Nobel Laureate for Chemistry Dr. Peter Agre's keynote speech "Opening doors worldwide through medical science " on Friday, March 24, 2017, at the Udayana University in Bali (Indonesia)

It is a pleasure to be here and I would like to thank for this wonderful honor and opportunity, and thank you also to the International Peace Foundation for organizing this visit. I think as academics we share so much, despite the fact that our universities may be so far apart. What I hope of sharing with you this afternoon is not a retelling of the water-channel discovery, but something which I find even more fundamental, and that is the shared fellowship of scientists worldwide. Together we have the opportunity to open doors, open doors between countries which are otherwise not always friendly. I plan to show you today is mostly a series of photographs. The young people are all familiar with Facebook, we older people maybe not so familiar, but I think that Facebook shares faces and the stories which I hope to tell.

A little preface, let me just add some background.
As American scientist, a citizen of the United States, I am aware that we are not always viewed so favorably abroad, as you can see in this compilations, all taken by Zogby in 2004, where citizens of five different Arab countries are polled about their impressions on the United Sates. You can see that the majority got a negative and unfavorable response, but when the same individuals were polled on their impression on the US science and technology, the impression was very different, it was very favorable. There is something about science that we share worldwide, it’s an opportunity for the United States and the world.

I break my talk into four sections and first I would like to talk a bit about my science upbringing. We all came from somewhere and my family was Norwegian, and at the end of the 19th century an opportunity to have land, a farm, brought them to the US. It was in the United States that the opportunity of education lifted the possibilities for my family. This was my father, the first member of the family to attend a university where he studied chemistry and became a chemistry professor. His hero, Dr. Linus Pauling, was one of the first visitors of the International Peace Foundation and participated in the BRIDGES dialogues. He was a great chemist who discovered the alpha-helix in biology, the principal structural features of proteins, and he also used every opportunity when he was invited for science lectures to give a second lecture about peace. What he focused on was the need for the ending of thermonuclear weapons testing and the environment. Fifty years ago the United States, the Soviet Union and China were in a competition to

develop more and more powerful hydrogen bombs, casting and releasing them into the atmosphere. It was Dr. Pauling who's extracurricular involvement lead to a worldwide recognition of thermonuclear casting and who was able to convince the US government to join the Soviets and the Chinese to ban that testing of nuclear weapons in the atmosphere. That's why Dr. Pauling won his second Nobel Prize, the first he received for chemistry, the second for peace. He set a high standard for all scientists, to realize that in addition to our laboratory and teaching efforts, we need to advice the public and guide them.

When I started my scientific career I looked like this, and now I am an old man with a white beard. I am not trying to fright the students, but time moves on. I've spent the better part of a year between my undergraduate and my medical studies travelling in Asia, Japan, Taiwan and Southeast Asia, as far as Singapore, I wasn't able to come to Indonesia, then I crossed India, Pakistan, Afghanistan and Europe.

It was with a youthful energy and enthusiasm that I pursued a career in medical science. Working in a laboratory, science is about discovery, it isn't simply reading books. I worked in a laboratory of this gentleman, Pedro Cuatrecasas who was himself a refugee from Francos' Spain. He was very suave and elegant, but we, the students in his lab, where much less photogenic. I think now that we look like a motorcycle gang. This is 43 years ago. But here you can see scientists from all around the work working together for a common purpose: discoveries that can be translated into useful activities.

One summer we were joined in the laboratory by these two young men: nothing special, two young bearded men smiling. The man on the left is Naji Sahyoun, a Palestinian who graduated in an American university in Beirut, raised to fear Israel and with an adversarial position towards Jews in the United States; and on the right is Marvin Siegel who is the son of an orthodox Rabbi from Brooklyn, New York, raised in a Zionist household, fearing Palestinians; but working together the two men became the best friends, and this is something that happens at laboratories and universities everywhere. Scientists become friends.

The second topic I would lo touch on briefly is science as an international career. Water, the solvent of life, without water there is no life, and of course water at disequilibrium can be very dangerous, and the discovery of the channels trough which water transfers throughout the body won me the Nobel prize. They also gave me an

opportunity to reach beyond my career as a research scientist and to develop a career on the public side of science, including science diplomacy and visit scientists around the world.

So here we were, my wife Mary is here with me today, our four children, thirteen years ago to receive the Nobel Prize. This was the start of a new adventure in my career, an adventure as a public person of science.

Now our work on malaria over the last decade has taken us around the world, and I am aware that you have malaria here in some parts of Indonesia, not the heavy burden compared to what it has been, but it is still a problem. As you can see on this map, the major burden of malaria is in the developing world, mostly Sub Saharan Africa, and it is our work in terms of the International Center of Excellence with three locations in Sub Saharan Africa to help the people affected by it. Zambia is the first focus of effort, has seen significant improvements. There is still malaria rampant in southern Zambia, but it is getting much better. Of course, as you all know, malaria affects children, it kills about 450 thousand children every year, children like this small African kids. In addition to the victims that it kills, many who have malaria are left with lifelong scars, brain damage and this child is left with permanent blindness because of cerebral malaria.

We work there in collaboration with the local people, we were able to build a laboratory with contributions of private philanthropy, including a mosquito sphere where we develop mosquitoes which will block the transmission of malaria. Here are some of our field workers in Southern Zambia. These are some of our field workers in southern Zambia, young man and woman, just like the young man and woman at the universities in Indonesia, following a passion to make the world a better place. You can see over the past 15 years that the burden of malaria in Zambia has declined remarkably. Not to zero, our work is not done, but we can accomplish great practical value. Of course the presence of malaria is abundant in the most rural and isolated locations where the subsistence farmers in Sub Saharan Africa working very hard to feed their families. It is our belief that the older people who have had malaria repeatedly are carriers, and they are the source of the parasites when the rainy season comes.

Here you can see a family of farmers in Su Saharan Africa, and they work so hard with such primitive implementations, the children work hard as well, the older children are

taking care of the younger ones and are carrying the maize to the market, but they know how to have fun. It is quite clear that the people in the developing world have hearts and souls, emotions, loves, fears and hopes, just like the rest of us. Their greatest treasure is their children, and that is the same for Indonesia I think, your greatest treasure is the young people. Aren't they adorable and don't they deserve to have lives like the rest of the world? Of course they do.

We also work in Congo, and the political instability makes our work much harder there. The Congo river, separating the Democratic Republic of Congo and the Republic of the Congo and here you can see one of our faculty members who lectures at the medical school in Kinshasa, where there are government buildings, but their purpose is no longer the same and the trains are no longer running, because of the social and political instabilities great challenges emerge. We receive aid in the form of gifts from American tax payers in the form of medicines that are made available, but the challenge is to get the medicines and the stock piles to the villages. There are no paved highways so it requires small aircrafts like this one which is flown by a Swedish missionary pilot, because this part of the Congo is swampy and marshy with a huge burden of malaria.

We also work in Zimbabwe, a sister-state to Zambia. It's a beautiful country with a political problem that is the President Robert Mugabe. He was the liberator of Zimbabwe by ending a period of repression by the white supremacists regime, but power is never permanent and after 37 years in power the instability and political chaos led to a corrosion of public health. This begs the question of how does one do a research project in a quasi dictatorship and the answer is that you can do more from inside the system then from working outside. We are working with a niece of Robert Mugabe niece, a wonderful person who allows us to do our work in the Zimbabwe, a beautiful country, just as beautiful as Indonesia, with wonderful people who lead very simple lives. There are clinics present, but they are not well organized, they need additional efforts in organization and that is something that the West can provide. It is during the rainy season when the malaria burden is the heaviest and the clinics are filled with young mothers and children suffering from malaria.

I will turn now to science and human rights briefly, because science has an opportunity for special interventions when scientists, engineers, health professionals and academics suffer repression around the world. Just a few examples.

The U.S. National Academy of Sciences Committee on Human Rights was lead by Thorsten Wiesel a Nobel laureate, who for several years organized efforts to come out on behalf of the oppressed scientists of the world. Saad Ibrahim, an economics professor from Egypt was imprisoned because he dared to critizise the government. At least because of the actions of the committee he was released from prison in 2003. Bulgarian nurses and Palestinian physician were sentenced to death in Lybia, charged incorrectly and unfairly to transmit HIV virus to young children. They were innocent and because of the actions of the committee a release was granted.

Another example is Dr. Binayak Sen, a pediatrician and rights activist from India who was caring for children in the poorest parts of the country when he was charged for sedition until the committee gained his release. Behind closed doors the Sciences Committee on Human Rights is very effective. There is also an organization that supports activities linking Palestine and Israel, lead by Menahem Yaari, a Jewish Israeli scientist, and Sari Nusseibeh, a Palestinian from the West Bank. They give scholarships and make research grants available.

Finally I will talk about science and diplomacy, that something very dear to my heart and something that's completely consistent with the vision of the International Peace Foundation. The American Association for the Advancement of Sciences Center for Science Diplomacy was developed nine years ago by Dr. Vaughan Turekian, and I am talking about some of the countries we have visited, starting with Cuba.

Cuba is so close to the United States, but ideologically so far, yet research collaborations between scientists from Cuba and the US have already occurred a long time ago. By working with the Cuban Academy of Sciences, showing here the president Sergio Jorge Pastrana, we remember the great collaborations of the past. The Yellow Fever Commission of 1900 is an example for this. The yellow fever was decimating Cuba and its cause was not known, but it was believed that the infection was transmitted by filth, and it was really the work of Carlos Finlay, a Cuban physiologist and scientist, who recognized that mosquitoes transmitted the infection. Also part of the commission was Jesse Lazear, a Johns Hopkins physician, who recognized that mosquitoes transmitted yellow fever and allowed himself to be bitten by mosquitoes, then developed yellow fever and therefore confirming the transmission, and unfortunately he died. So we like to remember Finlay and Lazear for their pioneering work, and we have plaques in their memory in both, Johns Hopkins Hospital and at the Cuban Academy of Sciences.

With the revolution changed much in between Cuba and the US, and the embargo has prevented the import of modern equipment as well as automobiles and such, and this has really hamstrung Cuba. There has been investment and the colonial architecture is well preserved and elegant, and they rely on the tourism industry. Tourism can be very helpful, this is something you experience yourself here in Bali, but that's not enough, you need universities to educate people and Cuba made major investments in science.

The old guard is still present in Cuba. Fidel Castro dies last year and I had the opportunity to meet with him actually, four years ago. His son Fidelito is not a politician, but a scientist like ourselves, and it was really his invitation that brought the delegation of the American Association for the Advancement of Sciences into Cuba. When I was meeting with his father, El Comandante, I realized that this former dictator of Cuba had a profound respect and admiration for science. At the end of our meeting together here we are, an aging Cuban dictator and an American grandfather, who disagree about many things but agree on some things, most notably that science and medicine can bring us together and list our countries.

I also had the opportunity to lecture at the University of Havana, a lovely venue. After the lecture the students stormed the podium. They have a lot of fresh enthusiasm for science and that can change the course of their countries history.

We also visited Myanmar, a part of Southeast Asia which is still relatively isolated 50 years after the military regime took charge in the country. Now things are moving in the right direction and when we visited we were able to meet with member of the Ministry of Science and the Ministry of Health and we met great enthusiasm for potential collaborations. We also visited the university in Yangon and I understand that the International Peace Foundation will go there soon with the BRIDGES event series. The people are lovely and hard working, looking for a better live and the challenges to accomplish that will be solved by the young people, our greatest treasure.

The Islamic Republic of Iran, a country which still has big problems with the United States and the two governments cannot agree on very much. Of course they are a theocracy where the supreme Ayatollah makes all major decisions. They elected a new president at the time of our visit three years ago, Mahmoud Ahmadinejad, a politician

with great limitations. But in spite of that, behind the scenes enlightened university-educated Iranian scientists had a positive effect. You may not recognize this man, this is Dr. Ali Akbar Salehi, born in Iraq and graduated at the American University in Beirut and the Massachusetts Institute of Technology, MIT, where he earned his doctor. He has great friendships in the US, two of his bothers living there and his niece is an eye doctor at Johns Hopkins, she is my eye doctor. This was a very sensitive visit but the people and the country were nothing but beautiful, here is a photo of my wife Mary with young people from Teheran University and the lecture I gave to Iranian scientists was similar to the lecture today.

The last photographs from Iran shows two classmates form MIT, on the left is Ernest Moniz, former United States Secretary of Energy and the classmate of Ali Akbar Salehi, the former Foreign Minister from Iran, as they put together the nuclear agreement. Something that science brought to the world, reducing the uranium enrichment in Iran and preventing them from developing nuclear weapons and bringing peace to the world. This is something we want to continue.

Finally I will talk a little bit about the Democratic People's Republic of Korea. Let me see a show of hands, who has been to the DPRK, raise your hands, and I see no hands. It is not easy to go to the DPRK, it is perhaps the last place on earth. They don't have a beautiful tourist industry but a cruel and repressed regime. It is a country with wonderful people, including wonderful scientists. American visitors to North Korea have been very limited, but you may recognize Denis Rodman, the former basketball star who was invited to North Korea. It is easy to be critical about Denis Rodman's visit to North Korea, but it was human contact, and maybe there is something that will come from that. We think that scientific visits may have more potential to achieve peace.

North Korea has many problems. The city of Pyongyang looks much like a ghost town at night with just a few people on the street, and the notion that they surviving because of Juche, that stands for self reliance and is a propaganda which is broadcasted heavily, but the DPRK can only survive because of food donations from other parts of the world. The citizens are constantly reminded to work hard for the country and that if they act out that there will be a fearsome response.

Yet science goes on in North Korea to a limited level, for example at Kim Chaek University which is also one of the three universities where the International Peace Foundation had dialogues early in 2016. Here I am with the vice president of the State Academy of Science in North Korea, and I have given him my necktie. This is a special necktie, because I was wearing it when I was presenting my Nobel lecture in Stockholm, and I gave it to him not as a personal gift, but for him to pass on to the first scientist from North Korean to win a Nobel Prize. I wish I would have two of this necktie so I could give one to you as well for the first scientist from Indonesia to win a Nobel Prize, because it will happen, it might be one of the young students who is here today.

In spite of the political repression in North Korea science goes on, scientists are doing biotechnology, crops development, and they have a special university amongst their educational institutions, the Pyongyang University of Science and Technology which is an English language university. It is a gift from a wealthy Korean-born American businessman who has given his fortune to foster a university with the hope that North Korea and the West come closer to together through science. The Pyongyang University of Science and Technology is a pretty formal institution where unlike in other universities, students march to class and we don't think about it as a party school. They listen attentive to their lectures and they only laugh when they're given permission to do so. Everything is done only when given permission, because there is no freedom. When I lectured in Pyongyang I included my desk joke and nobody responded until I told them that that was a joke, and then they all laughed. The students are constantly being watched and observed, but despite of all these obstacles science goes on.

The last photograph shown here you can see me with Dr. Li Gong Hong, the Director of the International Office of the State Academy of Science in North Korea. Now the children in North Korea are brainwashed into assuming that all Westerns are evil and aggressive. Dr. Hong and I spend a week together and when we had breakfast on the last day in Pyongyang he shared with me a story. He said: Peter, when my six year old grandson learned that I will stay at a hotel with Americans for a week he told me to bring along a rifle and to not trust the Americans.
I didn't quite know how to respond but I had an opened carton of granola bars which I gave to him and said to give them to his grandson and thought nothing more if it.
Three years later we had a follow up meeting where the leadership of the State Academy of Science from North Korea came to the United States and we met at the Carter Center in Atlanta, Georgia. The meeting began with a formal sit-down, the North Koreans on one side of the table and we on the other side, and it began with Dr. Hong reading a litany of complaints, very earnest and stern and probably written by his

government, indicating that this collaboration is not likely to be positive. When it was my time to respond I did so with the first thing that came to my mind, as I am not a trained diplomat, and so I asked: Dr. Hong, how is your grandson?
His stern demeanor relaxed and he smiled and replied: He is fine, thank you. I followed up by asking if he told him to bring the rifle to Atlanta, Georgia. He started laughing and said: Of course not, but he told me to bring back a carton of granola bars!

So perhaps this is the first step of science diplomacy and the major essence: Friendships of scientists around the world, where our shared goal is to make though our scientific talents the world a better place for our children and grandchildren.

In closing I would like to share some wisdom from China. Those of you who speak Mandarin will recognize these two characters which stand for “crisis”. But it is two characters, Wei, which stands for “danger, and Ji for “opportunity”. So the dangers of the world are many, climate change, the emergence of drug resistance against antibiotics and so on, but these are challenges which we can face and overcome if we put in our best efforts to overcome them and make the world a better place. So I would like to challenge the young students here today, work hard, being a scientist is not always easy or financially rewarding, but you can make the world a better place. Your families, your country, the world is counting on you.

Thank you.

Question:

To achieve peace in this multidisciplinary approach, with science, economics and medicine I wonder if this can’t include politics? Can science and politics work together, especially on an international scale?

Dr. Peter Agre:

I think this is a very important issue and I must say the US has many wonderful qualities, but the scientific background of our politicians is not one of them. I think it is a special burden that the scientists in the US and in other countries as well to make knowledge useful to the public, so that scientists can use their information in a very useful translational manner. For example policies about the use of antibiotics, it's quite clear that antibiotic resistance is emerging, because of the indiscriminate use of large amounts of antibiotics in animal feed, or the inaccurate prescription of antibiotics for non appropriate illnesses, and I think this is where scientists working as an advisory board members or even themselves running for political office can change the direction for society. The information is not fully useful until it is in the public, so I think this issue you raise is very important, and I am not suggesting that you drop out of medical school and run for office, but maybe someday that would be a good thing to do after you finished your education.

Question:

You have very extensive experience in basic research as well as in clinical research and as an influencer in your community and do you have any advice how to implement basic research into clinical research and bring that knowledge to the community?

Dr. Peter Agre:

How do we bridge the distance between basic science, biochemistry for example, and clinical medicine? Oftentimes members of the same faculty should share information, but unless they know each other and attend each other's meetings they don't do that. I don't think we have to choose always basic problems which are quickly to apply, but we should always be mindful.

In 1939, the year I was born, the first molecular disease, Sickle Cell Anemia, was discovered by Dr. Linus Pauling whom I mentioned before. Sickle cell disease is a terrible problem that is affecting individuals of African descent, and while we understood

that the disease has a molecular level now for 68 years, we still don't have a therapy for it. So knowledge is not always a guarantee. Let me give you another example, the emergence of the HIV infection in the 1980ies, which were uniformly fatal. Scientists responded and were able to develop therapies, antiretroviral therapies which are now used worldwide and have changed what was a uniformly fatal disease into a lifelong chronic problem which can be managed. So the latter is an example where science responded very quickly which it not always can. Within the scientific community the basic scientists attend the clinical meetings and clinicians attend the basic science meetings and the students have a background in both, then we increase the possibility of accomplishing this.

Question:

Where does your interest come from to travel the world and also to work for peace?

Dr. Peter Agre:

Well the world is a very interesting place. As a student in high school, I had the wonderful opportunity to travel to the Soviet Union. That was 1966 during the Cold War when the Soviet Union and the US were bitter enemies, yet what I discovered was friendliness by the Russian and Ukrainian people which was very invigorating. So in part is was the opportunity that I had as a young person that gave me a lifelong fascination.

I don't want you to overstate the importance of our work at the Center for Science Diplomacy, we are not official diplomats and our goal is not to make international policy but to build friendships in most of the countries which other things can follow and have also big impacts, like the example I gave you in Iran. I think we should always focus our efforts on the issues at home but look for opportunities to be of value wherever that may be.

Question:

According to your talk I would surmise that the more scientist we have the easier or likelier it will be to achieve peace, and that begs the question of how can we make people interested in science and to love science? Or how do we increase the number of scientists so that scientific understanding of society is increased?

Dr. Peter Agre:

I think we have to realize that most people are not scientists, but all children who attend school get some scientific background, and I think that the early childhood education, including the sciences, is very important. I don't think this has to be in a very advanced level, but some understanding of how natural selection for example occurs. We can breed milk cows randomly or we can breed them more productively, and this is something that we all understand as natural selection, but there are some parts of society that will reject the notion if it is described as evolution. So I think the scientists in addition to doing their work need to be in a dialogue with the public and communicate in a very open and friendly manner, not to overwhelm people with all the information they have, but provide a context so that nonscientists, and that's most people, can make proper decisions.

Question:

How did you feel when you made the remarkable discovery of aquaporins and solve the riddle of the water channels in cells and how did you manage to have an interdisciplinary approach in your research?

Dr. Peter Agre:

How did we feel after we discovered the aquaporins? We were very happy, needless to say! In truth we know that this was a significant discovery, but we had no idea of how much interest it would be. We were a small laboratory at which Johns Hopkins is a

famous institution with many laboratories, and many of them being small laboratories, so we were not the so-called big guys in the field. You make an observation that is nice and interesting, but it doesn't need to be of world-shaking significance to be exciting and positive. The importance really grew with the recognition by others and requests for lectures all around the world. So it was a little bit staggering, but we could only continue in this field and be competing with big laboratories by collaborations with other laboratories. Therein lies the great lesson in science, you don't have to be the biggest or best funded to do something of importance, but you might have to team up with other experts who's techniques complement your own.

We set about pursuing specific projects and teamed up with others that were introduced to us, and I felt that one advantage I felt I had was, that my scientific training was broad and not completely narrow in one subject. The second advantage is that I have three brothers and two sisters, which in the US is a rather large family, and when you are one of six kids you learn how to get along with others, particularly being of medium height in a Norwegian family, my siblings are all much bigger than I am.
I think to maintain friendly relations and engage other laboratories and share credit, is a very joyful experience.

Question:

I study and love mathematics and I wonder if you have any policies or philosophies that guide you in your life, especially something that would be related to science?

Dr. Peter Agre:

I don't feel ideologically embedded in science. I think I benefitted from my scientific background and upbringing, and I hope that this is worthwhile for society as a whole. I didn't enter science as a child with the idea that I will be a pure scientist. It was really the encouragement that I had to become a medical doctor that caused me to study science, and later as a medical student I reconsidered, because when practicing medicine full time there is less possibility for basic research especially related to disease. So I think it's really the experiences that I had that made me so positive about the potential value of science in life. As a mathematician you can go many directions

that I can't go, because I am not skilled at mathematics. Certainly in biology, one of the hardest area is computational biology, studying massive databases of genomic information, and only people with sophisticated mathematical background can do this.

Question:

Based on your experience as medical practitioner, how effective would you say are medical sciences as tools for diplomacy and how could young students get involved in this?

Dr. Peter Agre:

I think the US has been blessed with unbelievable wealth and economic advances in large part because of scientific discoveries in university campuses. I think it is generally accepted that "to whom much is given, much will be required", that is averse in the Christian bible, and I think in all other major religions similar understanding exists. Those with wealth and resources should help the ones with less wealth and resources. Not necessarily because we try to buy their friendship, but it is the proper thing to help children to grow up and have a happy and normal life. I think the byproduct of that is international friendship.

The notion of science diplomacy sounds very grand. I think the possibility to study in other parts of the country or in other countries bring the great opportunity to build international friendships, and I think if you have success in your scientific career then opportunities will come. So I think you have to advance your studies and seek opportunities as they come, and I think they will largely be determined by the success of your career, whether as basic scientist, clinical scientist or clinical practitioner.

As a young student you do the proper thing by applying yourself to your studies. Being a science student is not a part time endeavor, it's very demanding and the courses are difficult. It is all a process but there are many opportunities and I encourage you to continue your studies and be patient.