

Origins Symposium Science and Society Panel

Lawrence M. Krauss: Thanks. This is something else I said earlier but it is truly amazing. 12 hours of science to a full 3000-person auditorium. Well, you should, you have to applaud yourselves because this is just amazing. There are very few places in the world where this is actually possible. And this panel is a slight change of pace. And I am very pleased and honored that the distinguished panelists have agreed to come here, and that Roger Bingham has agreed to narrate it.

Roger Bingham is actually at the Computational Neuroscience Department at the Salk Institute. But he's also the producer of the Science Network and in fact an Emmy Award winning producer. And we've partnered with him, and as many of you know, the entire event, including the scientific symposium were broadcast live on the web, and they're also being produced into DVDs which we're going to make available to schools and also to air on The Science Network because a key part of what we want to do is reach out to the public nationwide and Roger and his team have been great helps. Roger, in fact, narrates a big event down in San Diego that I've been to, and he's the perfect person to host and introduce this panel.

So, with no further ado, I'm really happy to introduce Roger Bingham.

Roger Bingham: Good, thank you, thank you. Spectacular crowd. How many of you have actually seen anything on the Science Network? The Beyond Belief, do you know about the Beyond Belief? Yes, good, thank you. There will be no magic tricks, I'm afraid. I was very nervous about coming out here after Jason because it's a bit of a mood change, but let's see what we can do. We have an extraordinary panel, let me start with Ann Druyan. Annie is obviously a screenwriter, she is a novelist, she is the CEO of Cosmos Studios, and was one of the writers, with her husband, of *Cosmos*. Ann Druyan.

Neil Tyson is an astrophysicist, the director of the Hayden Planetarium in New York City. He's the host of NOVA's ScienceNOW Series, and a Pluto demoter. Thank you.

Neil deGrasse Tyson: Pluto had it coming, Pluto had it coming.

Bingham: You know, when I was coming out here I said to Neil, do you mind if I introduce you as a 'Plutocrat'?, and he said "No you gotta do it for a general audience," but you guys would have gotten that. I'm absolutely sure of it.

Lucy Hawking, Lucy's a novelist, writer, also. Most recently she's been working on some children's science adventure books, which are enormously important, with her father, Stephen Hawking. Lucy Hawking.

There's a wonderful section in the Science Times, one of the few remaining things on the science in newspapers these days, the New York Science Times, called "Conversations With..." and those conversations are conducted by, and there are books by also, our next guest Claudia Dreifus.

And finally there's usually a lot of hyperbole used about in the broadcasting business, people say things like "the broadcast legend" indiscriminately, but this is a broadcast legend: ladies and gentlemen, Hugh Downs, who was co-host, was on 20/20 of course, hosted NBC's *Today Show* for nine years. He began, most famously, I suppose, being Jack Paar's sidekick on the *Tonight Show*.

Let me start with a little bit about a mood changer if you don't mind. Does anyone, this is going to be a fairly obvious question here, but how many of you recognize the name Carl Sagan? Okay, fairly unknown figure. So here's a passage from *The Demon Haunted World: Science as a Candle in the Dark*. By the way, if you look on the Science Network website you'll see that we use a candle as our, as one of our brands, and we talk about sharing Carl's vision of science as a "candle in the dark". But let me just read this to you, from *The Demon Haunted World*. This was 1994ish, about fifteen years ago.

Science is more than a body of knowledge; it is a way of thinking. I have a foreboding of an America in my children's or grandchildren's time – when the United States is a service and information economy; when nearly all the key manufacturing industries have slipped away to other countries; when awesome technological powers are in the hands of a very few, and no one representing the public interest can even grasp the issues; when the people have lost the ability to set their own agendas or knowledgeably question those in authority; when, clutching our crystals and nervously consulting our horoscopes, our critical faculties in decline, unable to distinguish between what feels good and what's true, we slide, almost without noticing, back into superstition and darkness.

So at a time when science and reason in a nation's deliberations have been repeatedly challenged as irrelevant or elitist - this is my commentary, we've finished Carl's quote now – and science seems to be estranged from society, his words sound prophetic, an alarm call. And think about this: that was just fourteen, fifteen years after the triumphant broadcasting of *Cosmos*, which was a very "up" sense of science. So we've gone from *Cosmos* to Carl's view, his prophecy if you like, in 1994, 1995, in a *Demon Haunted World*. Here we are, the same period on, the question is, the alarm call, has it been heeded, is it being heeded? This is the question I want to start the panel off with, to try and find out if we're actually on an upswing again. So, Hugh, do you want to take a stab at that to begin with?

Hugh Downs: Thank you, Roger. It's ironic, I think, that science at this point finds itself in the position of a messenger who is about to be killed because of the message that he is delivering. And this is painfully ironic I think in view of the fact that science over the years has brought messages to us that have greatly enhanced the quality of human life. And what is against them, I think we have to guard against being simplistic enough to

blame this all on religious fundamentalism, even though that is a big factor, particularly in the case of evolution. I want to touch on that. But there is, unfortunately, a kind of a not only anti-science but an anti-intellectual, anti-rational, neo-Luddite, dumb-down, know-nothing, mentality that has emerged with some organizations, that is attacking science. Science is under attack at this time. And one of the things science has done, and I'm sure Neil is going to touch on this, astronomically, is over the ages it has pulled out a series of rugs from out from under humanity, that have been very unsettling and very eroding to our sense of comfort that comes through our superstitions and our prejudices. And humanity is not happy about that.

So, my feeling is that since it goes beyond science, it is a very large movement, and a big question is what do we do about that? Well, there are a number of theories about what the best way to tackle all that is, and I am sure a couple of those theories will come out in our discussion. That said, I am concerned about the fact that there is that much movement against science, which is sort of a savior to us. That is the achievement, and you hate to see humanity sort of afraid of its own intellect, and it almost amounts to that. That's not true of all humans, obviously, but there are enough to make this powerful movement. I'll subside with that, and then we'll go where we go with it. Thank you, Roger.

******Bingham:** Since I invoked Carl's ...[9:20]... Annie could I get you to respond to that as well? Where are we, where are we going?

Ann Druyan: Well, I think it's a mixed picture. I think that we've come out of a period of fear based politics and fear based religion and we're moving in the right direction. I feel like our new president respects science, and he's made that clear. And that's such a joy after having eight years of a president who proclaimed his contempt for science by saying "nucle-ar" every chance he got. It was a kind of badge for him that he was proud of, his ignorance. Now we have this brilliant president who has great potential, so I think that we're moving in the right direction.

When I was a kid, I always used to wonder if when Columbus was sailing out of the little Spanish port town that he sailed from, if people like fishermen and tradesmen around the harbor looked up from what they were doing and said, "Wow, Columbus is going off to discover the New World." Well, of course, I realized soon after that that wasn't the case because even Columbus probably really didn't understand what he was about to do; but beyond that, there was no means of communication so that immediately the great discoveries of Columbus could be spread to everyone.

A month ago I was at Cape Canaveral, witnessing the lift-off of the Kepler mission: the first spacecraft mission to search for new worlds, extra-solar worlds, worlds that circle different suns. Now, Claudia and her colleagues at the New York Times, Dennis Overbye, did a brilliant story about Kepler, but beyond that the coverage was minimal. And it was, I actually was at the launch, I saw this spacecraft lift off at night, like a little dime of light in the night, with maybe a hundred or so other people. I went home to watch

the news and saw stories about everything else; one line on the ticker that Kepler had actually successfully lifted off.

There is something wrong. Everyone is fascinated by the search for extraterrestrial intelligence, by the search for other worlds. And yet there's a kind of disconnect. Don't want to take too much time, and I will defer to my colleagues here, but I just wanted to say that there's a failure of public education. We're not telling the great stories, of the lives, of the generations of science and engaging new generations in the scientific enterprise. Thank you.

Bingham: Well, so that's your business. That's the business you're in. You bring people in a planetarium, you go on television, you –

Tyson: So she says everything sucks and you say it's my business? Therefore it's all my fault now.

Bingham: There you go.

Druyan: No, no I really don't think everything sucks. I think it's a mixed picture.

Tyson: I'm just kidding, I'm sorry. I actually, well, I think Hugh you spoke brilliantly, we all agree, and I also agree with you, but I'm not *as* cynical about the state of affairs, for a variety of reasons. Thirty years ago, when *Cosmos* aired, premiered, on PBS there was like five TV stations, right? That was it, kind of, right? Of course there was no internet, no computers, no PCs that is, and so you could go months surfing - the word wasn't in use back then - getting up from your couch to change the channel of the television - you could go months before you would stumble upon science programming. Yes, there was the weekly Marlin Perkins with the animals, and then the undersea guy, Jacques Cousteau, you had them, but that was it. You know this – that was it. So, *Cosmos* represented sort of a break through in access to the science frontier. A kind of singular breakthrough.

Who would have thought back then, if I went up to you, because you're active producing this show and there it is airing, and I say "Ann, in thirty years there's going to be an entire television station devoted to just science!" I don't think you would believe me that that would even be possible. Other stations, not one hundred percent devoted to science, but major portions of their portfolio given unto science. Even stations such as The History Channel, formerly known as The Hitler Channel, because that's all they showed, was World War II. And then, they got hip to the fact that maybe science sells. Maybe the *Cosmos* sells. And on the third season of that show, called *The Universe*, that many of us in this program this week were actually interviewed for. And so, so, access to science, however, whatever are the publishing challenges that exist in the science sections of the printed newspaper, I don't see any shortage of the coverage of science in the media, or in broadcast media or in news media or in cable or broadcast television.

And so, I'm a little more hopeful, even though the state of affairs and the science literacy of the nation is low, embarrassingly low, scarily low, access to science is not. And so, what we need is to establish the conduits to the cosmos that the nation can then grasp. And then, bathe in all the glory.

Bingham: See, I think that the way in which people select what they want to view in science is shifting, and you're an example. I'm – when you came to the Beyond Belief meeting, the first Beyond Belief meeting, Annie, you were there as well, Richard Dawkins as well. There was a little section where you had an exchange with Richard Dawkins and we weren't posting anything from the Science Network at the time, but pretty soon there were little clips that started appearing on YouTube. And if you look now, you'll find that that exchange between Neil and Richard is now the sixty-second most viewed of all time on YouTube, not in the “Science and Technology” section, but in the “How-To and Style” section. So there's an awful lot of people that elected to go and watch this sort of stuff in their own way on the net.

I'm wondering whether they're going there because they can't find it in newspapers. And we know of course, that CNN just shut down Miles O'Brien and its entire science reporting team. Other newspapers are folding all over the place, there's this oasis in the New York Times left. So I want to ask Claudia where she thinks things are going and what some possible solution might be.

Claudia Dreifus: Well, it's really a complicated story and it's daunting to be representing all of print media. I'm a contributor to the New York Times Science Section and I'm working on an island of great commitment and wonderful quality work. We have thirty people on the staff of the Science Section of the New York Times, that's more than there are on some newspapers. Just a few weeks ago I was at the American Association for the Advancement of Science's meeting and I presented awards to science writers, half of them had lost their jobs - these award winning writers – in the past year, because there's just so much contraction going on in the industry.

But I think the real problem is not so much the media itself, but I think scientists should look to themselves, because I'm afraid scientists are not very good communicators of what they do. And, I'm sorry to say, some of it, why this is is multi-factorial, some of it is the fault of the university culture, that they function in where no one is generally, except for perhaps ASU which is a remarkable and different kind of place, it really is. But let's face it, most university professors at most colleges, including in English departments, tend to be obtuse and not particularly intelligible. And I, and this is true of scientists who are very busy and into their own work and have not been in the public square. And I think what began to happen about eight, nine years ago with the growing politicalization of science was a very big shock to the science community. I think that they saw over the past decade their lack of public engagement and their lack of involvement in the media, which Hugh, don't you agree, can be anything you put to it. If you put out a good story, the media will cover it. And science has a good story, but it hasn't put it out. Carl Sagan and some of the people at this table, Neil, Hugh, Laurence, and Brian Greene are people who tell it well, but that's rare.

And I think this last election, when you actually saw the candidate for the vice-president of a major political party actually campaigning against fruit-fly research as if this was a wedge issue was shocking, deeply shocking, to the scientific community. They had a wake-up call, and I think they really want to get political and out there and they want to engage. I myself have done my little contribution towards science literacy. I now teach a course to graduate students in biology at Columbia University called “Writing About Global Science for the Mass International Media”. I want to teach scientists how to write, how to tell their own stories, and I think it’s a good first step. Let me tell you that they’re game. Three times as many people showed up for my first class as there was room for. So I’m optimistic.

Bingham: So that obviously invites response from Neil, but let’s just, let’s just hear from Lucy first. Because one of the solutions here obviously is the next generation, and getting kids involved in this, which is your primary activity here with Stephen.

Lucy Hawking: It is, that’s right. Every time I come into the United States, at emigration, the emigration officer says to me, “And so, what do you do?” and I say, “Well I write children’s adventure stories about astrophysics”. And they just go “*kachunk kachunk* – come in”. So it’s unusual, I’m actually very, very optimistic. I spend a lot of talking to people about science, I spend a lot of time telling stories about science, mostly to people who are under the age of twelve. The enthusiasm is overwhelming.

I write, as I said, I write children’s adventure stories about physics, I write them with my father, and we started writing them because of the enthusiasm we were getting from kids. My son is now eleven, but when we started he was about eight and he wanted to know what his granddad did; he wanted to try and understand what work his granddad had done. And you know, I thought well, what are we going to do? I can’t really start reading him *A Brief History of Time* at age eight. I thought, yeah right, we need something. We need something that we can kind of get into together. And then his friends at his birthday party, his friends were coming up to my dad and going “So, Stephen, umm, Stephen, what would happen if I fell in a black hole?” And my dad was writing the answers for these kids and everyone was fascinated and I noticed something as well: I noticed the adults were waiting, waiting for the answers. And then my dad would give the answer and the adults would all nod and go, “Oh yes. Oh, I knew that. Oh yes.” And I sort of thought, well this is brilliant. We’ve got this, we could really fill in the issue, we could write an adventure story because scientists see science as an adventure, and that’s why these are adventure stories about discovery and about the thrill of discovery, and about excitement and challenge and passion and courage. All things that, you know, that my father has displayed throughout his career. And, we can teach people something at the same time.

And they have been really popular, we get a lot of letters from children, from teachers, and from librarians saying that this is great, that children are starting science clubs. All sorts of things – that they’ve done art exhibitions, they’ve put on plays, they’re using the information in a lot of different and creative ways. And so I’m very optimistic because I

know that the enthusiasm is there for the kids, I know that all sorts of people are doing a lot of work to bring them information. And also, it's different ways. And like festivals, like Origins, like what Neil does. And it's just joining it all up. So I kind of think it's going to be okay.

Tyson: What?

Bingham: What?

Tyson: I have further evidence that we've come a long way, if I might. When I was in high school, in New York City, at the Bronx High School of Science – I've got one guy from the Bronx Science right here; actually that was Shelly Glashow, who actually went to the Bronx High School of Science, and one of seven Nobel Laureates who are graduates of the Bronx High School of Science. All in Physics I might add.

Bingham: Didn't Brian Greene and Lisa Randall both go to Stuyvesant?

Tyson: They went to Stuyvesant, but they did not win Nobel Prizes. I'm just saying, I'm just saying.

Bingham: You know, we've...

Tyson: But that wasn't the point of what I'm trying to say! I want to say that in my day if you were a nerd that was sort of a villifiable title. Villifiable label. And you would get slammed into the lockers by the football players and you couldn't get dates and you were just not welcome into the rest of society. Until the rest of society learned that it's the nerd who can fix your computer. And so, there came this economic force, and it's the nerd who could launch a brand new industry, a new economy of tomorrow. And so the nerd became actually kind of cool. And then the richest person in the world is the patron saint of nerds. And so, there has been a phase shift in much of the community, much of the nation, about how you look at people who have this special kind of talent. And, 30 years ago that just simply was not the case. And so, I see that as a very positive sign. Another point about the Kepler Mission, Ann, back in the days of Voyager, you remember Voyager, the grand tour of the planets. In the day of Voyager, that was kind of the only thing going on in planetary science. It was a big story – spacecraft with enough energy to escape the solar system, and you would attach all kinds of stuff to it for aliens to find, that was great – the heartbeats and songs and Chuck Berry and everything. You did it! Right?

Druyan: Thank you.

Tyson: Right? And I want to just applaud that, okay. It wasn't just put on any spacecraft, but on the spacecraft that would leave the solar system and never come back. My point is, back then that received a singularity of focus because that was sort of the biggest news of the solar system. But right now we've got a mission to Pluto, we're in orbit around Saturn, we've got rovers on Mars, orbiters on Mars, spacecraft to Mercury, monitoring the sun, and so-

Druyan: No, no, may I clarify something?

Tyson: Okay. Yes, so I just want to say, so I'm—

Druyan: No, first of all, I'm sorry, I will take a back seat to no one in terms of optimism. I am totally optimistic. And as I began my remarks, I think the fact that eighty-six percent of the American people were proud that the Obamas were representing us in Europe is a sign that change in our civilization is not only possible. We are witnessing it, we have seen it happen. As a woman who came of age in the 1950s I can attest to the sea of change in terms of people's attitudes towards women. No, and, scientifically, in terms of our reconnaissance of the solar system, this is a golden age.

What I thought we were asked to address was how many of us beyond that small percentage of people who are captivated by this. I mean, I think one of the great things about Carl Sagan was he didn't want to preach to the choir, he wanted to publish in Parade Magazine. He wanted to reach everyone, because his passion for communication was not only because, as he said so many times, "When you're in love, you want to tell the world". And so, he wanted to spread the news about science and the revelations of the modern scientific revolution and how there is a kind of spiritual soaring, uplift to these discoveries. Yes, but what I'm saying is that by making science forty minutes of compartmentalized boredom in school, we kill the joy that Lucy was talking about. We kill it off. So that by the time people are just ten years later it's virtually all gone. Yes, people like to watch the Science Channel and they like to watch NOVA and *Cosmos* is on iTunes and Hulu and everywhere you look, that's true.

But I'm talking about breaking through that barrier so that the people who already know that they're interested are supplied with the information they want. I'm talking about reaching a much greater public and I think in order to do that one of the things we have to do is we have to teach science as a way of seeing absolutely everything. So that in kindergarten, when the children first come to class, maybe the night before school begins, they're taken out to see the stars. And they're welcomed to join the generation of searchers that we have been searching for forty thousand years. And that everything we know is built up on the struggles and the searches of the generations that came before. And to give people a sense of science as a way of thinking and seeing and not just a compartmentalized subject taught three times a week, maybe by someone who is also teaching physical education.

Downs: Neil mentioned that so much is going on now, and there's justifiable criticism of the press, generally, and the way these things are covered, but some of it is not the press's fault. There is a natural decay of attention on the part of the audiences. There will come a time when a spaceport where people or crews are taking off to go to Mars; people won't go there to watch that. People used to go to airports to watch a 747 take off.

Dreifus: That's right.

Downs: And they don't do that anymore. So it's very hard to keep up with that kind of thing. And the other thing I think about in defense of the press, and I'm not saying there isn't valid criticism, but scientists have arrived at many of these truths, most of which are a great use to humanity, using arcane language that simply is not available to people who don't have the mathematical background or concerted long term interest in a astronomy and those things. To understand that vastness of the universe, for example, is very difficult to explain. And I remember Carl Sagan talking about that a lot, and getting it across. The impossibility of making, even in the mind, a scale model of the entire universe, it's just not possible. So that has sort of led to a feeling of overwhelmingly suffocating humility to humans. And you can look at that the other way around. We can take pride in being part of such grandeur. I think it was Arthur Eddington that said "We are citizens of no mean city", and so it's a great place to be and it's the job of the press I think to get across that kind of enthusiasm, and help people in their inability to understand just how scientists arrive at these truths.

Dreifus: I think also that the problem is less the press than the education system. We all know that kids come into school loving science, running to the planetarium and to the Museum of Natural History, and by the time they're ten it's beaten out of them. How did that happen and how can it be stopped? I think that's the crucial question.

Tyson: I'd just like to add that not a moment goes by I'm not conscious of the fact that Carl Sagan ventured into vistas not previously allowed in the scientific community. When he appeared on Johnny Carson *The Tonight Show* that was considered shocking by his peers.

Druyan: And they mistreated him for it.

Tyson: "You're a scientist appearing on a late night talk show, are you out of your mind? You're writing for Parade Magazine, are you out of you mind?" And so, I don't for a minute take any of that for granted, because he did it first, he did it better than anybody, and I and my colleagues are in this sort of cleared path behind him doing just that. And so, I can say that while not enough of us in the scientific community, to your point earlier Claudia, that public outreach is not rewarded in research science. It's simply not. Worst, I would hope that it was just neutral. But in so many of the sciences it's not neutral, it's actually a demerit. I can say, however, with some confidence, that in the astrophysics community, since we had Carl Sagan whose, some of his blood is on the tracks, and he came first, the rest of us saw the tidewaters rise, the budget-waters rise for our space missions in the presence of Carl's activities. And so, to this day, I can do what I do, and my astrophysics colleagues can do what I do, without much fear, without it counting against us. And I credit that all to Carl, completely. So I just want to say, Ann, not a moment goes by without me recognizing that, I want to just thank you all, back when you did that, okay? Okay.

Druyan: Thank you.

Hawking: I'm sorry. No, I was just going to say something to Neil. I think it was Paul Dirac who said "You can't be a proper physicist and be a popular one at the same time". And he was the Lucasian Professor of Mathematics at Cambridge University, so same chair that Isaac Newton held, and the same one my father now has. And I think that he cast a very long cold shadow over the area of physics and the idea of explaining physics in popular terms, in ways that people could understand. And so, yes, it's a testament to Carl Sagan that he broke that taboo. And took it out there and said "No, you can understand this. This is relevant to you". And further from him will come other people, including, but not only, my father, who has followed in that great tradition. I just want to share with you a little memory I have of one of my father's first popular lectures, which wasn't meant to be a popular lecture at all, it was about twenty five years ago in Moscow. It was being translated by simultaneous translation. At one point my father said, "The universe is just a question of plumbing," and at that point the translator had had enough of him and she ripped her headset off and said, "I'm not translating this rubbish any longer. I'm only going to work for proper scientists in the future". And so, yes, we have come a long way since then.

Dreifus: You know, I want to add to it that one of the marvelous things about Laurence, who is responsible for this evening, is how much he is willing to engage in the public square. Not just politically, involved in public campaigns, but can you imagine what his colleagues thought when he wrote a book called *The Physics of Star Trek*? Now, I have my students read that book.

Tyson: There's two different remarks to that, Claudia, there's not just simply that he wrote it, but that the book did well.

Dreifus: That can earn you enmity that will not be forgotten.

Tyson: There you go.

Druyan: Well, we're primates. You know? No, and that's the fact of it. We're primates. And so I think –

Dreifus: Are we bonobos or are we chimps?

Druyan: Well, we may be chimps in the process of evolving, of letting our bonobo self come forward. I think part of the fact that women play such a much larger role in every sphere of life, in our lifetime, is a sign that we are trying to emphasize that bonobo part of ourselves.

Dreifus: Yes, our inner-bonobo is coming out.

Druyan: And how lucky we are to live at this moment, when it's happening.

Bingham: So we have a president who said that he wants us to restore science to its rightful place in the U.S. Agenda. We have a Leader of the House who said that if you

ask her for an agenda she'll give you four words: science, science, science, and science. So the climate is right, despite the turmoil that's going on. I don't want to say that there's a parallel, but let me at least suggest, as I've spoken to you before about, if we go back 350 years. The Royal Society is 350 years old in 2010, I'm just giving you a little plug here, because the Science Network will be doing a Beyond Belief meeting in 2010, and we'll be calling that one the "Merchants of Light". Do any of you recognize the reference, this is a reference from Francis Bacon's book *The New Atlantis*, in which he said, he was talking about the setting up of a community of essentially scientists. He was talking about setting up Salomon's house, which is essentially the Royal Society. And the only commodity of external trade was light, the light of understanding. So these people were the "merchants of light". So we're going to have a meeting at some point, and I'm getting to this right now. If you imagine that meeting as a board meeting, a share-holders meeting, for the state of science, this huge enterprise over the past 350 years, what are the success stories? Where are we going? How do you see communicating it? Neil, do you want to have a go at that?

Tyson: Yeah, thanks. I'd say, first of all, that I'm cynical in a fundamental way here, in my old age and after several tours of duty in Washington D.C., learning how the sausage gets made. I have come to conclude that this stated resurging interest in science does not derive from any deep, romantic sense and longing to understand our place in the universe. In my judgment, and I think, defensively, in my judgment, it comes about because enough people are coming to learn that innovations in science and technology are the foundations of tomorrow's economy. And we're watching our economy fall while the economies of other nations who have made these investments rise. And so, in the end, since nobody in a capitalist system wants die poor. At some point science and technology ends up reigning supreme. I wish it was for more lofty reasons than just not wanting to die poor, but I'll take it if I can get it.

Bingham: Alright, still being realistic, there was an editorial in the September 2008 issue of the Journal of Science, by Norm Augustine, who was a former Chairman CEO of Lockheed Martin, and he wrote the National Academy's, chaired the National Academy's committee that produced the report "The Gathering Storm", remember this one? And he pointed out that the number of U.S. citizens receiving PhDs in engineering and the physical sciences had dropped by twenty-two percent in a decade, U.S. high school students rank near the bottom in math and science, that only eight of the 535 members of the U.S. Congress list themselves as engineers or scientists, in contrast to China, where eight of the nine senior leaders hold such degrees. That is your point?

Tyson: Well, first of all, that's a little misleading, because at the time that report was written, while the statistics were correct, eighty percent of graduate students were foreign nationals, only twenty percent of, in the sciences and engineering twenty percent or less were American, at the time the foreign nationals would come here, get their PhDs, and stay. And so, that's cool, you just sort of become a naturalized American citizen and bring your brilliance to bear on our economy.

Bingham: You were on this committee, actually as I recall, weren't you?

Tyson: Well, actually I was on a couple of other commissions, but invoking those data in the service of the conclusions that we drew. So the point is that today with the sort of xenophobia that has come out of the past decade, foreign nationals, even if they do come to be educated, it's much harder for them to stay. If they don't have a job by six months after the PhD they're sent back.

This is a recipe for disaster. The entire illustrious history of discovery in America is marked by the brilliance that was brought to us by immigrants and others who came here seeking freedoms of all sorts. There are grave economic consequences to closing off the access that foreign nationals would have to our nation. So I just wanted to say, that's a consequence of that behavior. I didn't worry that it was eighty percent non-Americans, that doesn't matter if they come here and stay.

Dreifus: I'd like to pick up on something you said earlier about cross-market reasons for people getting into science. I find as an interviewer who interviews scientists that if scientists, yes they're clunky about telling their story, but their story is quite idealistic, and if they could get it out I think it speaks to people's hearts. This morning you all heard from Barry Blumberg, the Nobel prize winner who solved Hepatitis B. I remember interviewing him once and I asked him, "Well, Dr. Blumberg, how does it feel to have saved thousands of lives?" because he found the vaccine as well as the virus, and he said, in utter simplicity he said, "Thousands? No, millions. Millions".

He never took a patent on that vaccine, he never did it for profit, but he knows. He knows what he did. And a lot of scientists are like that. They need to find a way to get that out. They're not the mad guy in *Jurassic Park*, the fat guy who's trying to blow up the world, they're great idealists and they move this world forward.

Tyson: Yeah, but Claudia, be careful – not be careful, consider the fact that we all agree. You speak to a passionate scientist, you'll be swept off your feet by the seduction that is that frontier of science. But, at the end of the day, somebody's got to pay for that science. And I'm suggesting that it's the people who pay for it that don't want to die poor.

Dreifus: Okay.

Tyson: And so, whereas the people doing the research, they're not the ones driven by the economic factor.

Dreifus: And the people who pay for it want that shot of Hepatitis B vaccine. And they are very glad –

Tyson: And see "I don't want to die" is a great urge to pay for stuff too.

Druyan: Whether rich or poor, right?

Tyson: Right.

Dreifus: So I think if scientists can get off their butts and get out and find a way to tell that story in English that people will get it.

Downs: That's a big challenge.

Bingham: So I misunderstood. Were you saying, Neil, were you saying that you didn't think that a top-down run government impetus is where a solution lies? The fact that you've got Stephen Chu there, John Holdren, Jane Lubchenco, Steve Koonin, Harold Varmus, you don't think this helps?

Tyson: No, no I guess I don't know what I was saying. Let me try again, just briefly. I was trying to combine two thoughts and maybe I did it imperfectly. I wanted to agree with Ann that one of the noblest causes for exploration is to more deeply understand our place in the universe. Not only the universe of the large, but the universe of the small. Our relationship to bacteria, to viruses, to the rest of the animal and plant kingdom, nature. And so, one should do that simply because it's a beautiful thing to do. But at the end of the day, scientists do not control budgets. Politicians control budgets. And in democratic societies people elect politicians who control budgets. And so, I submit to you that this resurgence of restoring science to the front of the agenda is not the consequence of people finally realizing how beautiful it is to discover science. My read of that landscape is that it's the consequence of people not wanting to die poor, because they are recognizing the economic value of this investment. And so, I'm applauding it, yes, you've got good folks up there, I mean the president's Science Advisor and the Secretary of Energy, these are talented people, both physicists in fact. So, that's cool. That's my bias there. Because physics is of course the foundation of chemistry, itself the foundation of biology. That's just the fact! That's just how that builds. So, while I'm sort of dissing biologists, let me add that, no I don't mean to diss biologists, but the notion that we discover cures for Hepatitis and other things that might kill us, in the urge to fund this because of the "I don't want to die" urge to fund, keep in mind that the urge to triple the budget for the National Institute of Health relative to NASA or the NSF or other drivers of the physical sciences. Consider that you walk into a hospital, essentially every machine with an on-off switch invoked in the diagnosis of the human body without cutting it open has foundations based in some principle of physics. And so you cannot fund one without the other – all the frontiers of science need to happen simultaneously and it's the unexpected cross-pollination that makes the revolutionary advances in our understanding of ourselves.

Druyan: Right, that's right.

Bingham: I guess one of the points I was making – by the way, there are microphones, as you probably have figured out, on both sides, so if you do have any questions please feel free to go and get one.

Tyson: Can I ask Lucy a question?

Bingham: Yes, yes. I expected you to start moderating at some point.

Tyson: Lucy, I've got a question for you. People come up to me, I have never written a book for children, although occasionally kids can read the books that I write. But the kids are not my target audience. We know, and you've experienced firsthand, that kids are kind of born investigators of the world. So the real challenge here is to sustain that, not to sort of create it from whole cloth, because they're already doing it. So let me ask you, do you see yourself stoking an already burning flame, or do you find the need to actually ignite the flame in kids that already had it extinguished by their school or by their unwittingly protective parents?

Hawking: Well, it's an interesting question. I wouldn't like to set out to knock schools or parents so I would like to think that what we are doing in talking to kids, in writing for them, is engaging their curiosity and maybe igniting an interest, maybe that interest wasn't there. I mean I have some kids come up to me afterwards and said things like "I only signed up for you talk because I wanted to get out of playing hockey, but actually it was really good and I enjoyed it," so you just never know. We talk to such a broad spectrum of kids that it's hard to say, but there is a great enthusiasm there, and I've definitely, definitely picked up on how ready they are to absorb and take on complicated questions and to ask questions.

And there's something else that plays into that, which is something Claudia said, which is about scientists and their ability to communicate. I can't speak across the board, but we did have one experience when I asked various different scientists if they would be interested in writing short essays for children on a variety of frequently asked questions, like I asked a modern recent astronomer if he'd like write an essay on "Is there anyone out there?" and the response I got from these very distinguished scientists was always the same. It was incredibly humble, they all said, "But why do you think children would be interested in what I have to say?" And you see, that was really interesting because I said, "Well, yes of course they would be interested in what you have to say, and of course they want to know what work you're doing," and they all, there seemed to be this sort of general feeling that people didn't want to hear from them, the people didn't want to know what they had to say. But I sort of persuaded them and I talked them into it, and we put together this very nice little collection of essays which tell things like how to find a planet in outer space and what is the Goldilocks Zone. And it's very accessible. But it took quite a lot of persuading with the scientists, this was something not only that they could do it but that people would be interested. So I don't think that answered your question at all, sorry. I just rambled off.

Bingham: Let me just find out, how many of you, have you read, do you know Natalie Angier's book *The Cannon*? Right. So there's a section there where she's talking to the historian of science, Peter Galison, from Harvard, who says exactly what you were saying there – we take these bright bouncy little objects that are full of energy and so on, and we manage to persuade them that science is boring and so on and so forth. But there's a movement to kind of shift that now, and Peter talks about it as if it's like the myth of Sisyphus, trying to push this rock up to the top again. And he says that we've now got the

boulder balanced at the top, with a lot of potential energy, just one little push and it converts into kinetic energy. That's physics, isn't it? Kinetic energy.

Tyson: Indeed, yes, physics.

Bingham: So, I think what the question is, one of the questions I want you to brood on is what's the push. But can we, let's go to one of the questioners first of all, before we lose this. Who's, yes, you're the head of the line.

Audience Member: Thank you all so much, you absolutely have enticed our thinking and helped us understand what we need to do. The one thing that I've found, and I've been here since nine o'clock this morning, actually nine thirty, I was late, is that we have not heard from the young scientists who are students here at Arizona State University, and the reason I bring that up is that I serve on the Board of Directors of the Burnham Institute of Medical Research in La Jolla and I listened to seven of those young scientists talk to the Board of Directors last week. Every one of them had a foreign accent, and after the meeting I asked the question as to how many of those young scientists, who are fully employed, fully engaged and doing great grant work, were from the United States. And eleven percent of those on the faculty at Burnham are from the United States. So, my question is, we need to engage those young scientists from other parts of the world to find out what happened in their lives, as they were matriculating, to make them become scientists. And maybe from them we can learn what we need to do here, as well as the work that you are all doing. So, that's all I wanted to say. Thank you.

Bingham: So popular legend has it that once upon a time in this country being a scientist wasn't very well paid and you should be a lawyer or work in finance, perhaps that will shift back again.

Tyson: I can tell you also that there are essentially no unemployed scientists or engineers. Meanwhile you have artists violining in the street, and painters. I mean, it's just there's certain realities of society.

Dreifus: There are unemployed engineers.

Tyson: Not badly unemployed.

Dreifus: I don't know. May I speak to that? Because I was talking to the Science Club, the Biology Club at Columbia last week, and what was really interesting was that a lot of the students were women and American-born women of immigrant families. But what was really interesting was how afraid they were to talk to their American colleagues and peers about what they did at school. There was a young woman whose parents came from El Salvador and she was saying she was really interested in science issues but she was afraid of talking to her girlfriends about it, because she didn't want to seem nerdy! And I said, "Well why don't you speak up for your interests? Why be afraid to say, hey, I'm a scientist and proud?" And it hadn't occurred to her. I still think that science kind of needs an anti-defamation league.

Tyson: Well, there's a whole website called SkepChicks, I don't know if you know about it. These are women who themselves are nerdy, who like nerdy men. No, I'm serious! Check it out! SkepChicks! These are women who could care less about Brad Pitt but are after, they're interested in science themselves, and will discuss nerdy topics. And so I'm claiming that there's a movement underfoot, and it'll take a little time, but it will rise up.

Druyan: Nerd is cool!

Tyson: And the geeks shall inherit the earth!

Bingham: And you were on this website, why?

Druyan: I was going to say that, I was going to say the same thing!

Bingham: Alright, we agree: science rocks. Now we just have to get that message out. Yes, so, please.

Audience Member: Hello, my name is Victoria, I'm a young scientist, and I'm very proud to be a scientist. I ask the panel a question or a comment to an old Chinese proverb. It says, "Tell me and I will forget, show me and I may remember, involve me and I will understand. And based on this proverb, which is kind of my teaching ethic, I was wondering how you perceive the education system, the university environment, and also media. Because in part I feel the education system and the media system is almost partly like armchair science where you're just sitting back and watching other people, and you're not engaged in the process continuously. And the other question I'm asking is why is science, why is there also a barrier to science, is the process of science really elusive? And, each of you, what do you think is the definition of science. I've even asked professors and some of them can't give me a straightforward answer.

Bingham: Okay, before we get to the answers, just so you know, Lawrence has just issued an edict that we have about five minutes left. So, it's speedy.

Hawking: Can I just give a very quick answer to that as it relates to what we've been doing with children?

Bingham: If you can speak at relativistic speed, yes.

Hawking: That proverb would pretty much describe the way we set about trying to explain some of the work my father has done, and other scientists, to children, because of the way children were asking him questions, which was all about what would happen to them if they went to a different planet, if they flew too close to the sun. So we wrote everything in terms of what it would be like if you were actually there, as an involvement thing, to make it real and vivid to them, in order to capture their imagination and so that they would get involved. So that's absolutely the thought of what we've tried to do.

Downs: There's something that Neil touched on that I have not seen anywhere in the press. Now maybe it has had some coverage, but that's the economic aspects of the value of funding science for its research. There's a challenge, I think, for the press, to get that out to people and maybe not focus solely on trying to get people to understand the more stratospheric aspects of how science is done. I would like to see the press rise to that challenge and show something about the economics, because so much is driven by economics rather than the more pure scientific things.

Tyson: And briefly I can address this directly. I think the Chinese proverb is a bit overrated in the following way: if all you do is sit there and get lectured to, and the lecture is boring, yes, you're not engaged and you don't become a scientist. And the claim is that if you're engaged physically, kinetically, then you'll understand a concept better. I don't deny that. But, what I will claim is that it is possible to be lectured to in a way that you are so riveted by the content, and the content is scintillating on a level that you are completely transformed. And that is a rare talent. I think Carl Sagan had that talent, I would sit and listen to Carl Sagan for months, for years. And it's possible to be intellectually engaged, and that's the challenge of the educator who stands in front of a classroom. Because you can't physically engage everybody because there aren't as many, you'd need an educator for every student practically to actually put that into affect. So you need the rare educator, and I bet you, by a show of hands, who here has had, how many singular sort of teachers have there ever been in your life? And I bet you it's not more than three or four, teachers who transformed who and what you are as a person. It's not more than three or four. You've had dozens of teachers, scores of teachers in your life. You want to take those teachers, and they should be first in line for the cloning machines that come out of the, out of the thing. And lastly, definition of science, there's too much crap out there, "Oh, it's hypothesis, uhh, uhh." Science is do whatever it takes to not fool yourself into thinking one thing over another in deducing the nature of the world around you.

Druyan: Amen

Tyson: That is what science is!

Druyan: That's it.

Tyson: It's not more complicated than that! It's not! The source of inspiration can come from anywhere, it doesn't matter. As long as you put in the checks and balances to resist duping yourself into thinking something is true that isn't. That's all it is. That's all we do.

Dreifus: And I would add that universities need to start valuing teaching as much as they value research.

Bingham: So, well, it seems from this program today that ASU's one place that's doing it. I'm sorry guys, there's no time for any more questions.

Krauss: There isn't. And I know we could go on all night, and you know, it's really amazing when you ask five people and you think that the dynamics might work. But like everything today it's just exceeded anything I could possibly have imagined, and I really, really appreciate all of you, my old friends and one new friend, for coming, and for Roger for doing this, and all of you. So, we're going to take a little break but I want to thank everybody.