[APPLAUSE]

BASSAM SHAKHASHIRI: Thank you very much. Good afternoon, everyone. It's almost evening.

It's a pleasure to be back at MIT. It's always a pleasure to be back in the Boston area because this is where we first lived, when my family and I came to the United States in 1957. In fact, we arrived here September 17, 1957. My dad came as a visiting professor to Harvard from the American University of Beirut. And then Harvard said, stay another year stay, another year. He never went back.

So I enrolled at Boston University. My dad then moved to NIH. Both my parents are deceased now. But the Boston area is very special to us because it was the first place that we lived in this great and wonderful country of ours. And then, I'm very, very happy to be back as a guest of Professor Lippert, and the students in his class, and the colleagues. And I promise you a good time, if you pay attention.

[LAUGHTER]

So what I really would like you to do is sit back and relax because I'm going to share with you, to begin with, some important convictions about what it is that we do in science and why we do it. I wish I had more time to go in depth. But I just want to go quickly through some of these convictions that I hold very deeply.

So let's see if this is going to work here. I want to see your faces. OK. I can still see your faces.

So *Science is Fun and the Joy of Learning.* That's the title of my presentation,*Science is Fun and the Joy of Learning.* And every word is carefully selected. You know, English is my second language. So I think about every word and its meaning.

I also want to say that it's a pleasure for me to see some old friends here, but also to make new friends. And to see someone who watched me in Singapore, when I was in Singapore-- Where are you? Right there, yeah, yeah-- about three years ago. So welcome.

So what I'd like to say to you immediately, that your brain and my brain will be different after this presentation, if you pay attention. If you don't pay attention, I can't do much about it. But both my brain and your brain will be different.

35, 40 years ago, when students went to medical school, they were told that the brain is an organ. It doesn't change very much. But now we know more. Through the neurosciences, we know a lot more.

We know about plasticity. In fact, changes in the brain happen. That's what education is all about. That's what learning is about, if those changes were not happening. So I just want to share with you the importance of being focused and paying attention.

We live in the most advanced society in humankind. And these advances are due to advances in science and in technology. I want you to think of this statement I just made. Everything we enjoy now is the result of advances in science and in technology. The advances are so great, much greater than we knew 50 years ago when I first came to this country, or a hundred years ago, or 200 years ago, or 500 years ago, a thousand years ago.

A long time ago, technology drove society. The printing press was invented. Electricity lit the world before we learned about the electron, before the electron was discovered. There are all kinds of connections between science and technology. But nowadays, it's science that drives technology.

Our ancestors were very good. They built cities. They built canals. They built pyramids. But now, we can build pyramids at the atomic level. You've seen pictures of them.

A great deal of wonderful transformations have happened because of advances in science and in technology. And it is the brain, our brain, that is responsible for those changes. We're all capable of doing good things, each one of us. And each one of us is capable of doing evil. And that's why we have to be selective about how we use the results of those advances in science and in technology. These are different parts of the control mechanisms that we know about now for the brain.

So please pay attention and bear with me. You came to see some experiments and some demonstrations. I promise I will get to them.

[LAUGHTER]

I promise I will get to them. But I want you to understand the perspective and the context for doing those experiments and those demonstrations.

So we all like to say that chemistry is the central science. And it is the central science. I like to say it's the familiar science. In fact, what I'd like to say, it's the science of the familiar because everything around us is made of chemicals.

The air that we breathe is a mixture of usually good chemicals. The food that we eat is a mixture of chemicals. The clothes that we wear are made of chemicals. Our own bodies are made of chemicals. What goes on inside our bodies is nothing but a series of biochemical reactions.

The medicine that we take when we are sick is a mixture of chemicals. The drugs that some people very stupidly experiment with are chemicals. Ah, some of you are smiling. I'm connecting with the already.

That's why we need to learn about chemicals, their proper handling, safe handling, proper disposal, their benefits. It's so complex, but it's beautiful. Beauty is part of science. It's an essential part of science.

Now having told you that everything around us is made of chemicals, I'd like to ask each one of you right now to reach out. It's OK, Lou. It's part of the effect. It already had the same effect on you. So that's good.

I'd like to ask each one of you right now to reach out and touch a chemical. Go ahead and do it right now. Somebody's tapping on somebody's shoulder. Somebody's is pulling somebody's hair. Don't pull it too long. Somebody is reaching out in the air.

Yes. Chemicals are all around us. And we want to learn and enjoy the beautiful chemical world that we live in. That's why I say chemistry is the science of the familiar. It's the science of the familiar.

So I want to share with you for just a few short seconds the theme that I have selected for the American Chemical Society. As Professor Lippert said, I will be the president beginning January 1. But I'm not waiting till then because I want to get a good head start and get going. The theme I selected is advancing chemistry, communicating chemistry; advancing chemistry, communicating chemistry; advancing chemistry, communicating chemistry. And I want to call your attention to the ACS mission statement.

One of the worst things that a presenter can do is show a slide and then proceed to read it. It's an insult to the audience. You can read it. But forgive me. I don't mean to insult you. I want to share with you the emphasis about this.

So it says, "To advance the broader chemistry enterprise and its practitioners for the benefit of Earth and its people." Such a profound statement, I only wish I had written it.

And then there's the ACS vision, "Improving people's lives through the transforming power of chemistry." "Transform" is a very powerful word. That's what happens to us when we become educated. This is what happens to us when we become learned individuals. This is what happens to societies when they become advanced and learned. They are transformed.

I've selected four initiatives. Next year is the sesquicentennial of the Land Grant Act. And the Land Grant Act, as some of you know, and I'm about to tell you if you didn't know it, transformed America. MIT is a land grant institution. Did you know that?

Raise your hand if you knew that MIT was a land grant institution. OK. Raise your hand now if you know that MIT is a land grant institution? Everybody-- right? I mean, look, I asked you to pay attention.

[LAUGHTER]

I said your brains will be different. My brain is being different already because I can tell from your reactions, when it is visual reactions, and also from your sound that you're sharing with me.

So we're going to mark the sesquicentennial of the Land Grant Act at the national ACS meeting in San Diego and Philadelphia by looking retrospectively at what chemistry departments have done in the past 150 years. So we educate ourselves about our heritage.

What I'm really most interested in is what we're going to do in the future, what you're going to do in the future? I'm not going to be around much longer. I hope a long time. But not as long as you're going to be. So we want to be prospective. We want a glance in the real view mirror. But we want to look ahead so we can be participants and leaders in transformations that are good for our human society.

Our second initiative deals with appointing a blue ribbon commission to examine the purposes of graduate education and research in the chemical sciences. Look at the purposes. Why do we have graduate programs in the chemical sciences? Has the German model served us well? Is it appropriate for the 21st century?

We make promises to graduate students when they come to graduate school. Do we keep those promises? Look at the duration of the postdoctoral appointment now. It's getting longer and longer. So we talk about employment issues.

We also look at the profile of the graduate students, diversity, as well as international part of the profile. And we want to, of course, remember that the graduate students were undergraduates before. And before that, they were in precollege. So we're going to segue to that. But the focus is on this level right now.

There'll be listening sessions. There'll be opportunities to interact via email, webinars, with this blue ribbon commission that I have appointed.

The third initiative is to help the public understand the science of climate change. The science of climate change, not the politics, not the economics, but the science of climate change. What is a greenhouse gas? What makes it a greenhouse gas?

Did you know that any molecule with three atoms or more in the gaseous phase is a greenhouse gas? Did you know that? Yes or no? Did you know that?

You didn't know it, right. Well, I just told you. OK. Every molecule in the gaseous phase, that has three atoms or more, is a greenhouse gas. But they're not all effective. And why aren't they all effective?

And what does it take for a molecule to become a greenhouse gas? We all know about dipole moments. Yes. You know about dipole moments? OK.

So what I'd like you to do is make connections between what you know and what you're hearing me say now because that's how we learn. And that's how we share the knowledge with each other. So it takes a dipole moment to effect, right? You're shaking your head. And I'm beginning to connect with you, right?

But there are molecules with two atoms in the gaseous phase that have a dipole moment too. Carbon monoxide, right? Well, it's not a greenhouse gas. How come? So what does it take to be a greenhouse gas? Think about it.

Here's the big question. How does the vibrational energy change into heat energy? I'm not going to ask any one individual to tell me the answer to that one. But I'm asking you to think about it.

How does the vibrational energy change into heat energy? You know, most of the air is nitrogen and oxygen. But now, we're putting greenhouse gases in there, more than we did before. Why?

Because the Industrial Revolution has been so successful, extremely successful. This is why we have the most advanced society in humankind. But because of the Industrial Revolution, we put more carbon dioxide in the air. We put more CO_2 gas in the air.

Is that a good thing? Up to a point, it's a good thing. If it weren't for the greenhouse gases, the surface of the planet would be as cold as it is on Mars and life as we know it would not exist. So there are good and not so good things about the greenhouse gases. And that's what this third initiative deals about.

The fourth one is to consider the possibility of establishing an ACS high school teacher fellowship program. We will be hearing about this later on from reading chemical engineering news and other sources.

So that's briefly what I want to focus on. It's not the only thing. But that's what I want to focus on for next year.

So advancing chemistry, how do how do we do it, through research. Research is so enjoyable. It's so rewarding. We ask questions. We want to know the answers. We're curious.

Why is the sky blue? Why is the sky blue? Scattering, you're to tell me scattering. OK, that's good. OK.

[LAUGHTER]

Why do leaves change color in the fall? One of the most beautiful experiences I had in my life, when we first came to Boston in 1957, a colleague of my dad at Harvard took us to New Hampshire, to Vermont, in the fall. It just-- it was-- I can't use adequate words to describe the beauty of the chemical transformations that were happening in the leaves and how the chlorophyll reaction shuts down.

And all these other colors are there already. But we don't see them because they're masked by chlorophyll. And just understanding that and asking questions is what we're trying to do, both in research and in education. Of course advanced chemistry by being innovative as well.

So I'd like to just take a couple of moments to tell you that in society today, we have two sectors, the science-rich sector and the science-poor sector. Who is in the science-rich sector? Colleges and universities, parts of industry, the national laboratories. Who is in the science-poor sector? Everyone else.

And those of us who are fortunate to be in the science-rich sector have an obligation to the people who are in the science-poor sector. I want you for a moment to think about science-rich and science-poor. But I also want you to think about what you hear on the news now daily and cross out the word "science" and cross out the word "science from the second one. And look at the turmoil that we have.

There's a gap that is widening at an alarming rate between those of us who are rich in knowledge and otherwise, and those who are not. And it's incumbent upon us to narrow that gap. We have to do it for a lot of profound societal reasons.

But I'll give you one crass reason why it's important for those of us in the science-rich sector to communicate with the science-poor sector. And you know what that crass reason is. The people here, in this sector here, they pay for what it is that we do in the science-rich sector, government funds, private foundation funds. So we need to be thinking about our role as science students, as scientists, as learned individuals in this regard.

All right. So there's scientific competence, which is what we acquire by doing research through education. There's scientific expertise. But there's also science literacy. Our goal should be to increase the level of science literacy among people in the science-poor sector.

Science literacy is the appreciation of science without a deep knowledge of chemistry, physics, or biology, or any other science. It's an appreciation. Let me give you an analogy to make this point as clearly as I know how. And this analogy comes from sports. I know as a classroom teacher the danger of using analogies because you remember the analogy, and not the real thing that I'm talking about.

Just as we have professional football players, baseball players, hockey players, and so on, we have sports fans. Without those sports fans, you know the interprofessional sports enterprise would be nothing. You also know that's not an exaggeration.

So what we need, we need scientists and we need science fans. And we want those science fans not to be sitting in the stands as passive spectators. We want them to follow what we're doing. Some of them might even show up on the playing field to become scientists like us. But we have to pay attention to them so we can improve the level of science literacy.

Communications. There are many elements to communications. I just list five of them here. One is to inform, to engage-- that's what I hope to do very shortly. I promised you I'll do experiments. They're engaging. I'm going to get to that-- to educate, to advocate, and to persuade.

There are other parts of it. There's entertain, all kinds of things you can think about. But those are the five I want to try to focus on as important elements of communication.

In the scientific community we communicate with each other very well. But we don't do it as well yet with people in the science-poor sector. So we have to work on that.

One purpose of communicating chemistry is to showcase chemistry at its best in addressing significant human and societal issues. It's very important that we do that, very, very important that we do that.

Here's a statement from a very famous person. Everyone knows this person by name. And he said, "Most of the fundamental ideas of science are essentially m and may, as a rule, be expressed in a language comprehensible to everyone." You think about that. He said most of the fundamental ideas of science are essentially simple, or maybe simple to him. But no, that's just a joke. Now, you think about what he's saying. OK.

So we have to find ways to improve our communication skills to the public at large. And so I want to mention to you very briefly an activity we do at the Wisconsin Initiative for Science Literacy, asking graduate students to include in their thesis a chapter, explaining the research that they just finished, to their mother, to their grandfather, to their neighbor, to anyone, to their former high school classmates. So that they get to appreciate what it is that someone spent five, six years, working hard, using taxpayers' money and other people's money, to improve knowledge and to give us rewarding experiences. And the goal, as I say, is to explain the candidate's scholarly research and its significance to a wider audience, that includes family members, friends, civic groups, newspaper reporters, state legislator, and so on.

And if you do this, we give you $500. We're beyond $10 now. We're beyond $10 among the graduates. This is catching on. And we will assist in the public dissemination of this.

So I'm going to tell you how you can find out more about this because you can read those chapters. We have them posted them on my website. My website is www-- they all start with www, you know that, right? And then scifun-- S-C-I-F-U-N-- .org. Somebody is writing it down. You don't have to write it down.

Just say it quietly a couple of times, scifun.org-- S-C-I-F-U-N-- .org, scifun.org, scifun.org. Now, this is how we memorize things. But why do we memorize things? To store them in our memory banks? They use them. To use them.

So I'm going to check with my web master in the next couple of days to see how many new hits we get from the Cambridge area. See if anybody's been to my website. OK. All right.

The great master Leonardo said, "There is no higher or lower knowledge, but one only, flowing out of experimentation. We're getting close to my keeping my promise, keeping my promise. That's what you came here for. So I'm going to do some experiments.

And my latest book is volume 5 in this series. It deals with color, light, vision, and perception. It deals with what happens in front of the eye. But now because of advances in neurosciences, we learn more about what happens behind the eye. So that's included in this book here.

And there's a little flyer that you may pick up as you walked in or when you walk out. And if you have a favorite high school teacher, you might want to give him a copy as a Christmas gift or a holiday gift, if you wish to. The book has been out now since February. This is the cover of the book.

What are these three things that you see here? What do they look like?

AUDIENCE: Drops of water.

BASSAM SHAKHASHIRI: Mumble, mumble, mumble. I like that because everybody saying things-- huh?

Are they paperweights? They could be. They're actually water droplets. That's what are. They're water droplets, as some of you said.

So here's an experiment that I want-- the first experiment I want to ask to look at. This is a checkerboard. This is about perception because you're going to be seeing things now. And the brain, the brain sometimes plays tricks on us.

So here's the checkerboard. And you see this object right here. And you see it casts a shadow. So my question to you is, is the shade in square of number 1 the same as the shade in square number 2, yes or no?

AUDIENCE: Yes.

AUDIENCE: No.

BASSAM SHAKHASHIRI: How many say yes? Raise your hand if you say yes. And how many say no? More people say no.

So we have to train ourself to do this. Now, remember now, this one is labeled number 1. This is labeled number 2. I'm going to now cover this. And now, you see that they both have the same shade. You see that, right?

So those of you who said yes before probably have seen this.

[LAUGHTER]

And you know what? Your brain is using the knowledge that you had from before. That's great. So let's look at this one more time. So I take it off. You see.

So what's going on here? The shadow is telling the brain something. And we have to develop the skills with our brains to sort out the information, and be very careful about it, so we have the proper interpretation.

So this is when I cover it now. You see this shadow cannot be seen. And that's how we started with it.

So we have to make connections. We have to make good connections. We don't want to have any impedance problems. That's what we don't want to have.

And I want to show you why we want to do experiments and demonstrations, why we want to be engaging. This is why. That's why. That's why. That's why. That's why.

You just look at those faces. You just look at those faces. And each one of them is engaged. Engagement is important. But what's really important is what happens after that.

So we're going to now get into what happens as you become engaged. Lights out, please. Because we're going to do some experiments, in addition to the one we did.

Yes. Yes. I know you've waited too long. I know. I know.

When we do experiments, we'll obey all the safety rules. You notice I have my goggles on. Did you notice that? I just pointed it out as a reminder. For those of you who noticed and those of you who didn't, you just saw that I have them on.

I have a fire extinguisher right here. It's ready to be used, just in case something goes out of control. I'm not planning on anything going out of control. But we have it as a safety precaution.

So what I'm going to do is take a match and strike it. You like that, right?

[LAUGHTER]

So this is an example of what we call a combustion reaction. I'm going to light a candle. And--

AUDIENCE: Whoa.

BASSAM SHAKHASHIRI: --I'm going to-- whoa is right, see. Engagement.

I want to tell you something that I have observed over the years. I've been doing these demonstrations for over 40 years. Youngsters and people in retirement homes are not inhibited like the rest of us. So we have to allow ourselves to express ourselves.

So this is an example of a combustion reaction. And it is, of course, related to Michael Faraday. You know who Michael Faraday was, right? He used to gather young people around Christmas time at the Royal Institution and do experiments with them. And one of his most famous lectures is on the chemical history of the candle.

So what I'm going to do now, because you're paying good attention, I'm going to reach back into my back pocket and get my wallet out. What do people usually keep in their wallets?

AUDIENCE: Money.

BASSAM SHAKHASHIRI: Money. What else?

AUDIENCE: Credit cards.

BASSAM SHAKHASHIRI: Credit cards. What else?

AUDIENCE: Driver's license.

BASSAM SHAKHASHIRI: Driver's license, if you're old enough to have one. What else?

AUDIENCE: Pictures.

BASSAM SHAKHASHIRI: Pictures, all kinds of things. So what I'm going to do now is I'm going to reach in here. I'm going to take a dollar bill and I'm going to put it into the flame, just like that.

AUDIENCE: Wow.

BASSAM SHAKHASHIRI: Was that too fast?

AUDIENCE: Yeah.

BASSAM SHAKHASHIRI: Well, I asked you to pay close attention, didn't I? I'm trying to engage your brain.

So that was not a real dollar bill.

[LAUGHTER]

That was a fake dollar bill. That was a phony dollar bill. It's called flash paper.

What we always do in science is repeat the experiment. So I take out what looks like a dollar bill. But it's not a real dollar bill. I bring it close to the flame. It disappears into thin air.

It looks like magic. I love magic. Magic is engaging, but not informative. Magic is engaging.

So this is paper that has been treated with chemicals so that when it burns, it doesn't leave any ash behind. It's called flash paper. And so what are the chemicals that are used for this?

You want to think about this, right. So you want to educate yourself about it if you want to. And you might want to go to my website to learn more about this.

How do you get to my website?

AUDIENCE: www.funsci.org.

BASSAM SHAKHASHIRI: OK. You got it.

So now I would like to ask someone in the audience to volunteer to help me with the next experiment. Who wants to help?

Well, let me tell you first what I need help with, OK.

[LAUGHTER]

I'd like someone in the audience to let me borrow from them a real $1 bill. Is there someone in the audience who would let me-- who would trust me with a real $1 bill or a $5 bill?

Steve, how about a $20 bill, huh? You got a $20 bill?

OK. Here's a $1 bill. It's a real $1 bill. You know what I'm going to do with it, don't you? You know where this is going.

So combustion, combustion is--

AUDIENCE: You did say borrow.

BASSAM SHAKHASHIRI: Huh?

AUDIENCE: You did say borrow.

BASSAM SHAKHASHIRI: I did say borrow. You know what? That's a very important observation that you made and you are reporting it. Because the whole exchange for the benefit of society works on the element of trust.

You trusted me with this $1 bill. So I did say borrow, which means I'm going to give it back.

AUDIENCE: Right.

BASSAM SHAKHASHIRI: I didn't say what form it's going to be in when I give it back.

[LAUGHTER]

So, well, I have a jar right here. And I have in this jar-- what does it look like? I have a liquid. What does it look like? It looks like?

AUDIENCE: Water.

BASSAM SHAKHASHIRI: It looks like water. The way we described this liquid is to say it's a clear and colorless liquid, which is what water is. So I'm going to take this liquid and-- so I want everybody to see the jar right here, get this out of the way.

I'm going to take the dollar bill. I'm going to soak it in this clear and colorless liquid, which looks like water. And I'm going to fish it out using those tongs. You see, it's dripping like any wet object would.

And then I'm going to take it to the flame. Take a good look at it now. It may be last time you see it. So here is the dollar bill on fire, or is it?

AUDIENCE: No.

BASSAM SHAKHASHIRI: But you did see a flame, didn't you?

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: So now I ask you, can this liquid be water?

AUDIENCE: No.

BASSAM SHAKHASHIRI: You know from experience that water does not burn under these conditions. So I will tell you what's in this jar. This clear and colorless liquid is a mixture of rubbing alcohol and water, isopropyl alcohol and water.

You know also from experience that when you burn alcohol, what color flame do you see? It's kind of bluish. Do you remember what color flame you saw here? It was a little yellowish.

That's because we also added a little bit of sodium chloride in there. The eye is more sensitive to the yellow color than it is to the blue color. So we added the sodium chloride to enhance the visibility of what's going on.

How can sodium chloride enhance the visibility? So we're exciting the electrons and the sodium ions. They go to a higher energy state. Do you remember all the stuff that you learned in atomic structure, and so on? Make connections. Make connections with that.

So I give you back this dollar bill because I said I would borrow it. So here it is. So what does it feel like? Of course, it's wet. It's 50% water, 50% alcohol.

So wait a little bit until it dries. And then you can-- so thank you very much. Give her a hand for helping out with this.

[APPLAUSE]

So when you burn something that has carbon in it, you get carbon dioxide. Carbon dioxide is a gas at room temperature. We can't see it because it has no color. And we can't smell it because it has no odor.

But everyone knows about carbon dioxide gas because you know about carbonated beverages. In fact, they're called carbonated beverages. They have carbon dioxide in them.

I'm going to do an experiment right now so that we can learn a bit more about how much carbon dioxide is dissolved in this liquid. And to do this experiment, I'm going to use a baby bottle.

[LAUGHTER]

You remember that, huh?

So this baby bottle has been modified slightly. I have replaced the nipple that has the hole in it where the milk flows out, with the rubber bulb from a medicine dropper. And this is a very strong piece of rubber.

I'm going to try to show you how strong it is by attempting to blow air in it to see if I can inflate it. Here we go. Can't do it. It's very, very strong.

So now, please listen carefully to this very familiar sound as I open the can. You've all done this or seen someone do it. Here we go.

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: Did you hear that? Now, the can is open to the atmosphere. That's the sound from the metal.

I'm going to take the liquid and put it in this baby bottle. What do you see? You see fizz. You see bubbles. What kind of bubbles are those?

They're carbon dioxide bubbles. Where are they coming from? They're coming from the drink, from the liquid. But the pressure now is open to the atmosphere. And that's why they're bubbling out.

So I'm going to fill it to the top, take the screw cap and tighten it. What should I do next?

AUDIENCE: Shake it.

BASSAM SHAKHASHIRI: You've done this experiment before, huh? So I shake it. And now you see how much carbon dioxide is dissolved in this carbonated beverage. There's so much carbon dioxide in there it's able to partially inflate this strong piece of rubber, that neither I, nor any other human being, can inflate with all the powers of our lungs.

But you already know that there is a lot of carbon dioxide in drinks like this because what do you do after you take a sip or two?

AUDIENCE: Burp.

BASSAM SHAKHASHIRI: Burp. Yes, you burp. When you burp, please do it gently and politely. Your burp because the carbon dioxide gas is coming out of the liquid.

So now let's see if I can release the pressure a little bit here. I do it carefully. If I don't do it carefully, what will happen? I will make a mess. You're right. It'll spread out.

But I don't want to make a mess because this carbonated beverage has, among other things in it, sugar. And that sugar is sticky. I don't want to have.

So there it is. It's open to the atmosphere now. And the carbon dioxide still bubbles out.

You know from experience that when the drink goes flat, it doesn't taste as good. Right? Right? You're shaking your heads. Why doesn't it taste good, as good? Because all the carbon dioxide has disappeared.

So why do we like carbonated beverages? Some of them have alcohol in them. Some of them have some sugar or sweetener in them. We like them because when we put the liquid in our mouth, the tiny gas bubbles come out of liquid and they tingle us under the tongue and give us a pleasant sensation.

So that's about carbon dioxide gas. It is a colorless and it is a odorless gas.

Now, what I'm going to do is an experiment using another form of carbon dioxide. It's called dry ice. Dry ice is solid carbon dioxide. And you'll notice I'm putting what on?

AUDIENCE: Gloves.

BASSAM SHAKHASHIRI: Putting gloves. And I'm going to open this bucket and pick up three chunks of carbon dioxide, solid. This is solid carbon dioxide.

It's temperature is minus 78 degrees Celsius. It's very cold. That's why I use these gloves to protect my hands from frostbite. These gloves are not very good insulators. But for this purpose, they're good because I'm not squeezing on the dry ice.

Dry ice changes from being a solid to a gas by a process we call sublimation. Sublimation is happening right now. But we can't see it. How come we can't see it? Because carbon dioxide is gas, is what?

AUDIENCE: Invisible.

BASSAM SHAKHASHIRI: It's invisible. It has no color. By the way, if you ever see a colored gas, you run away from it. You heard me. If you ever see a colored gas, you run away from it because all colored gases are poisonous. All colored gases are poisonous.

The converse is not true. There are some colorless gases that are deadly poisonous, including the close relative to carbon dioxide?

AUDIENCE: Carbon monoxide.

BASSAM SHAKHASHIRI: Carbon monoxide. OK. So, all right.

So sublimation is happening right now. We can't see it. And I'm going to put those three back in here. And I ask you to focus your attention on what you see between my two hands here. What do you see between my two hands?

AUDIENCE: Cylinders.

BASSAM SHAKHASHIRI: What shape are they? Cylinders. How many of them are there?

AUDIENCE: Six.

BASSAM SHAKHASHIRI: And are they big cylinders or small cylinders.

AUDIENCE: Big.

BASSAM SHAKHASHIRI: Well, how big is big? This big. Yeah, I know. That's this big.

[LAUGHTER]

I'm going to ask you to do the very same thing I ask my students in my freshman chemistry course at Wisconsin to do. In order to sharpen your powers of observation and develop the skills of reporting these observations, I ask you to pretend to be the play-by-play radio announcer, describing to someone who is not with us what's going on, not the TV announcer. That person has got it made because the picture tells almost everything.

So there are how many cylinders?

AUDIENCE: Six.

BASSAM SHAKHASHIRI: And what do you see inside the cylinders?

AUDIENCE: Colored liquids.

BASSAM SHAKHASHIRI: Colored liquids. OK. I'm listening to you on the radio. And what I hear you say is that there are six cylinders. And they have in them colored liquids.

Come on. Your brain learned a lot more information than those two statements. So they're about this big, you said. I can see you on the radio saying, it's about this big.

You've got to do better than this. Are they 100 millimeters in size? Are they 10 liters in size? Are they somewhere in between? Yes. We put a bracket on it. When we estimate in science, we put a bracket on it.

And they have, yes, colored liquids. How do you know they're liquids? They could be gels. How do we find out? We shake them up a little bit because we know from experience.

It's a keyword. We learn things. Our brain learns things. So we use them. So they're liquids.

And they seem to be arranged in some kind of order. What is the order? It's the order of the color in the liquids. And they're arranged in pairs. This pair has what colored liquid in it?

AUDIENCE: Blue.

BASSAM SHAKHASHIRI: This one?

AUDIENCE: Pink.

BASSAM SHAKHASHIRI: This one?

AUDIENCE: Purple.

BASSAM SHAKHASHIRI: All right. So I'm going to take chunks of dry ice and put them in the cylinders in a very special way. And when I get done, you tell me what the special way is.

AUDIENCE: It's blowing out.

BASSAM SHAKHASHIRI: What's blowing out? Do you see any bubbles? What kind of bubbles are those?

I wish I had a camera and take a picture of the facial expressions I see here. A lot of interesting things are happening. How interesting are they? Are they interesting enough that you want to ask questions about them?

AUDIENCE: Yeah.

BASSAM SHAKHASHIRI: Yeah. Well, you want to know what's in there? You already know what's in there, the dry ice. I put the dry ice in there.

What did I put the dry ice into? Into the cylinders that have colored liquids in them. And I put the dry ice in every other cylinder. I didn't put it in every cylinder right, every other cylinder, leaving one for comparison purposes.

So these are dyes. They'll change color when the pH of the liquid changes. Because carbon dioxide gas in water gives us carbonic acid. Every time we drink a carbonated beverage, we're drinking acid. Did you know that? That's a weak acid.

But these cylinders have in them a little bit of sodium hydroxide, before I did the experiment. And they changed color because carbon dioxide, the gas, combines with the base that's in there. And the dyes are acid/base indicators.

So this pair had an indicator called bromothymol blue. This has phenolphthalein. And this had a mixture of indicators. So in this pair, the color changed from what to what?

AUDIENCE: Blue to yellow.

BASSAM SHAKHASHIRI: How about this?

AUDIENCE: Pink to--

BASSAM SHAKHASHIRI: To what?

AUDIENCE: Clear.

BASSAM SHAKHASHIRI: Clear. This is a clear and colored liquid. This is a clear-- this is colorless, your right. Clear and colorless do not mean the same thing. From now on, no one in this audience is going to confuse the words "clear" and "colorless." This is a clear and colored liquid. This is a clear and colorless.

So now I ask you to focus your attention on this cylinder. Actually, you can focus your attention on anything you want to. You can even not pay attention if you want to. We live in a free country.

But if you want to follow the experiment with me, I want you to focus your attention on this one. And tell me, count them out, how many different color changes you see as I drop the dry ice in there?

[BUBBLING]

I'm listening to you on the radio.

AUDIENCE: Wow.

BASSAM SHAKHASHIRI: One. Wow, I heard wow. What kind of a count is that?

AUDIENCE: Three.

BASSAM SHAKHASHIRI: Three so far? Three different color changes. But you know, I'm listening to you on the radio. And you want me to appreciate what you're seeing. So what were the color changes that you saw? Why couldn't you say those? You see how we have to help our brain make the right observations and make the right reporting.

So what about this stuff that's coming off of the top? What does it look like?

AUDIENCE: Gas.

BASSAM SHAKHASHIRI: It looks like gas. But actually what it is-- it looks like smoke. But it's not smoke.

What's the name of the stuff that floats up in the sky. You can just say it. You don't have to raise your hand. Just say it.

AUDIENCE: Clouds.

BASSAM SHAKHASHIRI: Clouds. It's a fog. It's fog. It's a mist. It's condensed water vapor.

The condensation is taking place on the cold carbon dioxide gas bubbles that are coming from the sublimation process. That's why sublimation is happening right now, right here, and also in this bucket. But we can't see it. But over here we can see it because gas is mixing with what here?

AUDIENCE: Liquid.

BASSAM SHAKHASHIRI: Liquid. And here gas is mixing with what?

AUDIENCE: Gas.

BASSAM SHAKHASHIRI: Gas. OK. So I always think, T-H-I-N-K, T-H-I-N-K, remember that. If you remember anything about my visit with you today, remember to T-H-I-N-K. Remember to think.

So condensed water vapor is coming out. The mist is flowing downward. Why is the mist flowing downward?

Because carbon dioxide gas is denser than air. It's heavier than air. And if we knew this, this is a beautiful way to be reminded of it. And if we didn't know it, we just learned it.

So what I'm going to do here-- because she turned it off. Ah. No. I wanted it on. Let's see if it still works.

So I'm going to take this bucket, this bucket right here. It's empty except for what?

AUDIENCE: Air.

BASSAM SHAKHASHIRI: You can't see air. And I'm going to take the hot boiling-- ah, well, it's hot. I don't know if it's boiling. It was boiling. You could see it.

I'm going to use my gloves now to protect my hands from heat because I don't want to burn myself. And I'm going to dump this water in here. I don't want to get the water trapped in the gloves because you know what ther will happen, what will happen to my-- here we go.

So what do you see coming off the top?

AUDIENCE: Steam.

BASSAM SHAKHASHIRI: Steam is invisible. You can't see steam. What are you seeing?

AUDIENCE: Water vapor.

BASSAM SHAKHASHIRI: Water vapor. This room is full of water vapor. Otherwise, my throat would be drier than it is right now.

What are you seeing coming off the top?

AUDIENCE: Water vapor.

BASSAM SHAKHASHIRI: You're seeing a mist. It's condensed water vapor. The hot water vapor hits the cold air. It condenses. And then it gets the same temperature. It disappears.

So what I'm going to do now is take the bucket of dry ice and put the dry ice right in there.

[YELLS]

[LAUGHTER]

Just be careful not to touch the water because the water is very hot. All right. OK.

So what I'd like you to do now is to go back and sit. Go back and sit where you were sitting before. I know that's--

Condensed water vapor is what we see. We see the fog is moving?

AUDIENCE: Down.

BASSAM SHAKHASHIRI: Downward. Why? Because the condensation is taking place. And the carbon dioxide gas, which is denser than air. This is a good way to demonstrate this. So I'm going to take this out of the way and put it right here.

This is how they make fog in the movies sometimes. Take boiling water, add dry ice to it. And you put a fan on it and blow it.

And I have to tell you this little story because it's a true story. I do a lot of these presentations all over the world. In Madison, Wisconsin, my adopted hometown, I was at the airport one time. And a whole bunch of kids, about 20, maybe 25 kids, they saw me from a distance. They were getting on an airplane, going on a field trip to Washington, DC.

And they ran to me. And they didn't say, hi, Dr. Shakhashiri. You know what they said? Condensed water vapor.

[LAUGHTER]

That's what they said. They learned it. They learned it. They said condensed water vapor. So they learned it.

OK, good. All right. So now, we're going to do an experiment. Let's see. This is moving along very rapidly here.

I forgot the directions for the next experiment. But you know, I brought my book with me. So here's my new book.

So is it OK if I open the book and read from the book a little bit? Would that be OK? Is that OK?

Ah. You see, this is not an ordinary book. This is a hot book.

Actually, it's just the book covers. What's on the inside? I'll show you.

There's a couple of batteries right here. I'll walk around so everybody can see it. I have two batteries.

Batteries have stored in them chemical energy. And there is a filament up here. And then there is a flint that I soaked with lighter fluid when you were not looking.

And what I have not told you yet, and you have not seen it, but I'm going to show it to you and tell you right now, there's a button down here.

Can you can see the button down there? Huh? What color is the button?

AUDIENCE: Black.

BASSAM SHAKHASHIRI: Come on. You're doing the play-by-play description. Yeah, black. It is black. You have to report your observations.

So you know about the fire triangle. It takes three things to have a fire. What are they? Something that burns. Oxygen, usually from the air. What's the third one? Heat, a source of ignition, a source of ignition.

So you watch how I do this now. I stand over here. I move the book away from my face.

[LAUGHTER]

I'm connecting with you because you're paying attention. And I open the book. And when I push the button, chemical energy changes into electrical energy. And this light bulb filament is like all other filaments. It is not 100% efficient.

It gives off light energy and-- and so let's see what happens when I push the button here, away from my face. OK. You saw that, right?

So you tell me now, you tell me what happens when I close the book? What happened when I closed the book? Just say it out loud.

AUDIENCE: Cut off the oxygen.

BASSAM SHAKHASHIRI: Cut off the oxygen. You're like the students in my class. You give a correct answer, but not to the question that I asked. And that's why people sometimes don't do well on tests because they don't answer the question.

So what was the question that I asked? I asked you what happened when I closed the book? What happened when I closed the book?

AUDIENCE: The fire went out.

BASSAM SHAKHASHIRI: The fire went out. Why did the fire go out?

[LAUGHTER]

Because there is no oxygen. You get it. We have to train our brains so we are connected with each other properly.

So I open the book now. Is there oxygen or not?

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: But there's no flame. How come there's no flame?

We're missing the heat. What should I do? Stop talking and push the button, right. That's what I should do.

So I push the button. There it is. I'm running out of fuel. OK. OK.

So this book cover is from volume 5. And now I have used it once. I cannot take it back on the airplane with me. But even if I could, I don't want to because I want to give it to Professor Lippard as a memento of my visit here.

[APPLAUSE]

So you can use it safely, Steve. And you know why? You know why we teach about the fire triangle? Not to help people start fires, but to help people put out fires. You think about that.

So let's see. We've got a couple of other things going on here. What am I holding with my two hands right here?

AUDIENCE: Bottles.

BASSAM SHAKHASHIRI: What kind of bottles? Come on. Do I have to ask all the questions all the time? Play-by-play description, right.

Are they what? What size bottles are they? What are they made of?

AUDIENCE: Plastic.

BASSAM SHAKHASHIRI: Do you realize how much technology is involved in this, in just making this bottle? Look, there's a shoulder here. There's an opening here. A lot of science and applications of science are involved in making those two-liter bottles, that are made of?

AUDIENCE: Plastic.

BASSAM SHAKHASHIRI: Plastic. They're made of plastic. And there's a little bit of a clear and colorless liquid near the bottom of each one of them. And I'm going to tell you what the liquids are.

The liquid in here is hydrogen peroxide. It is 30% hydrogen peroxide, not what you buy in the drugstore. What you buying the drugstore is 3% hydrogen peroxide.

And what do you buy it for? Because if you have a cut, you put the hydrogen peroxide on your wound. And what do you see?

AUDIENCE: Bubbles.

BASSAM SHAKHASHIRI: Bubbles. What kind of bubbles are those? They're oxygen bubbles. Because hydrogen peroxide breaks down very, very, very, very, very, very slowly into water and oxygen. But if there is something that speeds up that breakup, a catalyst, then it goes very fast. And the blood and the skin have in them such substances.

So I'm going to take what looks like a small tea bag right here. I'm going to put it in there. And see if we can catalyze the decomposition or the breakup of the hydrogen peroxide.

You can see that already-- what do you see on the inside? What do you see coming off the top here?

AUDIENCE: Condensed water.

BASSAM SHAKHASHIRI: Condensed water vapor. It's a mist. It's a mist, right?

And where is it coming from? This reaction of the breakup of the hydrogen peroxide into water and oxygen is exothermic. It gives off heat. So the water is boiling.

And the boiling water, when it hits the cold air, it condenses. And we see that until the temperature gets to be the same as the air temperature. And we don't see it anymore.

So we always like to repeat the experiment in science. But before I repeat the experiment, I want you to look very, very closely, if you haven't been doing so already, about what else is happening to the plastic. But what is this? What is this?

I'm listening to you on the radio. I can't see this. What is this? Tell me. Tell me out loud. Huh?

The plastic bottle is shrinking. Amazing. When I was a student at Boston University, I learned that if you take a substance and you heat it, it stretches.

But this is plastic. This is made by people. So plastics shrink. You all know that plastics shrink because you've heard of shrink wrapping. How does shrink wrapping works?

You cover something up with a plastic sheet. And then what do you do? You heat it.

How come when we heat plastic, it shrinks and when I heat a piece of copper, it stretches? How come? This is not a rhetorical question.

I want to do T-H-I-N-- what? "K" about this. So be thinking about that.

So we repeat the experiment. We're do the experiment right here. And there it is again. Let's see if the same thing happens.

As you're watching that, I'm going to do now an experiment right here whereby I have this beaker. It's volume is about 600 milliliters. And it's empty, except for?

AUDIENCE: Air.

BASSAM SHAKHASHIRI: All right. I'm going to put it on top of this other beaker. They're going to flip around like this. So everybody can see it.

And I'm going to take two liquids, a clear and colorless liquid in my right-hand bottle and a clear and colorless liquid in the left hand. OK. You see that, if you're paying attention over here. But if you're still looking over there, then you're not watching this. And that's really what it's about.

You have the freedom to choose what you want to do. And you will be effective in what you want to do. Be very careful about it.

So that's kind of interesting right there. And you know what? Don't rush into anything. I'm rushing right now. I'm keeping an eye on the watch here.

You all have other things you want to do. You probably want to go watch the Patriots play. That's up to you. But lots of fascinating, captivating, engaging, educating, informing, changes, transformations are happening over here.

So watch this. I take this clear and colorless liquid and I put some of it in the beaker, about a hundred milliliters. How do I know it's about a hundred millimeters? I'm reading the markers here, on the beaker.

And I take about a hundred millimeters of a different clear and colorless liquid. But you don't know it's different. They look the same.

And look at this. Look what's going to happen now.

AUDIENCE: It's yellow.

BASSAM SHAKHASHIRI: Isn't that one of the most fascinating observations you make? You take two clear, colorless liquids. You mix them together. And you get a yellow substance, that is insoluble in water.

And you notice what happened over here? So this is-- this fell over. So it's pretty hot. I don't want to have it-- there it is. I want to have it-- it's going to fall over again. I'll prop it over here.

So the little tea bag has in it a catalyst called manganese dioxide, MnO_2. It has large surface area. It catalyzed the decomposition of the hydrogen peroxide.

Is this one going to fall off? We'll wait and see.

This is lead iodide. I mixed potassium iodide solution with lead nitrate solution. So the magician never tells you how the trick works. But in science, we like to know what's going on.

So I close these back the same way. And now I'm going to ask you a question. I have a magnet coated with Teflon. And it's sitting on top of a motor, which I want to turn on.

Can you see the bars spin?

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: And you tell me what direction is the bar spinning when we look down at it? What direction is it?

AUDIENCE: Clockwise.

BASSAM SHAKHASHIRI: When you look down at it-- I'll slow it down a little bit so you can see it better.

AUDIENCE: Clockwise.

AUDIENCE: Clockwise.

BASSAM SHAKHASHIRI: It's spinning clockwise, what we call clockwise.

Now, what I would like you to do is to visualize that you're not looking down at this spinning magnet. But you're looking up at it. Imagine there is a ceiling fan up there. And it's moving in the same direction as this bar.

So what is that? Here's what some of you are doing, is you're doing this. And you're looking up. And what do you see? What do you see up there?

AUDIENCE: The light.

BASSAM SHAKHASHIRI: Counter-clockwise. You're confusing me. Is this my right hand or my left hand.

AUDIENCE: Right.

BASSAM SHAKHASHIRI: I'm looking up at it. It's my right hand. I put it down here. It is my?

AUDIENCE: Right.

BASSAM SHAKHASHIRI: It's still in my right hand. You're really confusing me.

What's going on here? Here's what's going on. I want everyone in the audience, everyone, stick your finger out like this. And you and I are going to rotate our fingers in a clockwise direction. Go. Clockwise.

Hey, I said clockwise. What are you doing? Clockwise. Watch me.

AUDIENCE: Clockwise.

BASSAM SHAKHASHIRI: I'm doing-- look. When I turn around like this, I'm doing it clockwise too. But when I turn around like this, what do you see?

AUDIENCE: Clockwise.

BASSAM SHAKHASHIRI: So you have to think. You have to think about the perspective that you have in making observations. By the way, where does this idea of clockwise movement and counter-clockwise come from?

AUDIENCE: Clocks.

BASSAM SHAKHASHIRI: Clocks. Yeah, I know. It comes from clocks.

[LAUGHTER]

Where does it really come from? Do you know?

AUDIENCE: The Sun.

BASSAM SHAKHASHIRI: From the sundial. It's from the sundial. And as far as we know, was the sundial first observed in the Northern Hemisphere or in the Southern Hemisphere? As far as we know, it's in the Northern Hemisphere.

So I want you to visualize, like you did with the ceiling fan, the sundial in the Southern Hemisphere. Oh, yeah. Right. I want you to think about that and see which direction it's going in. All right. It's moving.

So now what I want to do, two more experiments. So here's a beaker. I have a question for you.

Do you suppose there's a way for me to hold this beaker up in the air without touching it.

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: So let me borrow your book. Now, it's your book, Steve.

I don't mean put it on a book like this. I'm touching it right now. Do you suppose there's a way to suspend this beaker up in the air without touching it? Yes or no.

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: Some of you are saying yes because you know how it's done. And some of you are saying yes because you trust that I'm going to show you how to do it.

So here's what we're going to do. We're going to take-- you're doing the play-by-play description. What is this?

AUDIENCE: A balloon.

BASSAM SHAKHASHIRI: What else can you tell me about it? Does it have a color?

AUDIENCE: It's blue.

BASSAM SHAKHASHIRI: Look. I am told the brain receives every second about 11 million bits of information. And a brain can't sort them all out at the same time. So we have to train ourselves how to make observations and report them. So here we go.

Ta-da. Is the beaker up in air?

AUDIENCE: Yep.

BASSAM SHAKHASHIRI: Am I holding it?

AUDIENCE: No.

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: So can you explain what this is? I pulled it out. Can you explain how this works? Can you explain how this works?

So I want you to think about this. You also know what's going to happen when I let the air out of here.

AUDIENCE: Let go.

BASSAM SHAKHASHIRI: Let go. OK, I'll let go. You've done that before. Why does that happen? Lots of interesting things happen in science with familiar items.

So how do you explain what happened here? What? You're thinking about it?

Some people say that when I inflated the balloon in here, there was a change in the pressure. I want to tell you-- you can think about that too. I didn't bring it with me. But I went to the glass shop at the University of Wisconsin chemistry department and I sawed off the bottom of the beaker and it still works. So it's not the change in the pressure.

But everyone here everyone, everyone, including the little kids, know the explanation as to why this works. But you haven't thought about it. You haven't connected it yet.

So what I'd like you to do is take both hands right now and rub them very fast with each other. Rub very fast. What do you feel?

AUDIENCE: Friction.

BASSAM SHAKHASHIRI: You feel friction? You feel heat, which is the result of friction. As I said, you're like the students in my class. So friction. So can friction be related to this? You think about it. You think about it.

So now what I want to do is do another experiment with the balloon right here. This time, I'll take what color balloon?

AUDIENCE: Yellow.

BASSAM SHAKHASHIRI: This balloon has a hole in it so that doesn't work. I'll try this one.

I inflate the balloon, let some air out. And then I tie it. And now I'm going to ask you a question. Do you suppose there's a way for me to hold this balloon up in the air without touching it?

So I don't mean put it in a beaker like this. I'm not touching it now. Do you suppose there's a way for me to suspend this up in the air without touching it, yes or no?

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: Those of you who say yes-- those of you who say yes know how it's done or trust that I'm going to show you how it's going to be done. So suppose I take this balloon and I blow air in it, like this. That was held up in the air without touching it. But that's kind of hard on my neck.

So suppose I take-- suppose I take this. What is this?

AUDIENCE: Blow dryer.

BASSAM SHAKHASHIRI: Is the balloon up in the air? Am I touching it?

AUDIENCE: No.

BASSAM SHAKHASHIRI: What is holding the balloon up in the air.

AUDIENCE: Air.

BASSAM SHAKHASHIRI: Air? There's air right now, but it's-- now, you're going to help me with that. Thank you. Thank you. Thank you.

AUDIENCE: Go faster.

BASSAM SHAKHASHIRI: No. I was pushing the cold one. Look, you know. Each one of you knows. What was coming out the nozzle here? What was coming out of nozzle? A stream of air, right? A stream-- wind, that's what it was.

So here we go. So do it again. Now, watch what I do here. Watch how I turn this. Watch how I turn this to the side like this.

You can see how big of an angle you can get away with. See that. See that. All right. All right, I'll have it back from you please.

You're all thinking about what the explanation is. Thank you. You're all thinking about the explanation because what I'm going to do next is take this. What is this?

AUDIENCE: It's a ball.

BASSAM SHAKHASHIRI: A Styrofoam ball.

AUDIENCE: Whoa. And a balloon.

BASSAM SHAKHASHIRI: And a balloon, up there. Am I touching any of them?

AUDIENCE: No.

BASSAM SHAKHASHIRI: What was holding them up in the air? Thank you. Moving air, right.

Look. You all know this effect. You stand on a street corner and a big bus goes by, what do you feel? Woo. And you're driving on a highway and the big lorry truck passes by, what do you feel?

AUDIENCE: Nothing.

[LAUGHTER]

BASSAM SHAKHASHIRI: You know what? I believe you. That's your observation. I respect you for making an observation. But watch for it next time, OK?

Now, this is a scientific principle. You all know what this principle is. It's named after a Swiss mathematician. It's called--

AUDIENCE: Magic.

BASSAM SHAKHASHIRI: Bernoulli's principle, Bernoulli. Look. You all know about this.

I don't want to get too personal about this one. You took a shower this morning. You turned the water on. Did the shower curtain move in or out, if you have a shower curtain? Sometimes we don't have shower curtains.

So there's a change. There's a stream of air that causes things to happen, as we just saw here.

So now I'm going to do an experiment. This experiment, with this, with this. What is this?

AUDIENCE: Plastic bag.

BASSAM SHAKHASHIRI: Could I ask you to help me with this experiment? OK. So what is it that Lou and I are holding? A plastic what? A piece of plastic. What color is it?

AUDIENCE: Blue.

BASSAM SHAKHASHIRI: Do I have to ask all the questions all the time?

AUDIENCE: No.

BASSAM SHAKHASHIRI: No. You are asking them. You have to make these observations.

Look. How long is it? It's about what? Is it about 1 meter, 10 meters? It's 2 meters in length.

I have an opening at this end here. Do you have an opening over there, Lou?

LOU: No.

BASSAM SHAKHASHIRI: It's sealed. OK. So I'm going to change sides with you. I'm going to give you this opening right here. You hold it like this. You got it?

And I'd like you to blow air in here so that we can count how many breaths it's going to take her to inflate this. And don't make her laugh now. OK. Come on, go.

One, two, three, four. That's enough. I don't want you to hyperventilate. You know what hyperventilation is? Is it related to carbon dioxide gas? So this is what she did with four breaths.

Now, I'm going to let the air out that you put in there and give you the closed end. And then I'm going to show you, if you pay attention, if you pay attention, I'm going to show you how you can inflate this two-meter long bag with one breath.

You're smiling at me. You don't believe me. Do you remember what she did? She blew into it the same way you and I blow into a paper bag.

So now I'm going to do it this way. I'm going to open this up like this. I lift it up a little bit so it's about-- yeah, right. Here we go. Let go.

[LAUGHTER]

[APPLAUSE]

Did you see how it was done? Would you like to try it?

LOU: Yes.

BASSAM SHAKHASHIRI: Yeah. That's the spirit. See, Leonardo said, you know, about experiments.

So I take all the air out. And now you do it the way I did it, not the way you did it the first time. One long breath, right down the middle. Whenever you're ready.

Close it off.

[LAUGHTER]

Only one. Only one. A lot better than the first time, right?

[APPLAUSE]

So here's a question for you. Do you think she has that much air in her lungs?

AUDIENCE: No.

AUDIENCE: Yes.

BASSAM SHAKHASHIRI: Do you think I have that much air in my lungs to blow this? What's the explanation? What?

Well, the thing-a-ma-jigger doesn't have much in air in it right now. So look. You all know the explanation for this because we just went through it in the previous set of experiments. What did I blow out of my mouth and what did she do? A stream of moving air.

Remember, one of my slides says connectivity. You make connections. You make connections between what you see and what you already know.

So a stream of moving air creates a partial vacuum and air comes in from the outside. That's called "what's his name" principle. What's his name?

AUDIENCE: Bernoulli.

BASSAM SHAKHASHIRI: The whole thing was a setup. You knew that. That's why-- OK.

So here's our grand finale. Here's our grand finale. It's a repeat of that experiment, which we're going to do. In this, you're doing the play-by-play description. What is it?

AUDIENCE: Black.

BASSAM SHAKHASHIRI: Black what?

AUDIENCE: Black tub.

BASSAM SHAKHASHIRI: Black tub. And what is this?

AUDIENCE: Cylinder.

BASSAM SHAKHASHIRI: And I take a clear and colorless liquid from this bottle. And I put it in there. And this clear and colorless liquid is 30% hydrogen peroxide, 35% hydrogen peroxide.

And I take what? I put some of this in there. But I want to help the hydrogen peroxide break down into water and oxygen. So what do I need?

I need a catalyst. I could use manganese dioxide. But it's not the only catalyst. I'm going to use this liquid right here. This is a clear, but slightly colored liquid. It's slightly yellow. So I'm going to put some of that in there and see what happens.

AUDIENCE: It's yellow.

BASSAM SHAKHASHIRI: What's happening? You're doing the play-by-play description, not me. Ah, it's going out of control here. I better put it down here.

So this is that the decomposition of hydrogen peroxide using potassium iodide solution as the catalyst. So the different catalyst caused a lot of different changes to happen. And this is why we need to learn more about the science of the familiar, which is chemistry.

And I want to really thank you for coming this afternoon-- this evening. I want to ask you one more time, what does my T-shirt say?

AUDIENCE: Science is fun.

BASSAM SHAKHASHIRI: That's what I like, enthusiasm, science. So whatever you do, do it-- do it-- do it with a purpose in mind. Try to help the plasticity in your brain.

But it's not just your brain that we're talking about. It's what's in your heart. Because one of the important elements of communication is what you feel in your heart, which is not something that was on my slide.

So thank you all very much. Thank you, Steve. Thank you, Lou. Thank you, everybody.

[APPLAUSE]

And remember, no matter what you do, science is fun. Thank you very much. Thanks.

AUDIENCE: Thank you.