Special topic

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Education, Human Rights, and Peace – Contributions to the Progress of Humanity

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Abstract: I started my chemistry adventure while in high school, where I was the only female in a science and mathematics-oriented class. During our Junior year of high school, we were sent to the desert, close to the Red Sea in Israel to build roads. In the summers, we were in a Kibbutz on the border to help with the work needed. After work, we had time to discuss our future. Upon graduating from high school, I was drafted into the army, and in the evenings, started my college education and majored in chemistry. After finishing my term in the army, I continued my undergraduate studies in chemistry while raising my son. As I was conducting research on isotope effects, I realized that I wanted to make chemistry accessible to all. My tenet in life is that equal access to Science Education is a human right. I developed a method of teaching chemistry using art, music, dance, drama, and cultural backgrounds which attracted students at all educational levels to chemistry. I felt that as chemists, we have obligations to make the planet a better place for humankind. At this point, I became very active in working towards Scientific Freedom and Human Rights; helping chemists in the Soviet Union, China, Chile, Guatemala, and many other countries. The American Chemical Society established the Subcommittee on Scientific Freedom and Human Rights in 1986 and I chaired this committee for 26 years. At great risk to my personal safety, we succeeded in preventing executions, releasing prisoners of conscience from jail and bringing dissidents to freedom. This work led me to use chemistry as a bridge to peace in the Middle East by organizing Conferences which bring together chemists from 15 Middle East Countries with five Nobel Laureates. The Conferences allow the participants to collaborate on solutions to problems facing the Middle East and the World. The issues are; Air and Water Quality, Alternative Energy Sources, and Science Education at all Levels. Eight conferences were held and the ninth is scheduled for 2019. More than 600 Middle East scientists already participated in these conferences. Considering that most of the participants are professors or directors of science institutions who have access to thousands of students, the number of people in the network is in the thousands. Between the conferences, the cross-border collaborations are ongoing despite the grave situation in the Middle East. In these conferences, the participants succeed in overcoming the chasms of distrust and intolerance. They do not just form collaborations, but form friendships. Hopefully, we will manage to form a critical mass of scientists who will be able to start the chain reaction for peace in the Middle East. Commitment, perseverance, and many times, bravery, helped me to overcome the obstacles I encountered.

Keywords: Andrei Sakharov; chemistry; chemistry education; courage; Distinguished Women in Chemistry and Chemical Engineering; Human Rights; isotopes; Middle East; peace; science diplomacy; science through art; scientific freedom; woman chemist.

Stimulations for becoming a scientist

I was born and raised in Israel, which was a developing country at the time. We did not have toys or chemistry sets. Many of my colleagues in the US claim that chemistry sets turned them on to science; especially to chem-

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istry. We did not have anything like that, but from a very young age I was fascinated by a lot of things around me that only science could explain. I remember when I was 3 years old that I spent a lot of time looking at a small wooden box called a "radio" and being puzzled. I distinctly remember thinking "how come I live in Haifa and this box is saying: this is the Voice of Jerusalem." I remember myself going around and asking people "how can a miracle like that happen? Jerusalem is far away from Haifa." At an even younger age, I was fascinated by mirrors. I spent a lot of time looking into mirrors and thinking, "who is there? Where is this person?" I was very jealous that my next door neighbors were identical twins and asked my parents where my identical twin was. They tried to explain that I did not have one, but I was convinced that when I looked in the mirror, I saw my identical twin and wanted her to come out and be with me, until I learned that what I saw in the mirror was myself. Then, the question was, how come?

Because we did not have toys or organized activities, we had to invent other ways to occupy ourselves and this developed our creativity. The combination of my curiosity and creativity persuaded me at a very early age that I would be a scientist. Somebody once gave me a book about Madame Curie and her discovery of Ra and Po. I became extremely interested in learning more about radioactivity and isotopes. My research in later years focused on secondary isotope effects.

In Israel, we have another school between high school and college – the Israeli military service, where men and women are both drafted (Fig. 1). I found myself at age 17 having to share a room with 50 other women whom I had never met, doing exercises which I never wanted to do, and sacrificing my personal comfort. In those 2 years, I developed leadership skills, learned to give to others and to my country, and had ample time to think about my future as a chemist.

After my service in the army, I completed my bachelor's and master's degrees at the Technion-Israel Institute of Technology and my PhD at the Weizmann Institute of Science. I was very proud that my son attended all three ceremonies for my Bachelor's, Master's, and PhD degrees. In those days, it was very unusual for an undergraduate student to have a child. My field of research was secondary isotope effects, specifically Oxygen and Carbon Isotope Effects. As a graduate student, I was invited to the US to deliver a lecture in the Gordon Conference on Chemistry and Physics of Isotopes. I was lucky enough to meet Professor Frank Long from Cornell University, who invited me to join his group at Cornell.

Upon completing my PhD, I moved to the US with my son for my postdoctoral fellowship at Cornell University and continued my research on isotope effects. Working with Frank Long gave me the opportunity to become involved in issues of Science and Society, Arms Control and Disarmament, and Human Rights. From Cornell, I moved to Northwestern University and then to the Swiss Federal Institute of Technology in Zurich (ETH) [1]. After a research career on isotope effects, I decided that in order to contribute to the progress of humanity, I should become involved in science education, especially for the underprivileged, and make science accessible to all.

Fig. 1: Women entering military service.

Education

I decided to teach in an inner-city arts university with open admission and a high-percentage of minorities. These students would never have taken a chemistry class taught using traditional methods. The first class that I offered was called *Chemistry in Daily Life*. After a few days of registration, I realized that there were no students registered for my class. I had to become creative in order to attract these art-oriented students to register for the class.

I invited a group of students to join me in a bar across the street (as an Israeli, I was not familiar with the legal drinking age in the US). The students ordered their drinks and I heard terms like Bloody Mary, Screwdriver, Black Russian, Green Grasshopper, and Pink Lady. I was puzzled with all these names and asked the students to explain what they ordered. They responded: "Oh, this is orange juice and alcohol", and "This is tomato juice and alcohol". I asked the students, "What is alcohol?" There was silence. Then someone said, "Alcohol is something that makes you feel good." I then inquired, "Yes, but what *is* it?" and no one could answer me. I then proceeded to explain to them the chemistry of alcohol. In a short while the structure of ethanol had been drawn on everyone's paper napkin.

After a while, the entire bar was participating in the discussion and I decided to continue my informal chemistry class. I ordered salad with oil and vinegar for everybody. When the salads arrived and everyone started eating, I asked: "What is vinegar?" Again, no one knew. I told them that it is acetic acid, and soon everyone in the bar had the structure of acetic acid drawn on a paper napkin. At that stage I told them that ethanol and acetic acid can react with each other to form an ester, and this ester is sometimes used as nail polish remover. Everyone in the bar was shocked and frightened, believing that they had nail polish remover in their stomachs. I had to calm them down by explaining that this reaction required a catalyst, and explained what catalysts are. After 3 or 4 h had passed, I made the announcement: "To the ones who will register for my *Chemistry in Daily Life* class, the semester is 15 weeks long and, after today's session, you only have 14 weeks left." This is how I got my first class. I had no need to recruit students after that because by word of mouth students learned that my *Chemistry in Daily Life* class was one of the most interesting classes at the college [2].

This experience taught me a valuable lesson about teaching chemistry: If you make chemistry relevant to the student's life, experience, environment, and interests, you can teach them anything you want, even secondary isotope effects. I learned that you have to adjust the methods of teaching to students' different styles of learning. In 1977, it was unusual to make chemistry relevant to students' lives, relevant to the environment, and relevant to students' interests. Many chemists were suspicious that I was sacrificing the chemistry in order to attract the students by using these methods. By the 1990s, teaching chemistry to non-science majors in a relevant way became the rule, and no longer the exception.

In order to use science for the progress of humanity, science must accessible to all. Otherwise, a two-class society [3] will emerge, divided not by royalty or socio-economic status, but by knowledge of science. In 1977, inspired by my students, I developed alternative methods for teaching and assessing science through art, music, dance, drama, and rap. These methods proved to be extremely successful, especially with underprivileged students.

The central piece of this method is that the students show their knowledge through projects, which they can produce either alone or in groups, and through the use of different media to present their projects to the class (Figs. 2 and 3). For example, a group of theater students showed their understanding of the concept of ionic bonding through a drama, which followed Shakespeare's Romeo and Juliet. In this presentation, sodium gave his extra electron to chlorine to make her his wife. Following the theme of Shakespeare's tragedy, water came along and separated the couple. They ended the drama by having each participant hold up a plaque stating, "Learn to take every tragedy with a grain of salt," where the plaque that said "salt" was held up by the NaCl (table salt) couple. Other students presented a project on the chemical bond called the "Bondfather" and followed the "Godfather" story line, where a mother comes to Don Mendeleev to ask him for help because her daughter is in an ionic bond with a boy named sodium and she wants her in a covalent bond, where electrons are shared. The students spent long hours to produce their projects and to master the understanding of the abstract concepts of chemistry, which they tried to explain in this fashion. An advantage of this method

Fig. 2: A cartoon book explaining the fission reaction and the atom bomb (art student).

Fig. 3: A movie depicting the discovery of Ra and Po by Madame Curie, as well as her presentations in front of the French Academy, was produced by a team of film students.

is that these projects were used as an alternative assessment method. The students presented their projects to the whole class, where their fellow classmates along with the professor assessed their knowledge of the subject.

An old African proverb says, "It takes a village to raise a child." Therefore, these methods were also employed in workshops designed to enhance the teaching skills of Chicago Public School teachers, parents, and students. Teachers created their own projects to communicate their understanding of scientific concepts covered in the workshops. After the workshops, they incorporated these methods of teaching and assessing students in their own classrooms. A group of teachers created "The Element Connection" as a parody of the television show "The Love Connection". This creative theatrical presentation involved sending contestant Oxygen on dates with Helium (whom she found "too flighty"), Carbon (who had "too much energy – he wanted to bond with anyone!") and finally with Iron, with whom Oxygen established a successful bond (it turned out they were "a little rusty at relationships") [4].

Fig. 4: Young dancers representing chemical concepts visually during a Gordon Research Conference.

In a very poor neighborhood of Chicago, students, including some who were homeless, came to a dance studio, where they took dance lessons at night. Sitting on the floor of the dance studio, holding the periodic table, I taught the students chemistry. Other colleagues of mine, also devoted to making a change for underprivileged youth, worked with me on developing and implementing this program. These were most unusual conditions for teaching and learning: not only did we have to bring materials for studying chemistry, but we also brought food and warm clothes for the Chicago winter, which were donated to the students. Many in this program continued on to college and some even to PhD programs in science [5]. In our efforts to improve science teaching in the Chicago public schools, we mixed together students from diverse cultural backgrounds. We made an effort to have Christian, Muslim, and Jewish students study together so they did not just learn chemistry, but also tolerance and appreciation for different religions, races, and cultural backgrounds in order to advance the progress of humanity.

In 2001, I was asked to deliver a plenary lecture at a Gordon Conference on Science Visualization and managed to raise enough money to bring 25 of the African-American students who had learned chemistry at the dance studio, to participate in the conference. They demonstrated to the scientists their understanding of scientific concepts through dance (Fig. 4). The audience reacted with a standing ovation and a chorus of "bravo!" which contributed to the students' self-confidence and self-esteem [5]. In 2000, I received the first international award in the new democratic South Africa from the World Cultural Council. This gave me the opportunity to adopt the school district of Soweto and to introduce the methods of teaching science through the arts to the children. These methods were extended to many institutions in the US and around the world [1].

Human Rights

For 25 years (1986–2011), I chaired the newly established Subcommittee on Scientific Freedom and Human Rights of the International Activities Committee of the American Chemical Society (ACS). The Subcommittee pressured ACS to become an effective instrument for promoting scientific freedom and human rights around the world.

In 1988, I met with the famous Soviet dissident, Andrei Sakharov (Fig. 5), who received the Nobel Peace Prize in 1975 for his work on nuclear disarmament and his outspoken criticism of human rights violations everywhere. Based on Sakharov's advice, I took a crash course in Russian before returning to the Soviet Union to work with dissidents in 1989 and 1990.

I frequently entered the Soviet Union with groups of chemists from ACS or the American Institute of Chemists (AIC). During the day, we visited universities, gave lectures, and met with chemists. After midnight, at risk to my own safety, I would go by myself to meet with dissidents in dark alleys. We would go together to somebody's apartment, where in a dark attic, I delivered lectures, distributed professional journals, and collected background information and CVs from more than 200 dissidents. Afterward, I could work on their behalf in the US. My actions were considered illegal in the USSR and if caught, could have resulted in my arrest.

The Subcommittee was instrumental in the 1987 release of the Russian prisoner of conscience, chemist Yuri Tarnopolsky, who upon arriving to the US 2 weeks after his release from prison, addressed several hundred people in Chicago at an ACS section meeting. Many in the audience were moved to tears. Yuri summarized his understanding of the work of human rights activists in a letter to me stating: "*I often wondered what could make a person living in freedom, safety, and comfort to fight for someone deprived of all that and languishing on the other side of the globe…. I realized that both the faraway victim and his American guardian angel had something in common. They had the same ability to go against the tide, and they did for science something which could hardly be rationalized, an exhausting messy job of fixing its very foundation, invisible on the pages of professional journals they kept science both human and humane*." He helped me understand why I had risked my life more than once for the benefit of people whom I had never met [1].

Vil Mirzayanov worked as a chemist in the main center for the development of chemical agents in Russia. After Russia signed the Chemical Weapons Accord, he blew the whistle when he made public that his Institute continued to develop chemical agents. He was arrested in 1992 and charged with violating the laws against "divulging state secrets." The Subcommittee spearheaded the campaign to secure his release. In 1994, Mirzayanov wrote: "*For your cordiality, for your humanity, and for your kind impulse…in expressing sympathy and concern for a person you do not know… this is indeed something close to sainthood*."

In 1996, the Subcommittee worked on the case of nuclear engineer and former Russian naval officer Alexandr Nikitin, who was arrested that year for treason. His crime was his contribution to a 1994 report of the Bellona Foundation, an international environmental non-governmental organization based in Oslo,

Fig. 5: Andrei Sakharov and Zafra Lerman ca. 1988.

Norway. The public report focused on "Sources of Radioactive Contamination in Murmansk and Archangel Counties," and raised serious questions about the safety of decommissioned Soviet nuclear-powered submarines. In February 1996, the Russian government retroactively created laws so they could charge Nikitin. I traveled twice to St. Petersburg, Russia, and secretly met with Nikitin to learn first-hand about the case. In 2000 before the charges were dropped, we managed to bring Nikitin to Washington DC, where he addressed more than 1000 attendees in an ACS meeting. This event was televised live by C-SPAN and covered by many media around the globe.

After the Tiananmen Square incident in 1989, the Subcommittee turned its attention to China and began meeting with the Chinese delegation to the UN on a monthly basis to discuss human rights cases. We worked diligently on behalf of astrophysicist and activist Fang Lizhi, whose ideas and writings inspired the pro-democracy student movement, which helped lead to the Tiananmen Square protests. On June 5th 1989, Lizhi, worried about his safety, was granted asylum in the US Embassy in Beijing, where he stayed for 1 year. The Chinese government had him at the top of its "Most Wanted" list. The human rights groups succeeded in bringing him to the US in 1991. He gave his first speech in Chinese to China through the Voice of America from my office.

In 1992, I travelled to China and met with Chinese officials to discuss the fate of those imprisoned after the Tiananmen Square incident and to request their release. I met with dissidents, including physicist, philosopher, and activist Xu Liangying, who was under house arrest. I managed to deliver a letter from Lizhi to him and bring back his response. In 1995, I delivered a plenary lecture at a conference in Beijing, which I dedicated to all imprisoned scientists and students in China and publicly asked for their release.

Cuba was another challenge for the Subcommittee on Scientific Freedom and Human Rights. Because of the American embargo on Cuba, Americans could not freely visit Cuba without a license from the Treasury Department, a process that took a long time and did not guarantee that a license would be given. We believed that in order to foster scientific freedom in Cuba, the Subcommittee should arrange for an ACS delegation to attend Cuban Chemical Society Meetings to deliver lectures and interact with Cuban chemists. We went through the complicated US approval process to receive the necessary license. Since 1998, seven delegations have gone to Cuba. While in Cuba, we dealt with scientists who were in prison and whose human rights were abused.

Sakharov's advice to me in 1988 was to never let up on the pressure one applies to governments or organizations that abuse human rights. I try every day to live by his credo.

Chemistry as a bridge to peace

The collapse of the Soviet Union did not end the need for the ACS Subcommittee on Scientific Freedom and Human Rights and its work. In 2001, after September 11, the subcommittee turned its focus to the Middle East. Our experience with the Soviet Union had demonstrated that defending scientists and standing up for their freedoms supported efforts to improve the human condition. The situation in the Middle East was different. As opposed to a bipolar world pitting political systems against one another, the Middle East represented a place where centuries-old religious, cultural, and political differences created an environment of mistrust and intolerance [6]. The Subcommittee felt that scientists have an obligation and responsibility to use their special status and scientific knowledge for the progress of humanity and turned their attention to the Middle East.

I suggested to the Subcommittee that we organize a conference where we would bring scientists from all 16 Middle East countries under one roof to develop collaborations and friendships that would overcome the chasms of mistrust and intolerance. The Subcommittee decided to bring the idea to the International Activities Committee (IAC) of ACS. When the idea was presented, silence took over and you could hear people breathing. When the IAC brought the idea to the Board of ACS, it gained approval and the Board spearheaded the project. IUPAC (International Union of Pure and Applied Chemistry), RSC (Royal Society of Chemistry), and the GdCh (Gesellschaft Deutscher Chemiker) joined as co-sponsors [5].

When the planning started, it was the height of the second intifada. We had to be very careful and vet every scientist invited to the conference. Many of the scientists I had approached were hesitant to accept the invitation because they feared their government's reaction to their working with Israelis. To alleviate this problem, we invited six Nobel Laureates to the conference and then wrote to the Middle East scientists that this would be their only chance to spend 5 days with six Nobel Laureates in a small group (Fig. 6). The ones who needed approval from their governments told us that their ministers of science encouraged them to attend so that they could interact with the Nobel Laureates [6].

The goal was to provide a forum where participants from Israel, the West Bank, Gaza, Iraq, and other Middle East countries could explore what unites them rather than what separates them; to identify opportunities to develop activities which require collaboration to solve common problems; to reduce the level of personal animosity and the tendency to demonize the unknown other. The participants would spend 5 days together under the same roof. The structure of the forum would include interactive workshops on the environment, air and water quality, science education, entrepreneurship and innovation, nuclear and chemical security, medicinal chemistry, nanotechnology, sustainability of resources, and energy and materials. The workshops were designed to form collaborations on these subjects. An ample amount of time would be dedicated to poster sessions (Fig. 7) and informal networking activities designed for the purpose of forming friendships. The idea was that getting together in this forum would foster a change in attitude among the participants and help overcome years of distrust and intolerance.

Because of what we hoped to achieve, the meals, coffee breaks, and tours were just as important as the lectures and workshops. This was where friendships and collaborations would be formed. One of the rules for

Fig. 6: Nobel Laureate Roald Hoffmann in a discussion with two women scientists.

Fig. 7: Poster session.

the conference was that no accompanying members were allowed. As chemists, we understood that in order to facilitate the best interaction, we should not dilute the solution.

In December of 2003, the first conference was held on the island of Malta (hence the name "Malta Conferences") because the committee felt that an island would be safer than the mainland. Despite all the obstacles that we had to overcome in order to bring these scientists under one roof, the first conference was a success. At the end of the conference, the group looked like they had attended a family reunion and not a meeting of scientists from countries whose governments are often hostile to one other. As an Iranian scientist wrote, "*The entire event was truly informative, scientific and hope the science diplomacy will bring us closer to peace. Now, we all came back safe to our countries. While we are hundreds mile away from each other, but we feel as a same family. This is my great pleasure that I'm a member of this family.*" An Iraqi scientist wrote, "*My pleasure to be one of Malta family member, I found Malta conferences one of the very important event I attended during the last ten years to insure the success of science diplomacy approach for creating peace in the Middle East.*"

Today, more than six hundred scientists from 16 Middle East countries (Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Oman, Palestinian Authority, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates) and Morocco, as well as 15 Nobel Laureates participated in the eight Malta Conferences (2003, Malta; 2005, Malta; 2007, Istanbul, Turkey; 2009, Amman, Jordan; 2011, UNESCO headquarters, Paris, France; 2013, Malta; 2015, Rabat, Morocco; 2017, Malta). A critical mass of cooperators, who know and respect each other, is being developed to foster better cooperative relations between countries. Considering that most of these scientists are university professors or directors of institutes interacting with a high number of students, the mission of the Malta Conferences reaches much further than just the participants.

Important outcomes are a result of these Malta Conferences, including: (1) Jordan, Palestine, Israel, Egypt, and Kuwait formed a working group on Drinking Water Quality Assessment in the Middle East, conceived at the Malta III conference, and received funding from IUPAC to continue the assessment. (2) There is no clean drinking water in Gaza. Collaborations were formed between scientists from Al-Azhar University in Gaza and scientists from the Technion-Israel Institute of Technology for heavy metals analysis (ICP analysis) of water samples brought from Gaza to be analyzed at the Technion. (3) Palestinian students from Al Quds University are pursuing PhD studies at Weizmann, although Al-Quds degrees are not recognized by the Israeli authorities. (4) At Malta VIII, a resolution on the humanitarian water crisis in Gaza was written by scientists from Israel and Gaza and distributed to the relevant authorities [7]. A letter from participants from Gaza stated: "*On behalf of the entire Gaza, we would like to express our gratitude to Malta Conferences Foundation that continue giving us a highly regarded platform to keep Gaza on the international agenda and to introduce a new image different from the stereotyped one with grassroots evidences that development and peace is possible in Gaza against all the odds.*" (5) During the Malta VIII workshop on entrepreneurship and innovation, participants dove in and envisioned companies that would require cross-border collaboration. For example, participants developed the concept of a start-up company, "Every Drop Counts", for the conservation of water resources and educational materials teaching water conservation [9].

Importantly, many of the friendships would not have come to fruition without the Malta Conferences. The conferences allow scientists who are otherwise separated by cultural, religious, or political boundaries to come together. A participant from Israel commented, "*to be able to sit with someone from Iraq, Gaza, or Syria is a tremendous opportunity that I would not otherwise have had.*"

Bringing all these scientists together is becoming harder and harder in our fractured world. To find a country willing to issue a visa to all participants is near mission impossible and requires many months of sleepless nights and important connections. In Malta VIII, we were successful against all the odds to receive a visa for all participants, despite the fact that the last several visas were granted only 24 h before the start of the conference.

The goal is to form a critical mass of scientists to start a chain reaction for peace. If we had the finances to form the critical mass needed of 250 000 scientists, we could make a significant change in the Middle East and in the world [8] and contribute to the progress of humanity.

In a 2013 speech on the floor of the US Congress, Congresswoman Jan Schakowsky declared, "*The Malta Conferences are the only platform where scientists from 15 Middle East countries are collaborating and*

cooperating on scientific issues as well as developing professional and personal relationships with each other. The common language of science is used for science diplomacy, which serves as a bridge to peace, tolerance and understanding in the Middle East." [10].

Article note: A special collection of invited papers by recipients of the IUPAC Distinguished Women in Chemistry and Chemical Engineering Awards.

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