GLOBAL LEADERSHIP DIALOGUES

Insights and Inspiration from Change Leaders

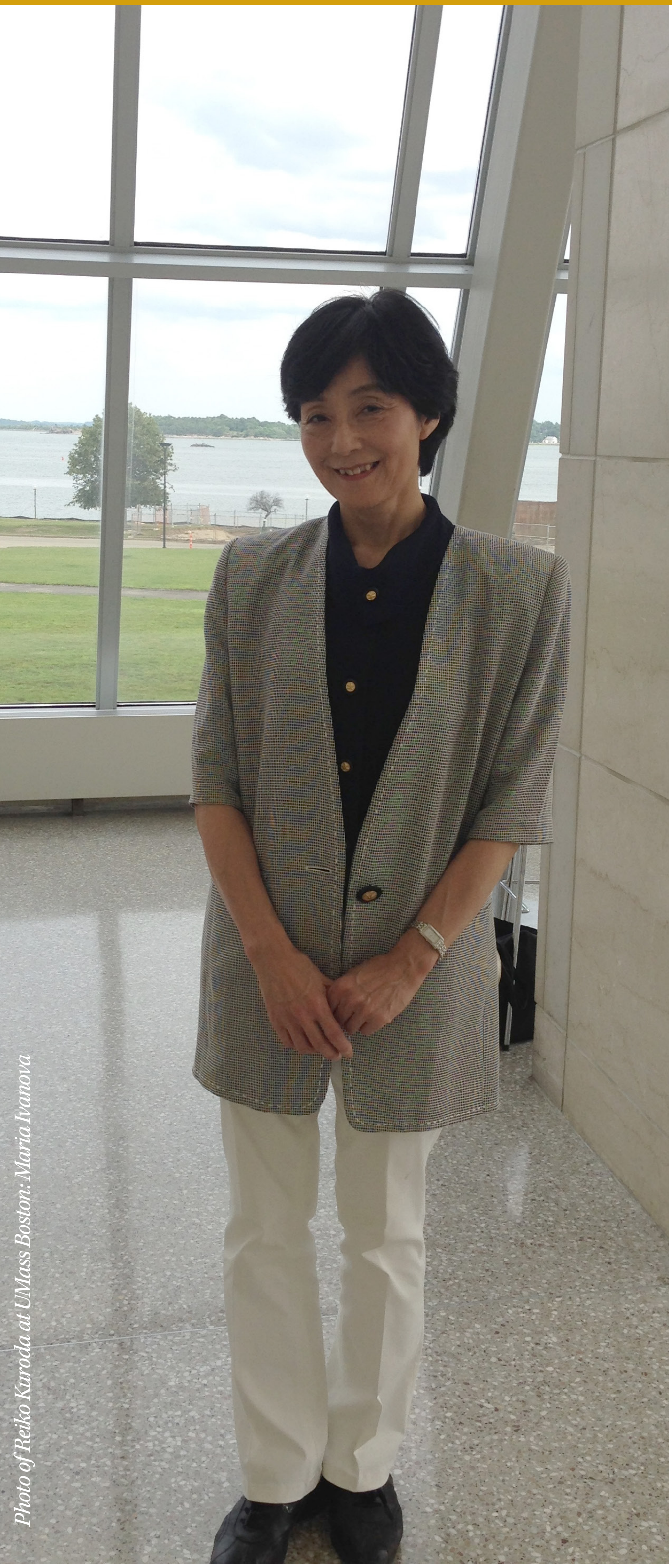

Photo of Reiko Kuroda at UMass Boston: Maria Ivanova

Pioneer Chemist

REIKO KURODA

One of the world's leading chemists, Reiko Kuroda is a professor at the Research Institute for Science and Technology at Tokyo University of Science and professor emeritus at the University of Tokyo. She previously worked at King's College London as a postdoctoral research associate in the Department of Chemistry and as a research fellow and honorary lecturer in the Department of Biophysics, and she held a permanent position at the Institute of Cancer Research in London.

Kuroda is also a leading policymaker in Japan and globally. She was a member of the Committee for Realizing a Gender-Equal Society, the Council for Science and Technology Policy (CSTP), and vice president of the International Council for Sciences (ICSU). Currently, she is a member of the Royal Swedish Academy of Sciences and holds appointments as a fellow of The World Academy of Sciences (TWAS) and of the Scientific Advisory Board of the Secretary-General of the United Nations.

She has received numerous prestigious awards for her exceptional work, especially in the fields of chemistry and biology. She was awarded the Saruhashi Prize in 1993; the Nissan Science Prize in 1994; the Yamazaki-Teiichi Prize in 2004; the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science, and Technology (research division) in 2009; and a 2013 L'Oréal-UNESCO Award For Women in Science. She also received the Prime Minister's Commendation for Efforts Toward the Formation of a Gender-Equal Society in 2014 for her work in promoting equality for women scientists. Kuroda has a bachelor's degree in chemistry from Ochanomizu University and a PhD in chemistry from the University of Tokyo. In addition, she was awarded an honorary doctorate from the Chalmers University of Technology, Sweden, in 2009.

Maria Ivanova, co-director of the Center for Governance and Sustainability, sat down with Reiko Kuroda in July 2015 at the University of Massachusetts Boston for an interview for this issue of the Global Leadership Dialogues.

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CENTER FOR GOVERNANCE AND SUSTAINABILITY
JOHN W. McCORMACK GRADUATE SCHOOL OF POLICY AND GLOBAL STUDIES
UNIVERSITY OF MASSACHUSETTS BOSTON
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UMASS BOSTON

You are a renowned scientist in Japan and internationally. What inspired you to pursue a career in science? Please tell us about your professional journey and some of the milestones in your career.

You may be surprised to hear I had no natural science background. My father was a professor of classic Japanese literature. His hobby was his work. He purchased many specialized expensive books, and our house was full of his books. I was brought up in that environment, but my passion was nature. When I was a little kid, I would go to ponds to get frog eggs and would bring them back to see how they hatched. In those days, however, we girls were not really allowed to go out to play, whereas boys were able to go anywhere. We had to stay at home to help Mom with the cooking and cleaning. But I really wanted to go out to see nature, the sky, plants, and insects.

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When I was in the final year of primary school, I joined my school's chemistry club as an after-school activity. In that year, two branches of our school merged. I made new friends with pupils from the other branch, and they belonged to the chemistry club. I even asked my mother to make me a lab coat! Later, at my junior-high school, there was no chemistry club, so I joined a choir group, an art club, and a basketball club. I was not doing anything chemistry related in my high school days. Then, I had a hard time to decide what subject to study at the university. In those days, girls would choose literature or English and were not expected to study science or engineering. To learn the basics of natural sciences, on the other hand, a person needs a college education, so I decided to choose natural sciences. I thought if that did not work out, I would study literature, as the subject was familiar to me, thanks to my father.

And how did you become a professor?

I wanted to do research. My parents encouraged me to get a PhD, so I went to the University of Tokyo. At that time, there were hardly any jobs for women with PhDs. It was not easy for men, but for women it was almost impossible. And if you got your PhD from the University of Tokyo, the top university in Japan, it was a problem in a strange way, because women could not be in high-level positions. There was no Internet in those days and no job-hunting tools I could access by myself. Your supervisor would tell you about possible opportunities for research assistants at a university and pass along a recommendation.

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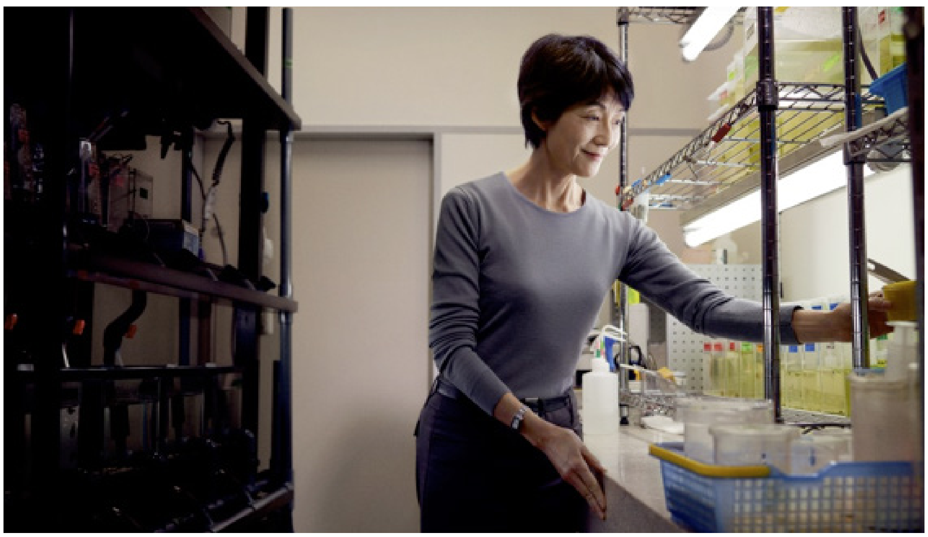
I realized there were very few job prospects in Japan, and I really wanted to go abroad. My father did not oppose my going to England, and I decided I wanted to work with Professor Steven Mason at King's College. He was doing really fantastic work. He used to work with philosophical

Tokyo University of Science

and historical aspects of science, while doing chemistry and spectroscopy. In the final year of my PhD, there was an international conference on crystallography, which Professor Mason attended. When I heard that he was looking for a postdoctoral researcher, I wrote him letters, sent him my published papers, and he accepted me. I took the position and was successful in completing the work that my predecessors could not. He applied for another grant, and I remained working with the research team.

Despite the job description, there was no X-ray diffractometer in the Chemistry Department that I needed for my work. Eventually, I found out that the King's College Biophysics Department had the instrument, and they allowed me to use it. While doing work there, I had some spare time between experiments. I visited a lab to chat and sometimes helped out with their work. After a while, they invited me to join their team, and I moved from the Chemistry Department to the Biophysics Department. I became more interested in life sciences, and I started working on cancer research.

First I worked on X-ray crystallography of complexes made from short fragments of DNA and small chemical compounds such as carcinogens or anticancer drugs, analyzing their interactions. I then realized that studying this topic using X-ray crystallography is not enough to understand what is actually happening in our bodies and that I should employ techniques of molecular biology. Thus, on the weekends I went to a lab in the same department to learn about experimental techniques of molecular biology. My first paper in molecular biology was actually published in *Nature* in 1983, so I was very lucky.



Kuroda in her laboratory at Tokyo University of Science, Japan

You were the first female professor in natural sciences at the University of Tokyo. How did that come about?

Because I had a permanent position and was advising PhD students in England, I had no intention of going back to Japan. However, someone had told me that it was the first time that the Chemistry Department at the University of Tokyo was asking for applications for an associate professor position. They suggested that I apply for the position even though I had no chance because they had internal candidates as well. I did not spend a lot of time preparing the application and decided to send it off.

There were three open positions, which is why they were asking around. One hundred forty-nine individuals applied. I had even forgotten about it, and the next thing I know I get a telephone call saying they were going to offer me the position. It was really a shock because I was certain that I was not going to get it. So when I was offered the position, I had to take it. I took the offer, giving up my position in England, as it was the first time that they had offered the position of associate professor to a woman in the faculty's natural science departments. People said that I would never be promoted to full professor, but in six years I was promoted, which was very quick. I worked very hard. I could not believe that I was the first woman full professor in natural sciences in the history of the University of Tokyo.

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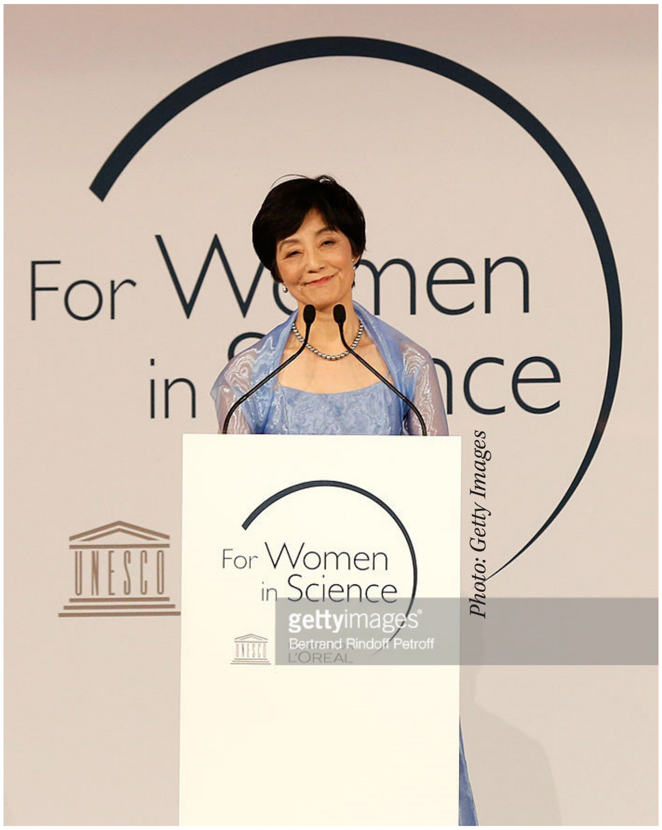
You mentioned how difficult it has been for women in academia, and you have really faced some challenges as a female scientist. How did you overcome those challenges, and what would you say to young women scientists today?



In 2013, Kuroda was awarded a L'Oréal-UNESCO Award For Women in Science. This award supports and recognizes the accomplishments of women scientists.

Young women scientists are in far better conditions now, maybe due to affirmative action. But I would say, for both young men and women, you can complain as much as you want to, but do not stop there. If you just keep complaining, "I am underprivileged, and this is the reason why I cannot do good work," people may sympathize with you, but they cannot help you.

If you really want to do something, you must think hard, and you will come up with an idea. If you say, "I have this problem, but I want to do this and I think this may be the way to do it," then many will come to help you willingly. Do not just complain because it will not serve you, and you will not achieve anything.

So, to go back to the chemistry, you work on chirality. Can you explain this concept to our readers? What are some of your findings?

I have to tell you, this is a very important issue. *Chirality* comes from the word "cheír," a Greek word for hand. The left hand and the right hand are different; they are a mirror image of each other, and we call this characteristic *chiral*. The same applies for molecules. Two important molecules of life utilize one particular handedness. All living organisms including human beings utilize DNA and RNA for inheritance. What is written in the DNA and RNA is the code for how proteins are structured. Proteins make our muscle and a variety of enzymes that dictate every process in our life, such as food digestion and breathing. Surprisingly, proteins are made up of only left-handed (L-) amino acids, although there are an equal number of right-handed (D-) amino acids in nature. Further, DNA and RNA use only "right-handed" sugar (D-deoxyribose/ribose). This is true in every living organism, such as bacteria, plants, and animals. There is not a single exception.

Thus, at the molecular level, our bodies are completely one sided, although it looks bilateral macroscopically having both left-handed and right-handed parts. This leads to very important consequences. To make it easier to understand this, I created the "shoe and sock principles." What the shoe and sock principles say is, first, if you put your right foot in your left shoe, you know you have made a mistake. But you cannot tell when you are just wearing socks. Second, if you have a toddler with daddy's big shoe, it does not matter which shoe he/she puts on, because it is far too big. Third, if you put your foot into socks, the socks take the chiral shape of your foot. If you take them out, your socks go back to their original nonchiral shape. But if you wear them for far too long without washing, the toe part will get thinner, and you can see the left and right difference. These are my shoe and sock principles for the general public.

To put this in a more scientific way, chiral substances interact with chiral substances or chiral electromagnetic waves, and then you can see the difference depending on the handedness. Even chiral objects interact with nonchiral objects; there is no difference. Second, to have the chiral recognition, it has to be of the same order of magnitude. Third, you can induce dynamic chirality to nonchiral objects, and you can change the dynamic chirality to permanent chirality, just like making a hole in socks.

Now we know that our bodies are made up of only one-sided molecules, particularly proteins. If you taste something, it is a completely different taste sometimes depending on the handedness of the compounds, as the first principle states. A drug effect may be completely different as well. The famous thalidomide case refers to the chiral thalidomide drug. Left-handed thalidomide seems to have a teratogenic effect, which produces malformation in babies, causing them to be born without arms after their mothers took the drug as a sedative during pregnancy. This is the left and right problem, and the drug contained equal amounts of the left- and the right-handed molecules. The right-handed thalidomide appears okay, whereas the mirror image left-handed molecule produced the deformity. Following this tragedy, the U.S. Food and Drug Administration (FDA) issued a rule allowing drugs to have both the left- and right-handed molecules in them but requiring proof that they would not cause adverse side effects.

Thus, it is crucially important to obtain only one-handed molecules. I am working on the chemistry underlining the chiral recognition, separation, amplification, and transformation, during the crystallization processes in particular. I have found unique ways to separate left- and right-handed molecules very easily by supramolecular crystallization, or unique solid-state chirality recognition.

Another topic I am studying is the mechanisms of snails' left-hand or right-hand coiling, which is determined by a single gene. Interestingly, there are not many phenotypes that are determined by a single gene. For instance, the color of your eyes or your height involves many genes. The snail coiling, however, is determined by a single gene, which was claimed long ago in the late 1800s, before the Watson, Crick, and Wilkins discovery of DNA structure, (i.e., the Mendelian gene). But I have proved that it is indeed determined by a single gene in modern terminology.

We have found out that cytoskeletal dynamics at the very early embryogenesis stage is the handedness-determining step, and we could identify several candidates for the handedness-determining gene. We could further create mirror-image creatures by mechanically rotating blastomeres to the opposite directions dictated by the gene at the crucial developmental stage. We could show that this operation transfers the site of expression of particular important genes to the mirror-image side. In fact, the genes are common to vertebrates and determine our body handedness, such as the leftward location of our heart and the direction of our gut coiling, etc.

It is exciting to learn that a single gene determines the body handedness. It is not only left and right determination but also has broader implications in organismal development in general. Is it not fantastic that you start off as a single fertilized egg, and it splits into two, four, eight cells, and so on, until you become a fully developed human being made up of 60 trillion cells? Your skin, blood cells, and liver cells have all the same DNA information. But somehow, some are switched on, and some are switched off to make different cell types. It is fascinating to learn if I can trace this development process using chirality, taking advantage of the existence of mirror-imaged creatures as a reference.

Chirality *refers to the property of handedness (left and right handed), which plays a role in the functioning of biological molecules.*

Is it not fantastic that you start off as a single fertilized egg, and it splits into two, four, eight cells, and so on, until you become a fully developed human being made up of 60 trillion cells?

What are some of the practical consequences of your research?

One is developing simple methods to produce chiral drugs, agricultural chemicals, or food additives of one particular chirality as I mentioned earlier. I have also developed spectrophotometers that can measure chirality even in the solid state, as these instruments were not commercially available. Using this, I could study protein misfolding of ß-amyloid, for example, which is relevant in developing Alzheimer's disease. If you find a way to stop aggregation of these proteins, it may help understand the mechanisms, prevention, and treatment of these neurodegenerative diseases. My work on snails should help our understanding of the establishment of body plans, including in human beings, as mentioned previously.

This is very fascinating, and it is applied science with very significant consequences for different aspects of human life. But, there is a whole other side to your career—your engagement in policy. You were a premier scientist, but you have worked as a scientific advisor in the government. How did that come about? What has your experience been, and what are some of the lessons from that engagement?

At first, I really did not want to be involved in policy, but they were looking for someone who works at a university and they also wanted a woman. Moreover, because I had experience living outside Japan, I was more outspoken. I told them that I did not have any experience and that I was a scientist, but eventually I realized it is important that natural scientists have an ability to communicate with policymakers or sociologists.

Because I was attracted to literature as well, I enjoy communicating with them. The lesson I learned was that you have to have a broad view and not confine yourself to your own subject. You have to be able to see what is going to happen in the future. It may not be good for your research area, but if it is important, you have to say so and not necessarily promote your own field. The most important thing is to build the citizens' trust in science. You have to study, think, and learn how to communicate effectively with people. I must say I had no time for training and did it by "OJT" (on-the-job training). Then you have to prioritize what you need to do, ask for help from those around you, accumulate knowledge, and understand how policies are made. I am still learning.

So how did the advisory board to the prime minister function? What was the task that the prime minister asked the scientists to accomplish?

The systems are slightly different now from my days in Japan. We had a meeting once a month with the prime

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minister and seven ministers, including education and agriculture, as well as a meeting with the science and technology policy minister once a week. We made the five-year basic science and technology plan and decided which area to focus on (environment, basic research, energy issues, food issues, etc.) by asking people from government and science communities to present their proposals. I learned a lot working in this position, and I am thankful for the experience.

Now you are working with policy at a global level as a fellow member of the UN Secretary-General's Scientific Advisory Board. What could we learn from the national type of science advisory board?

The systems are different. The UN board meets only twice a year. Still, we have had the opportunity to set the stage for the next 15 years in regards to the Sustainable Development Goals (SDGs), for example. Additionally, because the Secretary-General appointed us, we are able to address crosscutting issues. International scientific advising is more complicated, as we have to deal with diverse conflicting issues involving developing and developed countries or global versus regional concerns.

If we were to crystallize the lessons on what would make a science-policy interface effective, what would you say they would be?

I think we should give policymakers more than one scenario and their probabilities so that policymakers can choose. They would have to tell us—scientists and citizens—the reasons why they chose one scenario over another and start a discussion in order to build trust. As scientists, we have to figure out what the policymakers need as well as what we can say as scientists. Natural scientists really understand hypotheses, experiments, results, and probability, but at the same time, people's feelings and needs are equally important.

In order for scientists to learn those skills and understanding, I set up a minor course at the graduate school of the University of Tokyo 11 years ago called the Science Interpreter Training Course. In this course, there are two targets. One is a quite popular one, which is *how* to communicate, that is, write, interview, and exhibit scientific results to nonscientists. The course I teach focuses on *what* to communicate and deals with controversial issues, how to think underneath statistics, understanding statistics, and various issues of critical thinking. The course is held nearly every Saturday for three hours, at the graduate level, with students from all over the University of Tokyo (from agriculture, philosophy, law, natural sciences, etc.), and is limited to ten students.

The main objective of my courses is to give students some sort of understanding of what science is, what it can offer, and what the science-policy relationships are. Four of my former students went on to work in the government, and I am really looking forward to at least one or two becoming politicians, because we need politicians who have a science background and have a critical way of thinking.

We will conclude with one last question. What keeps you up at night, and what inspires you?

I am full of intellectual curiosity, and I want to find the molecular basis of the Wonder of Nature. Somehow time is not kind to me; it just flies.

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Ban Ki-moon delivers a speech at the inauguration ceremony of the UN Secretary-General's Scientific Advisory Board in Berlin in 2014. Professors Kuroda and Ivanova are members of the Board.

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With a growing reputation for innovative research addressing complex urban issues, the University of Massachusetts Boston, metropolitan Boston's only public university, offers its diverse student population both an intimate learning environment and the rich experience of a great American city. UMass Boston's 11 colleges and graduate schools serve nearly 17,000 students while engaging local, national, and international constituents through academic programs, research centers, and public service activities.

Part of the five-campus University of Massachusetts system, UMass Boston is located on a peninsula in Boston Harbor, near the John F. Kennedy Library and Museum, the Massachusetts State Archives and Museum, and the Edward M. Kennedy Institute for the United States Senate. To learn more about UMass Boston, visit www.umb.edu.

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Based on in-person interchanges, the stories told in the Global Leadership Dialogues Series offer insights into the professional work and personal experiences of notable professionals in the global governance field. The series provides in-depth perspectives on what these leaders think about key issues in global governance, what inspires them, and how they imagine the future.

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