Energy runs called SunShot, ten- year program to try to hit a goal of $0.06 per kilowatt hour per utility scale PV, and we're already more than two- thirds of the way to the goal, less than half way into the program. The same kinds of progress in motion on electric vehicles and bio fuels and wind. It's an exciting time and a time that we think is tremendously important for all major economies to keep up the ambition and keep driving these technology at scale.

On the efficiency side, that is at least as important, energy efficiency is often called the first fuel. We believe that energy efficiency in every major sector is a critical strategy to both drive down emissions and save consumers billions, and we have seen that operative in transport sector through the fuel economy standards that are going to, over the course of the program, for fuel economy standards and the vehicle sectors, they will save the equivalent of a whole year's worth of emissions in the U.S. economy. And the President has made clear that we'll move ahead with additional fuel economy standards or heavy duty vehicles next, building on the growing impact from the light duty vehicle sector that's already in place. And then it's just worth noting that in the building sector, we have tremendous action by the Department of Energy that delivers ten appliance standards in the last year on track to their goal of accumulative emissions reduction of 3 thousand million metric tons, or three giga- tons of abatement for appliance standards by 2030. Other programs that are buildings challenged and plants challenged and a whole suit of other things in motion to drive efficiency.

Just a quick word on what we're doing beyond the energy sector. So the non CO2 greenhouse gases are really an important part of the picture for us, and an example of that will be the hydro-flora carbons, emissions that are growing so quickly. We are, of course, working on the diplomatic front intensively towards an amendment to the Montreal protocol to comprehensively and globally address HFC emissions, but in the meantime we are working very quickly and on the domestic front as well.

That includes convening and outreach and real leadership by U.S. companies and global companies including this set of commitments referenced on the slide to take private sector actions that would avoid 700 million metric tons, the CO2 equivalent cumulatively through 2025, but it also includes policies taken undertaken the EPA, under the Clean Air Act that have more impact and more to come on that front.

And as I mentioned, we're very intensively engaged in all of the terrestrial carbon fluxes both measuring them ever more precisely, and doing what we can do bolster our carbon syncs

as part of our overall efforts. And then I'll just wrap up with this slide that shows some of the results that we're starting to see. This is actually a snapshot of the overall primary energy use in the U.S. in 2005 and 2012, and I think it's mainly worth noting that over a period of time where real economic growth occurred, we see overall energy consumption declining substantially, so remarkable progress on energy productivity, and of course you see some of the mega trends you're aware of in the energy sector on this slide. The doubling of renewables over this period, and the non-hydro renewables, excuse me, and the natural gas playing an ever more important role and the petroleum savings from fuel economy measures and otherwise.

We think that the suite of efforts in motion through the Climate Action Plan measures like the EPA's Clean Power Plan for the power sector will build on and accelerate this momentum, and we are accordingly on track to hit our 2020 goals, and laying the foundation to deliver against the 2025 goal as well. Thanks and I look forward to the discussion.

>>John Holdren: Good, and thank you very much for those reports, and the floor is now open for questions and comments from PCAST members. The first flag up is Maxine Savitz.

>>Maxine Savitz: We're all very excited and delighted for all these years of work coming together. A question I have, how is there going to be measurement and verification of what each of the countries are doing and the reporting so you know along the way the transactions to the goals, particularly related to what we're doing and also China. There are skeptics who say they're saying it but it's not going to happen.

>>Richard Duke: Let me start and I am sure Kelly will want to add something. It is a centrally important question. We think these transparency mechanisms are the core of the answer. When you look at the bi-annual reports that I have mentioned, and when you listen in to one of these multilateral assessment processes, where every country has a chance to challenge the country that is presenting their actions and their emissions trends, we think that gets back to what is needed to create the clarity and accountability for every country. We're doing everything we can to push more for that in the Paris outcome. We think we made some very important progress in Lima in securing more commitments from all of the countries to those kinds of transparency mechanism, and I think frankly, it's incumbent upon civil society to make sure, and the academic sector and otherwise, to make sure the process is taken seriously, and the right kinds of data are available, and that everyone feels that accountability. I'll note as I eluded to already, in the carbon sector, there's particular challenges, and we have tried in our first biannual report to be very forthright about the fact that our projections around future land sector carbon fluxes are necessarily uncertain at this stage, and our data are imperfect in those sectors. It's certainly true for other countries as well. We have tried to squarely acknowledge those challenges and we're working very hard to remedy the data and measurement challenges in that part of our emissions, our net greenhouse gas emissions, and so that's just an example where I think these transparency mechanisms do help to surface challenges around data and accountability, and it has certainly been part of motivating us to address those challenges as best as we can.

>>Kelly Gallagher: Let me just add a couple of points about what we achieved in Lima in

this regard and I also want to talk about... We thought a lot about this in the context of the U.S. China agreement so I can tell you how we thought about it. Paragraph 14 of the Lima Call for Action contains a whole set of recommendations of what should be included in the INDC. Like, you know, your reference point, what is your base year, time frames, periods for implementation, scope and coverage. It's a very detailed paragraph and the whole idea there is to try to get in the outset, in the INDCs, as much detailed information so that we can track it over time, and so that countries will report over time through this assessment process, and will be able have that kind of dialogue with them. To be able to say, well, in 2015, in your INDC, you said this about this sector with this baseline and this scope and coverage. That's an important outcome for us in Lima.

With respect to China, this has been a very sensitive issue for China over, kind of the past, I don't know, two decades, I guess of negotiation on climate change. We were really pleased by the way China decided to put forward its targets, so first of all, we'll all be able to track whether or not China peaks and I think that's a very clear, you know, measurable outcome. And we will able to see if China begins to slow at the rate of growth of emissions during the time period between now and 2030.

Also, though, the fact they complimented the peaking target with the non-fossil target, is very helpful. It's not like China can magically install, you know, 800 to 1200 giga-watts of non-fossil energy in 2029. They need to start doing that, and they already have, frankly. They need to start doing it right away and that's very tangible and physical assets that we'll be able to monitor and see between now and then. And we also think that complimentary target will help China to peak earlier. It changes business as usual, whatever business as usual would have been for Chin, and we also hope it will allow China to peak at a lower level than it would have otherwise without the target.

So we thought they were good ways, we will be able to see what China is doing and we also, in our own analysis, try to think about how the United States and its target compares in terms of rates of reductions, annual rates of reduction with other countries. Now, it wasn't possible to do that for China because of the way they put forward their targets, but we were able to compare the US target with the European union's new target, and it turns out that the expected annual pace of reduction is exactly the same between the United States and Europe, an annual pace of reduction of 2.8 percent.

>>John Holdren: Good. Dan Schrag is next.

>>Daniel Schrag: Thank you, and thanks to both of you. I have to say you've really rejuvenated excitement in the international process by this and I have to say also, not just the international negotiation process, but also, you know, getting China to take these steps clears away a major political obstacle in the U.S. and one of the long term objections. Whether it actually results in any action on the other side of the isle, we'll see, but clearly China getting serious about this is a huge step forward and congratulations to both of you. I have two questions, one about China and one about the U.S. One is about nuclear in China. As we know nuclear in the U.S. is slow, the economics are very difficult. But China is going full speed ahead. The AP1000 program seems to be accelerating and the claims at least, from Westinghouse and China, are that a number like $3,000 a kilo watt are, those are the numbers being floated

around which is a huge drop from the $8,000 or $9,000 which are being talked about here. Of course, the big concern is that if China has an accident, it could put the brakes not only on nuclear in China but nuclear all around the world. So the question is, are there ways and really, Rick, this is a question, you probably have expertise in this from your old DOE days, the question is are there ways that the U.S. can engage with China on that program to make sure that to the best ability possible, we help them put in the safety capacity to make sure that doesn't happen because that's going to be a very part of our mix as well if we're going to achieve our goals. Because we're going to be losing our own nuclear fleet over the next 30 years as the retirements occur. On the U.S. side, if you look at the CO2 reductions we have achieved so far, the two biggest factors are shifting from coal to gas in the electricity sector, and a reduction in petroleum consumption, and of course, the petroleum consumption is partly driven by the recession, and partly driven by the sustained high price of oil, and that's now collapsed. And the question is how do we think about that? Do we think that the CAFE standards are enough to combat the market forces that are going to be pushing the other way over the coming years, and what do you think about that?

>>Kelly Gallagher: I'll start with China. I am tempted to defer to Pat Falcone on this question on nuclear but let me just say, China is banking on a very large expansion of nuclear power in order to meet its non-fossil target, and to achieve a peaking in 2030. If you look at what the business as usual estimates were for peaking by other international sources, many were post 2040. If you look at the world energy outlook, it was after 2040. The US EIA was 2038. The MIT Chinois Study that's been referenced a lot in the news was after 2050, so one way, one very substantial and important way that China intends to achieve these targets is through a big expansion of nuclear. I have no idea if those price numbers are accurate. I think it's fair to say that nuclear isn't cost competitive with many other options in China either, but even so, China is really committed, clearly very committed to a big expansion of nuclear and so the question you raise about plant safety and also about non-proliferation, I think you were implying that, are good questions and those now it becomes a very significant challenge for us to help China make sure they do it well.

>>Richard Duke: Thanks for the questions. I'll just say on the question of China briefly that, of course, there's tremendous substitute ability in the power sector as you know, and part of that is the energy efficiency opportunity and it's worth underscoring how central to China's plans energy efficiency is. That's really one of the key drivers of this for them and so it's hard to know from today's vantage point what mix of nuclear renewables even carbon capture, but most centrally efficiency will end up delivering what they need. We are optimistic that some combination of those will allow them to deliver these new goals they have set. I think you're absolutely right that in the -- as the (inaudible) case shows, there's a collective interest in nuclear safety since we all rely on nuclear as part of our clean energy solution set, and we all deal with reverberations of any kind of accident that occurs so that's certainly a priority for the administration in China and more globally and we'll stay focused on that. On your second question, with respect to some of the key drivers for emission reductions and what the trends look like in particular in light of current oil price movements. Let me just say first, the coal and natural gas shift that we have seen in the power sector is something in many ways, it certainly

has been an important driver of some of the recent emissions reductions, it's also worth noting that trend has largely stabilized as natural gas prices through this Shell Gas opportunity came down, you saw in a sense of - - I won't call it a one-time shift but it was largely a one off, and so as with renewables, also for natural gas and in general, for the power sector, we think that the critical next step is a durable foundation for sustained transition towards ever cleaner sources in the power sector, and we think that's exactly what the EPA's Clean Power Plan will allow states to do through their respective state plans to give that certainly to investors for the long haul and that transition in the power sector.

On the transportation sector, I think that you flagged a number of the key moving pieces. It is certainly true that in that sector and economy wide, the 2009 recession did temporarily drive down emissions, but as I indicated in my final slide, we have continued to reduce overall economy wide greenhouse gas emissions well after the recovery took hold and we have had, as you know, years and years now of very sustained job growth and economic growth that's fantastic track record at this point for the economy, and we continue to drive down emissions even as the economy has grown. And we think things like fuel economy standards for vehicles are part of that approach because we're saving consumers money through those fuel economy standards at the same time we're driving down emissions, and that's a perfect formula.

And then with respect to the question of oil prices, I think I'll just reference the President's remarks this week where he did, I think, very appropriately, remind consumers that oil prices have been and will remain variable and they shouldn't probably run out and buy gas guzzlers just because the prices are low right now.

>> John Holdren: We have about nine minutes left and three flags up. That means the questions and answers can only take three minutes per flag. Mario.

>>Mario Molina: I would like to be very brief then. I was going to make a comment and I'll make it very briefly just to thank you for being here and also about the China achievement is indeed huge. It's a big change from the field of protocol which was a non-starter that only developed nations should get started. But the question has to do with using these carbon syncs, that's a possibility of including those in the INDCs as part of the commitment to reduce emissions, and I mentioned that because here in PCAST we had some time ago, we were working on project on offsets. We didn't quite publish the project but the conclusion was is it was not quite sensible to include these carbon syncs as part of the commitment to reduce the emissions because of all kinds of issues like the ability to measure it like Maxine mentioned, and also permanency. It's clear that there's so many benefits not to have deforestation of tropical forests, the sort of thing that Brazil is doing, but then again the question is do you include it as part of your reductions and clearly, reforestation is another issue because you can't guarantee that it will last long enough. we can't (inaudible) I don't know whether in Lima, any of these sorts of things came up and whether it will indeed acceptable for developing countries to include this as part of their commitments.

>>Richard Duke: Thanks for the question Mario and that's a very important topic for us and I think globally as well. As I sort of noted briefly in our first biannual report, we really did very intentional and very transparently show the range of uncertainty in our estimates of future

carbon syncs for the U.S. economy. I think those challenges are absolutely present for us and for other countries, those measurement challenges that you're referencing, and I feel we need to work our way through them because if one takes the long view on this challenge as the United States, Euro, and other countries drive down emissions of greenhouse gases, the sort of remainder in terms of terrestrial carbon fluxes becomes ever more important in a sense.

If anything, I think we need to simply invest more intensively in the analytic and data and the measurement and the methodologies to make sure we have a handle on that increasingly important sector of our economy and the global economy, but the challenges you referenced are very real. And so we're committed to kick starting those efforts domestically and we're working as much as we can with other countries on the comment measurement challenges.

>>Kelly Gallagher: Let me quickly answer your question on whether it's going to be allowed in INDC. Anything is allowed at this point. Every country is allowed to choose whatever they want to put forward as part of their INDC but this introduces risk. You need to be able to account for your emissions going forward.

>>John Holdren: Good, Michael McQuade.

>>Michael McQuade: My compliments again on the China work which is a spectacular announcement for all us of us and to Dr. Duke, thank you for the work you did on the previous life on greenhouse gas cost abatement curves, and the amount of hours of fun activity that generated for many of us trying to understand this stuff. Very specific question on the last chart you had which was showing the transition from various fuels, fuel sources, I'm struck by the fact it goes to 2012 so in some sense, it doesn't yet really show the impact on hydraulic fractioning and alternate gas transition at the level that's occurred over the last two years but I think there's even an acceleration there, similarly the cost curves on PV that you show, they have gotten cheaper. I'm curious then, we doubled solar and wind between 2009 and 2012 and yet you're suggesting we don't double again for twice that long. Is it low hanging fruit? Is it natural gas is cheaper? Is it being conservative? What do you think?

>>Richard Duke: Thanks for the question. This takes me back to my dissertation work on the buy down of technology including solar and I think what you see there is of course, doubling becomes harder as you have a la intervals there simply reflect that math. We are very optimistic about this suite of clean energy solutions we have in the power sector and more broadly, and we think as a practical matter in terms its of the non-hydro renewables pace, we will and can sustain a very rapid pace that allows that set of technologies to play a huge role in our power sector going forward. And in an ever larger role and again, the thing that has been missing for renewables policy is stability, and the Clean Power plan forthcoming from the Environmental Protection Agency provides that durable foundation for investment through 2030 and effectively beyond. So thanks!

>>John Holdren: Rosina Bierbaum

>>Rosina Bierbaum: Since time is short, congratulations - an exciting breakthrough and it

really does raise optimism for Paris. Let me just ask you to amplify on two areas that PCAST is really interested in, where you started Kelly, carbon capture sequestration demo and then the smart cities. The last time I looked at this, the World Bank's World Development Report suggests that we need 20 big demo CCS projects to prove in geologies and geographies that this will work and that's a monstrous wedge CCS that is needed to keep us anywhere near the two- degree increase world. So if one of you can say something about the two-degree increase world. I was wondering if you could talk about the cost, size, and demo and prospects for others, and then second, on the city summit, is it like smart city you are thinking about kind of smart cities of today or kind of brave new worlds with autonomous vehicles, electric cities, etcetera, because PCAST is thinking about both of these issues, thanks!

>>Kelly Gallagher: Ok, let me be very brief, on the CCS question, it is clear it would be very helpful and useful if we had that technology available here in the United States in terms of being able to increase ambition over time which is something we would like to go and it's crucial in China. When we were doing a lot of modeling about whether it was possible for China to peak even earlier than 2030 a crucial question was is CCS available or not. That's why we were so pleased that China agreed to do this project with us on carbon storage because we can't afford to wait much longer in getting a long term storage project up and running in China to increase confidence in the technology or at least experiment with it and demonstrate it.

The Chinese are actively exploring sites right now. We have already actively begun seeking other countries to partner with us through the Carbon Sequestration Leadership Forum, and a number of firms have already approached us with interest in participating with the project so the goal is to get a feasibility study going this year, this calendar year and to get it moving as fast as possible.

The Enhanced Water Recovery project, EWR project is going to move even faster because the site has already been identified and the firms have already committed, but that's at a smaller scale so that will launch this year.

On the cities question, initially the summit that we're looking to hold in fall of this year, will really be focused on sharing best practices of cities of today but the sort of second track of the cities piece which was the smart infrastructure for urbanization, that was suggested by the Chinese because they're looking at building so many new cities and they wanted to build smart cities, not dumb cities. So there, I think we're trying to really develop a work plan and that's something we have to do by this strategic and economic dialogue which is going to be in May or June of this year.

>>John Holdren: All right, we have not exhausted the subject but we have exhausted the time allocated to discuss this morning so I want to thank Dr. Gallagher and Dr. Duke for very informative presentations and a great discussion. It was terrific to have you with us.

Lab-to-Market Progress

>> John Holdren: We are now going to switch topics to consider progress on advancing the pace of translation of discoveries in the laboratory to applications in the marketplace and elsewhere in society. To lead our conversation on that subject, we're fortunate to have Doug

Rand who is assistant director for entrepreneurship in OSTP and a remarkably multi –talented individual. Doug has undergraduate and master's degree in evolutionary biology from Harvard, a law degree from Yale Law School, a business degree from the Yale School of Management, and he writes plays. Doug, pleasure to have you with us.

>> Doug Rand: Thank you, Dr. Holdren, and thank you all it's an honor to be here this morning. I'm mindful that this presentation is sandwiched between a historic breakthrough in global climate negotiations and New York Times best-selling author but I'll try to keep it interesting.

So I wanted to give a progress report on all of the lab to market activities going on as a presidential priority. As the President has stated many times, at the same time that we need to sustain and increase the nation's investment in the R & D enterprise, that R & D is essential also for keeping America's competitive edge and enormous economic impacts in terms of job creation and sometimes the creation of entirely new industries and I just wanted to include this quote from a recent trip he made to the Argonne National Laboratory.

So these lab to market activities that we'll talk about together today—I wanted to do just a quick bit of framing so as you all know, the federal government spends over $130 billion on R & D each year which is an incredibly important national investment. This is connected primarily at universities and federal laboratories and what we're not talking about today in terms of R & D commercialization, tech transfer, lab to market, call it what you will, is the very gradual long term more or less unpredictable spill overs from basic research that we all know have massive economic consequences in the long term. That will continue to happen as long as we maintain this large and important investment in R & D over all.

So an example near and dear to my heart back when I was an evolutionary biologist, is that, you know, if it wasn't for some biologists picking around at some hot springs in Yellow Stone, we wouldn't know about the, you know, the thermophilic bacteria which led to tack polymerase, PCR, which led to all modern bio-technology.

So I don't think, correct me if I'm wrong, I don't think that the micro-biologist poking around in Yellow Stone had a revolution in bio-technology in mind but they just wanted to look at cool bugs and so when we talk about economic impact, of course this long term unpredictable process can't be over stated. What we're talking about today is what are the technologies that are being generated through federal funding, whether, you know, internally at the labs or externally at the universities that are on the edge, that are near to the edge, that have near term potential maybe within a decade to make that leap from a laboratory experiment to a marketable product and one thing that the White House has been trying to do in collaboration with the agencies and universities is really taking a holistic view of this R & D commercialization process that traditionally there's been, maybe not a singular focus, but a pretty strong focus on just the transaction of IP licensing. You know, in the wake of Bayh-Dole and other important legislation that we open up a bunch of tech transfer offices and open up the volts of IP and we try to, you know, open up that marketplace and just see what happens and that continues to be important. I mean, we should talk about streamlining those transactions but we wanted to take a more holistic view of all the different elements that are necessary to accelerate that translation of federally funded research from a lab to the marketplace.

So one quick review of the policy milestones here in terms of these efforts, the President signed a presidential memorandum in 2011 focused on all of the research agencies with a big footprint in terms of federal laboratory research and that led to, and that continues to lead to a renewed focus across agencies on the importance of accelerating technology transfer and also a focus on, not just licenses to big companies, but spinning off high growth start-ups as well.

There was an important PCAST report in 2012 that really talked about the future of the U.S. research enterprise over all but spent a lot of time, I think, very helpfully emphasizing the importance of collaboration with industry, both in the part of national labs and universities and then about a year ago, the President rolled out his management agenda as part of the last budget which really covers a range of activities to improve the efficiency and effectiveness of governing for the 21st century. As one important part of that is lab to market—how do we open up government assets as a platform for innovation and job creation and that includes open data on the one hand, which I'm sure is a topic you have heard a lot about but also federal R & D and promising technologies is another government asset that which is another government asset which the public has invested in and we want to improve the return on that investment.

So there's about—and this president's management has led to a sustained inter-agency approach. It's part of—there is a cross agency priority goal that's dedicated to it that OMB is monitoring on a quarterly basis and so it's driving a lot of activity throughout the agencies in five major categories that I wanted to run through with you and give you a couple of concrete examples of the kinds of promising activities that we see driving and accelerating this lab to market transition for promising technologies.

So one is developing human capitol, so this is an example of something that really isn't about transactions. It's about the transfer of knowledge between the private sector and the public sector.

So first is outside in. How do we get more individuals with really deep private sector expertise into the government, into the national labs, not just to, you know, go hunting for the one promising technology that they're going to pop out and form a company around in their next act, but really too deeply embed in an agency, really work closely with the technology transfer professionals, you know, within agencies as well as the researchers and serve as a resource and collaborator within the agency to improve technology transfer broadly. We have seen some really promising successes on this front with NIH which has really pioneered some entrepreneur and residence type programs so where they brought in folks with private expertise to help them evaluate their entire portfolio technologies. Right now, through the Presidential Innovation Fellows program there's some extremely talented fellows at the Department of Energy right now who have just been let loose to do some really, really important work that, you know, we'll have more updates on in the future to improve the transparency and translation of Department of Energy technologies. So that's the outside in tactic that we're trying to pursue and more agencies—technology transfer fellowships, entrepreneur and residence—call it what you will.

And then there's inside out. How do we make sure that really talented researchers within the federal labs who want to make that leap and try to commercialize a technology that they themselves have developed, have the ability to do that in a way that's responsible and ethical, not unduly burdensome. Now obviously, I'm sure you are all familiar with a lot of

universities have experimented successfully with entrepreneurial lead policies for faculty and, you know, we want to hold up those examples and hope they spread more but also figure out how we can make that more of a standard way of doing business within the labs and one interesting distinction that we found through this inter-agency work is that most of the government owned contractor operated labs, primarily the Department of Energy, if you look around, we did an inventory, most of them have some kind of entrepreneur leave policy, some of them with pretty good stats around. The real problem is with government operated labs, primarily the Department of Defense, or NASA or NOAH, you know, wherever you look, there isn't a rich tradition of entrepreneurial or industrial leave there, in part because of the perceived and real barriers in terms of ethical concerns.

These are real concerns. We don't want to be, you know, steam rolling them in any way but there's an interesting pilot that's a foot of the army research lab to figure out how we can do this under existing laws and regs and we continue to work with the Office of Government Ethics to see what additional opportunities there are. So hopefully not too long from now, the GoGo labs will have this as an embedded process as the GoGo labs already do.

And then finally under this human capitol effort, there's a really promising trend right now to deliver really high quality experiential entrepreneurship education to federally funded researchers and that includes both students and investigators and it's starting to include both university researchers and national lab researchers and one of the programs that's delivering this that you may already be familiar with, but I want to spend a little time reviewing, is innovation core, or, I-core, which began at NSF in 2011. So it's still a pretty young program and is really focused on identifying small teams of scientists who may not have had any kind of training or experience in entrepreneurship and putting them through more or less a three month boot camp and not technology maturation, right? They have already got the technology. They already have a hypothesis for what its commercial applications would be, but really to test those hypotheses about the market application very rigorously over a very short period of time by "getting out of the building" and talking to 100 or more potential customers in a very short period of time. This is the lean starter methodology that has become in many ways standard, you know, outside of academia and—but it's very well suited for these small research teams because it is effectively bringing the scientific method to the process of commercializing a new technology and spitting out a company and we've seen some really compelling successes both in terms of, you know, hard data, in terms of, you know, companies that have actually raised follow on private capital and have successfully spun out and are delivering technologies and also, anecdotally, this can be a life changing experience for faculty and students.

The teams usually consistent of a PI plus either a, you know, a post-doc or graduate student, sometimes even an undergraduate is the actual entrepreneurial lead and then it's incumbent on the teams to also bring along a mentor with private sector experience. So, it's not NSF identifying the mentors. The team actually has to bring it along.

So this started at NSF and they—NSF created a national innovation network with a number of funded nodes so you can see on this map here there's one at Georgia Tech, there's one at the University of Michigan, there's some multi-institutional nodes in northern California, southern California, Texas, here in the DC area and New York, and then the orange dots are I-core sites which are smaller grants for really capacity building for a lot of diverse regions of the country to develop teams that can then compete to join the I-core process and some really

exciting developments we have seen just in the last year is different agencies getting into the game and piloting this in new and exciting ways.

So very recently NIH committed to adapting the I-core curriculum for biomedical researchers and its own portfolio and also adapting it for SPIR grantees. So, there are two important adaptations. Figuring out how you deliver this curriculum for devices and therapeutics and other biomedical innovations and also how we bring it a little bit downstream for small businesses that have already received federal funding but may also benefit themselves from testing their hypothesis and one thing I should have mentioned is that it is more or less inevitable that during this I-core experience, whatever the hypothesis was for commercial applicability that the team had in the beginning is almost always overturned, sometimes pretty dramatically by the end of the process, and so, you know, for example, I mean, just to pick one example, I saw a team present that had an acoustic technology that they were sure was going to have some kind of military application and they went all over talking to as many folks in the services as they possibly could and then someone had the idea, well we're not getting much traction here, we should really talk to some, you know, some different customers that may not have been on our radar. They started talking to hospitals and by the end of three months they completely pivoted from trying to develop something for the Navy to trying to develop a more portable, low-cost sonogram for the hospitals that has a much greater chance of commercial success and that they never would have thought of going into the process. So we're seeing NIH pilot this for bio-medical research and for existing small businesses, not pre-commercial academic teams, and another exciting development, just recently, the Department of Energy announced the winners of an intramural solicitation so that ENREL is going to become a new node in this network and is really going to bring this curriculum not to just to intramural university researchers but to researchers within the national labs where there's an enormous about of expertise, and enormous amount of entrepreneurial ambition but this will be carving a new channel for that, and so, a number of the DOE labs are getting in the game and will be selecting teams from within the labs to pursue this boot camp so we're looking forward to the results of those pilots. Another major theme we're pursuing with the inter-agency is empowering more effective collaborations. So, you know, from an agency-wide level, how can we give an agency—really make it real that they're prioritizing R&D commercialization consistent with agency mission and we're seeing some interesting activities both at Department of Energy, championed by Allen Williams who, you know, was, and to an important extent remains a senior advisor on commercialization to the secretary and is now, of course, the confirmed director of RBE and also there's some interesting activities going on at DOD to make sure that technology transfer and R&D commercialization are a core part of what the enterprise is doing across their labs.

We're also looking to really look through the entire rule book and make sure that all of the labs really understand and make use of the full range of technology transfer authorities that already exist. We were very pleased that the Congress approved the President's request for $6 million in the latest appropriation for NIST to really beef up its already important role as an inter-agency coordinator for lab to market activities, and so, I think you are going to see rapidly this year them coming out with some really high impact materials for agencies to use that don't just expose the existing authorities but really make an important pitch for what the best practices are and what the most promising approaches are that most agencies can adopt.

And then there's some interesting activities going on in terms of co-funding of this kind of, you know, R&D and translation activity. You know, one interesting example is in the last farm bill that was passed, the Secretary of Agriculture is now authorized to set up a $200 million fund that they are calling the foundation for food and agricultural research which much like the foundation for the NIH is going to serve as a bridge between, you know, private sector funding, food and agricultural R&D, and inter-mural research and so we're looking for ways for more agencies to do that, with or without a special congressional appropriation.

Another arena where we're making progress and I think is an exciting spin on what would be more sort of traditional focus on IP transactions is bringing open data to lab to market. So, every federal agency, every university, has a portfolio of intellectual property that's ready for licensing right now but data about that intellectual property is pretty balkanized. It's in a lot of different silos. Even agencies that are doing a great job exposing that data on their own web sites don't necessarily make it easy for that information to be harvested by a lot of new comers in the marketplace that want to try to create, you know, one search to rule them all and so a number of agencies have made good strides in opening up that data in raw form, putting it up on data.gov/research as a substrate for innovators to try to build new and better search tools and so we continue to try to make progress on that. I would single out NIH. They've really done some excellent work, frankly on a shoe string budget to experiment with APIs and RSS fees and other ways to make sure that the raw data is available, not just a proprietary search tool and we are going to see a lot more developments on that front in the coming year.

We also want to make sure that all of the data about federal R&D facilities—so not just the intangible assets of IP but tangible assets that external innovators and entrepreneurs can use that at least the raw data about what's available is out there and so NASA, NIH, NIST, DOE and other agencies are opening up that data on data.gov and are also exploring ways to streamline the process.

In this slide here, I just, just two examples. The researcher in the upper left is using an advanced photon source at Argonne which, you know, has a long tradition as a user facility of allowing external researchers and entrepreneurs to—and in this case, I think it's a battery company to use equipment that they never could have afforded otherwise, and so, you know, if you want more of something, reduce its cost. We should be using this public investment in R&D facilities to reduce the cost of innovation, particularly for small innovative and boot strapped, often boot strapped, companies and then the President, when he was at tech shop last year really emphasized this. You know, he talked about, you know, how we should take these investments, increase their utilization.

He did make the point that there's probably a particle collider here and there that he doesn't want anybody messing around with but, you know, aside from that, there's probably a lot of important resources where we can increase the utilization rate.

There's also more we can and should be doing to streamline and simplify IP licensing. The NIH and Department of Energy has done great work on this and, again, not just exposing data about the R&D facilities that are already available, but making those transactions more streamlined so there's a lot of footwork at DOE and elsewhere that is going to be exciting in the year to come to make that happen.

We also wanted to make sure that, you know, the now greater than $2.5 billion

investment that the federal agencies make in the on small business innovation research program and also the small business technology transfer program. This is the core part of our lab to market activities because this is R&D conducted by thousands of small businesses per year. It is federally funded and is often, you know, a bridge between what goes on in the labs and what is ultimately introduced to the marketplace.

So there's a number of efforts of SPIR to make the solicitation topics more transparent, so more innovators even know these types technologies exist, to streamline the application process so it is less burdensome, to reduce undue burdens during the SPIR performance period so that companies can and are encouraged to pivot in line with the lean lodge methodology that we talked about earlier, make sure that the best practices for commercialization activities are shared across agencies, and to make sure that over all the solicitation topics put up A&P are aligned with national science and technology priorities. Like, for example, at the Maker Fair—White House Maker Fair earlier this year—a bunch of different agencies with SPIR programs announced some really high potential impact solicitations around, you know, 3D printing and other core technologies to make manufacturing more affordable for small businesses. Finally the last pillar is how do we evaluate impact.

So, you know, in the near term, thanks to the presidential memorandum I mentioned earlier, NIST is leading the agencies to collect much more diverse suite of metrics than they had in the past and that will come out in the next technology transfer report that's submitted to Congress. So this is, you know, not just inputs like R&D expenditures but also, you know, outputs.

So the number of IP licenses, the number of creatives, is something that has been collected for a long time, but there's a lot more new metrics that agencies are collecting in terms of, you know, how many new start-ups are being created? How many creative are for small businesses?

So we'll get an interesting new lens coming very soon about some of those near term outputs. But, of course, the ball game is not just near term output metrics, it's longer term economic outcomes which are, for a variety of reasons, harder to measure. It takes a while to know whether the creative you've executed today actually leads to, you know, a new product or service. There are barriers to collecting that data from companies, of large or small, you know, many years out. There's a lot of efforts afoot to try to make it happen more effectively whether you look at I-Edison at NIH or the Star Metrics Program at NSF or what NIST is collecting so, you know, in the near term, NIST I know is trying to look at least, you know, aggregate all of the great literature on how we measure longer term economic impacts so that agencies can be guided on that front.

So those are the five pillars. Just quickly before we go to Q and A, I wanted to conclude with a couple of areas for exploration that the inter agency is looking at as part of this lab to market initiative. We want to make sure we're not just focusing on the inter mural labs, that we are engaging with universities, because all of the things we talked about in terms of opening up IP data, in terms of streamlining access to R&D facilities, is something where, you know, universities are going to play an incredibly important role alongside federal labs.

There's a clear theme across technology transfer offices, intramural and extramural, in terms of, you know, pursuing a paradigm of high quality deal flow that leads to the best long term impacts as opposed to just trying to chase the highest revenue deal in the near term that

we want to encourage and them, one kind of grass roots phenomenon that I think is really compelling is that a number of federal agencies are starting to support start-up accelerator programs in a lot of different arenas. So these are, you know, a little bit of money, a lot of mentorship, a short, urgent burst of activity to get a promising, you know, start-up team from idea to prototype and this is happening all over the federal government, whether it's the Sun Shop program at DOE, launching its Catalyst program to reduce the cost of solar technologies. The State Department has a great program for technology and science entrepreneurs, particularly in the Middle East and North Africa. The NIH is opening up its vaults, not just opening up its vaults, but highly vetting technologies that it wants start-ups to have commercialized they have formed a breast cancer challenge and a neuro challenge around that. The DOD is getting into a similar game in partnership with Arizona State University with its Furnace program. So, AFRL in New York, and a number of other services, are, again, trying to identify technologies that they have in their vaults, that they're inviting start-ups to come in and commercialize and we're seeing that with health IT at HHS as well.

So that's the end of my remarks. I'd love to spend the remainder of our time addressing any questions you have or any ideas for further action to achieve greater lab to market impact. Thank you.

>> John Holdren: Good. Well, we have flags up already. Susan Graham was the first one I saw. So, Susan?

>> Susan Graham: I want to come back to the issue of opening up RNDS and making the IP available and so on and I wonder what thoughts you have about how to actually pull that off. There have been situations in the past where the community has expressed an interest in having data of that kind and actually making it happen in the government seems to be incredibly difficult.

>> Doug Rand: Sure.

>>Susan Graham: How are you going to do it?

>> Doug Rand: It is incredibly difficult in government and it appears to be incredibly difficult in the university space as well. That's the bad news. You know, I think the good news is that we're seeing more progress on this front. I don't think it's ever as rapid as one might hope at the outset, but let me give you a couple of examples. I mean, there are kind of two approaches that are emerging. The traditional approach is, you know, let's have the government build a website that tries to, you know, draw data from a number of different agencies. The federal lab consortium has done a great job at this. They continue to put out new iterations of their own, federal technology search tool, which is really helpful. But, you know, they face the challenge that any site like this, you know, even outside of the R&D context faces which is it requires, you know, buy-in on the activity on the part of every single agency and sub-agency and that's an additional task, an additional burden and it isn't necessarily something you can count on. So they will continue to build out that tool and I think in some highly productive ways.

But at the same time, I think a newer approach is in line with the open data initiative and the presidential executive action on open data is—whatever we're building, we should make the raw data open and machine readable and easily accessible, so that we're not just building a data base that some external party has to come in and scrape the data to build their own tool. We're making that data open from the outset and that's something that the Department of Energy is in the process of doing with its own. I mean, they invested a lot, I think, in a very useful and powerful IP search tool throughout their entire portfolio. I think it's like 16,000 different patents. Now, they're working to make sure that they're using the latest technologies and opening that data up in raw form so that external innovators can build their own search tools that may be complimentary, and so, I think that's going to be the key going forward, is making sure that all the agencies are doing like DOE and NIH and others are doing to not just build their own search tools, trying to make their own search tools, as good as they can, but acknowledge that, you know, your average entrepreneur or even big company looking for a promising technology isn't thinking, let me go agency by agency, right?

They're going to want focus on a technology arena that may have a relevant IP across a bunch of different agencies, across different universities, so we're in active discussions with universities as well because they face the same issues. Every single technology transfer office—they've got the data. I mean, that's their job is to expose that data to potential collaborators and licensees. But there are some, you know, if we're successful in building the tools to open this data within the federal agencies, I think we can hopefully be able to share and improve those tools with the university community as well.

>> John Holdren: Good. The next person I saw was Bill Press.

>> William Press: So, when I was a manager at a national lab, the tech transfer office reported to me, and I got to celebrate the triumphs which were typically when there was someone at the national lab who had an entrepreneurial bent and they had a com—what they were bringing to the table was a combination of IP and the human capital in themselves that they wanted it to succeed. But sadly, at least in my experience, that was the exception and not the rule. The rule that I got to see more of was sort of the failed marriages, you know, the jilted suitors where the company would come in and license something and before the license was signed, the PI in the lab was just very enthusiastic they would license this and afterward, that person, for perfectly valid reasons, didn't want to go off and take entrepreneurial leave and spend a few years of their life , and I got convinced that if we could find a way to unleash it, there's just much more IP there than can be touched if the model is that the IP developer also has to be the human capital who is willing to, you know, sink risk and their life into it because people often go to national labs to make their careers there, not take entrepreneurial risk, but to work in basic or applied science in, I don't know how to say it—a gentle atmosphere both compared to academia and compared industry.

So I perked up at your idea of the tech transfer fellows. I wonder, do you see them as playing a role where they could be circulating in some way as a resource within the labs, so that they could capitalize, pun intended, on these cases where the IP doesn't have the required human capital attached to it?

>> DOUG RAND: Sure. Thank you. I think there is a lot of potential there on at least, you know, two different fronts as you said, you know, outside in and inside out. So, I think there's a lot of potential to bring that private sector expertise, to bring these fellows who kind of want to, you know, spend some time in the national labs, not to just make the deal, but to give back to the country, and circulating them, not just at, you know, at headquarters here at Washington, but also out in the labs is a really good idea we would love to see more of.

That's a fine question. You know, we have seen some interesting models and we're trying to make it clear, it doesn't actually cost that much. So, when NIH did its entrepreneurs and residents program, they had a couple of innovative approaches. Some of their EIRs were funded in collaboration with a non-profit in Maryland that kind of put them on its payroll for a fraction of their time but kind of brought in some third party funding to let them run around NIH. They were also able to, in some cases, use SPR administrative funds, like a carve-out from SPIR to fund some of these folks, and also, you know, we've seen the Presidential Innovation Fellows Program. It's agency funded, but it's not a giant appropriation necessarily. So I think a little bit of money goes a long way, I think, to increase the porosity of the borders between industry and the labs, and then, I would also add that, you know, DOE is an agency to watch on both of these fronts. I think they're doing some really good thinking on how to increase those collaborations that they're looking to roll out soon, and they've already announced this lab core program which is really, really focused on the inside out process of, yeah, it's totally fine and expected and as it should be that maybe the majority of researchers who have chosen to make their careers at national labs want to stay there and don't want to pop out.

But, for those who do, there should be a catalytic programming and training to allow them to do that. And so, that's what lab core is really about.

>> John Holdren: Okay. Chad Mirkin is next.

>> Chad Mirkin: Fantastic presentation—very important area! I think you guys really have moved the needle, certainly at universities in terms of just changing the culture and instilling the concept of entrepreneurship as being an important part of the whole exercise. Even at North Western now, it's a part of the evaluation of faculty which is encouraged at almost all levels which has been really exciting to see, something that wasn't true when I first started my career.

When I think about what has to be done in terms of happening to all this and taking advantage of all the incredible talent and opportunity that we have, to me, there are five categories that really count: intellectual property, talent, culture—and you have touched on all of those in a very significant way—but money and speed are two very important issues as well, and you have talked a little bit about money in SPRR competitions and things like that, but the speed component is also quite critical, and one of the things that's always been lacking from my perspective is that when you have ideas and being able to access those dollars from the government is a very, very slow process and sometimes not in sync with the whole entrepreneurial activity. In addition, and this is connected to Bill's question, the regulations and conflict of interest issues and policies within the labs and also universities vary all over the map, and, I guess, the question is, have you looked at those in detail and asked what we can do

to try to change, adjust, and accelerate within the limits of reason?

>> Doug Rand: Thank you, that's a really good question. I think I would say I can answer that with a hopefully satisfactorily response and then an unsatisfactory one which I would love to get your input on. The hopefully satisfactory response is that you can. Yes, led by the NIST team that's really focusing with renewed resources and commitment this year on inter-agency activities is trying to attack that very question of deeply engaging on, you know, what are the current ethical guidelines, again both real and perceived, and figuring out what some solutions might be that apply to the federal labs broadly across agencies. So I think if we do our jobs we should have good news to report on that front, you know, later this year.

When it comes to universities, I would love to, either now, or later, get more feedback from you and others on what are the levers we can use productively to try to figure out how to sort out some of these perceived barriers because as you said, you know, it's a patch work. Different universities probably have different policies all over the map. You know, everyone has got their own GCs, so, if there are things that we can do, collaboratively with the universities, whether working with some of the major associations or other mechanisms, we'd love to do that.

>> John Holdren: Good. Maxine Savitz?

>> Maxine Savitz: Thank you for your presentation. Two areas—following up on what Bill—I am on the other side, on the industry side. It was at the point that Allied Signal, now Honey Well, and I had the first person ever to come from Oak Ridge to our facility for a year to scale up a process. He was in vetted for him to learn it. It was almost—the whole transfer almost fell apart because the State of California, where we were located, had rules about worker's comp and things like that, that we could not pay for. Fortunately, at that time, Lockheed Martin, who was running Oak Ridge then, had facilities in California. So, they could cover it. So, the whole area of, you know, much easier—it was much easier for me to send somebody down to, or out to a lab, than the other way. Not one, you have to have the interest, but even having the interest, or the policies, regarding the state. So, the federal government either can cover it or some way, I don't know. But it's something—make sure it's still not a barrier. On the IP, in our research enterprise study, we mentioned about how certain universities like Penn State, Minnesota and all, are just sort of giving the IP to industry so that they can scale it up and act the speed as opposed to long negotiations and the amount of money that the labs get back from their IP is relatively small. So, you know, is there a way, by accelerating it, giving non-exclusive licenses, that let people, if they want them, to take it to the next step and sort of open it up so you're not having these long negotiations and then how much you're going to get back after so many years and things like that.

>> Doug Rand: Absolutely, I mean, it's been very interesting to see just over the past few years this proliferation of interesting approaches which are often, you know, unique to a given university, as you have said. You know, PCAST highlighted a number of approaches some universities are taking to, you know, give some away. Other universities are trying to just dramatically streamline the licensing process so there's less frustration involved in it, and, you

know, I think there's a couple of things we have done. We should probably do more to try to encourage that level of experimentation to streamline what's going on at tech transfer offices in new and innovative ways. I think it was helpful when NACIE, the National Advisory Council for Innovation and Entrepreneurship, that's run out of commerce put together a letter from, I think it was about 130 university presidents, that they would, you know, undertake a number of activities to prioritize R&D commercialization and one of them was trying to streamline what's going on at their tech transfer offices. But, I suspect more could be done on that approach and one thing we are hearing from so many universities that is, admittedly, not a deep insight, but, I think, an important one for us to keep in mind is that, you know, the decision rights are really not necessarily at the level of the technology transfer office. You know, the ability to really be, to really be, unburdened by these sort of quarter to quarter, year to year, imperative to be generating revenue—it has to come from the top of the university administration, and so, I think, the opportunity to work at that level with universities I think will be important going forward.

>> John Holdren: Great. Next, is Jo Handelsman. Mic, please. You have to start over because they cannot hear you on the webcast without it.

>> Jo Handelsman: In discussions with Universities, are you talking to the PIs themselves in addition to the tech transfer offices? Because in my experience, a lot of the tech transfer offices think they are doing a better job than the PIs think and that's because they only know about the PIs they know about, and there are many PIs who don't want to start companies, or don't have the connections in companies, but would be much more involved in tech transfer if they had better tech transfer offices, and that is not a criticism of the tech transfer offices. Some of them are just too small to cover the breadth of university discoveries and so the second part of the question is are there ways of collectivizing them and providing some sort of more centralized service for connecting technology with the right company?

>> Doug Rand: You know, that's a really good point. You know, in conversations with tech transfer offices, we should probably, you know, trust but verify. So yes, I think we should explore ways. I mean, you know, anecdotally, I think we get, you know, the agencies and, you know, STP are getting decent feedback from PIs through programs like I-Core where the PIs are the primary participants, but it would be good to figure out how to do that in a more organized and repeatable way.

>> John Holdren: Well, extraordinarily enough, there are no more flags and we have come to the end of the allotted time for this topic so, Doug, thank you very much for a terrific presentation and good discussion.

>> Doug Rand: Thank you very much!

Aging in America: How can S&T help?

>> Eric Lander: Well welcome back everybody after our break. We now turn to a

session on aging, what science and technology can do to help with aging in America. It's a topic that is of great interest to the PCAST and I think of great interest to the President and of great interest to many people in this country and we have two really remarkable speakers, two very thoughtful people who have kindly agreed to come and join PCAST and help educate us and doing this on the web, many other people as well on both the challenges and possible solutions. Now, the question of aging in America is a very broad and complex topic and not all of it touches on science and technology but science and technology is a part of many of the aspects of it and hopefully many of the solutions going forward.

So I'd like to briefly introduce our two speakers. We have with us, two folks who have been to PCAST and we're grateful their coming back and sharing their wisdom again. Molly Coye is the chief innovation officer of UCLA's health system. She is previously the founder and CEO of Health Technology Center a non-profit educational research organization. She has been the commissioner of health for the state of New Jersey and the director of the California department of health services and it's great to have you back. You have been helping us for quite a while.

Our other guest today who is Atul Gawande who is a surgeon at the Brigham Young Woman's Hospital and an executive director of Ariadne Labs, a really exciting laboratory that stretches across the Boston bio medical community and brings people together to think about really novel solutions in public health, both inventing them and scaling them up and I have the pleasure of interacting a great deal with Atul on this where I get to serve on his advisory board for Ariadne Lab which has been really an exciting thing and also in his copious spare time when he's not being a surgeon and the executive director of a laboratory, is a best seller and writer for the New Yorker.

So with these two over qualified guests here, I want to thank you both and I think we're going to turn to Atul first who most relevantly has just written a book that many of us have read, Being Mortal: Medicine and What Matters in the End, who is going to set the broader frame. Well turn to Molly who is going to, I think, talk about specific ideas of what we might do and then we'll leave copious time for discussion because I know that PCAST will be very interested in that. Thank you both. Atul?

>> Atul Gawande: Well, I'm delighted to be here—flattered, and also embarrassed in certain ways so let me make a few disclaimers. First of all, I'm embarrassed because I come to you not as an expert—I'm a surgeon and here we have Christine Castle who has written the textbook on geriatrics, and so I know you have incredible expertise. I am getting to talk too. Second, you know, we're two people coming from the medical institutional frame work and a lot of what I think we both agree is most of the problem is that medical institutional frame work. And so, you know, apologizes for that.

And then what I am going to talk to you about is a lot of what I ended up investigating as part of this book I wrote was about our failures on the medical side that stem from the problems for aging and in the ways we can support better aging and end of life.

So I start out by talking about the idea that I didn't learn a lot of in medical school. I learned a lot about many things but mortality oddly enough was not one of them. Our perspective from a healthcare institution point of view is we're here to fix. We're not terribly good and have not built the knowledge, the support, the technologies around how to help

people deal with the unfixables and the two big unfixables are aging and dying and that plays out in enormous number of ways ranging from economically to how systems run, but at the deepest level about suffering and I think the last five years I have spent investigating the literature, talking to experts, doing interviews with the people themselves. Give me a chance to tell you a couple of takeaways and that leads to a further embarrassment which is, which Eric eluded to, which is technology may not be central to improving the aging experience, though it can be our component, and our failure to innovate in that area reflects a larger picture.

We have added 30 years of life expectancy during the 20th century. Before 1960, that was about adding life to people at the beginning of life. It was to the young and public health measures, improving childbirth and its safety but since 1960, we have added five years for people over the age of 65 so now when you reach the age of 65, you live on average, two decades more and that's climbing and improving. The motivation for my investigation was the medicalization of that phase of our life. That 1945, most people died and aged at home. And by the 1990s, it was nearly 85 percent who died in institutions, hospitals number one, nursing homes number two.

And what we have seen, I think is that we have had a 50 year experiment in medicalizing mortality as treating it another problem to cure and if we can't cure it, we'll treat it. That approach has failed and it has produced substantial suffering and it stems from a couple of key lessons, I think. One is that we failed to recognize that people have priorities besides just living longer. Besides just getting one more week, one more month, one more hour. Our best way to learn what those priorities are for people's lives, what really matters in their lives, why they want to be alive, is to ask them. And we don't ask. We don't ask as doctors. We don't ask as nursing homes, as assistive living centers, independent living, and we don't ask as family members. There are a few basic questions that we have to ask repetitively of people. What is your understanding of where you are with your health? What are your fears and worries for the future? What are your priorities if time is limited? What are you willing to sacrifice and what are you not willing to sacrifice along the course of the way? Who will make the decisions if you can't since 70 percent of us will reach in that final phrase, a point where other people have to make decisions for us and we have not managed that. Once we realize that we don't ask what matters to what people who are vulnerable at the end of your life, we realize we're not asking at the point many stages long before that last few weeks of life.

We're not asking at a key moment which is when you lose your chance to be independent, when you no longer are successfully, physically, or psychologically take care of yourself at home or at least without help. And my investigations were tied to a seemingly—answers seemed tied to a seemingly unrelated study but a set of research studies by a Stanford professor Laura Carsonsen who did a landmark series of research investigations tracking and studying the emotional lives of people as they age and she has had a remarkable series of investigations tracking people aging 18 to 94 over many years of their life, following them over time.

And, you know, the take away from this is that as people age, their desires and their emotions change. We move from getting and achieving to wanting close relationships with people who are very important to us and having intimate relationships and that our emotions change. People, we still live with this myth that as you get older, you get unhappier and in fact, as we get older, we get happier so although our health declines and our abilities decline,

we become more disabled, people age 75 are happier than people age 45. Rates of depression, rates of anxiety. Now, there's a couple of things though. That changes when we institutionalize people. Then people become pretty miserable. And second is that the dramatic change has been that we have not just added years of life over the course of the century, we changed the trajectory of life. In the 19th century, there was no clear relationship between getting older and being at risk of dying. Dying was a universal experience, or dealing with disability or frailty, you could have happen at age 25, 45, you just felt lucky if you got older.

And so therefore, a long time in our history we did not see living a good life as being independent and of good health. That was not, you know, that was not the only goal. If you ask a doctor what our goal is, our goal is to keep you healthy but then we have no answers for what happens when your health declines, when you can't be independent anymore and it doesn't fit with this view that there's a large population of folks that we have to be helpful with who are aging, frail, and dealing with serious illness and the medical focus on health and survival I think is that we're lost if it's not possible, we lose sight that wellbeing is bigger than just health and safety and survival and the result is suffering and I'll point to a couple key places that we see this.

So when you look at the design of nursing homes these days, they're built around safety as their priority instead of around the idea that we're making people's purposes in life more successful. And you see the tradeoffs daily. So they're built increasingly to look like hospitals, they're built around a nursing station. The biggest complaints in nursing homes are about food restrictions. So you'll have medical orders that you can't eat anything against—except—pureed food and people will be written up for hording cookies and you're living in a place, first of all, where you can be written up and second all, that you can have restrictions that say, you know, 85 years old, some Alzheimer's disease, we're worried about your swallowing, you can't have anything but pureed food therefore caught hording cookies. You know, let them eat the damn cookies.

And the further difficulty is it's more than just food and other creature comfort constraints, it's also about being able to identify what is important to you and having the connections that allow you to do it. Often staying connected to community, being able to go to a church or a synagogue outside of that nursing home and I describe places that understand that a life worth living is possible even when your life has become tremendously restricted. And the places that I think we're seeing emerging and there are a lot of them around the country are changing the story by redesigning care and capabilities around supporting autonomy despite often severe disability and often severely poor health.

Technology is part of that but much more is understanding that the goal is that we have a way to identify what people's priorities are and allow them to prioritize them beyond the demand of just safety and medical ideas of survival. I don't know whether we should turn to Molly to go from there but have at it.

>> Molly Coye: Okay, thank you! Well, in theory I should be more of the representative of both technology but also of medical technologies but I read a Atul's book in preparation for coming and for those of you who haven't read it, please do because it's a perfect framing of how to think about how technology could be used to make people lives better towards the end of life and I think you will see as you go through some other series of presentations or reports in

this area, there's a big difference between people who see the benefit of technology is being able to fix an illness that someone has, versus people who see the purpose of technology as supporting individuals to live the way they want to for as long as possible.

And only a part of that has anything to do with their medical condition. So if—I turned off there, sorry. I'm going to go through a very few slides. The first one here is talking about what kind of health system we want to have. I would say that the last 20 years in healthcare, we have been trying to get to a model A. That basically what Henry Ford did was standardize the process of production and he also developed a new means of distribution with the car retailers and what we have been doing is trying to standardize for quality improvement and efficiency the production of healthcare and we say it's the production of health but really, it's the production of healthcare services and we're trying to distribute a little bit more broadly through more emphasis on ambulatory care and primary care. Tesla if you any about it, came in and has innovated in some very new important ways. Probably the most important one is the business model because they're producing something that doesn't require gasoline so it completely changes the economics of the car. We need huge change in the economics of healthcare. We don't have a Tesla yet in healthcare but what they did do was essentially re-imagine what the experience of driving could be and consumer reports gave it a 99 points out of 100. It was the best thing they had even seen from every parameter that they could look at. So these are like some of the best institutions that Atul describes in the book. All around the country we have Teslas that are better than the current way of providing clinical services and living situations but I would argue what really most people in the U.S. want and I don't have stock in any of these companies, I'm just trying to illustrate a point. Is self-drive healthcare. They want the equivalent of what Google, may, if they're successful, do. Now, the self -drive cars on the roads in California and my brother was driving next to one the other day and he saw, you know he got really excited about it and he's a little crazy so he started edging over to see what it would do. And sure enough, it dropped back. You know, it did everything right but think of every senior that we're trying to take their driver's license away and the kids are trying to figure out at what point do we do this, what if instead we give them the keys to a self-drive car?

So the technology would allow them to remain independent to make decisions about what they want to do much longer and so it is these—some people use the term assistive technologies and people think, most people think about that as just hearing aids or glasses, very minor kinds of things although they can be terribly important in the life of the individual but there are a lot of non-health technologies that will offer huge potential for—I'm sorry, I keep hitting the wrong button here. So I have three key observations I wanted to make. The first is that we suffer from a disproportionate focus of medical innovations. So for example, Mass General is just one of a number of different places that have taken tele-health and said, how can we make life more convenient for our patients and most of their patients are seniors with multiple chronic diseases and so when the patient goes home in the last appointment before they go home, the physician says do you have an iPad or a smart phone or something where you could answer some questions that we send you and would you prefer to answer questions that way rather than having come back to the clinic, and a huge proportion, almost every patient, says yes. Almost all of them in that context have some kind of equipment that could work. If not, they're considering the advantages of paying for a very small tablet for the

patients because his ability to communicate and stay on top of what is going on is so valuable and so important. This is a map that we actually saw on Wednesday at the PCAST meeting presented by a colleague that I have worked with for a long time from the center for information technology research in the interest of society.

This is at the University of California and a number of the other UCs and I think it's a very good map of the typologies of technologies that are relevant and helpful, particularly in aging.

As you'll see a good deal of these are platform technologies and services and what I mean by that, for example, is you may have heard about the VA has a lot of in-home monitoring. They give the individual monitoring kit to a patient. In the past that meant that the VA had to have people who would go into the home, help them set it up, and if that didn't collect all of the information they wanted, they had to make it interface with something else.

So there's an example of a very good young company that now is a platform. They work with AT&T and when they send the kit with the patient, the patient can take it home with them. 95 percent of the patients can get it up and going without anybody coming to their home or helping them because this is a consumer technology and healthcare doesn't do consumer technologies, so they got other kinds of capabilities involved. Sensors and the services wrapped around them are closer to medical technologies as we think of them and those are wildly exciting! We're working at UCLA. We have sensors that can tell if you're developing ileus after an abdomen procedure. We have sensors that can tell if the hip or knee transplant—implant—that you had is deteriorating. It can hear the grinding of the implant so there's a lot of things in that medical area that will be very helpful, but the most important will be the technologies, the mobile apps and gaming, the technologies and motivational strategies to engage the consumers and help them do what they want to change their own behavior and these are very, very powerful.

If you look here on the right hand side, there's medication management, a remote lab meaning that we now can do most lab procedures from one drop of blood and it will be brought to your home in the next year or two and also be done in pharmacy clinics so very little need for seniors ever to go to a lab again.

So a lot of the travel and the difficulties for seniors will be reduced. We have covered in PCAST a lot of that in our working group, a lot of the information about how robots can help people live independently so only a few of these are really clinical like remote lab. A lot of these are technologies that are developed somewhere else and doctors don't know anything about this. And yet we assume that the medical system is the way people ought to access these technologies. So I would say the second piece and I know there's a risk here because you are at risk of being quoted is that providers are a barrier to the distribution of most effective technologies and services for the aging. I would include in technology here, the broader meaning. If you look in Merriam Webster at technology, it's really codified systems for the application of human knowledge and it includes business models, it includes structures and work processes. So the fact that technology is only enabling and I agree with Atul, there's almost no technology just put in front of a senior and bam, you're ready to go. You need a service wrapped around it but reimbursement is a subset of that, is a real problem.

And so therefore, we can't assume that most seniors are going to learn about all these things because they sit down with a primary care physician and I think that leads to some of the recommendations we may discuss later on. Oh, okay. Well, let me give some examples.

Augmedix here, and again, I do not have any financial relationship to any of these companies. Augmedix which we're piloting now at UCLA, allows the primary care physician in the office visit to not have to sit in front of the EHR because there's a remote scribe watching the visit through their Google glass and hearing it and pulling up everything that he or she might get from the computer instead of going to the computer and looking at the film, you just sit there and you say to your scribe, please pull up the films. Please pull up the labs. And then if the physician is forgetting some preventive care, the scribe can say, don't forget, Dr. Green, you're supposed to get a pneumonia vaccine for her this time and it is a revelation in terms of taking out the hours of documentation time for the physicians. 95 percent of the patients say yes, no problem. They welcome this. So even seniors are not offended by this and so this kind of thing can now be carried into the home. We can have the community health worker wearing this with a nurse supervisor behind when it's needed, 90 percent of the time the community health workers are just interacting with the person and taking care of them and asking them questions but if there's a clinical problem, just pop on the Google glass and don't worry about transporting the person to the primary care clinic or to a specialist.

So these are not directly clinical technologies and they're ones that when you first present them to physicians, you know, the only thing that's a selling point is the idea they might not have to document in the EHR. But it's very disruptive because it doesn't take long for a patient to figure out well, why do I have to come and sit in the office for somebody to do that. So these are very, very disruptive. Zipnosis which we are also piloting at UCLA is completely online diagnosis and treatment for patients with minor episodic illnesses. They have a URI. They have got a rash. They can go online and load snapshots of their derm condition and if the physician judges it this is a minor enough episodic illness, they get a diagnosis and prescription to go to the pharmacy.

>> Who is the physician?

>> Molly Coye: The physician, it's run through an algorithm and then the final review, the diagnosis and recommended treatment is reviewed by a physician and University of Alabama is doing some very good studies on it now. We're using it with our own patients, not patients we don't know yet, but the main, if we get good studies out of Alabama, I think the log jam will be broken, because again, as you know from Clay Christianson and everybody else, convenience and affordability drives a lot of the innovation but you can begin to see the life of the senior changing quite remarkably because they can remain in their home, in the community and getting the medical and healthcare they need does not have to be as huge of a problem. So last of all, a little bit echoing in what Atul is saying, is it's not the technology, stupid. The technology is so far ahead of our ability to use it well, we have technologies and I am going to end with an example of this, that were developed ten years ago and it's still mainly restricted to one health system in the whole country.

So the issue here is not to develop better technologies. We should get out of the way of that happening but it's the need for the awareness of the potential and so the main recommendation I would make is that I hope that in the next two years, a great deal of money would go into establishing, perhaps, regional centers based on current models that are very, very successful, like some of the ones that Atul is describing but with money for all of the health

systems in that area to learn about this and to innovate further on it, to redefine innovation and healthcare away from the purely clinical and into helping people live and die the way they want to.

And I think we could capture the imagination of most young physicians and some decent proportion of those middle age and elderly as they become more aware of their own mortality. That's something that's feasible to do. I was very involved when CDC and IOSH set up the first occupational health centers around the country. There was ten regional centers in the late 70s and all of a sudden, everybody in healthcare was redefining themselves as an occupational health specialist and they all started to learn about it. They never knew about it before so there is a real potential here.

Let me give you an example of what one of the models might be that didn't happen to be described in Atul's book. Kaiser began in the early 2000 to think about how they could move a lot of their care out of hospitals and even out of clinics when possible. They did a thing called vision 2020 which, in which, all of their leadership came together and thought about what if we say that's our goal. We try to redefine care to do that. So building on that, by about 2005, an organization that you can go on and look at online, Partners in Care Foundation in Los Angeles which is a non-profit that grew out of the VA, I'm sorry, the VHA, voluntary, no that voluntary housing— VNA, Voluntary Nursing Association which tends to do a lot of home care, and non-hospital based services in many cities. They partnered with Kaiser and built in home palliative care. This is like hospice but they decide we're going to start earlier, like Atul mentioned, we are going to start earlier, a year before, and the way we'll identify the patients is we'll ask the doctors, would you be surprised if your patient died in the next year.

And if the physician said no, then that was the best indicator of who would be a good target for this and people did not have to give up curative care. That's a big regulatory thing that we could talk about, because as soon as you get people in this kind of care, their need for and desire for curative starts to go down because they finally have the comfort of people who know them and are helping them live the way they want to and make the choices that they want to.

The service's a blended model. It begins still quite strong on curative and gradually and not with the effort of the care workers, the care workers are neutral. They want what the patient wants to do but given the opportunity, patients choose to migrate towards more a more palliative model. The services are provided in the home. Even the physician visits in the home and very few times does the physician need to come to the home. Sometimes, in the beginning of this the physician goes once so the family feels good about it and they feel safe and secure but it's mostly nurses and licensed clinical social workers that are providing most of the care. It reduces as you would expect emergency room visits because usually, if you're taking care of a dying relative and all of the sudden they start to have some problem, you're scared. It's the evening. The doctor's office is closed. You call 911 and the rest of it is a downward cycle that we all know.

Instead, this system has a 24/7 nurses on call, familiar with that family and the situation and able to help them deal with it. The total cost savings and this is in several published studies with Kaiser varied from 37 percent to 45 percent less in terminally ill patients receiving traditional care.

So I would suggest that we think about this as a pill. If pharma came up with a pill that

saved one third of expenditures in the last year of life, satisfied patients, kept them out of the hospital and the ED, we would have retailers breaking down the doors. Our regulations would support it, et cetera.

But this is a very good example of something that combines technology, because they use tablets back and forth. They have in-home medication reconciliation systems that can scan the medications and make sure they're not taking their husband's medication or an old one. There's lots of technology involved but you can tell the whole story without even mentioning the technology because the point is to help people live the life they want to live.

So I have a short list of recommendations that I would be glad to go into, but I think we should go back and forth with Atul.

>> Eric Lander: Some discussion here, I'm going to invite members of the PCAST to raise their flags. And I don't know, but first Atul would you like to add something more or?

>> Atul Gawande: Maybe I just should say, what can we do about this? Yeah. Yeah. What can we do about this? Okay. So there's a couple of things. One is, what is this? What is the goal? That requires us thinking about a couple of things. Who are we trying to help? And I don't think it's people who are, you know, whatever age, independent and you know, suffering with some health issues but on the whole, spending their life without need of feeling they're dependent on services in a way that, whether it's medical services or nursing services and others.

So if we say we're talking about the people who begin to need caregivers, then I think we start to be able to say who. What is the goal?

The goal to me is those caregivers will know my priorities. They will respect them and help me achieve them as best possible. Now surrounding that ability is we need to be able to supply the family and caregivers with certainly technology, science and innovation and that's about the discoveries of what are the most successful systems for doing this and the discoveries for the most successful technologies to aid them are.

The leverage points then are, you know, there's regulation, there's financing, there's implementation. Financing is a clear barrier and there are interesting but, you know, limited time for being able to act on them but let's name a couple of things. One is that in some other countries, they have combined long term care and acute care as insurance and so, you know, people have been interested in some of the work our laboratory has been doing but they're really coming from abroad because when they are able to deal with people who are in assistive living and help keep them more independent for longer, help avoid hospitalization and things like that, they benefit greatly by being able to have that combination approach.

So there's some opportunity for this mission to be able to frame that agenda and do some investigation because that whole agenda isn't even laid out, I would say.

But that is not something that in two or three years can be accomplished. It's moving a process down the road we have to move and we have to think of it as ten to twenty year process. So just getting it under way is important.

Second, on regulation there are some regulatory barriers. It will be curious to hear Molly's perspective on that because she has been in that regulatory role. What I have perceived in the course of going through this is that the regulations are often focused on safety but don't

talk about the idea of the tradeoffs involved and letting people make their own choices about their priorities and tradeoffs but it's often the interpretation of the regulations that is the barrier.

So if a nursing home is not allowed to leave knives for residents who happen to be in wheelchairs to use, that's because an inspector has said that's the way they interpret the very broad regulations but many of the positive deviants, as I call them, institutions that are climbing out of the woodwork and making these places work have found they can work with regulators successfully to allow people to, yes, even have a knife with their bagel in the morning.

Or even a bigger deal, are you allowed to go to a refrigerator by yourself and choose what food you want. Incredibly controversial about whether you let places do that and that's the place we've come to and it's not actually regulation. I think that's held back.

So what I would say is the place that can be acted on earliest, is that there happen to be in every state a percentage, it can be between 1 and 10 percent of the places, of the approaches for elder care that include at home, in assistive living or in full 24 hour services that have innovative ways that people actually feel they're in a home and they genuinely feel they have caregivers who know their priorities, respect them, and help achieve them with the range of services and tools and technologies to make it possible and that we, like under health reform which has opened the window to alternatives for fees for service payment and in the five years it has happened, it's climbing to 20 percent of people in Medicare are under those arraignments because it's been creeping up from the pilot testing of those kinds of approaches that—this is an organization that could push for evidence based policy and the development of pilots that allow us to move down this road just to get to five or ten percent of places that would allow these things to happen.

We're not going to get to 95 percent in the next five or ten years. But we could get to five percent and make sure those winners are succeeding.

>> Molly Coye: Sorry. Yeah, I would certainly support that. I think it's very good and very important. I think though, there are a couple of other categories that could be opportunities, some of them are—I'm not sure if all of them are legislative or regulatory but think about the fact that most insurance doesn't pay for hearing aids and this is a clear item that if you could act, encourage action on that, that is really something that could be changed in two years and could make a huge difference.

So I would encourage you to call on any groups that you would want to but to have a short list of five or six things that really anybody working in this field thinks is just does not make sense and most of them have to do with reimbursement and those kinds of things should be fixed. The parallel to that, that's the sort of take care of the bad stuff. Take care of the things that don't make sense. The parallel to that though on the let's incent and reward and even more than that, make examples of the best, is the idea I mentioned of perhaps through CMMI or CMS, have a special program that defines what good care is from a point of view of patients, how is that done, sorry, of the consumers, the elders and really not just give money to those institutions, that's very nice, but put money into making sure that the whole health community in the surrounding region starts to learn and that there's a process of transfer of knowledge and we did this in the quality movement in the early 2000s and it could be done in this area but the point is it can't be captured, I hate to say this, but it cannot be captured by the

physicians. When CMS did a big transition, this wasn't CMMI, but CMS did a big transitions of care program on preventing readmissions to improve the care there. They did this about three years ago and they required that it be a community based organization that wasn't a healthcare provider to lead in it. So at UCLA, we worked with that group, Partners in Care which had worked with Kaiser and the difference in something, when it's not lead by the clinicians from the hospital or the clinic that they are sure they know what is going to be needed, has turned things on its end and they cut our readmission rate in half. It's changing a lot of what we do. So I think the emphasis has to be on working with the organizations for example that Atul is suggesting and others who really know how this orientation has to be shifted so we are meeting what the patients—I'm sorry—I'm a doctor. I keep saying patients. But what the seniors want in these conditions and not medically what we would prescribe for them.

So that's what I would say is the upside is the sort of shining beacon idea that's basically let's get more attention to the solutions that have been really possible. The in home palliative care is now spreading throughout Kaiser. They have seen this. They invented it. They know it makes sense. They are taking it to their other regions but everybody else around the country thinks palliative is either something you do in the hospital in the final days of life or maybe in the clinic with a geriatrician which means maybe 1/1000th of the elderly population will have access of that.

So those are two areas. The third area is that there is a—and this may be in common with a lot of other areas and I would add that, Craig, maybe you would want to speak on this? There's a real opportunity because there are so many new technologies from other sectors, telecommunications, data analytics, et cetera, and the people in healthcare who are working with them now tend to be our brainiest docs working on really interesting solutions but they're not focusing on this area. There's very little intercourse back and forth with assistive living and a lot of the other areas. There is Leading Edge which is a part of the Assistive Living Group and there are some efforts. I don't want to make it sound like there is nothing going on but a real focus to try and incent the technology developers to work on these problems would be very helpful.

>> Eric Lander: Great. I'm going to turn to some of the members of PCAST who have their flags up. I saw Jim Gates and then Chris Cassel.

>> James Gates: Thank you! And thank you to the both of you for a very interesting and informative brief. This question really is to you Dr. Coye. As my colleagues here know I have a wife who is a medical doctor and so I hang out with doctors sometimes—medical doctors, as opposed to real doctors as some of my friends say.

But my question has to do with this whole idea of what might be referred to as a user generated medical diagnosis and processing because I cannot tell you the number of times recently when I have been around a number of my wife's friends and they talking about the patients who come in, have used an online service to provide them with what they think is the correct diagnosis and when they get in the doctor's office, the doctor says no, this is just totally wrong.

So it's the issue of, what are your thoughts about controlling that part of, kind of the user generated diagnosis and processing. I would like to hear your thoughts on that.

>> Molly Coye: Well, here is where I think—I assume there must be a lawyer or two on the committee...

>> Eric Lander: No.

>> Molly Coye: Okay.

>> Eric Lander: It's not a science yet.

>> Molly Coye: Okay, all right.

>> Eric Lander: Or a technology.

>> Molly Coye: Okay. But, a lot of those cases, because I'm in a lot of these conversations too, is when people go on the open web and they're reading a bunch of stuff and they think that means that they have that disease and they come in. That's different from the kind of service that I was talking about where when you register your, you're giving all of your history and information as though you were going to a doctor's office and that organization has liability for what they say to you. So it actually comes under the same kind of jurisdiction and liability. I am not so worried about the explicit, here is a service. Like, say if it was a lab service. There are lab services today. You can mail a drop of blood and get it back, but hat has a whole set of regulations so I don't this that's going to be— It's clear why some people could be confused between the two models but the ones that are actually the more medical model will be fine. And I have no answer for the first problem.

>> Atul Gawande: I think mainly that it is we're at a primitive stage of being able to use information technology to, you know, empower people to have more of the medical knowledge and also be able to take more medical action. So, the result is we have diagnosis based on noise and you have a lot of misdiagnosis that can come from that, but it's very unclear whether that's over all beneficial or not because we are getting people to come to attention more quickly.

The next phase is the people using their phones and other things to monitor cardiac rhythms and other things. You know, Venod Khosla has been a big advocate of the idea that the digital doctor that can just intermediate the doctor and the main concern is how to, you know, that is generating even more noise in many ways. You can monitor your heart rhythm every day all the time and when there are alerts, somebody has to act on them and putting services around that build to make it go.

The likely direction I think it goes, and this is relevant to this committee although you know you are going to have to work to connect it into this particular task is that access to your data in the medical system itself is really crucial because if you have ways that your medical data can talk to your personal data and then you use that, you know, within the requirements for electronic health records, it sounds like you have talked about this. Yes.

>> Eric Lander: We have done reports over the years. It's a sore subject, Atul. Carry on.

>> Atul Gawande: So I won't even—you know the issue. If people could get into that system and pull it out, yes.

>> Christine Cassel: Thank you all, and thanks for raising that issue, Atul, because as recently as yesterday we had an intense conversation with some folks at key positions in government about that and I agree with you. It continues to be—here's a place Molly where the law says that the patient owns the record but still, very few places have figured out how to make it a reality. So, it's an important challenge.

I wanted to get to kind of a version of Jim's question about consumer information. You know, we do live in this world where we think that patients are consumers and they are shopping and families are shopping and the world of information ought to be out there on the internet so people can find out report cards on these institutions and find out which ones are better, and interestingly enough, the government is trying to do this with more and more of its hospital compare, physician compare, and nursing home compare, the three big web sites. The hospital and the physician compare get almost no use at all. Nursing home compare actually does get a lot of use from families, maybe because there's enough time for the person to sort of work through it, but that said, the information on there are quality metrics that come out of that whole regulatory framework tool that you describe as being in many places misguided, and if not, completely ineffective.

And so, meanwhile, there's been a proliferation of other kinds of information. Yelp, for example, and even Zagat's ratings are getting into healthcare now and some of that information is more understandable to consumers but one would argue less rigorous and perhaps even less accurate, it's hard to say. So what kinds of, if there was going to be the kinds of questions that you framed four questions for us that people ought to be asking that physicians ought to be asking their patients, is there a way in which those questions could be turned into quality measures or performance measures that actually could be reported so that when people are shopping around for where can I get health for my mother or my spouse, they would be able to access that kind of information?

>> Atul Gawande: Yeah, so the—when I talked to people who are in the nursing homes, what they tell me is look, we don't sell to the parents, we sell to the adult children of the parents, that they're largely the ones who make the decisions and that's when the barrier comes in. So, they're very interested in safety. As one of the people put it to me, safety is what we want for those we love and autonomy is what we want for ourselves. So the children, the children are making choices and looking at those ratings and saying I don't want my mother to ever have a fall, but not asking is your mother allowed to choose to not be in that wheelchair all of the time because they actually have some capability of walking or one of the things that made my wife's grandmother most miserable is they took allow her heels. She wasn't allowed to wear heels when she was in a home because they feared it would harm their fall rating. And really, the trouble isn't the fall rating. You care about the falls, but it's the context. You want to have enough of a world of measures that we add to those measures, the ones that begin to measure whether we have autonomy and whether we have some sense that people you know, I go back to the basic questions of whether people know my priorities,

respect them, and help me achieve them and that set of components are nowhere in those metrics and could easily be added. It does not even require, in the beginning, that's a regulatory change that may be possible as a first step and I don't see there being a tremendous controversy in beginning to ask that we really start measuring that because that's the offsetting side of it.

We want safety, but we want to know we're not sacrificing it to the point, look, the safest place to be is being strapped to your bed and never getting to ever move and eating exactly what they put in the tube for you but that is not the life that baby boomers are going to accept heading into the next phase of our culture.

>> Eric Lander: Indeed. Craig Mundie?

>> Craig Mundie: I wanted to add a little to what Molly was saying and also this question of information technology. You know, there's a long history that whenever new technologies is invented, the first thing they do is the old thing with the new thing, as opposed to thinking, is there a completely different way to solve this problem. And I think one of the problems, and we see it over and over again, is that there is such a huge disconnect between the technology community at large—It's inventing a lot of these things, sensors, information technology, you know, connectivity, cars, and, you know, the medical community that kind of lives in this, you know, highly regulated environment and when you get into these spaces that are not so, you know, as you said, these are not the drugs. They are assistive things, or these contextual things. We have to find a way to get past, you know, this regulated mentality in terms of how the experimentation can get done in my view and we need to find ways to permit that. I think people in these aging, and certainly when you talk about the Kaiser and the palliative care experiments, I think it's fascinating because many of these people who are otherwise going to be frustrated, or think, look, I'm in an end of life situation anyways, they're always willing to experiment in many cases. You know, they say well let me try the drug, or, I'll do whatever it takes, and I think here we have things that are not life threatening but we don't even give people essentially an option to experiment. You know, we're talking the other day about, you know, you want to live at home? You need some kind of assistance, you know, with just dressing or bathing and we were only half joking, we said, you know, many people, if they are queried now are less embarrassed at the thought of having a robot do them do those things than having another person doing them in their home, and yet, you know, we don't think about it that way.

So I think that there is a huge opportunity. This world is going to be so full of sensors and data, not just, you know, your cell phone is your doctor. I think we are going to have a lot of data and if we start to intersect it with the clinical data, it is going to be possible for people to get a lot of advice and a lot of counseling and a lot of support with less and less intermediation by people and I think the question is how do we let it happen, Molly?

>> Molly Coye: Yeah. Thank you. Well, I really agree with that and you made me remember one of the things that we had been working on and I think is really a big opportunity is that there is at least one large and there may be several others that I don't know about, technology offerings that are platforms where people can put their advance directives in the

cloud and give access to their family and they could give access to—it's called My Directives and they've done testimony for Congress. I mean, there's a lot of interest in this but I think it could be a very big deal because you can have those questions asked, not just how do you want to die, but how do you want to live? What is important to you? Because imagine if, you know, the IHI conversations project and what you have written about in your book, imagine having those five questions that Atul was talking about added to the advance directive and it would be feasible to have everybody be able to say, okay, here I am. I have my advance directive and then you tell your family about it and they have the password to get in because one of the problems, you know, we were talking about my perspective as a regulator having regulated in two states is that many people who have done an advance directory, were repulsed, and they put it on their refrigerator, when the medics come to take care of them there are county and city regs that prevent them from following what the post or the advance directive says. Yeah, it is just like, you know, they can't not intubate somebody and it is the interpretation of regulations kind of thing. These are very complicated. So I think it's less about regulating that everybody has to fill out an advance directive than establishing a capability where everybody would be encouraged and if there is it is not very expensive, I'm sure, but if it's a cost, that it would be Medicare paid for.

>> Eric Lander: Are these directives accompanied by a video or are they just written sort of things?

>> Molly Coye: Right now, it's written but, you know, there are cases where people have developed video statements and I think that would be very meaningful.

>>Eric Lander: I imagine it would be much more powerful.

>>Molly Coye: I mean this is the kind of thing we should have a challenge to some of tech people to develop add-ons to the My Directives kind of thing.

>>Atul Gawande: I just want to add a point that I think is central to why has not this been developed, and part of the beauty with what has happened with technology is that the iteration cycle has gotten faster and the problem identification cycle has gotten faster but it's been problem identification by software engineers from the problems in their own lives. You know, Mark Zuckerberg was solving the problem of how do I find out what all of the freshmen girls look like when he made Facebook and then gradually expanded there and eventually became a tool that the elderly use, you know, 15 or 20 years later. The cycle, the part of the trouble is that the people who's problems we're are describing are not part of that iteration cycle and those are two kinds of people. They are the caregivers. In that world, the software engineers don't know the world of the caregivers. They don't know what it's like to log into a computer for two minutes and a 15 minute office visit and what the slowness of the time is and how, you know, technology right now is misery for care givers, but then also, they don't know in the same way they know intimately the problems on a Friday night, they don't know the problems of the life of someone who is 70 or 75 years old and has trouble walking in that night.

And then you see incredible innovations. We hear the story and often it's my

grandmother had this problem and I couldn't believe it. I was watching her have this problem and then the iteration cycle, you know, they began making a software or hardware tool and they could iterate with their grandmother and solve it and then it became a wider problem, but it's a little too happenstance and there is some opportunity to change the iteration cycle and the identification cycle by moving people into those environments and atmospheres and connecting them.

It is an industry and an environment that is ready to happen. There would be substantial dollars flowing but we need to close that cycle and that is another potential area that can happen relatively fast.

>> Eric Lander: Susan Graham, I think, has the last question within our time.

>> Susan Graham: So in this discussion as in most discussions of aging, we're focusing on people who have challenges in taking care of themselves. The first observation about that is that there are people of all ages who have challenges taking care of themselves and so we need to understand what's different about the challenges that older people face. But my other question is, what about the people who are aging but not yet infirm or profoundly disabled? And, I mean, the only mention I heard was about the hearing aid issue. So do you have some thoughts about…?

>> Atul Gawande: We might differ on that, but let's see what we say. Part of the history that I feel like we discovered was that at the end of the 19th century, the problem of the not infirm elderly person was that if you were just becoming not well enough because your hearing was going or things like that, you couldn't work anymore but you could live. We made it, you were impoverished, right? So pensions were the most powerful most important things that happened. Social Security, for allowing people to not have that mean that you were impoverished and no longer had independence because you could not afford to live anymore. And the fascinating thing over the last century has been the creation of retirement and we're living in a golden age where the wealthiest population is that population who have retired who have the chance for independence because financially it's more and more feasible and then have the ability to live independently. I think there are some basics like making sure reimbursement or things like hearing aids or the right vision care or dental care and other components that are often left out of care that are serious problems for people in those circumstances and can be frustrated are important but I think the reason why we end up focusing on the people who reach dependency is because it was never included as part of that vision, what it means to have a life that's worth living because we have assumed that, hey, once you are dependent, the American way is you're independent, so it's not worth living anymore so it's all about preventing it from happening rather than also managing that well.

>> Molly Coye: And I would like to say that I think that for the seniors who wouldn't perceive themselves as having a significant medical problem and hopefully this will be many more people in a much longer period of time as we go in the next two or threedecades, that there's a lot of evidence to suggest there's a lot you need to do during that time to maintain yourself and there's very good emerging work on wellness and there's some old 20 year old

evidence in terms of exercise and how it maintains elder people's health and prevents the onset of a lot of chronic diseases.

So I know we don't have time to go into it here but there are a lot of technologies that support that quite effectively for people in their 50s and 60s. So we should keep that on the horizon. We should remember that it's an important part of it too. It's a down payment on our own children's financial future to make sure we prolong that period of time.

>>Eric Lander: Great, well, we have come unfortunately to the end of our allotted time but this has been an enormously helpful conversation. I am just struck by how valuable it is to have two such humane people come and you know really think about this from a broad point of view of the experience of aging because think in science and technology applications, it is possible, although I don't think our group here is doing it, to imagine this as yet another problem to be solved with a piece of technology and I think the injunction you have given us to think about what do people want, the autonomy questions, and that this is fundamentally a question that is not occurring in the hospitals. It's about aging in place. It's about people being able to age and eventually die as they want to. Those are very helpful for us in thinking about how we can then, ask, within that context, how science and technology can play a role.

So I want to thank you both very much for joining us and I think the whole PCAST would like to thank you.