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Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise

H. N. Cheng, Editor
U.S. Department of Agriculture, Agricultural Research Service
New Orleans, Louisiana

Marinda Li Wu, Editor
American Chemical Society
Washington, DC

Bradley D. Miller, Editor
American Chemical Society
Washington, DC

American Chemical Society, Washington, DC

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Foreword

The ACS Symposium Series was first published in 1974 to provide a mechanism for publishing symposia quickly in book form. The purpose of the series is to publish timely, comprehensive books developed from the ACS sponsored symposia based on current scientific research. Occasionally, books are developed from symposia sponsored by other organizations when the topic is of keen interest to the chemistry audience.

Before agreeing to publish a book, the proposed table of contents is reviewed for appropriate and comprehensive coverage and for interest to the audience. Some papers may be excluded to better focus the book; others may be added to provide comprehensiveness. When appropriate, overview or introductory chapters are added. Drafts of chapters are peer-reviewed prior to final acceptance or rejection, and manuscripts are prepared in camera-ready format.

As a rule, only original research papers and original review papers are included in the volumes. Verbatim reproductions of previous published papers are not accepted.

ACS Books Department

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Foreword

This book, *"Jobs, Collaborations, and Women Leaders of the Global Chemistry Enterprise,"* is the third in a series of three ACS Symposium Books based on my presidential initiatives and symposia.

The title of this book may sound eclectic. The first two topics in the title originated from two of the seven recommendations made to the ACS Board of Directors in the final report of my presidential Task Force, *"Vision 2025: Helping ACS Members Thrive in the Global Chemistry Enterprise."* (The complete Vision 2025 Task Force report is covered in Chapter 22 of the first ACS Symposium Book in this series, called *"Vision 2025: How to Succeed in the Global Chemistry Enterprise,"* ACS Symposium Series 1157, published in 2014.)

Recommendation #4 from the Vision 2025 Task Force report was: "Discuss with U.S. and global stakeholders the **supply and demand of chemists/jobs** to bring them to a better equilibrium. Initiate a task force to look at options, including immigration-related issues." Thus, to study this issue in the U.S.A., I commissioned another presidential Task Force on the Supply and Demand of Chemists and Jobs in the summer of 2013. This second task force was chaired by Tiffany Hoerter of the ACS Committee on Economic and Professional Affairs (CEPA) with representatives from several other stakeholder national ACS Committees. The results of their studies, deliberations, conclusions, and recommendations are covered in Chapter 2 of this book.

Recommendation #5 of my presidential Vision 2025 Task Force report was: **"Collaborate with others, including chemical societies around the world** regarding public communication, education, advocacy, chemical employment, and other topics." Thus, the International Activities Committee chaired by Dr. H. N. Cheng and the International Activities Office led by Dr. Brad Miller as its Director partnered to organize an "Innovations from International Collaborations" symposium in August 2014 in San Francisco. Several of the invited international speakers were leaders of chemical societies around the world. The speakers were also invited to author chapters for this book, and my co-editors and I are grateful they all did.

The third topic in the title of this book is based on another international symposium, "Women Leaders of the Global Chemistry Enterprise," which I personally organized as Immediate Past President for the 248th national ACS meeting in San Francisco. I have long been a champion for women in science and a firm believer in the importance of both diversity and inclusivity — two of ACS's core values. Thus, I was inspired to invite fifteen women leaders to share their personal and professional journeys — first as symposium speakers and later as chapter authors for this book. I had met many of these women pioneers as leaders of other chemical societies during my travels as ACS President-Elect and ACS President. Other invited speakers included the CEO and Executive Director of ACS at the time, as well as past ACS Presidents, a Priestley medalist (one of only three women in the 139 year history of ACS), the first woman from Saudi Arabia to earn her Ph.D., and many others.

This global women leaders symposium provided a fantastic opportunity to gather an amazing group of role models to share their moving and inspiring stories. These outstanding speakers represented Asia, Africa, Europe, South America, the Middle East, as well as the U.S. It was truly an unforgettable and bonding event for all who attended — audience members and speakers alike! Despite coming from diverse regions of the world, common themes emerged on how these women in chemistry overcame professional and cultural barriers, and eventually achieved both personal and professional success via hard work, perseverance, and passion. I hope that the stories shared in this book will help energize and inspire women in science everywhere!

Thanks go to the national ACS Women Chemists Committee (WCC) and its chair Dr. Amber Charlebois for being the main sponsor for this global women leaders symposium and especially to Dr. Kimberly Woznack for her help. I was happy to invite Kimberly to contribute an informative Chapter 3 about women in academia in the U.S. I was also grateful for the support of many co-sponsors — all acknowledged in my own Chapter 22 in this book, entitled *"Partners for Progress and Prosperity: A Personal and Professional Journey."*

Special thanks go to this book's co-editors: Dr. H. N. Cheng, Chair of the International Activities Committee (IAC) and Dr. Bradley Miller, Director of the ACS Office of International Activities (OIA). It has truly been a great pleasure working with both of them on promoting international initiatives. One of the reasons I chose to run for ACS president was my strong desire to encourage ACS members to become more engaged and aware of opportunities in the global chemistry enterprise.

The topics covered in this book resulted from extensive work with partners such as IAC, OIA, the authors of this book, as well as many others — dedicated ACS staff as well as countless ACS volunteers, good friends, and supporters around the world during my three years in the ACS presidential succession. I am happy with what we have accomplished together and owe all my hearty thanks. Indeed, our work together helped make my presidential theme — that we should continue to work together on issues of common interest and mutual benefit as *"Partners for Progress and Prosperity"* — come alive when I shared it with chemistry communities on every continent except Antarctica (which I hope to visit someday). See my presidential article in *C&EN*, Jan. 7, 2013 as well as several ACS Comments for more details.

Last but not least, I also wish to thank my family for their continued support and understanding during these last three years as I worked tirelessly in the ACS presidential succession: my children who are now young adults enjoying their own exciting careers and contributing to society — my daughter Lori married to her Stanford classmate Evan, as well as my son Will; my dear mother Tsun Hwei Li, who just celebrated her 95^{th} birthday with friends and family from around the world; and my husband of 38 years, Norm Wu, who I especially wish to thank as a fabulous partner for life.

I hope you enjoy reading the many insightful chapters of this third ACS Symposium Book! Let's continue to "Partner for Progress and Prosperity" as we work to help solve global challenges. Thanks to all!

Marinda Li Wu
2013 ACS President

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Preface

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This book is the direct result of two symposia held at the 248th National Meeting of the American Chemical Society (ACS) in San Francisco in August 2014: (1) "Innovations from International Collaborations"; and (2) "Women Leaders of the Global Chemistry Enterprise." The symposium speakers were all well-known and accomplished leaders in the global chemistry enterprise, and a lot of valuable information was transmitted during the symposia. To preserve and document the information, the editors invited the speakers to contribute chapters to this book. In addition, the editors invited two special chapters from Hoerter *et al.* on "Supply and Demand of Chemists in the U.S." and from Woznack on "Mothers who are Chemists in the American Academe."

A total of 34 chapters are included in this book with contributions from almost all the speakers in the two symposia. For convenience, this book is divided into three sections: (1) Jobs, Careers, and Global Mobility; (2) Innovations from International Collaborations; and (3) Women Leaders of the Global Chemistry Enterprise. Chapter 1 is an overview chapter that summarizes the contents of all the chapters and also provides the background and the framework for the themes delineated in the book.

This book is intended to be useful to a wide range of audiences in the global chemistry enterprise, including scientists and engineers in academia, industry, government, non-profit organizations, and small businesses, as well as undergraduate and graduate students. For people interested in jobs, careers, and international educational and training opportunities, they may want to read Chapters 1-3. Particularly useful are the many resources currently available at ACS (and elsewhere) that are shown in those chapters. International collaboration is becoming an increasingly useful tool for career success. Chapter 5 (by Carroll) gives an overview of ACS products and services that can be used to facilitate international collaboration. Chapters 6-17 give many excellent examples of international collaborations and the positive outcomes resulting from such collaborations. Finally, Chapters 18-33 present the stories of 16 successful women scientists throughout the world who have overcome bias, family demands, and other difficulties to achieve notable success in scientific scholarship and/or professional leadership. These stories should be inspirational to all male and female readers.

We appreciate the efforts of the authors who took time to prepare their manuscripts and our many reviewers for their cooperation during the peer review process. Thanks are due to our many colleagues in the global chemistry enterprise for their interest, support, and collaboration. Particular thanks are due to Kimberly Woznack and Amber Charlebois of the ACS Women Chemists

Committee who helped to organize the symposium on Women Leaders in the Global Chemistry Enterprise and to ACS staff members for their help with both symposia. Special mention may be made of John Brodish and Patricia Kostiuk, who transcribed several PowerPoint presentations into text. We also thank Jack Nestor, Tim Marney, and Bob Hauserman at ACS Books for their patient and effective handling of the manuscripts. We hope that readers find the information given in this book useful as they chart their careers, balance their work/family obligations, cope with bias, or contemplate international collaborations.

H. N. Cheng
Southern Regional Research Center
USDA – Agricultural Research Service
1100 Robert E. Lee Blvd.
New Orleans, Louisiana 70124, U.S.A.

Bradley D. Miller
Office of International Activities
American Chemical Society
1155 Sixteenth Street, N.W.
Washington, DC 20036, U.S.A.

Marinda Li Wu
American Chemical Society
1155 Sixteenth Street, N.W.
Washington, DC 20036, USA

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Editors' Biographies

H. N. Cheng

H. N. Cheng (Ph.D., University of Illinois) is currently a research chemist at Southern Regional Research Center of the U.S. Department of Agriculture in New Orleans, where he works on projects involving improved utilization of commodity agricultural materials, green chemistry, and polymer reactions. Prior to 2009, he was with Hercules Incorporated where he was involved (at various times) with new product development, team and project leadership, new business evaluation, pioneering research, and supervision of analytical research. Over the years, his research interests have included NMR spectroscopy, polymer characterization, biocatalysis and enzymatic reactions, functional foods, pulp and paper technology, and green polymer chemistry. He is an ACS Fellow and a POLY Fellow and has authored or co-authored 192 papers, 25 patent publications, co-edited 11 books, and organized or co-organized 25 symposia at national ACS meetings since 2003. He is also the Chair of the ACS International Activities Committee (2013-2015).

Bradley D. Miller

Bradley D. Miller (Ph.D., University of Arizona) is the Director of ACS Office of International Activities. He has worked for ACS since 1999, developing programs, products, and services to advance chemical sciences through collaborations in Africa, Asia, Europe, Latin America, and the Middle East. He works with ACS staff and different governance units to create opportunities for chemistry to address global challenges through in-person and web-based scientific network development, research collaborations, and educational exchange. Miller serves on the U.S. National Commission for UNESCO and in 2009 was appointed to co-chair the ACS 2011 International Year of Chemistry Staff Working Group. He is also the long-time ACS staff liaison to the ACS International Activities Committee. A world traveler and an internationalist, he speaks English, French, Spanish, and Portuguese.

Marinda Li Wu

Marinda Li Wu (Ph.D., University of Illinois), the 2013 ACS President, has over thirty years of industrial experience spanning Dow Chemical R&D, Dow Plastics Marketing, and entrepreneurial experience with small chemical companies and startups including "Science is Fun!" which she founded to engage young students in science and enhance support for K-12 STEM education. She has served in many leadership roles at local and national ACS levels. She was elected to the

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ACS Board of Directors in 2006 and served as Director-at-Large until 2011. In 2011, she was elected to the Presidential succession of the American Chemical Society, where she brought fresh ideas, boundless energy, and enthusiasm for science to chemistry communities around the world. In 2012-2014, serving in the ACS Presidential succession, she was invited to give lectures worldwide and was made an honorary member of both the Romanian Chemical Society and the Polish Chemical Society. She also serves on the University of Illinois Chemistry Alumni Advisory Board, the International Advisory Board for the 45th IUPAC World Chemistry Congress, and the Board of Directors for the Chinese-American Chemical Society. She holds 7 U.S. patents and has published numerous articles in a variety of journals and magazines.

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Chapter 1

Jobs, Collaborations, and Women Leaders of the Global Chemistry Enterprise: An Overview

H. N. Cheng,[*,1] Bradley Miller,[2] and Marinda Li Wu[3]

[1]Southern Regional Research Center, USDA Agricultural Research Service, 1100 Robert E. Lee Boulevard, New Orleans, Louisiana 70124
[2]Office of International Activities, American Chemical Society, Washington, DC 20036
[3]2013 ACS President, American Chemical Society, Washington, DC 20036
[*]E-mail: hn.cheng@ars.usda.gov.

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The global chemistry enterprise continues to be active and contributes substantially to the gross domestic products and employment in many countries. This article provides an overview of the issues of jobs, collaborations, and women leaders of the global chemistry enterprise. The availability of jobs is a significant contributor to the attractiveness of chemistry and chemical engineering as a career and ongoing job satisfaction of professionals working in this area. Included in this article are the issue of supply and demand of chemistry jobs, women as professors and professionals, and increased access to international career opportunities offered by ACS International Activities. Collaboration has always been known to be an effective method to stimulate and accelerate innovation. With increasing globalization, international collaboration is becoming increasingly important. A large number of successful international collaborations are provided in the chapters in this book and summarized in this article. The chemistry profession has often been difficult for women because of various forms of bias and competing priorities of family and career. Yet, a number of women scientists over the years have overcome difficulties and achieved notable success in scientific scholarship and/or professional leadership. Examples of successful women scientists, engineers, and leaders are

cited in this article and described in detail in this book. All the information has been taken from the lectures given in two international symposia at the ACS national meeting in San Francisco in August 2014.

Introduction

The global chemistry enterprise continues to be very active with new products and processes developed in industrial and government laboratories and ongoing research and education in academia worldwide. The key to the success of the enterprise is the people involved. Some of the major challenges and opportunities facing the chemistry practitioners include jobs and careers, research and innovation, collaborations, leadership, and diversity. A schematic showing these issues is shown in Figure 1.

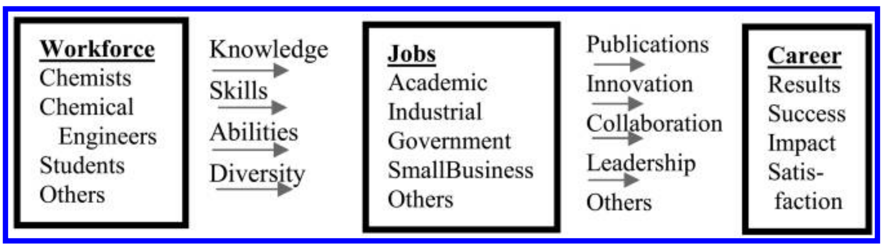

Figure 1. Some major issues facing chemistry professionals today.

Many of the issues in Figure 1 have been dealt with in two earlier books of this series (*1*, *2*). In the first book ("Vision 2025, How to Succeed in the Global Chemistry Enterprise"), 10 presidents of chemical societies around the world, together with leaders in academia, industry and government, share their perspectives on the future of the chemistry enterprise (*1*). The second book ("Careers, Entrepreneurship and Diversity: Challenges and Opportunities of the Global Chemistry Enterprise") provides expert guidance on different career paths, including entrepreneurship and new business start-up, as well as diversity issues in the workplace (*2*).

This third book is based on two symposia that took place at the 247th national ACS meeting in San Francisco in August 2014: 1) "Innovation from International Collaborations", and 2) "Women Leaders of the Global Chemistry Enterprise." The symposia speakers (and authors of the chapters in this book) are all leaders in the global chemistry community, and many are accomplished scientists and engineers. These global leaders share their valuable perspectives and experiences in this book.

This article provides an overview of the topics: jobs, collaborations, and women leaders in the global chemistry enterprise. These are important and timely issues affecting chemistry practitioners today. Jobs certainly rate near

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the top of most people's list of priorities. Jobs are also important to ACS as it seeks to help its members find and retain jobs. In the interconnected, globalized world today, collaboration is becoming an increasingly useful tool for career success. Collaboration can facilitate research, decrease time and cost, and permit risk-sharing. With faster and easier electronic communication, international collaboration is growing as an attractive option to facilitate innovation, access global talent, and produce better results.

As recent as 25 years ago, women faced a lot of obstacles to pursue and continue a scientific career. Since then, some progress has been made, but further improvement is still needed. The 16 chapters written by women in this book serve as valuable documentation of the various challenges faced by women scientists and engineers in the past and the present and how they managed to overcome them.

Because all the authors in this book are accomplished scientists and leaders in the global chemistry enterprise, their perspectives and experiences on the current topics should be of great interest to working chemistry professionals and students alike.

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Jobs, Careers, and Global Mobility

A key element in the issue of jobs is the supply of and the demand for jobs. An ACS Presidential Task Force was appointed by 2013 ACS President Marinda Wu to look at this issue. It was headed by **Tiffany Hoerter** of ACS Committee on Economic and Professional Affairs (CEPA). The task force did a great job. Among their findings (Chapter 2) (*3*), the chemical employment landscape seems to be shifting and starting salaries are declining. Moreover, the increased supply of bachelor's degree chemists has not been met with an adequate increase in demand. The task force recommends that the focus of ACS leaders, volunteers, and staff should be on the alignment of skills with employment needs. There is also a need for increased vigilance to remain at the forefront of chemical employment and economic trending (*3*).

Over the past forty years, the number of women in the chemistry enterprise has steadily increased; currently almost one-third of the chemistry workforce are women. **Kimberly Woznack** (*4*) has provided a chapter on "Mothers who are Chemists in American Academe: Resources to Support Academic Parents in Chemistry." She investigates the unique challenges and rewards present for women chemists working in academia, particularly highlighting some of the literature helpful to various specific affinity groups at the intersection of gender, profession, parental status, and discipline.

As the world is becoming progressively more globalized, international education and work experience is considered valuable by many employers. **Brad Miller**, in his chapter (*5*), describes the efforts that ACS has made to facilitate global mobility and international experience. He delves in detail on two ACS programs: ACS International Center™ and International Research Experience for Undergraduates (IREU). Both programs have been very successful, and many students and younger scientists have benefited from these programs.

Innovation and International Collaboration – ACS-Related Programs and Activities

In the current environment, innovation can often be facilitated by international collaboration. According to the figures reported by the Royal Society, more than 35% of scientific articles today are the results of international collaborations among researchers from different countries. In view of these trends, ACS has developed more programs and opportunities to increase international collaboration and innovation. In this book several chapters provide many examples of such programs.

William Carroll, in his chapter (*6*), gives an overview of ACS international activities and the mechanisms used to advance member-serving global engagement. He touches on ACS International Chapters, ACS strategic alliances and partnerships, international collaborative conferences (such as the Chemical Sciences and Societies Summits and Global Innovation Imperatives meetings), global outreach programs (e.g., BOOST program in Malaysia, Indonesia and Thailand, and Festival de Quimica in Latin America and China), and leadership coordination efforts to address human rights issues.

One of the successful examples of international collaboration was the International Year of Chemistry (IYC) in 2011. In the chapter provided by **Bryan Henry** (*7*), he reviews some of the successes of IYC, the various events and activities held around the globe, and how the global chemistry community can build upon IYC's achievements.

As another example, ACS has collaborated with the Pittsburgh Conference (Pittcon) since 1995 to improve analytical instrumentation expertise of early and mid-career analytical chemists from developing and transitional countries. In his chapter, **Richard Danchik** (*8*), who has been instrumental in this ACS-Pittcon collaboration, discusses how this collaboration started, and how it created new networking and educational opportunities for the participating chemists.

Morton Hoffman and Zafra Lerman, in their chapter (*9*), discuss the Malta Conference, which is another excellent example of international collaboration. These conferences have taken place biennially since 2003, and they transcend geopolitical boundaries and international politics to provide a forum to discuss scientific and educational issues important to the Middle East and the world. Hoffman and Lerman describe how using science as diplomacy has created a bridge toward peace in conflicted regions of the world and has led to innovative products, processes, and educational resources.

A good example of successful international collaboration involving an ACS technical division is the Pacific Polymer Federation (PPF), a cooperation initially between ACS Polymer Division (POLY), Society of Polymer Science in Japan (SPSJ), and Royal Australian Chemistry Institute (RACI), and now joined by several other chemical organizations. **William Daly**, in his chapter (*10*), provides the history and an overview of the founding, evolution, and operation of this organization and the ways it has stimulated international collaboration and innovation in the Pacific Rim region.

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Innovation and International Collaboration – International and Business Perspectives

Certainly ACS is not the only organization to recognize the benefits of increased international collaboration. A number of other organizations and businesses have been working to develop collaborative programs and activities in order to facilitate innovation and to further the organization's strategic goals.

The Brazilian Chemical Society (SBQ) has been promoting the progress of chemistry in Brazil through a number of programs, including international collaborations. In his chapter **Adriano Andricopulo** (*11*) describes the successful "Science Without Borders" program, which funds Brazilian students to study science and engineering abroad and top foreign researchers to work in Brazil for academic or research purposes. He also indicates that Brazil will host for the first time the IUPAC World Chemistry Congress in 2017.

Andy Hor, in his chapter (*12*), looks at Asia's growing economy, its emergence, and the opportunities for continued partnership between ACS and Federation of Asian Chemical Societies (FACS). Several possible approaches are suggested, e.g., faculty and student exchange, industrial consortia, trilateral agreements with a third party, and collaborative programs with individual chemical societies within FACS.

In a chapter provided by **Marcus Behnke** (*13*), he showcases a successful multilateral funding program managed by the Committee on Chemistry Research Funding under IUPAC. They have developed a robust system that overcomes administrative barriers to international collaborative research.

Sanjeev Katti and Ajit Sapre (*14*) report in their chapter that Reliance, one of the largest refining and petro-chemical companies in the world, is undergoing a major transformation with emphasis on R&D to support their businesses. They have embraced the open innovation concept and have engaged in sponsored R&D, collaborations, and joint development programs with appropriate Indian and international institutes and universities, national labs, start-up and established companies world-wide.

Peter Koelsch (*15*) provided a chapter illustrating 3M's successful product development processes. Globally 3M strives to have over 30% of its sales derived from products introduced during the past 5 years. In order to accomplish this, effective sharing of technology, capabilities, and customer insights around the globe is critical. He describes some important practices and provides some examples of how a global technical network collaborates and fosters innovation.

Eloise Young (*16*) works at NineSigma, and she discusses in her chapter how open innovation is a proven method for creating fruitful partnerships that can reduce time to market and uncover innovations that often lie at the intersection of two industries, or two technical disciplines. She has provided examples that show how successful international connections and discoveries have been made as a result of open innovation, and addresses the fundamentals of building an open innovation program.

In a chapter provided by **Lewis Whitehead, et al** (*17*), they discuss Novartis' Fellows program for African academic scientists. The program provides a 9 week-long industrial immersion experience at the Novartis lab in Cambridge, MA,

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in partnership with Seeding Labs. The Fellows learn new laboratory techniques and improve their science communication skills. In particular, computational chemistry has minimal requirements and is ideally suited as an area for scientific capacity building in Africa. This work was partly funded by an ACS International Activities Committee Global Innovation Grant.

Jorge Colón, in his chapter (*18*), discusses the workshops held in Puerto Rico and Haiti following the the 2010 Haiti earthquake in order to assist Haiti's future development and reconstruction efforts. The report that came out of those workshops is titled: "Science for Haiti: A Report on Advancing Haitian Science and Science Education Capacity." He presents an update of current international collaborations to advance Haitian science, as well as science education capacity and innovation.

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Women Leaders of the Global Chemistry Enterprise

In the global chemistry enterprise, women have played an increasing role over the years. Of course, these successes have not been achieved without difficulties or challenges. In this book 16 distinguished women scientists and engineers provide first-hand accounts of their personal experiences of how to meet and overcome these challenges. These stories are truly inspiring and helpful to readers who may encounter these same challenges in the future.

Darleane Christian Hoffman, in her chapter (*19*), recounts the role women have played in chemistry and how they inspired her to pursue a career in the field. She describes the profound impact chemistry has made on her life, and the opportunities given her even after marriage and having children. Through diligence and intelligence, she distinguished herself in transuranium chemistry and became the second female recipient of the Priestley Medal, the highest honor that ACS provides.

Drawing on nearly 45 years as a leader in the chemistry community and chemical communication, **Madeleine Jacobs** in her chapter (*20*) describes her life's journey, from a young girl growing up in her grandmother's house in Washington, D.C., to becoming the Chief Executive Officer of ACS, the world's largest scientific society. In her chapter, she provides insights on how to build a satisfying career and personal life.

Zafra Lerman, in her chapter (*21*), describes her chemistry experience and how she realized, while conducting research on isotope effects that she wanted to make chemistry accessible to all. Her tenant in life is that equal access to science education is a human right. She has developed a method of teaching chemistry using art, music, dance, and drama, which has attracted students at all educational levels. Her work has also led her to the creation of the Malta Conferences, discussed in an earlier chapter.

Ann Nalley (*22*) was born to poor cotton farmers in the early 40s, became a chemist, and was elected to be the 2006 President of ACS. She described in her chapter the obstacles she had to overcome as a woman as she earned a Ph.D. in Chemistry and the successes she celebrated along the way. She also shared success stories in undergraduate research and how these have contributed to her success.

Marinda Li Wu (*23*) once dreamed of becoming a scientist or ambassador. She chose to be a chemist and had a very successful career first at Dow Chemical, and then as an entrepreneur and owner of her own business while volunteering for ACS. The challenges she faced as an Asian-American woman strengthened her leadership skills. She just completed three years in the ACS Presidential succession. In her chapter, she tells her story of how destiny and determination impacted her journey to getting elected as the 8th woman and first Asian American President of ACS. Even now she continues to be a global "ambassador", advocating for science, education, and diversity.

In Brazil, the scientific profession has recently opened its doors to women. **Vanderlan Bolzani** (*24*) provides data in her chapter to show that despite improvements, female scientists in Brazil continue to face an uphill battle against discrimination, unequal pay, and funding disparities. She also gave a brief overview of the research on natural products chemistry from Brazilian biodiversity and her significant contributions in that field. She has proven that with enough passion and dedication, it is possible to overcome difficulties and achieve scientific leadership in her field and professional leadership in chemical societies.

Lydia Galagovsky, in her chapter (*25*), recalls the two dreams she had when she was a secondary school student: to become a teacher and to succeed as a medical scientist. As it turned out, she chose chemistry in college and obtained a PhD in organic chemistry that led to a career in both medicinal chemistry and chemical education in Argentina. Thirty years later, she has multiple achievements and realized both of her dreams. She also provides two pieces of advice for a researcher: work hard and persevere in the face of setbacks.

In her chapter, **Barbara Loeb** (*26*) tells the story of her personal life as a mother and her professional life as a faculty member at the P. Universidad Católica de Chile. She reflects on the challenges and opportunities of a woman faculty member, and her joy of teaching and "bringing up" teenagers to adults. She looks at both her personal and her professional life, and how much the two lives crossed paths and influenced each other.

Noemí Elisabeth Walsöe de Reca, in her chapter (*27*), recounts her experience studying chemistry, from early childhood to adulthood and motherhood. The author reflects on how hard work and dedication have led her to achieve her goals and earn several awards. She is active in research in Argentina with 300 papers and 33 PhD students. She has also raised three sons and is a busy grandmother as well.

Gheorghița Jinescu (*28*) presents in her chapter a brief story of her professional life, portraying chance and destiny on the road of becoming the first woman-professor of chemical engineering in Romania. She attributed her success to the help of her professors, her persistent hard work, her dedication to teaching, and her service to her profession. She has been active in professional activities and has made special efforts to help women engineers in their careers.

Mama El Rhazi (*29*) recounts in her chapter her chemistry experience: first earning a bachelor's degree in Morocco, Master's and PhD degrees in Paris, beginning her professional career teaching chemistry in France, and returning home to contribute to scientific development. She currently is a full time Professor

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in the department of chemistry at the University of Sciences & Technologies in Mohammedia. She has been President of the Moroccan Society of Analytical Chemistry for sustainable development and Vice President of the Federation of African Societies of Chemistry.

Bice Martincigh (*30*) recounts her experience in her chapter growing up in South Africa, studying chemistry and later becoming associate professor in the School of Chemistry and Physics at the University of KwaZulu-Natal in Durban. The author offers advice to aspiring female chemists through the lessons she learned: find an area that you really like, explore the field, rely on your own efforts and determination, and stand up for your beliefs.

In her chapter, **Samira Ibrahim Islam** (*31*) describes her decision to pursue science as a result of encouragement, inspiration, hard work, and perseverance. She completed her education abroad and became the first Saudi woman ever to complete secondary education, obtain a Bachelor and Ph.D. degree, and become a Professor of Pharmacology. She recounts her chemistry experience and the profound impact it made on women pursuing science in Saudi Arabia.

In her chapter, **Mannepalli Lakshmi Kantam** (*32*) retraces her life's journey, opting to pursue chemistry (instead of medicine), and becoming the first female director of a major research institute in India. She has been successful in designing and developing catalysts and innovative green and economical chemical processes. She has 290 research publications, 43 international patents, and numerous recognitions for her achievements. She attributes her success to her willingness to work and strong will to make decisions.

In Japan today, more women are encouraged to study science and engineering and work throughout their careers. This change is not easy because Japanese society has the long-held tradition that men and women serve different roles in society. In a chapter provided by **Kazue Kurihara** (*33*), she describes her efforts to change the traditional roles, and how she has successfully worked as a chemist through the Japanese system.

Supawan Tantatayanon (*34*) describes in her chapter her multiple roles as a daughter, wife, mother, teaching professional, and leader in the global chemistry community. She is strong, capable, confident, and adaptable. After earning a Ph.D. in chemistry, she taught and performed chemistry research in Chulalongkorn University in Thailand. She set up several new graduate programs, served in numerous science foundations and societies, and became the first female President of the Chemical Society of Thailand and the Federation of Asian Chemical Societies. In research, she made notable contributions in polymer chemistry, small-scale chemistry, and green chemistry.

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Chapter 2

Supply and Demand of Chemists in the United States

Tiffany Hoerter,[*,1] Jakoah Brgoch,[2]
William Richard (Rick) Ewing,[3] Katherine Glasgow,[4]
Lynne Greenblatt,[5] Laura Kosbar,[6] and Beatriz Rios-Mckee[7]

[1]Task Force Chair, Committee on Economic and Professional Affairs,
[2]Younger Chemists Committee,
[3]Committee on Corporation Associates,
[4]Committee on Science,
[5]Committee on Chemistry and Public Affairs,
[6]Committee on Professional Training,
[7]Graduate Education Advisory Board,
American Chemical Society, 1155 Sixteenth Street N.W.,
Washington, DC 20036, United States
[*]E-mail: tiffany.hoerter@dupont.com

A Presidential Task Force on Supply and Demand of Chemists in the U.S. was appointed by ACS President Marinda Li Wu in 2013. The purpose was to gather data to inform and guide ACS National Committees as they provide programs, products and services to the ACS membership. This is the final report of this Presidential Task Force. The initial Presidential Task Force report with its three recommendations was first shared with Dr. Wu in August 2014. Pertinent recommendations were then shared with six stakeholder committees of the ACS to gather more feedback for refinement of the recommendations. The final Presidential Task Force report was issued in September 2014 and disseminated within the ACS.

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Executive Summary

In 2012, ACS President-Elect Marinda Wu appointed the Presidential Task Force “Vision 2025: Helping ACS Members to Thrive in the Global Chemistry Enterprise.” One of the recommendations of the task force was: *Discuss with U.S. and global stakeholders the supply and demand of chemists/jobs to bring them to a better equilibrium* (*1*).

To address this recommendation, the Task Force on the Supply and Demand of Chemists in the United States was formed during the summer of 2013. Key ACS Committee stakeholders were identified and invited to contribute. The Task Force included Tiffany Hoerter, Committee on Economic and Professional Affairs (CEPA), Task Force Chair; Jakoah Brgoch, Younger Chemists Committee (YCC); William Richard (Rick) Ewing, Committee on Corporation Associates (CAC); Katherine Glasgow, Committee on Science (ComSci); Lynne Greenblatt, Committee on Chemistry and Public Affairs (CCPA); Laura Kosbar, Committee on Professional Training (CPT); and Beatriz Rios-Mckee, Graduate Education Advisory Board (GEAB).

It is the intention of the Task Force on the Supply and Demand of Chemists in the United States that the data provided and discussed in this report will be used to inform and guide ACS National Committees which provide programs, products and services to the ACS membership. It is not the Task Force’s intention to provide a comprehensive review and evaluation of the United States economic state of the supply and demand of chemists.

After an extensive review of the current and historic data relating to the supply and demand of chemists in the United States, it is clear there are some notable trends. From 2000 to 2013, the chemistry bachelor’s degree supply has risen substantially and the unemployment numbers for new chemistry bachelor’s degree graduates have risen as well (*2*). The production and unemployment of graduate degree holding chemists (MS and PhD) have remained stable over the same time period (*3*). While evidence that a shortage of STEM educated laborers remains (*4*, *5*), upon narrowing the data to chemists alone, it seems the supply of bachelor’s degree holding chemists has increased more quickly than demand (*3*). There also appears to be a mismatch in skill sets required by employers and those being provided during undergraduate education (*4*, *5*). The demand for chemists in the United States has been steady but the employment landscape is shifting away from basic manufacturing towards scientific research and development services (*3*). Unemployment for chemists is overall lower than many other majors; however, new graduate unemployment is very high (*2*, *3*). Finally, starting salaries are declining when adjusted for inflation (*2*). The data contained in this report further supports the conclusions from previous ACS reports including, *"Advancing Graduate Education in the Chemical Sciences* (*6*)*"* and *"Innovation, Chemistry, and Jobs; ACS Presidential Task Force on Innovation in the Chemical Enterprise* (*7*)*."*

To address the issues concerning oversupply of bachelor’s degree graduates, the mismatching skill sets, and the shifting employment landscape, the Task Force on the Supply and Demand of Chemists in the United States is providing the following recommendations for ACS leaders, volunteers and staff:

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1. ACS should continue to support members at all career levels with services to obtain, inform, maintain, and grow their careers including:

    - ACS Career Services: Tools to help chemists find jobs.
    - ACS Professional Education: Training courses to refresh chemists' skills
    - ACS Leadership Development: Courses and workshops to develop leadership skills
    - ACS Market Intelligence: Salary and trends in chemistry and related fields

2. The Committee on Economic and Professional Affairs (CEPA) should continue monitoring chemical employment data and trends, evaluate key trending parameters and continuously follow these parameters to highlight current and future trends. CEPA should inform ACS leaders, volunteers, staff and members of these trends.
3. Questions to assess the skills desired by employers and those held by new graduates should be added to the ChemCensus to assist the ACS in establishing programs, products, and services to address these needs and deficiencies.

Introduction

In recent years, the supply and demand of science, technology, engineering and mathematics (STEM) workers has been at the forefront of the public policy debate. Many reports point to a shortage of STEM workers in the US. *"Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (*8*)*"*and the subsequent publication, *"Rising Above the Gathering Storm, Revisited* (*9*)*"* by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, have highlighted the shortage of STEM workers in the United States. The America COMPETES Act of 2007 was passed with the intent "to invest in innovation through research and development, and to improve the competitiveness of the United States (*10*)." The legislation was reauthorized in 2010 (*11*), renewing US investment in STEM education and funding.

There have also been several publications purporting that the STEM work shortage in the US is false. Robert N. Charette's IEEE article *"The STEM Crisis Is a Myth* (*12*)*"* examines the literature on both sides and concludes that there is not a STEM shortage. The Economic Policy Institute briefing "*Guestworkers in the high-skill U.S. labor market: An analysis of supply, employment, and wage trends"* by Hal Salzman, Daniel Kuehn, and B. Lindsay Lowell claims there is an adequate supply of U.S. STEM workers (*13*). Michael S. Teitelbaum of Harvard Law School and the Alfred P. Sloan Foundation has published several reports (*14*, *15*) indicating that the current call for STEM workers is part of a *"cycle of alarms over supposed shortages of scientific talent, followed by booms in training and then busts in professional opportunity* (*16*)*,"* The debate over the STEM shortages informed the more focused study of the Supply and Demand of Chemists in the United States. Primary data sources for this analysis include:

- *Bureau of Labor and Statistics Occupational Employment Statistics (BLS-OES)* (*3*)
- *National Science Foundation Science and Engineering Indicators(NSF-SEI)* (*17*)
- *American Chemical Society New Graduate Survey (ACS-NGS)* (*2*)
- *American Chemical Society Salary Survey (ACS-SS)* (*18*)
- *American Chemical Society Committee on Professional Training Survey of Chemistry Degree Granting Institutions (ACS-CPT)* (*19*)
- *Hard Times, College Majors, Unemployment and Earnings 2013: Not all College Majors are Created Equal (Hard Times Report)* (*20*)
- *Bayer Facts of Science Education XVI: U.S. STEM Workforce Shortage – Myth or Reality? Fortune 1000 Talent Recruiters on the Debate (Bayer)* (*4*)

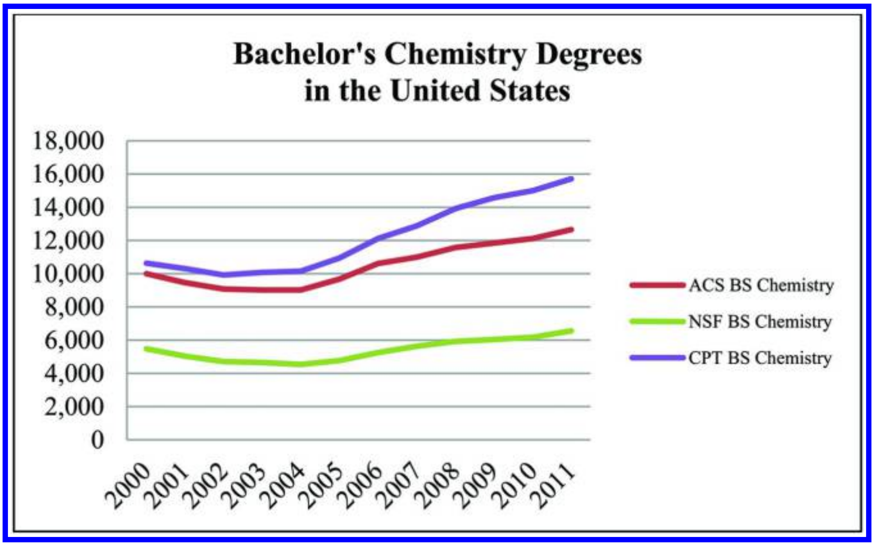

Figure 1. NSF-SEI (17), ACS-NGS (2), and ACS-CPT (19) bachelors chemistry degrees, 2000-2011.

Supply of Chemistry Graduates in the United States

The total supply of chemistry graduates in the United States has been increasing from 2000 to the present. The data from *NSF-SEI* (*17*)*, ACS-NGS* (*2*)*,* and *ACS-CPT* (*19*) vary in total number of degrees awarded due to differing definitions of a chemist, but they all trend similarly. These data sources indicate

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significant increases in bachelor's degrees in chemistry beginning in 2005 (see Figure 1). The ACS-CPT (*19*) data, comprised of self reported data from over 600 institutions, indicates the number of bachelor's degrees awarded rose from around 10,000 in 2000 up to almost 16,000 in 2011, a 60% increase. The *NSF-SEI* (*17*) *and ACS-NGS* (*2*) data trend similarly. In contrast, the number of students graduating with advanced degrees has been increasing at a more gradual, stable rate from 2000 to 2011 (see Figure 2).

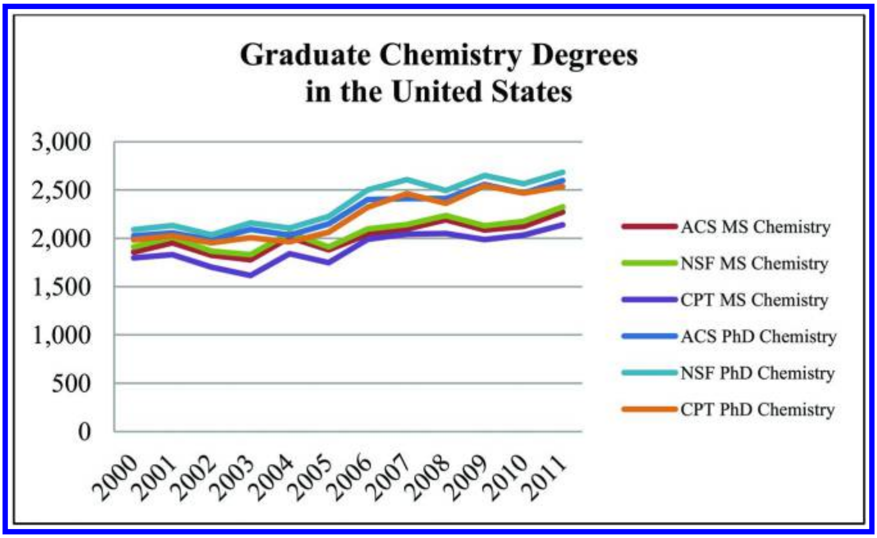

Figure 2. NSF-SEI (17), ACS-NGS (2), and ACS-CPT (19) graduate chemistry degrees, 2000-2011.

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Stability of Chemistry Graduate Supply

Evaluation of the supply data utilizing the principles of Statistical Process Control (SPC) was performed. The numbers of chemistry graduates at the BS, MS and PhD levels were evaluated based on the year over year increase. I-MR charts (*21*) were employed to assess the stability of supply for BS, MS and PhD chemists (see Figure 3). The percent change in graduates MS and PhD processes are both stable and within variation control, which is evidenced by no SPC rules violations in the graphical summaries. The percent change in BS graduates shows process variation control, but significant changes in the process center. This further supports that bachelor's degree graduates are varying outside the expected statistical variation and further analysis should be completed to determine factors causing this variation.

Supply Summary

According to *NSF-SEI* (*17*),*ACS-NGS* (*2*), *ACS-CPT* (*19*) and the SPC evaluation, the supply of bachelor's level chemists has increased substantially since 2005. Based on the observed increase in supply, a significant uptick in demand for bachelor's level chemists would be required for the supply and demand of chemists to maintain equilibrium.

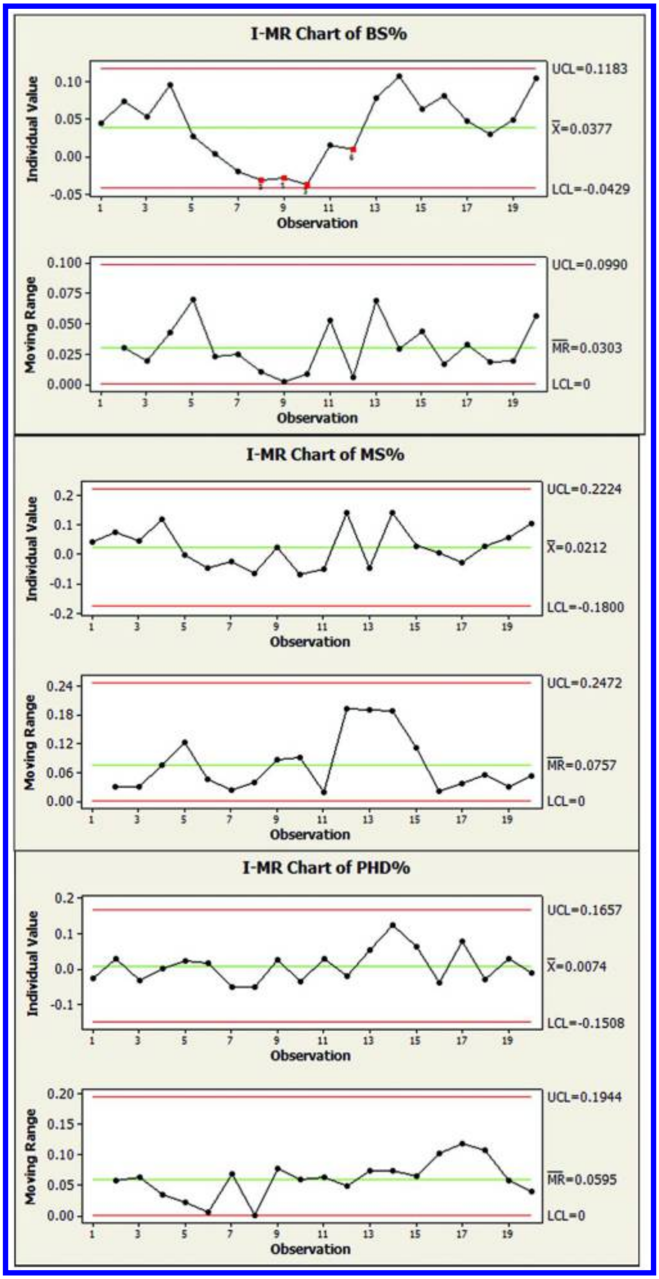

Figure 3. I-MR Evaluation of the supply of BS, MS and PhD chemists.

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Employment of Chemists in the United States

Analysis of the *BLS-OES* (*3*) data for chemists shows steady employment over the past decade (see Figure 4).

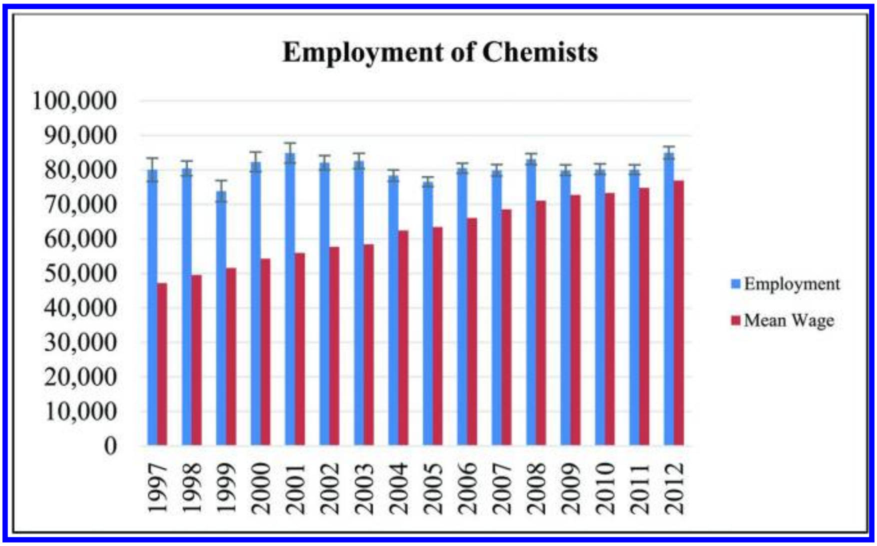

Figure 4. BLS-OES (3) employment of chemists, 1997-2012.

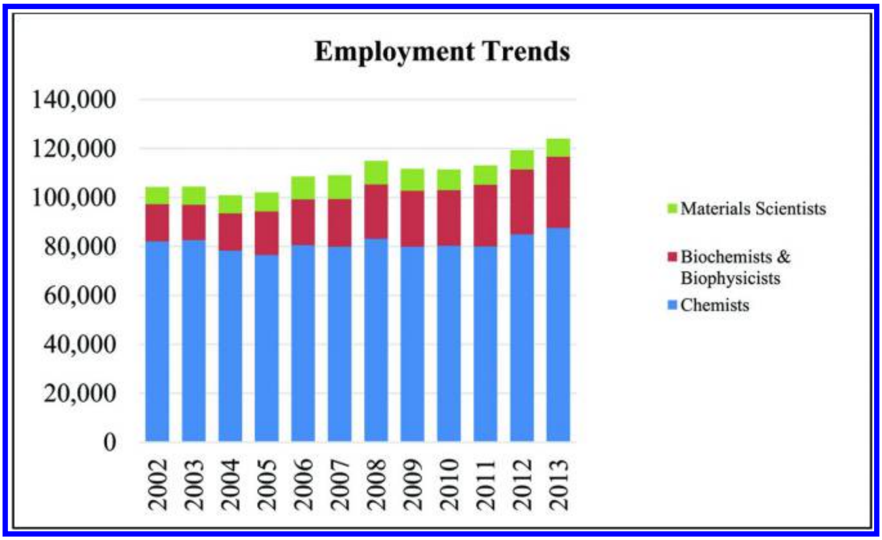

Figure 5. BLS-OES (14) employment of chemists, materials scientists, biochemists & biophysicists, 2002-2013.

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When related disciplines, such as materials scientists and biochemists (grouped in the *BLS-OES* (*3*) with biophysicists), are included employment shows an overall positive trend over the past decade (see Figure 5).

According to the *Hard Times Report* (*20*), chemistry is listed as one of the five majors with the lowest unemployment rate. This data is further supported by the *NSF-SEI* (*17*) and *ACS-SS* (*18*) (see Figure 6).

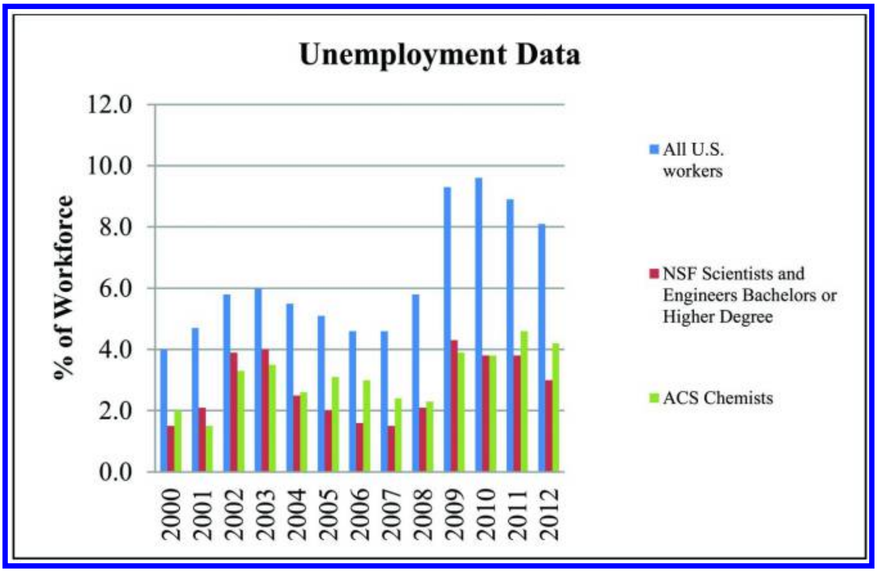

Figure 6. Comparison of unemployment data from the BLS-OES (3), NSF-SEI (17), and ACS-SS. (18)

The Shifting Employment Landscape

Analysis of the *BLS-OES* (*3*) data for employer trends indicates that 'Pharmaceutical and Medicine Manufacturing' and 'Scientific Research and Development Services' have been the top two employers since 2002 (see Figure 7). 'Architectural and Engineering Services', which includes 'testing services', was also among the top five employers. In 2009, a transition occurred; the top employer changed from 'Pharmaceutical and Medicine Manufacturing' to 'Scientific Research and Development Services'. Over the past decade, 'Pharmaceutical and Medicine Manufacturing' showed slightly positive growth (+8%) when compared to strong growth for 'Scientific Research and Development Services (+80%) and 'Colleges and Universities' (~200%). For chemists, 'Basic Chemical Manufacturing' was one of the top five employers until 2011 when 'Colleges and Universities' took the #5 spot as employment in 'Basic Chemical Manufacturing' numbers declined.

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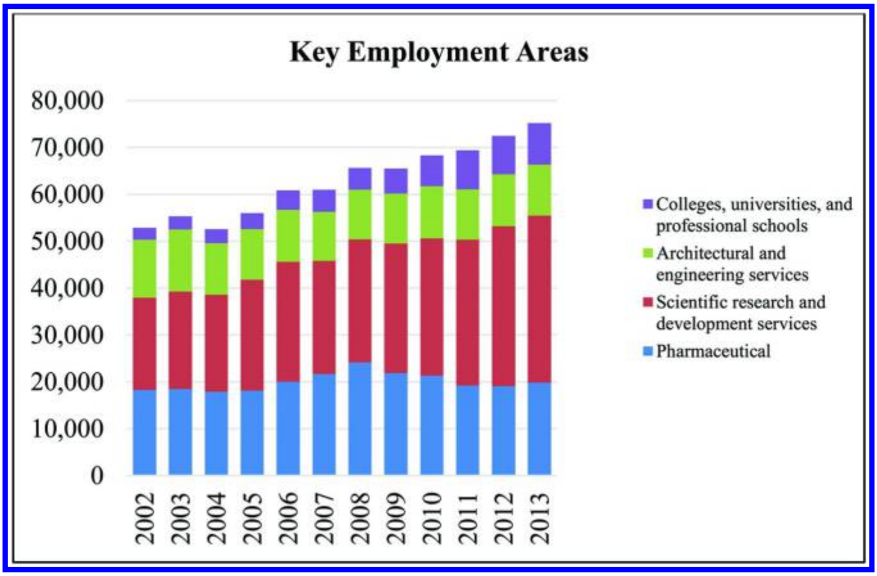

Figure 7. BLS-OES (3) key employment areas for chemists, biochemists & biophysicists, and materials scientists.

Based on the *BLS-OES* (*3*) data, it appears that there is a trend away from large industrial employment of chemists and towards a services-based model. Analysis of the *BLS-OES* (*3*) category of 'Chemical Manufacturing' indicates that after an employment peak in 2008, this category has declined 13% (see Figure 8).

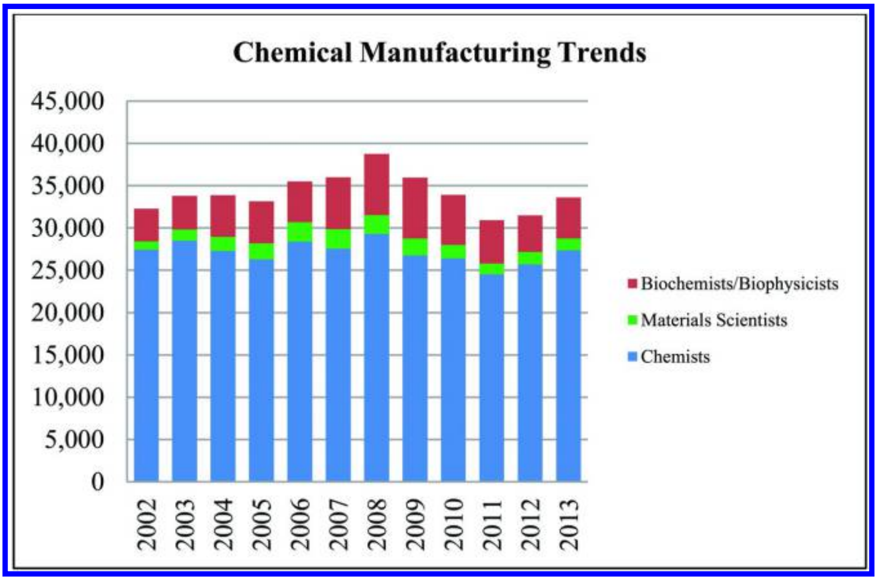

Figure 8. BLS-OES (3) employment trends in 'Chemical Manufacturing' category.

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This data is corroborated by the *ACS-NGS* (*2*), which is sent to all new graduates within the first year of their graduation. Two items agree well with the *BLS-OES* (*3*). First, those graduates who report entering industry are increasingly joining companies that are testing and service-based rather than manufacturing-based (see Figure 9). Positions in manufacturing companies are on the decline. This trend may be due to several compounding factors – off-shoring of research positions to low cost countries, increased automation for tasks which used to be performed by employees, and the shift from large internal R&D organizations to contract research (*22*, *23*).

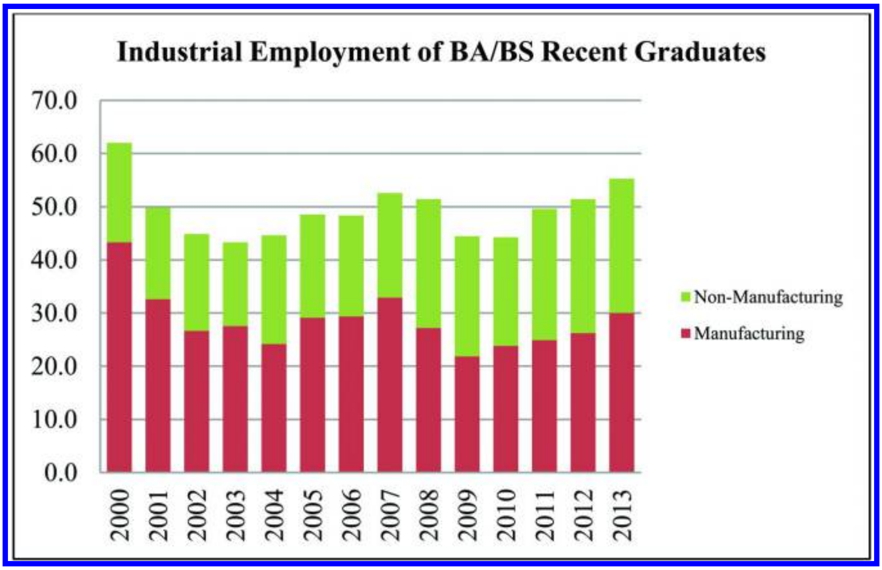

Figure 9. ACS-NGS (2) employment trends for recent BA/BS chemistry graduates in industrial positions (balance of respondents joined academia, government, or are self-employed).

Second, based on the *ACS-NGS* (*2*) data on employer size from 2000 to 2013 data, there is a shift away from very large companies (>10,000 employees) to medium (500 to 9,999) or small (<500) companies (see Figure 10). As graduates join companies that are smaller, they also are landing in positions that are more diverse than in the past. The same survey reports that in 2013, 20.7% of respondents classified their job as "Scientist or Engineer", a sharp reduction from the 2000 result of 36.4%.

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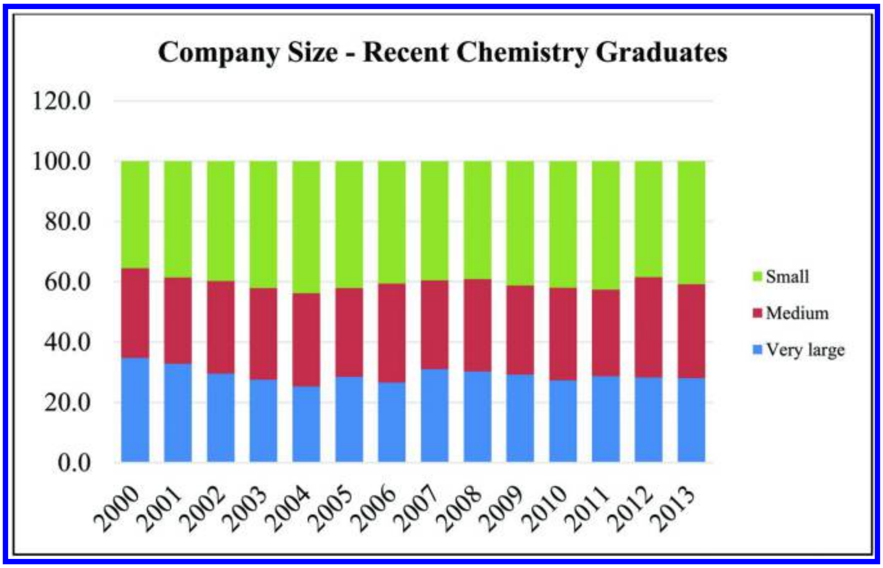

Figure 10. ACS-NGS (2) employer size as reported by recent chemistry graduates.

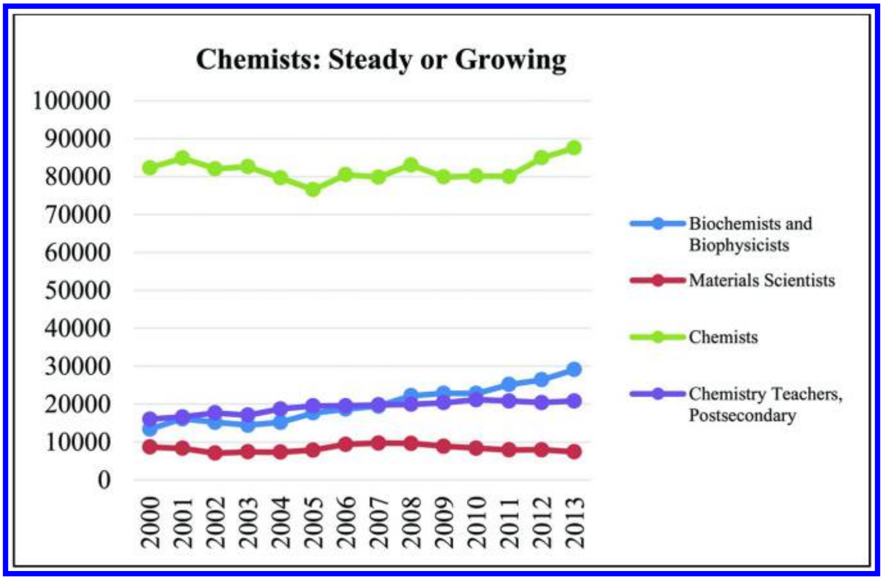

Figure 11. BLS-OES (3) chemistry-related disciplines: steady or growing employment.

According to *BLS-OES* (*3*) unemployment data, unemployment percentages are the highest for BS or BA chemists, and are lower for M.S. and Ph.D. chemists. Potential reasons for this include a shift of support staff moving to low cost countries and a concurrent decline in chemical manufacturing. Comparison of

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employment among degreed chemists versus those in chemistry-related fields further highlights this trend. In addition to the disciplines detailed above, information on employment for chemistry teachers, chemical technicians, chemical plant and system operators, and chemical equipment operators was analyzed as seen below (see Figures 11 and 12). The data are very consistent with previous observations: lower degreed positions are in decline.

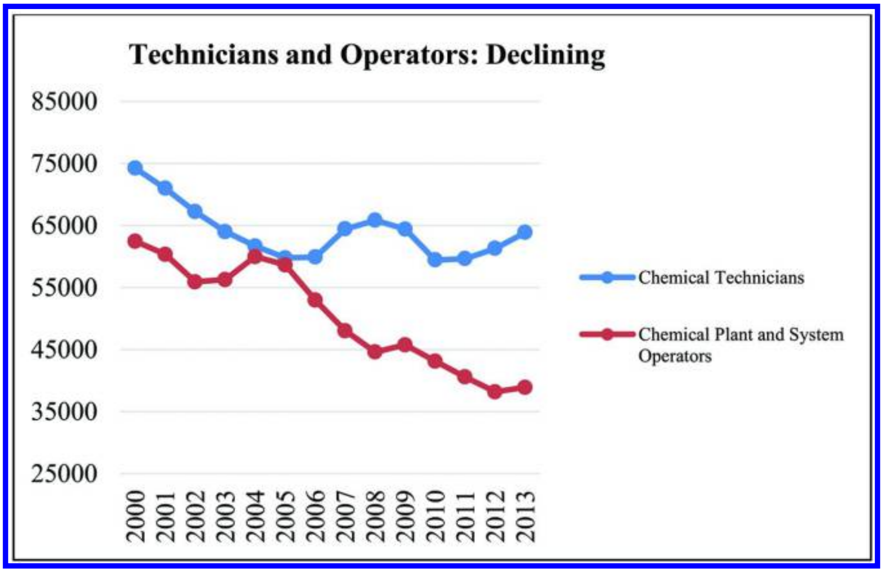

Figure 12. BLS-OES (3) chemistry-related disciplines: declining employment.

The ACS data for unemployment is evaluated for both new chemistry graduates ACS-NGS (*2*) and a broad sampling of ACS chemists ACS-SS (*18*) ACS chemist unemployment correlates to the *BLS-OES* (*3*) unemployment data; however, new graduate unemployment is substantially higher (see Figure 13).

Stability of Chemistry Employment

Evaluation of the employment data utilizing the principles of SPC was performed. The percent growth (year over year) of chemistry graduates was evaluated. I-MR charts were utilized to assess the stability of employment (see Figure 14). In our first example below, year over year growth of employment of chemists is a stable process (no violations noted) with a mean year over year employment change of +0.65%.

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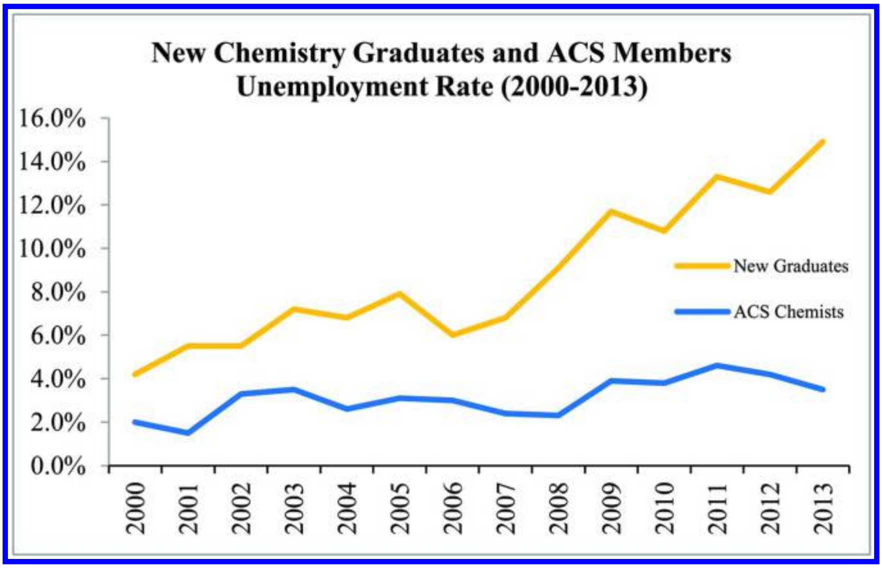

Figure 13. ACS-NGS (2) and ACS-SS (18) chemist unemployment rates.

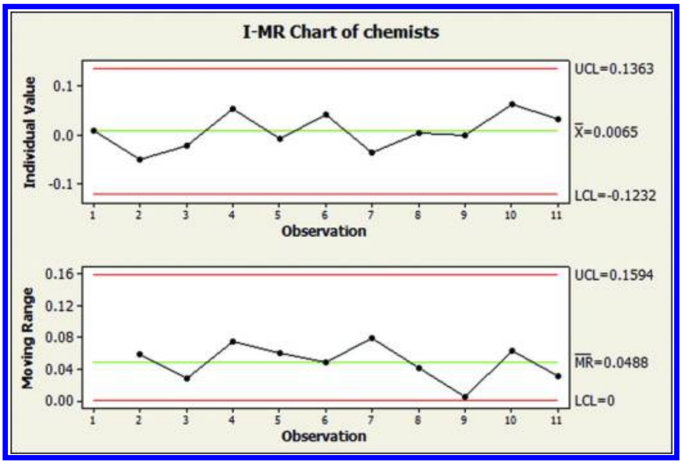

Figure 14. I-MR for chemist employment.

The SPC evaluation of the chemistry related fields showed that year over year employment in these areas is also stable; however, for the areas of 'chemical technicians' and 'chemical plant and system operators' the growth rate is stable and negative at -1% and -3%, respectively (see Figure 15).

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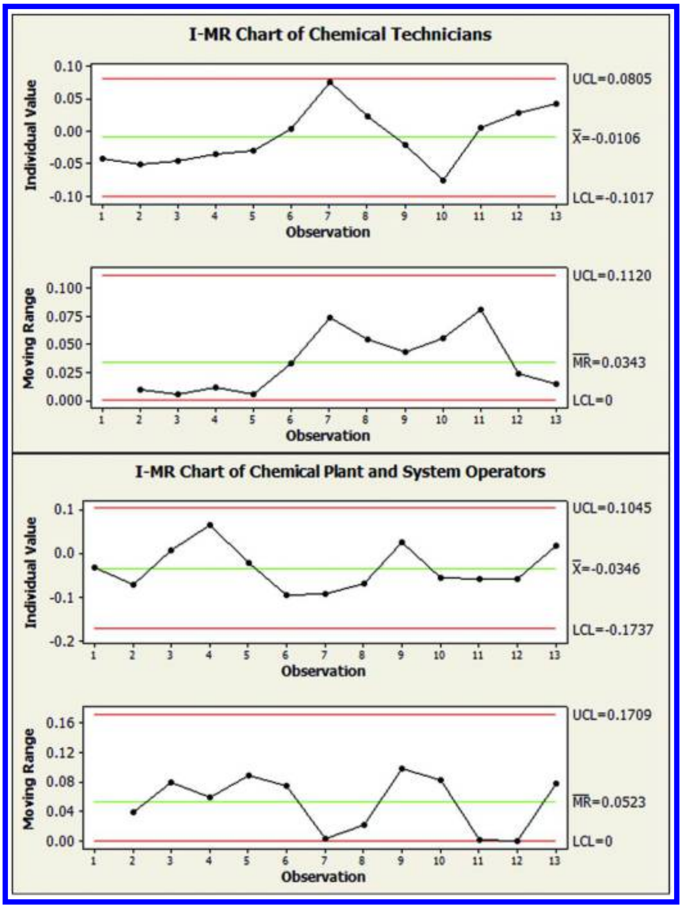

Figure 15. I-MR for chemical manufacturing employment.

Salary

Salary is often used as an indicator of employee shortages. According to the Hard Times Report (*20*), salaries for chemists are higher than the US average for both BS and PhD educated workers. Despite these higher wages, the ACS-NGS (*2*) indicates that the starting salaries for chemists at all education levels have been stagnant or declining for the past 10 years (see Figure 16).

Over the past three years, salaries for newly employed chemists have declined for bachelor's degree holders, increased for master's degree holders and declined for PhD degree holders according to ACS-NGS (*2*) data (See Figure 17).

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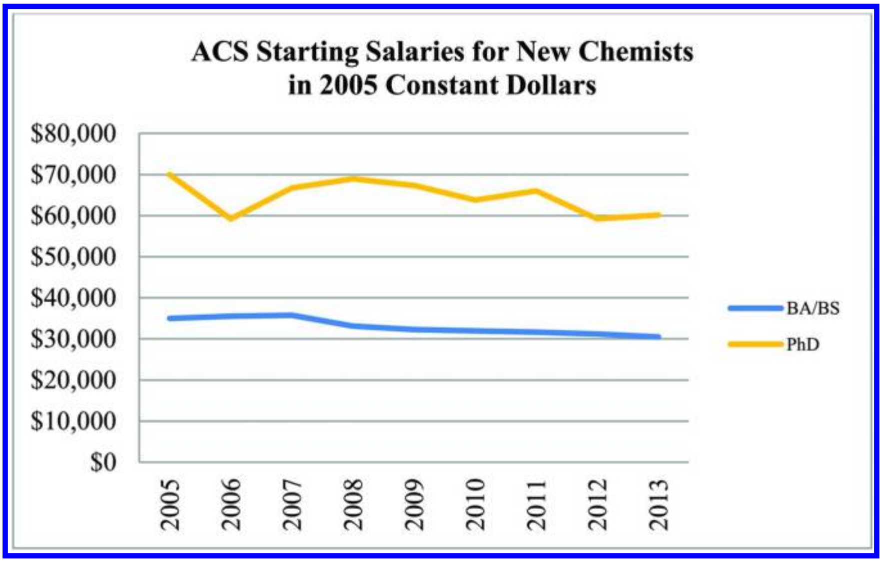

Figure 16. ACS salary data 2005-2013 by degree.

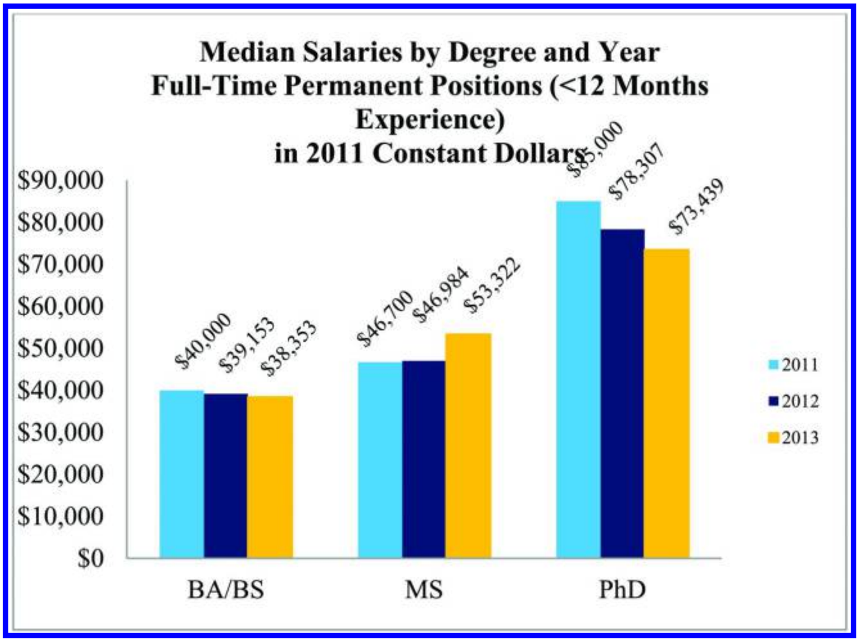

Figure 17. ACS-NGS (2) 2011-2013 by degree.

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Demand of Chemists Overview

Employment of chemists has remained steady over the last decade; however the employment landscape is shifting. Most notably, a shift away from basic manufacturing towards scientific research and development services has been occurring. While unemployment of chemists has risen overall since 2000, graduates with majors in chemistry still have one of the lowest unemployment rates in comparison to all college majors. Unemployment rates are highest for bachelor's degree chemists, most notably for recent graduates. This is evidence of a shifting employment landscape for bachelor's degree chemists.

Starting salaries for chemists remain higher than non-STEM salaries; however, over time the growth rate in starting salaries has not matched the rate of inflation and in some cases (bachelors and PhD's) a negative growth rate was observed. This indicates that the demand for chemists is not high enough to drive an increase in starting salaries.

Conclusions

Based on our evaluation of the *BLS-OES* (*3*), *NSF-SEI* (*17*), *ACS-NGS* (*2*), *ACS-CPT* (*19*), *Hard Times Report* (*20*), and *Bayer Report* (*4*) data, there appears to be a surplus of bachelor's degree chemists. The Task Force on the Supply and Demand of Chemists in the United States is providing the following recommendations for ACS leaders, volunteers and staff:

1. ACS should continue to support members at all career levels with services to obtain, inform, maintain, and grow their careers including:

    - ACS Career Services: Tools to help chemists find jobs.
    - ACS Professional Education: Training courses to refresh chemists' skills
    - ACS Leadership Development: Courses and workshops to develop leadership skills
    - ACS Market Intelligence: Salary and trends in chemistry and related fields

    Member support in these areas will provide members with skills that are desired in the upwardly trending chemistry fields. Additionally, these skills are transferable to alternative career pathways both within and outside the chemical enterprise.
2. The Committee on Economic and Professional Affairs (CEPA) should continue monitoring chemical employment data and trends, evaluate key trending parameters and continuously follow these parameters to highlight current and future trends. CEPA should inform ACS leaders, volunteers, staff and members of these trends.
    Monitoring and evaluation of employment data and trending will allow for trend specific targeting of ACS Career Navigator, ACS Career Pathways and future ACS Career programs, products and services.

3. Questions to assess the skills desired by employers and those held by new graduates should be added to the ChemCensus to assist ACS in establishing programs, products, and services to address these deficiencies.

   ChemCensus questions specific to employer desired skills and expectations as well as new graduate perceptions of skill importance may provide additional insight when making decisions about establishing programs, products and services.

In conclusion, the increased supply of bachelor's degree chemists has not been met with an adequate increase in demand. The chemical employment landscape is shifting and starting salaries are declining. The focus of ACS leaders, volunteers and staff should be on the alignment of skills with employment needs and an increased vigilance to remain at the forefront of chemical employment and economic trending. Finally, as ACS leadership evaluates its career programs, products and services, these trends should be kept in mind and should guide the decision making processes.

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Chapter 3

Mothers Who Are Chemists in American Academe: Resources To Support Academic Parents in Chemistry

Kimberly A. Woznack*

Associate Professor, Department of Chemistry & Physics, California University of Pennsylvania, 250 University Avenue, California, Pennsylvania 15419
***E-mail: Woznack@calu.edu.**

In this chapter, the author investigates the unique challenges and rewards available to chemists in academia. The author considers individuals who identify as professors, chemists, women, or parents, and the different roles that exist at the intersections of these identifiers. While there may be some unique challenges for each group, there is also substantial overlap in experiences of related individuals. The author then places a particular emphasis on women's experiences in chemistry, especially in academia. She discusses the challenges and opportunities of these various individuals, and provides comments and suggestions from the literature for those seeking to learn more about them. She also provides information on resources available and considers proposed solutions to the individuals in several categories who face particular challenges. The article is amply referenced with books and publications from the literature.

Introduction

This chapter investigates the unique challenges and rewards available to chemists in academia. In particular, I want to highlight some of the literature that would be helpful to various specific affinity groups at the intersection of gender, profession, parental status, and discipline. I felt it best to include a Venn diagram

(*1*) to help the reader follow the various groups described in the current literature (Figure 1). While there may be some unique challenges for each group, there is also substantial overlap in experiences of related individuals, so readers are encouraged to explore all of the literature.

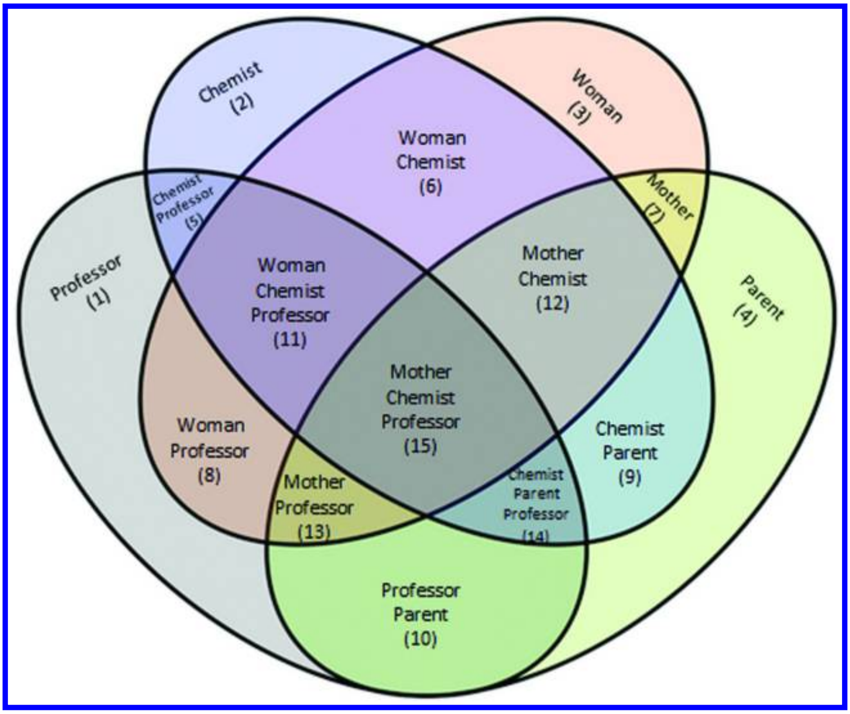

Figure 1. Venn diagram annotated with four different sets: Professor, Chemist, Woman and Parent (1).

In the Venn diagram in Figure 1, there are 15 different distinct areas or regions. Since one of the four categories chosen is the female gender (Region 3), then the other areas outside of this set contain people who are not identified as women. It could be suggested that those other regions are by default men or males. I choose not to label these regions as male to allow for inclusion of individuals who do not consider themselves part of a binary gender system but rather fall somewhere else on a gender continuum. One of the four sets chosen contains individuals who identify as parents (Region 4). This is also intended to be inclusive of all individuals identifying themselves as parents, including, but not limited to biological, adoptive, foster, step-parents, and others. It should be of note that there is no physical meaning or relationship to be drawn from the area of each numbered region; i.e., regions with larger geometric areas do not necessarily represent a larger number of individuals.

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This chapter places a large emphasis on women chemists. Why have I chosen to focus on women chemists? One reason is that I, myself, am a woman chemist. I consider myself an inorganic chemist, a chemical educator and, only more recently, an accidental gender studies scholar. The second reason for choosing this focus is that women are still underrepresented in many sciences, predominantly in the physical sciences, including chemistry. The National Science Foundation recently published data from the Survey of Doctoral Recipients from U.S. Universities (2013) (*2*). The results showed that the percentage of female doctorates in the physical sciences has climbed slowly, but steadily in the last two decades. In 1983, women earned 13.9% of the doctorates in physical sciences, while in 2013 women earned 29.1% of the doctorates in physical sciences. When the demographics of the 2013 earned doctorates in chemistry are examined more closely, women earned 39.6% of the chemistry doctorates. Diversity statistics on the American Chemical Society (ACS) website indicate that in 2010, the membership of the ACS was only 21.3% female (*3*).

Because the four main sets (Regions 1-4) are so broad, it is difficult to generalize the literature on each group. I have cited some professional societies that serve the populations in these broad areas. There are many professional societies supporting careers in the "Ivory Tower" (Region 1: the Professoriate) (*4*). Our very own American Chemical Society (ACS) exists to support chemists (Region 2) (*5*). There is an entire academic discipline devoted to Women's Studies (Region 3) (*6*) and exhaustive literature on parenting issues (Region 4). Region 5 contains individuals who identify as non-female (predominantly male) chemistry professors, without children. The impact children have on an individual's academic success will be described later in detail.

Women Chemists (Region 6)

There are several, wonderful history books which highlight the accomplishments of the first women in chemistry around the world. "European Women in Chemistry" (edited by Apotheker and Sarkadi), includes chapters highlighting women, such as Marie Lavoisier, Agnes Pockels, Gertrud Kornfield, Katharine Burr Blodgett, as well as Marie and Irene Curie (*7*). Other texts, such as "Women in Chemistry" and "Chemistry Was Their Life: Pioneering British Women Chemists, 1880-1949" both written by Marelene and Geoffrey Rayner-Canham (*8*, *9*) also highlight many female chemistry pioneers (not exclusively European).

Miss Jeannette Brown, organic chemist, scholar and ACS and Association of Women In Science (AWIS) Fellow, published her book, "African American Women Chemists" in 2012 (*10*). Her book includes detailed, meticulously-referenced biographies from many highly accomplished, pioneering, African American women chemists, including Dr. Marie Maynard Daly, the first African American woman to earn her Ph.D. in chemistry. Also included are the biographies of Dr. Johnnie Hines Watts Prothro, Dr. Esther A. H. Hopkins, and Dr. Reatha Clark King, to name a few. Miss Brown also includes the story of her personal experience as an African American woman chemist, as well as a fantastic timeline of the history of the women in the book.

I want to acknowledge the work of the ACS Women Chemists Committee, also known as WCC (*11*). The WCC mission is to be leaders in attracting, developing, promoting, and advocating for women in the chemical sciences, in order to make a positive impact on the profession and society. The WCC has several initiatives aimed at bolstering the professional development and recognition of female chemists at all career stages. At each ACS National Meeting, the WCC hosts programs to recognize the accomplishments of amazing women chemists and explore issues of interest to women chemists. While membership on this national committee is limited to appointed members and associate members, the programs run at national meetings and the award programs are open to all women chemists. In addition to this national ACS WCC, many ACS local sections also have local or regional WCC groups working to provide a support system for women chemists and encourage women pursue careers in chemistry.

I also want to mention that the ACS Division of Professional Relations (PROF) also has a subgroup for Women Chemists (*12*). All women chemists are invited to join this subgroup of the PROF. In addition, the WCC collaborates with PROF on many national meeting symposia of interest to women chemists.

Mothers, Especially Working Mothers (Region 7)

There has been extensive research and writing on the challenges faced by working mothers. I will mention only a few of these here. All working mothers, whether chemist/non-chemists, or faculty/non-faculty face challenges, in part because they more often do a larger percentage of the dependent care and housework.

In her book, “Opting Out?”, author Pamela Stone explores reasons why professional women are opting to quit their careers and stay home with their children (*13*). This is perhaps in response to a media-promoted myth that highly-educated, upper-middle class women in successful professional careers were choosing to stay at home because of a return to traditionalism. Stone conducted her research by interviewing 54 women who had interrupted their successful careers to stay at home with their children. Stone’s interviews were relatively unstructured, and aimed to determine what factors contributed to each individual woman’s decision to leave the workforce. Stone found that while the media spun high profile cases of successful women leaving as a result of their family life, most of the women she spoke with, in fact reported job-related factors as strong contributors to their decision to stay-at-home. I recommend this reading for working mothers in professional fields who may be considering leaving the workforce for any amount of time. In her final chapter, Stone includes policy recommendations related to work. I suggest this reading for managers who may be supervising working mothers.

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Accomplished economics journalist, Ann Crittenden, explores the undervalued role of mothers in her book, "The Price of Motherhood" (*14*). Crittenden challenges the social stereotypes that stay-at-home mothers are not "working," and rather are doing one of the most important jobs, which has the largest overall impact on human society. She goes about describing the various aspects to motherhood and the challenges all mothers face, as they appear through the eyes of a judgmental society. Crittenden's book is full of examples of how the current structures of professions are generally unfriendly to professionally employed parents, for both men and women. In the world described by Crittenden, paid-work environments are very unforgiving for parents who want to spend time with their children, and society has invented the fictitious "unproductive" housewife who stays home without completing any "productive" results.

It is worth mentioning that one field of study that could be considered a sub-discipline of Women's Studies is the research focused specifically on motherhood. The website for the Motherhood Initiative for Research & Community Involvement lists a huge array of publications focused on various aspects of motherhood (*15*).

Woman Professor (Region 8)

Most women employed in academia during the last two decades have Bernice Sandler to thank, even though they may not have ever heard her name or recognize her story to fight for equal rights for women in higher education (*16*). I am one of those women obtaining a tenure-track position at the rank of assistant professor who was unaware of the work of Bernice Sandler and other women who fought for a woman's right to join the professoriate. While I would not have considered myself a feminist fifteen years ago, hearing the "f-word" for me certainly conjured up a mental image of 1960's bra-burners. I was not the only female chemistry major at my institution, and I had one female chemistry professor join the department during my senior year. I graduated with my Bachelor of Science degree in the late 1990's and started looking at graduate schools. When I was looking at graduate schools, I encountered a female faculty member who had recently switched research institutions. She told me during my visit that no matter where I went to graduate school, I should never let anyone tell me that I could not complete my Ph.D. dissertation because I was a woman or let them give me the impression that women can not succeed in chemistry in graduate school. I was somewhat surprised at this warning, since my undergraduate studies seemed to go smoothly without detecting any directly overt bias or even any unconscious bias. It was through my experiences later as a faculty member, witnessing the very small number of women in the higher ranks of faculty and administration at many institutions, that I began to understand, or observe, the "leaky pipeline" and perhaps the impact of implicit unconscious bias and the difficult higher education policies for women and mothers who work in academe.

The text, "Career Strategies for Women in Academe: Arming Athena", provides an edited collection of contributions useful to those about to embark on

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an academic career or who are already in an academic career (*17*). As a post-doc and aspiring academic, I made great use of this book. Of particular interest to me were the chapters, "Paying Athena: Statistics, Statutes, and Strategies" by Ellin Kofsky Scholnick, and "Money Matters: The Art of Negotiation for Women Faculty" by Suzanna Rose and Mona J. Danner (*18*, *19*). One contribution, "Come and Be Black for Me" highlights the added challenges associated with the intersection of race and gender. Author Ethel Morgan Smith describes, with both honesty and humor, a typical day in the life of a female African-American faculty member and the plague of invitations she receives from white colleagues each February for Black History Month events (*20*).

A book that I discovered early in my career as an assistant professor was, "The Family Track: Keeping Your Faculties while You Mentor, Nurture, Teach and Serve" (*21*). This text, edited by Constance Coiner and Diana Hume George includes a vast number of contributions from faculty members at various stages in their careers, both male and female. The contributions are overwhelmingly personal and include diverse contributions from people at various career stages and at various family stages. The work includes chapters from single mothers, a father who is the primary caregiver, adoptive parents, and faculty members caring for elderly family members, and same-sex couples raising children, to name a few. The stories are often very emotional and it is easy to empathize with the authors as you read their very personal accounts of the struggles they have to overcome. While some of the contributions in this text are clearly from mothers, this text doesn't focus solely on mothers.

Chemist Parent (Region 9)

Region 9 in the Venn diagram corresponds to non-female, non-academic, parents. The vast majority of these subjects will identify themselves as chemists and fathers who work outside of academe, perhaps in industry, government or non-profit. To my knowledge there has not been research on this specific demographic.

Professor Parent (Region 10)

Region 10 in the Venn diagram corresponds to non-female, non-chemist professors who are parents. The vast majority of these will identify as fathers who are professors. Faculty fathers are highly represented and have historically been highly successful in a traditional academic setting. Just like mothers, fathers who are academics can also feel the stress of achieving the elusive work-life balance, especially when they may have a partner working full-time out of the home. "Papa, Ph.D.: Essays on Fatherhood by Men in the Academy" contains a diverse collection of contributed personal accounts from fathers who are professors (*22*). Published in 2010, this collection complements the previously published "Mama Ph.D.: Women Write About Motherhood and Academic Life" (*23*).

Woman Chemist Professor (Not Necessarily a Parent) (Region 11)

It is important here to include a description of the ACS Symposium Series Book 929, "Are Women Achieving Equity in Chemistry?" edited by Cecilia Marzabadi, Valerie Kuck, Susan Nolan and Janine Buckner (*24*). This book grew out of an ACS symposium held at the 226th National meeting in New York City during the fall of 2003. While the title does not mention the specific focus on academics, the book aims to explore the reasons behind the lack of female representation among chemistry faculty members. The text includes contributions from both chemists and social scientists working to determine what factors play a role in why Ph.D. granting institutions typically have fewer than 15% female chemistry faculty members. This text is a must read for women who are already in academic careers, or chemistry faculty who serve on hiring/search committees. I believe it is important for women chemists (perhaps as part of the work of the ACS-WCC) to continue to monitor the status of women in both academe and industry. Because this Symposium occurred in 2003, it would be great to see if the percentages of women have increased since that time, and perhaps I am suggesting that WCC do a follow-up symposium for the 15 year anniversary of this previous symposium in approximately 2018.

Mother Chemist (Non-academic) (Region 12)

While not focused specifically on the discipline of chemistry, "Motherhood, the Elephant in the Laboratory" contains a collection of contributed stories (edited by Emily Monosson) of scientists who are also mothers (*25*). The editor has grouped and ordered them chronologically (by decade) so that the reader might look for differences in experiences of those women who were obtaining their PhDs during the 1970s and graduates of more recent decades.

Mother Professor (Non-chemistry) (Region 13)

Mentioned previously, "Mama, Ph.D." describes the experiences of several mothers who are professors, while not necessarily the field of chemistry.

In this section I would like to enthusiastically describe the work of Dr. Mary Ann Mason from the University of California- Berkeley School of Law. Mason and her co-workers have been doing research on family structures and the career success of women for over a decade (*26*). In their book, "Mothers on the Fast Track: How a New Generation Can Balance Family and Careers", Mary Ann Mason and her daughter, Eve Mason Eckman, focus on what they classify as "Fast Track" careers: doctors, lawyers, professors, and executives in business and media (*27*). The book is divided into chronological chapters of career stages, "student years", "make-or-break" years, and the period "beyond the glass ceiling". While the book includes many different "fast track" careers, a large percentage of their discussion is specific to higher education faculty and I felt this was important to include here. In the section called, "The Door Not Opened: The Physical Sciences", the authors describe the persisting stereotype that women are

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somehow less able to achieve in mathematics and the sciences. They describe the stereotypical, unequal belief that mothers cannot be "serious scientists" because their research should be all consuming. The authors point out that this unfounded stereotype actually conflicts with the data that nearly 50% of male scientists become fathers after two years, while only 30% of women had children in the same time period. The authors describe the issue of the tenure decision being a "make-or-break" career event, and that many women have postponed having children, so as to avoid the risk of being taken less seriously. This make-or-break career chronology corresponds to a peak in women's child-bearing years. The authors provide data from the University of California system on the percentage of faculty members having a biological child, broken down by age and gender. The chart shows quite clearly that women have the most children in the 38-40 year age group, while men tend to have children earlier and continue to have them at later ages in their lives. The authors describe how many mothers end up transitioning from a "Fast Track" to a "Second Tier". The "Second Tier" for academics includes part-time and adjunct faculty members, among whom women are NOT underrepresented, but typically overrepresented. After a discussion on the very limited representation of women among the leaders in "Fast Track" careers (academic administrators) the authors wrap up with recommendations (for all career stages) on how to improve the system or transform the culture to better the workplace for both mothers and fathers in the "Fast Track."

The 2013 book by Mason and her co-workers, "Do Babies Matter? Gender and Family in the Ivory Tower" is focused exclusively on parenthood and academics (*28*). This research for this book was conducted for over a decade in the University of California system. Mason includes data showing that faculty careers are perceived to be unfriendly to family life among 70% of female graduate students and over 50% of male graduate students. Interestingly, the reasons men and women report for not having a child appear very different. While men report their level of income or their partner's lack of interest as reasons for not having a child, women more frequently reported the high demands on their time, and worries about their work being taken less seriously. Mason and co-workers describe the difficulty of transitioning from either graduate school or a post-doc into tenure-track positions, for academic couples or for women who already have children and outdated stereotypes about her perceived lack of commitment to the profession. The authors report that women in the sciences with preschool children are 27% less likely to get tenure compared to a man with a small child. The same woman without a child is still 11% less likely than a male scientist. Women with small children are also 21% less likely than married, tenure-track men with young children to have their research supported by federal grants. Mason and her co-authors make recommendations about reforming or refining the tenure system instead of eliminating it. They suggest offering paid parental leave for both female and male parents, as well as the ability for the parent to stop the tenure clock. Faculty members (both male and female) need to take advantage of these new policies to change the culture to be more accepting of reformed policies. Mason also suggests adding in more flexibility to academic positions, perhaps allowing for part-time work pre- or post-tenure with options to return to a full time position.

Chemist Parent Professor (Region 14)

The vast majority of the individuals in this category will identify themselves as chemistry professors who are fathers. To my knowledge no specific text has been devoted to this group of people. Men with children have been historically quite successful in the physical sciences in academe as we have seen in the previous section.

Mother Chemist Professor (Region 15)

My brother is a high-school English teacher. When I told him that I was writing a chapter for and co-editing a book, "Mom the Chemistry Professor" that focuses on the status of chemistry professors who are mothers, he admitted to me that he felt that was probably a very narrow audience on which to write (*29*). I have to agree that even in 2014, there are still not as many chemistry professors who are women as there are chemistry professors who are men. There are also not as many chemistry professors who are mothers as there are chemistry professors who are fathers. While the audience for this manuscript may be small, the fellow editors and I felt the message to women chemists who are undergraduates, graduate students, and post-docs was important. There are women who are currently enjoying successful careers as chemistry professors and who are also mothers enjoying successful parenting. The co-editors and I are pleased to share that we are already working on a second edition of "Mom the Chemistry Professor". In our second edition, one of our goals is to include more contributions from women of increasingly diverse backgrounds, so as to inspire young women from all backgrounds themselves into careers in academia. The first edition of the book contains chapters from sixteen mothers who were courageous enough to share their stories of both the challenges they encountered (hostile workplace reactions upon sharing news of their pregnancy, miscarriages, taking leave to have a child without any "maternity leave", balancing their own career with that of their spouse, divorce and single-parenting) as well as their successes (raising amazing children, earning their Ph.D., obtaining tenure, obtaining promotion, changing institutions, serving as department chair or as an administrator). The contributions in the book emphasize that the path to becoming a mother and chemistry professor may not be considered an easy or straightforward path, but all of the contributing authors indicate this is a path that, for them, has been an absolutely delightful combination.

Acknowledgments

I would like to thank Dr. Marinda Li Wu for inviting me to contribute this work to this ACS Symposium Series book. It has been a pleasure working with her and assisting with the programming for the Women Leaders of the Global Chemistry Enterprise symposium at the Fall 2014 San Francisco National Meeting. I would also like to thank the leadership of the Women Chemists Committee (especially Amber Charlebois) for their support and encouragement as I volunteer for ACS. I would like to thank the co-editors of "Mom the Chemistry

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Professor", Renée Cole, Cecilia Marzabadi and Gail Webster for their wonderful collaboration. Last and certainly not least, I need to thank my husband and family for their support that enables my own success as both a mother and a chemistry professor.

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Chapter 4

How Does ACS Promote International Experience and Global Mobility?

Bradley D. Miller*

Office of International Activities, American Chemical Society, 1155 16th Street NW, Othmer Building Room 1119, Washington, D.C. 20036, U.S.A.
***E-mail: b_miller@acs.org.**

With the rise of the internet and ease of access through mobile technology, globalization is occurring at a rate faster than ever before. Employers are increasingly recognizing international experience as added value in job candidates, and many now believe that studying abroad is essential to the education experience. Recognizing the impact a this experience can have on a student's life, the American Chemical Society has developed relevant programs and activities that promote international experience and global mobility. Two programs are highlighted in this work: International Research Experience for Undergraduates programs (IREU) and ACS International Center™. The ACS International Center (www.acs.org/ic) features listings on more than 350 scientific collaboration and research opportunities from over 100 different funding organizations in 15 different regions worldwide, surpassing any other such database of opportunities in chemistry. Anyone interested can easily search for these opportunities on the International Center website. The ACS IREU program provides talented chemistry and material science students with a cross-cultural experience at the best research laboratories abroad. Reciprocally, it gives international students the opportunity to study at domestic REU sites at U.S. universities. Both programs facilitate global networking and catalyzes international collaborations.

Introduction

Maintaining an international presence and cooperating with scientists around the world is important to ACS. ACS has 25,000 members in over 100 countries, with approximately 200 programs and projects having an international component and 4,500 yearly international attendees to ACS meetings. ACS Publications also have a heavy international presence, with 67% of articles written by international researchers and 4,700 worldwide organizational *Chemical and Engineering News (C&EN)* subscribers. Furthermore, 65% of the content in the Chemical Abstract Service (CAS) is from an international origin, and over 70% of the patent applications ACS receives come from Asia.

In view of the importance of international activities, ACS has organized many activities and programs that can help its members to acquire international experience (*1*). For example, for several years we funded a program called Global Research Experiences, Exchanges and Training (GREET), where several teams of students were sent to universities overseas to carry out research work (*2*). We currently provide Global Innovation Grants (GIG) (*3*), that often support international educational and exchange programs. We also organize many international meetings in collaboration with our sister chemical societies, such as Asian American Chemical Symposium (with Federation of Asian Chemical Societies), Chemical Sciences & Society Summit (with Royal Society of Chemistry, German Chemical Society, Japan Chemical Society, and Chinese Chemical Society), Transatlantic Frontiers of Chemistry (with German Chemical Society and Royal Society of Chemistry), and ACS Global Innovation Imperatives.

Two programs that are described in more detail in this article are the ACS International Center™ (*4*) and the ACS International Research Experience for Undergraduates (IREU) programs (*5*). Both of these programs are intended to facilitate educational and cross-cultural experiences at cooperating research laboratories abroad.

A Global Look at the International Experience

The role younger generations play in driving globalization is becoming larger every year. In 2011/12, more than 283,000 students studied abroad for academic credit. This is 3% more than the previous year (262,000) – and an all-time high (Figure 1).

The majority of these students are studying at the undergraduate level, a little over an eighth are studying at the graduate level, and about 1% are studying at the doctoral level. The majority of these students are studying social sciences while abroad. Only 9% are studying physical or life sciences and just 4% are studying engineering (Figure 2).

The most popular study abroad destinations for U.S. students are the U.K., Italy, Spain, France, China, Germany, Australia, Ireland, Costa Rica, and Japan – in that order (Figure 3).

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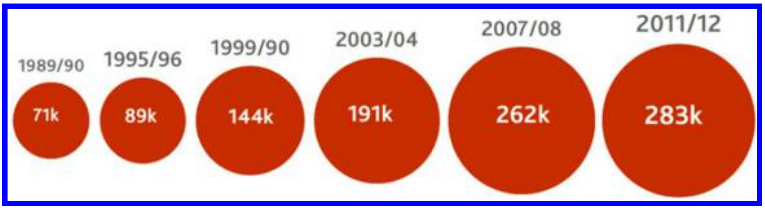

Figure 1. Number students studying abroad by academic year. Figure provided by the Institute of International Education. (2014) Open Doors Report on International Educational Exchange. Retrieved from http://www.iie.org/opendoors. (Reprinted with permission.)

Despite the increasing number of U.S. students studying abroad, an even larger amount of foreign students are coming to the U.S. to study. For instance, consider Germany and China. Of the 283,332 U.S. students who studied abroad in 2011-12, 9,370 went to Germany. Conversely, a total of 9,819 students came from Germany to study in the U.S. during the same time period (Figure 4).

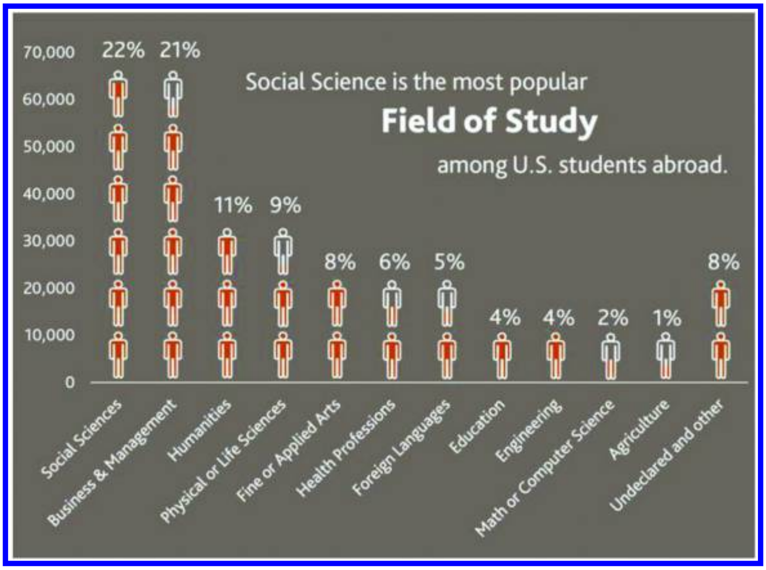

Figure 2. Number of students studying abroad by field of study. Figure provided by the Institute of International Education. (2014) Open Doors Report on International Educational Exchange. Retrieved from http://www.iie.org/opendoors. (Reprinted with permission.)

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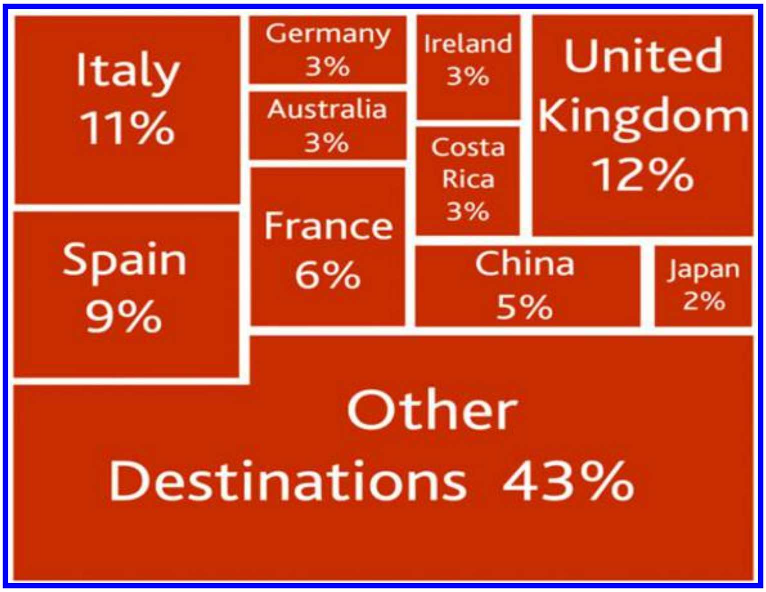

Figure 3. Leading destinations of U.S. study abroad students. Figure provided by the Institute of International Education. (2014) Open Doors Report on International Educational Exchange. Retrieved from http://www.iie.org/opendoors. (Reprinted with permission.)

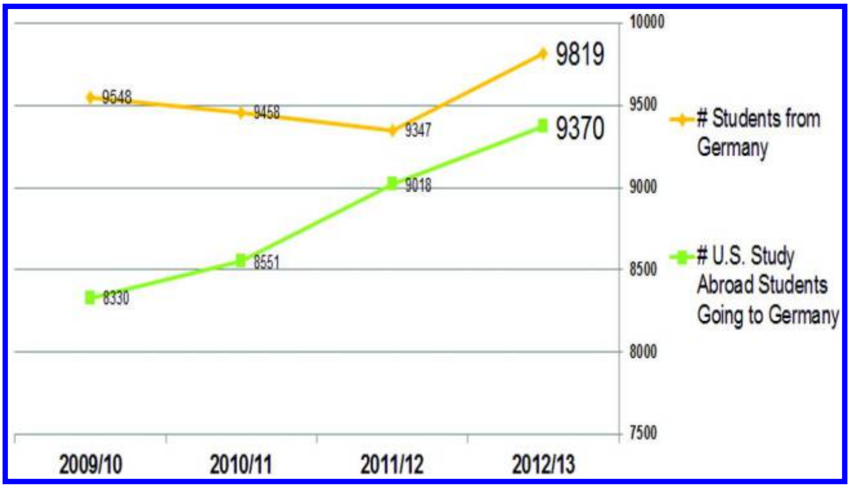

Figure 4. Number of American and German students studying abroad in the other's country from 2009-2013. Graph provided by the Institute of International Education. (2013) Open Doors Report on International Educational Exchange. Retrieved from http://www.iie.org/opendoors. (Reprinted with permission.)

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Of the 283,332 U.S. students who studied abroad in 2011-12, 34,000 went to China. Conversely, a total of 235,597 students came from China to study in the U.S. during the same time period – that's over 80% of the total number of U.S. students who studied abroad (Figure 5).

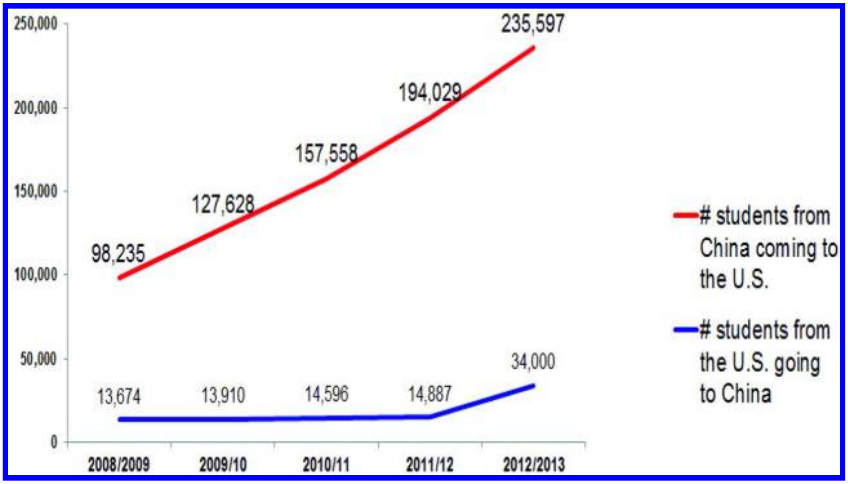

Figure 5. Number of American and Chinese students studying abroad in the other's country from 2009-2013. Graph provided by the Institute of International Education. (2013) Open Doors Report on International Educational Exchange. Retrieved from http://www.iie.org/opendoors. (Reprinted with permission.)

Value of International Experience

With the rise of the internet and ease of access through mobile technology, globalization is occurring at a rate faster than ever before. Employers are increasingly recognizing international experience as added value in job candidates. Many now believe that studying abroad, learning a foreign language, and learning about other cultures is essential to the education experience. Most people believe that in a global marketplace, spending time abroad and studying in another culture can lead to much personal and professional success (*6*).

In addition, international collaboration can boost the profile of the science for all researchers involved. In a recent article, the authors divided publication success into two categories: journal placement and citation performance. Analyzing all papers published between 1996 and 2012 in eight disciplines, they found those with more countries in their affiliations performed better in both categories. Furthermore, collaboration with certain countries provides more scientific impact than others (*7*).

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ACS International Research Experiences for Undergraduates - Overview

ACS recognizes the impact a study abroad experience can have on a student's life, which is why ACS has developed the International Research Experience for Undergraduates (IREU) programs (*5*). These programs provide talented chemistry and material science students with a cross-cultural experience at the best research labs abroad (Figure 6). Reciprocally, it gives international students the opportunity to study at domestic REU sites at U.S. universities. This nurtures the global networks of these programs and catalyzes future international collaborations. The programs are designed to attract and retain more underrepresented minorities in the sciences, and provide a global scientific experience to students at institutions with limited access to research.

Figure 6. Three U.S. ACS-IREU 2010 student scholars conducting chemistry research in laboratories in Glasgow, Scotland; Lyon, France; and Perugia, Italy and one German student conducting research in Irvine, CA. Photos courtesy of the ACS and were taken by the student participants (top-left clockwise): Markus Dörr, Julie Longo, Roselynn Cordero, and Erik Agueta.

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In the ACS IREU programs, students will develop their verbal and written communication skills while gaining a sense of respect and for, and understanding of other cultures. Students placed in international programs – and international students placed in domestic programs – will develop an international scientific perspective, while sharing their own experiences from home with their international peers. In doing so, students will integrate themselves within the global scientific community.

These experiences improve the participation, longevity, and career options of students in STEM fields. Since the program's inception, a number of alumni have reported that the experience was rewarding and gave them an increased appreciation for careers in materials research, as well as additional employment skills. By the numbers, three-quarters of IREU alumni reported that the experience influenced their career decisions, and nearly 4/5ths of alumni have gone onto graduate or professional school. Of the 138 ACS IREU alumni who graduated by June 2011, 15 of them co-authored publications resulting from their projects.

For the summer of 2014, 17 student, hailing from colleges all across the United States (Figure 7) were selected to conduct research in Germany, Italy, Singapore, or the U.K. through the program. They spent 10-12 weeks working on frontier chemical and materials science research project with a focus on sustainable energy, under the guidance of faculty members and graduate student mentors. They have all submitted the reports of their research to the ACS Office of International Activities (OIA). These reports were reviewed by members of ACS International Activities Committee (IAC), who provided guidance and suggestions. The students will give posters of their work at the ACS national meeting in Denver in March 2015. In addition, they will give a talk about their experiences at a symposium organized by OIA and sponsored by IAC at the Denver meeting.

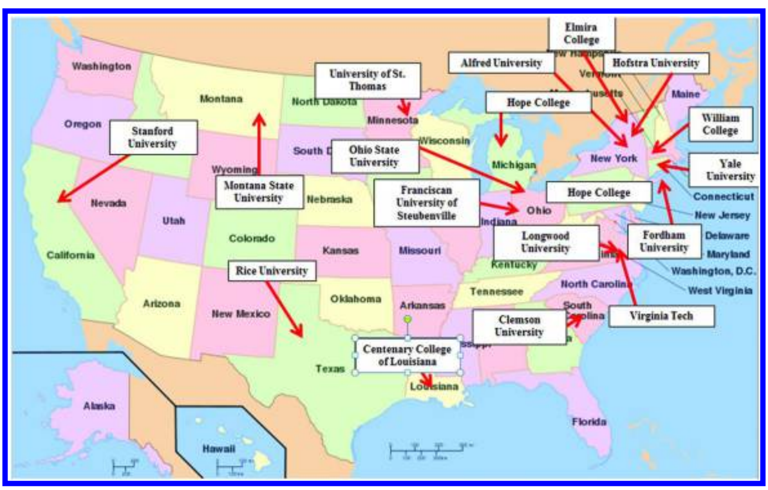

Figure 7. Institutions of the students selected for the 2014 IREU program. (Courtesy of the American Chemical Society.)

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ACS International Center

The ACS International Center™ is a great resource for students interested in global mobility and international experience (*4*). It features listings on more than 350 scientific collaboration and research opportunities from over 100 different funding organizations in 15 different regions worldwide (Figure 8), as well as other global opportunities. Experience levels for these programs are high school, undergraduate, graduate, postdoctoral, professional, senior, and faculty/academic. The twitter handle, @ACS_IC (*8*), provides up-to-the-minute information on upcoming application deadlines and new program announcements. The center also has live webinars and archived presentations from international organizations with information on how and where to apply. The center's forums provide opportunities to discuss issues in international mobility and program specifics with ACS experts. In addition, one can receive news updates on international programs, events, and resources by signing up for the the monthly ACS International Center newsletter.

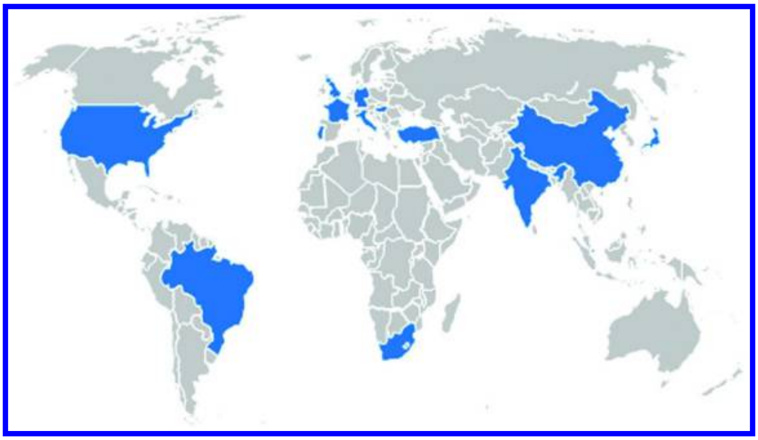

Figure 8. Regions where ACS offers programs include Turkey, The Netherlands, U.S., UK, Brazil, China, India, Singapore, South Africa, Japan, Hungary, France, Italy, Germany, and Portugal. (Courtesy of the American Chemical Society.)

The concept of the ACS International Center was created by Dr. Joseph Francisco, Past President of ACS. The site went live on December 31, 2012, and now houses over 600 unique opportunities, hand-collected and curated, surpassing any other such database of opportunities in chemistry. The website receives an average of over 3,000-4,000 unique visitors per month, a number which continues to grow with each passing month. The growth of the website is owed in large part to contributions from ACS International Center.

The ACS International Center is affiliated with 24 different embassies, institutions and international organizations who have joined hands with ACS to promote these international exchange opportunities to those seeking to gain an intellectual experience abroad. These include: The American Friends of the Alexander von Humboldt Foundation, German Academic Exchange Service (DAAD), Sao Paulo Research Foundation (FAPESP), Centre National de la Recherche Scientifique, Fulbright New Zealand, NL Agency, EURAXESS, German Research Foundation (DFG), French National Institute of Health and Medical Research (Inserm), The German Center for Research & Innovation (GCRI), Japan Society for the Promotion of Science (JSPS), Embassy of the Republic of Singapore, The Luso-American Development Foundation, Boren Awards, Japan Science & Technology Agency (JST), ConRuhr U.S.A., The Council for International Exchange of Scholars (CIES), Contact Singapore, Embassy of France in the U.S., China Environment Forum, United States-India Educational Foundation (USIEF), Inter-American Foundation, American Association of University Women, and the Global Language Network.

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The Transnational Practice of Chemistry and Allied Sciences and Engineering: Study, Research, and Careers without Borders

ACS will be holding a national meeting on March 22-25, 2015 in Denver, Colorado. In view of the current trends, 2015 ACS President Dr. Diane Schmidt will collaborate with the International Activities Committee and Office of International Activities to organize a symposium on "Transnational Practice of Chemistry and Allied Sciences and Engineering: Study, Research and Careers without Borders." This symposium will feature experts from industry, academe, and government labs who will provide perspectives on the "global-readiness" of STEM graduates in the U.S. and the world at large. The speakers are given below:

- Dr. Diane Schmidt (2015 ACS President)
- Dr. Judy Benham (Past Chair, ACS Board of Directors)
- Dr. Thomas M. Connelly, Jr. (Executive Vice President, Chief Innovation Officer, DuPont)
- Dr. Deva Hupaylo (Head, Industry Verification Branch, Organisation for the Prohibition of Chemical Weapons)
- Dr. Jay Steven Siegel (Dean, Tianjin University, School of Pharmaceutical Science and Technology)
- Dr. Luis Echegoyen (Professor of Chemistry, University of Texas at El Paso, Former Director, NSF Chemistry Division)
- Dr. Joe Francisco (Dean, Arts and Sciences, University of Nebraska)
- Ms. Angela Diaz (Washington Liaison for Education, Science, and Technology California Council for Science and Technology)
- Dr. H.N. Cheng (Chair, ACS International Activities Committee)

It is expected that the appropriate talks at this symposium will be converted into written manuscripts to be included in an ACS book in order to reach a wider audience.

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Chapter 5

ACS International Activities: Mechanisms To Advance Member-Serving Global Engagement

William F. Carroll*

Occidental Chemical Corp.,
5005 Lyndon B. Johnson Fwy, Suite 2200,
Dallas, Texas 75244-6100, U.S.A.
***E-mail: bill_carroll@oxy.org.**

In today's global environment, innovation requires international collaboration, ideation, implementation, and increased value creation. As the world is becoming more globalized, ACS has also increased the development of member-serving opportunities to facilitate networking, collaboration, and innovation endeavors. ACS is unique in that its global engagement is informed and driven by an explicit constitutional provision: "The SOCIETY shall cooperate with scientists internationally and shall be concerned with the worldwide application of chemistry to the needs of humanity" (Article II, Section 3, ACS Constitution). ACS is fostering global engagement for the benefit of its members through a number of programs and activities, including alliances and partnerships, ACS International Chapters, international collaborative conferences, global outreach activities, and leadership coordination efforts to address human rights issues.

Introduction - Chemistry in the Global Context

The world has changed with the increasing economic growth of many developing countries, the advent of new technologies, faster and cheaper information, increased competition, and rapidly evolving capacity. The chemistry enterprise is also changing by becoming more globalized and multidisciplinary, permitting greater mobility of people, money, products, and technology. As

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the information revolution facilitates increasing communication around the world, there are also increased opportunities for international collaboration and scientific exchange for global chemistry professionals. Thus, the global chemistry community is becoming more and more interactive.

Most countries in the world have active chemical and chemical-related industries, including pharmaceuticals, personal care, petroleum, polymers, and materials. As happens normally, many specialty chemical products can become commoditized in an increasingly competitive environment. To sustain growth, innovations and new products are needed for the future. Indeed, there are ongoing R&D in many companies as well as research activities in academia and government laboratories around the world. Some of the issues of interest to the chemistry community include jobs, careers, education, information management, and improved public perception of chemistry.

In its Strategic Plan, ACS has four strategic goals:

1) Provide information. Be the most authoritative, comprehensive, and indispensable provider of chemistry related information.
2) Advance member careers. Empower an inclusive community of members with networks, opportunities, resources, and skills to thrive in the *global* economy.
3) Improve education. Foster the development of the most innovative, relevant, and effective chemistry education in the *world*.
4) Communicate chemistry's value. Communicate the vital role of chemistry in addressing the *world*'s challenge to the public and policymakers.

Note that three of the above goals (*italicized*) have a global scope. In addition, the ACS Constitution has an explicit global provision: "The SOCIETY shall cooperate with scientists internationally and shall be concerned with the worldwide application of chemistry to the needs of humanity" (Article II, Section 3, ACS Constitution). Thus, it is not surprising that for many years ACS has been active in international activities. Moreover, ACS has redoubled its international efforts in recent years in order to take advantage of the global trends and to better serve its members (*1*).

ACS International Activities

Currently ACS has 25,000 members in over 100 countries, with approximately 200 programs having an international component, and 4,500 yearly international attendees to ACS meetings. ACS has also cosponsored seven Pacifichem Congresses since 1984. ACS Publications have a heavy international presence, with 67% of articles written by international researchers and 4,700 worldwide organizational *Chemical and Engineering News (C&EN)* subscribers. Furthermore, over 50% of the content in the Chemical Abstract Service (CAS) is from international origins.

ACS currently has five strategic alliances worldwide (Figure 1). These include the Chinese Chemical Society (CCS), the German Chemical Society (GDCh), the Federation of Asian Chemical Societies (FACS), the South African Chemical Institute (SACI), and the Federacion Latinoamericana de Asociones Quimicas (FLAQ) (*2*).

Figure 1. Regions of the world covered by ACS global strategic alliances (highlighted in blue). (Courtesy of the American Chemical Society.)

In addition, the ACS has cooperated and worked with many other international chemistry organizations, such as the Royal Society of Chemistry (RSC), the European Association for Chemical and Molecular Sciences (EuCheMS), and the International Union of Pure and Applied Chemistry (IUPAC). More generally, where there is mutual interest ACS looks forward to partner with scientific societies; regional, global, and intergovernmental organizations; nongovernmental organizations; and industrial associations.

International alliances and partnerships support the ACS Strategic Plan by engaging members and scientific professionals to advance the Society's mission and address many challenges facing the world, such as improved publicity for chemistry, support for chemistry education, and discussions involving clean water, air, energy, and food. Alliances are typically set up for three-year periods and are usually renewable if there is mutual interest. The ACS Board of Directors reviews the progress and performance of the Alliances on a quarterly basis and in regular meetings with the partners' leadership.

In addition, individual units within ACS (e.g., committees, technical divisions, and local sections) may enter into alliances with international organizations. Areas of interest may include opportunities to generate and exchange information; create place-based or virtual scientific and educational networks; collaborate on projects involving global challenges; coordinate outreach activities; and advocate for an improved public image of chemistry.

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ACS International Chapters

ACS International Chemical Sciences Chapters are strategic resources which support ACS global engagements and its members (*3*). ACS currently has international chapters in Hungary and Romania in Europe; Saudi Arabia in the Middle East; Hong Kong, Shanghai, Thailand, Malaysia, and South Korea in the Asia Pacific, and South Africa (Figure 2). For the ACS members in these locations, the International Chapters provide a means for them to socialize, exchange information, advance their careers, and gain recognition for their work. For ACS, the International Chapters are useful in gathering and catalyzing interactions among ACS members in various parts of the world. They provide member value and a forum for member engagement through local networking and collaboration. They serve as sources for ACS local ambassadors in promoting the Society's good will, activities, products and services. They provide a valuable link to connect ACS with its members in critical regions of the world and help those regions in their interactions within the global chemical enterprise. Overall, their role is to improve ACS's communication on global and grassroots levels, and collaborate with local chemical communities (or national chemical societies) on issues of mutual interest.

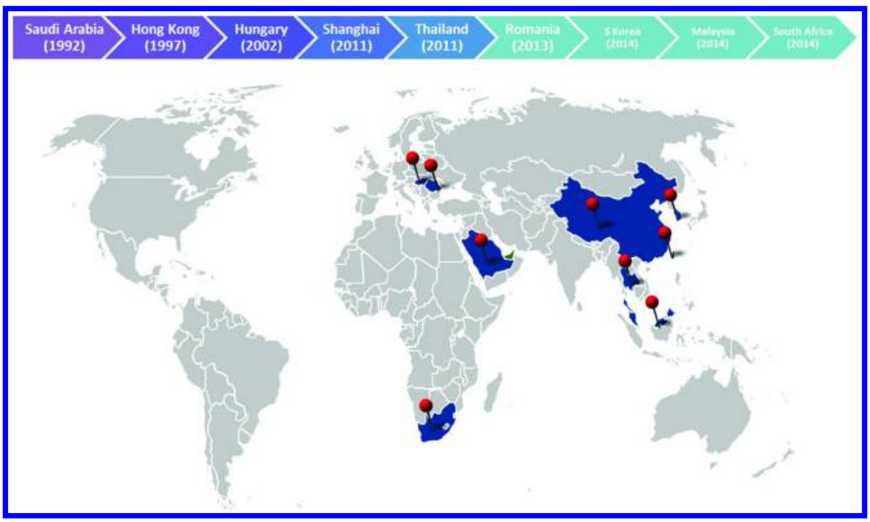

Figure 2. ACS International Chapter locations and dates of inception. (Courtesy of the American Chemical Society.)

ACS Bylaws permit the establishment of International Chapters, provided they meet the appropriate criteria. The proposed chapter needs to define its territory (normally not smaller than a state, province, or similar geographical unit). At least 25 ACS members living in the territory must sign the "Application

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for Chapter Status." Interim officers and a point of contact must be specified on the chapter application. Detailed plans for chapter activities, including a tentative schedule with activity locations, and a first-year budget, must also be specified on the application. In addition, while not required, all proposed chapters are encouraged to gain the approval of the relevant national chemical society before submitting. In addition to their previously defined roles, each chapter is responsible for submitting an annual report to the Office of International Activities.

International Collaborative Conferences

The international collaborative conferences represent an area of productive partnership between ACS and other international societies. Several examples may be mentioned here.

Asia America Chemical Symposium (A2CS)

This is a collaboration between ACS and Federation of Asian Chemical Societies (FACS). It started in 2011 and is ongoing on an annual basis. More detailed information can be obtained from the chapter written by Dr. Andy Hor.

Chemical Sciences and Society Summit (CS3)

This annual event brings together some of the most accomplished chemists and chemical engineers from around the globe and challenges them to propose meaningful approaches to solving society's most pressing needs. A theme is adopted every year, such as health, food, energy, materials, and the environment. The CS3 initiative is a collaboration between the ACS, the Chemical Society of Japan, the Chinese Chemical Society, the German Chemical Society, and the Royal Society of Chemistry. The symposia are supported by the German Research Foundation, the Japan Society for the Promotion of Science, the National Science Foundation of China, the U.K. Engineering and Physical Sciences Research Council, and the U.S. National Science Foundation.

ACS Global Innovation Imperatives (Gii)

This is an ACS program that was originally started and implemented in collaboration with the U.K.-based Society of Chemical Industry. Now administered exclusively by the ACS, the Gii program fosters creative solutions to imperative global issues (e.g., clean water, food, and health). Gii's goal is to promote action among ACS members, which include innovation leaders, multinational businesses and business executives, leaders in academia, government, and non-government organizations. For example, in December 2014 a Gii meeting was held in Singapore as a collaboration between ACS and Singapore National Institute of Chemistry, with the theme of "Water Innovation Treatment & Solutions 2014."

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Global Outreach and Educational Activities

ACS is also involved with a number of outreach and educational activities in different parts of the world. For example, ACS is working with Pittcon to send early-career scientists to attend the Pittcon meeting; this program is described in detail in the chapter written by Richard Danchik. Two worthwhile programs are the ACS International Center™ and International Research Experience for Undergraduates (IREU), both of which are separately described by Brad Miller in his chapter. Two other successful programs are described below.

BOOST Program

With $198K in support from the U.S. Department of State, in February 2013 ACS International Activities conducted eight in-country, soft-skill workshops for young scientists, engineers, and technologists in Indonesia and Malaysia as part of the Building Opportunity Out of Science and Technology (BOOST) program. Over 700 young Malaysian and Indonesian Science, Technology, Engineering, and Math (STEM) scientists participated in these workshops. Participants were invited to apply for travel awards to attend a subsequent Trainer Leadership Institute in August 2013 in Thailand. ACS representatives worked with these individuals to tailor the workshops to their own local contexts, thereby ensuring that Malaysian and Indonesian citizens can continue these workshops for young STEM talent even after the conclusion of ACS visits. Most of the 32 trainers have now completed their training events throughout Indonesia and Malaysia.

Festival de Quimica

Under the ACS Festival de Quimica program, 11 educational outreach events were organized in Colombia, Chile, and Puerto Rico in 2013 to encourage and engage middle and high school students and other enthusiasts in chemistry through activities geared toward the impact of chemistry in their local communities. The events drew nearly 800 students volunteering and performing chemistry activities in their local communities and more than 14,000 participants overall.

In 2014, ACS organized 2 festivals, one during the Chinese Chemical Society meeting in Beijing in August 4-7 and the other during the Congreso Latinoamericano de Química in Lima, Peru in October 14-17. For the festival in Beijing, Hong Kong and Shanghai International Chapters sent representatives to the training so they could organize additional festivals at the Hong Kong and Shanghai locations having the Chapters leading the effort. During the festival in Lima, Peru, for the first time one organizer from Colombia, Ms. Carolina Lizarazo Castillo, helped to lead the volunteer training. In addition, local organizers from Puerto Rico, Chile and Colombia continued to host trainings and Festivals during 2014.

Science and Human Rights

The ACS has a history of coordinating leadership and working internationally on cases where the rights and welfare of professionally engaged chemists, chemical engineers and chemically related practitioners are threatened. These efforts are informed by protections afforded by the Universal Declaration of Human Rights and directed towards human rights, scientific mobility abridgments and issues where ACS is uniquely positioned and qualified to impact cases in a meaningful way (*4*). ACS also offers quarterly webinars on science and human rights. This issue is also featured regularly in the on-line *ACS International News* (*5*).

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Chapter 6

International Year of Chemistry: Our Celebration

Bryan R. Henry*

University Professor Emeritus, Department of Chemistry, University of Guelph, Guelph Ontario, Canada N1G 4B5
***E-mail: chmhenry@uoguelph.ca.**

International Year of Chemistry (IYC) originated within the International Union of Pure and Applied Chemistry (IUPAC) but many organizations contributed to its success. In this short paper, I will summarize the events that led to IYC, describe the launch and give a brief overview of the myriad of activities. Finally I will try to analyze the legacy of this remarkable event.

Introduction

IYC 2011 was arguably one of the the most exciting and important achievements of IUPAC (The International Union of Pure and Applied Chemistry) that had occurred in many years. This paper is a very condensed version of an IUPAC task force entitled "Description and Analysis of IYC Activities (project # 2012-009-1-020). The members of the task force and a description of the project can be found at the URL in reference 1 (*1*). The final version of the full report was prepared by Julia Hasler, John Malin, and myself with the assistance of Fabienne Meyers (IUPAC Secretariat) and Chris Brouwer (PUBSimple) (*1*).

On a personal note, as President of IUPAC in 2006 and 2007, I have been associated with IYC from beginning to end. It was a tremendous privilege to watch the year unfold and to participate in this celebration.

Genesis of IYC

Since all known matter is composed of the chemical elements or of compounds made from those elements, humankind's understanding of the material nature of our world is grounded in our knowledge of chemistry. Indeed all living processes are controlled by chemical reactions. IUPAC and UNESCO strongly believed that it was time to celebrate the achievements of chemistry and its contributions to the well-being of humankind. The idea of holding a year of chemistry was first discussed in 2006, during the April meeting of the IUPAC Executive Committee. IUPAC Endorsement occurred in August 2007. In order to obtain an international year a motion must be passed on the floor of the UN General Assembly. IUPAC had no direct interactions with the UN and so we sought the help of UNESCO. UNESCO support for IYC was obtained in April 2008. They guided the motion through the UN. 24 Member States, led by Ethiopia, co-sponsored the proposal for the UN proclamation of 2011 as the International Year of Chemistry and it was passed in December 2008.

The objectives of the International Year were:

- Increase the public appreciation and understanding of chemistry in meeting world needs
- Encourage interest of young people in chemistry
- Generate enthusiasm for the creative future of chemistry
- Celebrate the role of women in chemistry. (2011 was the 100th anniversary of the award of the Nobel Prize in Chemistry to Marie Curie and of the founding of the International Association of Chemical Societies).

Launch Events

There were a number of IYC launch events. Some notable examples were:

United Kingdom

IYC activities were launched at the Houses of Parliament, with the Federation of African Societies of Chemistry. The President of the Federation of African Chemistry Societies, Professor Temechegn Engida spoke to dozens of parliamentarians, including UK Science Minister David Willetts.

Germany

A marvelous opening ceremony was organized by several chemistry organizations, including GDCh, on February 9th in Germany. The opening speech was given by Chancellor Dr. Angela Merkel.

Brazil

The opening event to celebrate the IYC in Brazil was held on March 23 at the Brazilian Academy of Science, Rio de Janeiro. It was attended by Brazilian government authorities in science and education, academics, representative associations, and the chemical industries.

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Australia

The IYC 2011 Launch was held at Parliament House, Canberra, in February, and was opened by the Minister for Innovation, Industry, Science and Research, the Hon. Senator Kim Carr. The chemistry and art subproject involved the periodic table and the engagement of school students. It's estimated that over 100,000 people saw the tables during 2011.

South Africa

The initiation of IYC was celebrated at the January Congress of the South African Chemical Institute and the Federation of African Societies of Chemistry.

The official opening ceremony took place under the aegis of the UN, UNESCO, and IUPAC from January 27 to 28, 2011 in Paris, France. Nicole Moreau, IUPAC President in 2010 and 2011, was instrumental in planning this event. The theme was "Chemistry and the UN Millennium Goals". The two-day event, which attracted 1100 participants, included an official opening by UNESCO Director General Irina Bokova.

Puerto Rico

There were two other Cornerstone Events organized by IUPAC. The IUPAC World Congress: "Chemistry Bridging Innovation among the Americas and the World" was held from Jul 30 to Aug 7, 2011 in San Juan

Belgium

The closing event was held on Dec 1, 2011 in Brussels. It was sponsored by the chemical and pharmaceutical industries. The event was opened with remarks by HRH Prince Phillipe of Belgium. The closing was forward looking. A group of young leaders gave their expectation of the world in 2050, and in particular the role chemical science would play in helping us to build a better world (*2*).

The IUPAC IYC website was designed and maintained largely through the efforts of Fabienne Meyers at the IUPAC Secretariat. It included more than 9000 contacts and provided a stream of information about IYC activities. Chemists from around the world were encouraged to list their plans and share their ideas. There were videos, instructional materials, and a plethora of chemical activities to interest students and the general public. During the year 2011, there were more than 400,000 unique visitors and 1.7 million page views.

Contributions from Chemical Societies and other Partners

Although IYC originated within IUPAC, many organizations contributed to its success. There were notable contributions from the United Nations and from regional chemistry organizations like FACS, FASC, FLAQ, and EuCheMS. Industry, NGOs, educational and research Institutions, and individuals also played important roles. However the key organizations that carried out IYC

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activities were the national chemical societies. They reached out to a variety of audiences, especially young people and the general public. The scope, originality and sheer number of activities are extremely impressive and impossible to summarize. The members of the task force solicited information from individual countries concerning their IYC activities. Over four megabytes of information was returned. The bulk of the IUPAC Task Force report on IYC is a summary of data the Task Force collected from the various countries (*1*).

Any statistical summary of the breadth and number of IYC activities is bound to underestimate what actually occurred. Some sense of the overwhelming success of IYC can be drawn from IYC website statistics published early in 2012. Over 1400 activities and 1000 special events in 100 countries were noted. Many activities never reached the website. This was particularly true in the United States where much of the activity took place in local ACS sections.

In this paper I have attempted to summarize a very small number of the IYC activities. In **Brazil** there was a massive response to IYC with very generous funding from the Brazilian government. A number of countries had design competitions aimed at young people. For example in **Bulgaria** there was a global chemistry stamp competition. The winner in the 12 to 14 age group was Vasilena Vasileva A reproduction of her very attractive stamp design can be found in our report (*1*).

A number of countries issued postage stamps in honor of IYC. In **Canada**, Canada Post released a stamp on October 3, 2011 in honour of IYC, featuring Nobel laureate John Polanyi and his contributions to chemistry. The stamp was unveiled at an event held at the University of Toronto. Canada had a wide range of activities celebrating IYC. Table 1 provides a summary of the events and the numbers reached.

Events were held for the general public in Helsinki, **Finland**, including a soap bubble competition. In **Lebanon,** in celebration of IYC2011, the Department of Chemistry at the American University of Beirut organized a seminar by Visiting Scholar Prof. Mostafa El-Sayed entitled: “Nanotechnology: Confinement of Material Size to the Nano-Scale; New Properties and Some Potential Applications in Material Science and in Cancer-Medicine.” In the **Philippines,** many IYC events were aimed at children, including an on the spot poster making contest. One of my favorite IYC quotes came from the Philippines. Roughly paraphrased, the quote stated: It is not expensive experiments that matter, it is the inculcation in the minds of the young of the love for science. That sentiment epitomizes what IYC tried to accomplish.

One of the most interesting IYC activities in **Kenya** involved Dr. Solomon Derese, a Lecturer at the University of Nairobi. During December 13 to 17, 2010, he climbed Mount Kilimanjaro in Tanzania. While at Uhuru peak (the highest peak in Africa) he displayed a small banner that read "Chemistry our life, our future IYC 2011”. **Sri Lanka** had many activities. From the very large number I have selected two that demonstrate the emphasis on outreach. CHEMEX 2011 was inaugurated on the 27th April 2011 by the Hon. Senior Minister of Scientific Affairs as part of IYC . It has been estimated that around 200,000 people consisting of school children, university students, businessmen, industrialists, academics and the general public visited CHEMEX 2011. The Australian

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National Chemistry Quiz program examination was held in various parts of the country. 15,463 students from 140 schools from both the Junior Division (Year 11) and the Senior Division (Year12) participated in the examination.

Table 1. A Summary of Outreach Events for the International Year of Chemistry in Canada

Initiative	*Public Reached*
Science Rendezvous	10,000
IYC on Jeopardy	9,000,000
Globe & Mail Ad	325,000
Joe Schwarcz Tours	1,500
Pierre Beaumier Tours	600
Olympiad	160
Hill Times Ad	10,000
YouTube Contest	5,000
Facebook/Social Media	1,000
Local Section Events	1,000
Daily Planet	10,000
Global Water Experiment	750
Commemorative Stamp	2,000
YTV	5,000
TOTAL 2011: ~9,376,000*	

* Please note that this number reflects the quoted viewership of Jeopardy!, which is a syndicated program. The number of Canadians who viewed the program would be much lower (estimate 750,000). Furthermore, the circulation of newspapers gives the maximum number of impressions the advertisements could have made and is not indicative of how many people took in the ad. The total estimate is 1,010,000 to 1,110,000 for all of 2011. Remove Jeopardy! and the Globe and Mail ad, and one obtains a conservative estimate of 50,000 to 100,000 people directly reached or involved.

China had an extraordinary event. The following link is to a musical performance by a Chinese Orchestra with vocal accompaniment entitled "Chemistry is you, chemistry is me" with lyrics by Qifeng Zhou (IUPAC Bureau Member), translation by Nigel Osborne and music composed by Dongqing Fang (http://baidu.56.com/kan/Sd7z/S8oi).

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Sweden produced a chemistry calendar which was a series of 12 short videos produced during the International Year of Chemistry 2011, one for each month of the year. They show how chemistry plays an important role in everyday life and point to the future by highlighting ongoing research. The videos combine scientific content with humor, adventure and action and appeal to adults and kids of all ages.

Thailand was another country with very many IYC events. There was an IUPAC Conference under the Patronage of Her Royal Highness Princess Chulabhorn. The National Science Weeks activities included chemistry and were organized by the National Science Museum and the Ministry of Science and Technology. Audiences numbered around 20,000 to 40,000 every day. Children Day in Chemistry Laboratory was sponsored by the Ministry of Science and Technology. They opened their chemistry laboratory for children on January 26, 2011 and about 4,000 people visited. There was three day chemistry training in 14,000 schools with audiences of about 50,000. A display on Marie Curie at the National Science Museum attracted audiences of more than 10,000.

The **United States** response to IYC was massive. All I will do here is to provide a summary with examples of major events. Much of the activity took place in local ACS Sections. ACS's IYC efforts were led by its International Activities Committee, Committee on Community Activities, Society Committee on Education, Local Section Activities Committee, and Divisional Activities Committee. ACS obtained a $1.1 Million NSF Grant but in addition a very large amount of staff time and effort went into IYC activities. An extensive report on these activities was prepared by Liezl Perez and Terri Taylor (*3*) and this summary is adapted from that report.

ACS IYC Partner Program arranged for other organizations to partner with them on IYC, such as the National Science Teachers Association. ACS Technical Divisions had programs to celebrate IYC at various meetings. Local sections did the global water experiment during National Chemistry Week. Pennies for PUR™ Water collected money to provide water packets for developing countries. ACS Saudi Chapter held an IYC Celebration in their country. A personal favorite for me was the Chemists Can Dance event held at the Spring and Fall National Meetings. *Kids Discover* magazine had one issue devoted to chemistry & IYC. A monthly email bulletin was put out by the International Activities Committee and highlighted IYC activities both national and international. There was an IYC Virtual Journal with four themes: Health, Energy, Materials and Environment. Chemistry 365 was an on line calendar featuring various items of interest to Chemistry including discoveries, famous chemists, chemistry of everyday materials, etc. The Madam Curie Display was an extensive collection shown at various meetings, such as National Meetings, and the Puerto Rico IUPAC Congress. Chemical & Engineering News had several general promotions of IYC. Finally the US Senate passed the following resolution designating 2011 as the International Year of Chemistry.

Senate Resolution 283 "recognizes the achievements made in the field of chemistry and the contributions of those achievements to the well-being of humankind and recognizes chemistry's ability to provide solutions that successfully address global challenges involving safe food and water, alternate sources of energy, improved health and a healthy and sustainable environment."

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A central event deserves special mention. **Water – A Chemical Solution** was a global experiment that was a signature/flagship IYC-2011 activity initiated and sponsored by IUPAC and UNESCO. It involved children and teachers in many different countries around the world. Aside from interesting children in Chemistry, it emphasized that water is essential to life and that provision of pure water is one of the greatest ongoing contributions of chemistry to human well-being.

Legacy of IYC

A final section of the task force report (*1*) looked at the legacy of IYC. Many more countries participated in IYC than those that are full IUPAC members. The IYC experience presents an opportunity for IUPAC to involve these countries in IUPAC activities. Moreover the 2011 activities and the Task Force report will help IUPAC in planning for its Centenary in 2019. For chemical societies there is an opportunity to build on the involvement of young people in various programs by continuing some programs and introducing others. Important interactions with industry occurred during IYC. Industry support was a key component. There is a real opportunity to continue such cooperation. At times, national chemistry organizations directly interacted with governments around IYC and we need to build on these successes. And finally IUPAC, UNESCO and chemical Societies from around the world interacted during IYC. We need to take advantage of these interactions in building future cooperation.

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Chapter 7

International Collaborations - Pittcon/ACS International Visiting Scientists Program

Richard S. Danchik*

Member, ACS International Activities Committee
ACS Councilor, Pittsburgh Section
25 Thorncrest Drive, Pittsburgh, Pennsylvania 15235-5215
***E-mail: rdanchik25@comcast.net.**

In the early 1990's the ACS International Activities Committee (IAC) identified the lack of expertise in analytical instrumentation techniques as a major problem in developing countries. The committee resolved to invite analytical chemists from selected regions to the United States to gain experience with analytical techniques. Since 1995 IAC has worked with Pittcon (Pittsburgh Conference) and its sponsoring organizers to facilitate participation at Pittcon by early and mid-career analytical chemists from developing and transitional countries. Funding form Pittcon, Society for Analytical Chemists of Pittsburgh (SACP) and the Wallace Coulter Foundation subsidizes the travel costs of attendees and also provides complimentary conference registration, housing, stipend, and travel medical insurance. Since its inception, this program has benefitted approximately 100 early- and mid-career chemistry practitioners from over 70 countries. This chapter discussed this program and how international collaborations have been developed and new networking opportunities occurred at Pittcon.

Introduction

Since 1995, the ACS International Activities Committee (IAC) has worked with Pittcon and its sponsoring organizers to facilitate participation at the conference by early career analytical chemists from developing countries.

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Funding from Pittcon, Society for Analytical Chemists of Pittsburgh (SACP) and the Wallace Coulter Foundation subsidizes the travel costs of attendees and also provides complimentary conference registration and complimentary hotel rooms for the participants.

IAC selects the region from which to invite participants. The Office of International Activities (OIA) contacts national chemical societies and other relevant scientific organizations and asks them to nominate scientists from their country to participate. Nominees represent industry, government and academia. OIA handles all logistics, including arrangements for publicity, solicitation of nominations and applications, and makes arrangements for local activities at Pittcon to connect participants to the ACS.occurred at Pittcon. The program is also advertised on the ACS website (*1*).

The ACS-Pittcon is an example of a very successful international collaboration. The present author has coordinated the ACS-Pittcon program since its inception.

Pittcon

Pittcon's mission is to sponsor and sustain educational and charitable activities for the advancement and benefit of scientific endeavors. Pittcon is the world's largest annual premier conference and exposition on laboratory science. Pittcon attracts more than 18,000 attendees from industry, academia, and government from 90 countries worldwide and is organized and managed by a committee of technical volunteers. Proceeds from Pittcon fund science education and outreach at all levels, kindergarten through adult in excess of a million dollars annually.

Pittcon is the world's largest analytical chemistry conference and exhibit. It consists of at least four key functions:

1) A showcase for scientific innovations in laboratory equipment, technology and supplies.

    a) Includes more than 1000 exhibiting companies worldwide
    b) Provides the opportunity to speak with technical staff to resolve problems
    c) Allows evaluations of the latest instrumentation, compares vendors, and participate in product demonstrations

2) Unique networking opportunities

    a) Interact with world renown scientists
    b) Attend conferee networking sessions to discuss topics of mutual interest
    c) Meet colleagues at complimentary mixers, poster sessions and other social events.

3) Educational Programs

   a) Build skills by attending short courses and technical presentations
   b) Discover the latest techniques and advances by attending more than 2,200 technical presentations
   c) Numerous Award symposia

4) Employment Bureau

   a) View hundreds of career postings for seasoned professionals or recent entrees into the job market
   b) Schedule onsite interviews
   c) Visit the employer and career information centers

More information is given in the Pittcon website (*2*).

ACS-Pittcon Program

The first in a series of visits for this Program occurred in February, 1995. Supported by a grant from the U.S. Trade and Development Agency, 10 scientists participated from Botswana, Ethiopia, Guinea, Kenya, Nigeria, Seychelles, Tanzania, and Zimbabwe. They visited Hampton University, ACS headquarters and the World Bank, made site visits to a number of instrument companies in eastern United States and attended Pittcon.

In the subsequent years, Pittcon, the SACP and the Wallace Coulter Foundation provided sufficient funds to make possible the invitees' attendance at Pittcon. In 1996, 15 Mexican scientists attended as part of the Program, 20 more Latin American chemists came in 1997, 14 scientists from India participated in 1998, 17 chemists from South America were present in 1999, 20 scientists from Central Europe were present in 2000, and 10 analytical chemists from Russia and the Former Soviet Union countries came to Pittcon in 2001. The Program was an excellent example of cooperation by IAC members as hosts for the Program.

The IAC selects the region from which to invite participants and the ACS Office of International Activities (OIA) contacts national chemical societies. ACS members with ties to the geographic region and other relevant scientific organizations ask them to nominate scientists from their respective countries to participate. OIA handles all logistics, including arrangements for publicity, solicitation of nominations and applications, book the delegates' travel and makes arrangements for local activities at Pittcon. Nominees generally represent industry, government and academia.

Since 1995, the Pittcon-ACS Travel Grant, administered by ACS's OIA has brought approximately 100 early and mid-career chemistry practitioners from over 70 countries. The regions/countries that have been invited over the years are as follows:

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1995: Sub-Saharan Africa (Botswana, Ethiopia, Guinea, Kenya, Nigeria, Seychelles, Tanzania, Zimbabwe)

1996: Mexico

1997: Central America (Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama)

1998: India

1999: South America (Argentina, Bolivia, Brazil, Chili, Colombia, Peru)

2000: Eastern Europe (Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Ukraine)

2001: Russia, Central Europe and Central Asia (Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan)

2002: Southeast Asia (South Korea, Malaysia, Nepal, Singapore, Thailand, Vietnam)

2003: People's Republic of China

2004: People's Republic of China (repeated due to problems with entry/exit visas)

2005: Sub-Saharan Africa (Benin, Botswana, Burkina, Faso, Burundi, Cameroon, Ghana, Kenya, Nigeria, Senegal, Tanzania, Zimbabwe)

2006: South America (Chile, Colombia, Costa Rica, Ecuador, Panama, Uruguay)

2007: Adriatic region (Albania, Bosnia and Herzegovina, Croatia, Macedonia, Serbia, Montenegro)

2008: Pacific Rim (Brunei, Malaysia, Philippines, Thailand, Vietnam)

2009: Central America and Southern Mexico (Belize, Costa Rica, Guatemala, Honduras, Mexico, Nicaragua)

2010: Middle East/North Africa (Egypt, Jordan, Morocco, Yemen)

2011: Eastern Europe (Croatia, Bulgaria, Ukraine, Macedonia)

2012: South America (Brazil, Argentina, Chile, Colombia, Venezuela)

2013: Sub-Saharan Africa (Cameroon, Ghana, Kenya, South Africa, Tanzania, Uganda)

2014: Southeast Asia (Indonesia, Malaysia, Thailand, Vietnam)

The IAC has chosen the following regional foci for the next two years of the Pittcon-ACS Travel Grant:

2015: Central America and Caribbean

2016: Balkans/Baltic Region (to be confirmed)

2014 ACS-Pittcon Program

As an example of this program, in 2014 the SACP granted $10,000 in funding to support the annual ACS-Pittcon Travel Grant. In addition, the Wallace H. Coulter Foundation, in conjunction with Pittcon, generously provided an additional $15,000 to support the delegation from Southeast Asia.

The delegation was composed of eight early- and mid-career analytical chemists from Southeast Asian countries as mentioned above. Delegation members represented academic and research institutions in their respective countries. As part of the grant, each delegate received the following benefits:

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1) Round trip economy class air travel up to $2,000 for international
2) Six-nights' hotel accommodations during the conference
3) Complimentary conference registration
4) A US $400 allowance for meals, local expenses and airport transfers
5) Travel medical insurance coverage.

While at Pittcon, the delegates had the opportunity to attend technical sessions, network with colleagues from over the globe and tour the exhibition. A photograph of the participants, together with IAC and OIA representatives is shown in Figure 1.

Figure 1. ACS-Pittcon delegation 2014. Front row from left: Elisabeth Rukmini (Indonesia), Lanny Sapei (Indonesia), Tran Thi Nhu Trang (Vietnam), Hooi-Ling Lee (Malaysia), Prinya Masawat (Thailand), and Leo Choe Peng (Malaysia). Back row from left: Mohamad Nasir bin Mat Arip (Malaysia), Mohd Firdaus Abdul Wahab (Malaysia), H. N. Cheng (IAC Chair), Janet Pifer (President, Pittcon), Rich Danchik (IAC Member and Pittcon ex-President), Brad Miller (OIA Director), Lori Brown (OIA Staff). (Courtesy of the American Chemical Society.)

Review of ACS-Pittcon Program

The ACS-Pittcon program was well received and garnered an overall score of 4.5 (from a scale of 1-5, with 5 being the highest score) from the delegates as reflected in the survey conducted onsite.

Some examples of the responses of several delegates of the program are shown below:

1) "It was extremely beneficial for me to meet up with other scientists from all over the world to get to hear of the issues they are facing from their context. I was excited about expanding my networks through the formation of a new African Pittcon Group that will have various agendas aimed at collaboration and increased scientific interests."
2) "An amazing huge conference! This gives me an eye opener to deliver back to Kenya."
3) "The conference had sessions on my own research fields and talking to other researchers has already started some future collaborations. It provided me with some personal growth experience that will enhance my development."

In summary, the Program has been extremely successful with outstanding results over the past 19 years. It has provided over 100 scientists from 70 countries the opportunity to collaborate with experts in their fields and to learn new technology and view the latest laboratory instrumentation and meet with the vendors and their technical experts on a one to one basis. With this experience, they take home a better understanding of technology and have developed lifelong contacts and networking capabilities. The Program also represents how technical societies and organizations can cooperate to provide meaningful outcomes that have world-wide benefits.

Acknowledgments

Thanks are due to ACS staff in OIA for administering the program over the years and for IAC members, past and present, for their efforts on behalf of the program.

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Chapter 8

The Malta Conferences: Fostering International Scientific Collaborations Toward Peace in the Middle East

Morton Z. Hoffman*,[1] and Zafra M. Lerman[2]

[1]Treasurer, Malta Conferences Foundation, Department of Chemistry, Boston University, Boston, Massachusetts 02215
[2]President, Malta Conferences Foundation, 1911 Grant Street, Evanston, Illinois 60201
***E-mail: hoffman@bu.edu.**

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The Malta Conferences, formally known as "Frontiers of Science: Research and Education in the Middle East," have taken place biennially since 2003, at which approximately 85 scientists and science educators, including students and early-career scientists, from 15 Middle Eastern nations (Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Palestinian Authority, Qatar, Saudi Arabia, Syria, Turkey, and the United Arab Emirates) meet for five days with six Nobel Laureates. The purpose of the Conferences is to provide a forum for the discussion of scientific and educational issues of importance to the region and the world that transcend geopolitical boundaries and international politics, and for the development of collaborations among the participants. The topics that are discussed include air and water quality, renewable energy sources, bio-medicinal chemistry, nanotechnology and material science, chemistry safety and security, and chemistry education at all levels. The Conferences are dedicated to the use of science diplomacy as a bridge toward peace in that troubled and very important region of the world. They feature plenary lectures by the Nobel Laureates, workshops, oral and poster presentations by participants from the Middle East, and ample time for everyone to make personal and professional connections. The result over the past decade

has been the establishment of international cooperation in areas of basic and applied research that hold promise for the development of innovative products, processes, and educational resources. Prior to 2011, the Conferences were organized by a committee with representatives from the American Chemical Society (ACS), the Royal Society of Chemisry of Great Britain (RSC), the International Union of Pure and Applied Chemistry (IUPAC), and the German Chemical Society (GDCh); since that time, they have been organized by the Malta Conferences Foundation, a 501(c)(3) charitable organization incorporated in Washington, DC www.MaltaConferencesFoundation.org/.

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Introduction

Instability and uncertainty in the Middle East, combined with water scarcity, global climate change, nuclear proliferation, and the lack of civil society, create a growing threat to the world. The political and economic climate currently shared by the nations in the region is grave. Events burst into violence almost daily, consuming lives and resources while threatening a far wider conflagration. Yet, within these countries, there are people who do the work of science and science education at universities and national institutes, and hunger to know their colleagues from across the forbidden borders and learn about the results of their research. This genuine desire on the part of concerned individuals to improve the quality of life and political stability in the Middle East could be addressed by identifying unique opportunities for collaboration among them to solve environmental, scientific, and educational problems.

In this article, we examine the nature of scientific collaboration and our attempt to use science diplomacy as a bridge to peace in the Middle East.

Scientific Collaboration

Anyone who has been engaged in a scientific collaboration immediately recognizes the characteristics that make it a rewarding and enjoyable experience. At the beginning, the collaborative partners bring to the scholarly problem a commonality of interests, perspectives, and goals. The act of collaboration demands interdependence with regard to talents, skills, and resources. During the collaboration, connectivity via telephone, electronic methods, and face-to-face meetings is essential. Because of the closeness that develops, the collaboration could well evolve into a friendship, which the participants must be willing to undertake. The essential ingredients for a successful collaboration are trust, understanding, commitment, and the willingness to resolve conflicts and disagreements in a civilized manner.

Given the situation in the Middle East where nations are in conflict with each other, themselves, and amorphous entities, how would it be possible for scientists in that region of the world, however well-meaning they might be, to establish and maintain collaborations? Would any right-minded persons want to do that, and would their governments permit them to do so? With the economic and political uncertainties, from what sources could the funding come in order to sustain cross-border collaborations?

The Middle East and Science Diplomacy

The Middle East is an area that has been in continuous turmoil for millennia; its current instability stretches westward into Northern Africa and eastward into South-Central Asia. The borders of many of the Middle East nations exist as the result of tribal and ethnic demarcations, wars, and bartering among powerful countries from outside the region to protect their own economic and political interests. At the epicenter of the continuing tension is the Israeli-Palestinian conflict, which, as recent events have shown, does not appear to be simmering down.

In the view of some in the region, the universal commonality of science makes it one of the few human endeavors that can bridge conflict and peace over very troubled waters. If science, as a diplomatic tool, can get representatives of nations of the Middle East to talk to each other in civil dialogue, perhaps the tensions can be ameliorated, at least to some degree, over time.

However, for science diplomacy to be effective, it must focus on specific activities that could lead to results the parties involved would find useful. As was stated in a recent editorial in *Science*, "Science diplomacy can facilitate addressing science-based questions whose answers are impeded because political relationships limit official interactions between the countries (*1*)." The challenge then becomes to define those science-based questions and create a mechanism that encourages dialogue despite the limited (or unpermitted) official interactions.

The Malta Conferences

During the 1990s, some members of the ACS Subcommittee on Scientific Freedom and Human Rights of the International Activities Committee, who had worked actively on behalf of the prisoners of conscience in the Soviet Union and believed strongly that it is the responsibility of scientists to use their status with their governments for the purpose of peace, turned their attention to the continuing and ever-growing turmoil in the Middle East. They reasoned that if scientists from countries in conflict could come together, leave politics aside, and talk about scientific problems of mutual interest, a positive direction toward some semblance of stability might be achieved. Such a conference would have the following aims:

- To provide a forum where scientists from countries of the Middle East can explore what unites rather than separates them;
- To provide a forum where there are opportunities to develop activities that require cooperation among the partners to solve regional problems;
- To reduce the level of personal animosity that exists in the region and the tendency to demonize the unknown other.

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.;
ACS Symposium Series; American Chemical Society: Washington, DC, 2015.
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In 2000, as a conference was being organized and the logistical problems (location, venue, funding, identifying the participants, etc.) were being resolved, the Second Intifada, a period of intense violence between Israel and the Palestinian Authority, began, giving new impetus to efforts to hold a meeting that would foster close scientific and personal engagement, facilitate networking, and encourage the development of collaborations.

The format of that conference, which was held in 2003, was carefully developed to maximize interactions, minimize distractions, and create a "level playing field" for the participants from the different cultural and economic environments. Because of security concerns, especially after 9/11, only carefully vetted participants would be invited and no "accompanying persons" would be allowed; furthermore, the location of the meeting would be in "neutral territory" outside the Middle East, yet near enough for ease of transportation. Working with a conference company with a great deal of experience in the Middle East, the organizing committee chose the Hilton Hotel on the Mediterranean island of Malta for having the requisite security arrangements; Malta, then not a member of the European Union, was able to guarantee entry for the participants although some had visa difficulties when making their flight connections at airports within E.U. countries.

The format of that conference, "Frontiers of Chemical Sciences: Research and Education in the Middle East," proved to be very successful, and has remained relatively constant over the past decade through the five subsequent biennial five-day meetings: plenary lectures by Nobel Laureates, keynote talks by other distinguished scientists, topical workshops with oral and poster presentations by the participants, and close contact at meals, sessions, and social activities.

The conference, which was described in *Chemical & Engineering News (2)* and *Chemistry International (3)*, brought together 35 chemists and chemical engineers from ten Middle East countries (Egypt, Iran, Israel, Jordan, Kuwait, Lebanon, Palestinian Authority, Saudi Arabia, Turkey, and United Arab Emirates), six Nobel Laureate plenary speakers (Claude Cohen-Tannoudji, France; Dudley Herschbach, U.S.; Roald Hoffmann, U.S.; Yuan T. Lee, Taiwan; Jean-Marie Lehn, France; Rudolph Marcus, U.S.), and representatives of the cosponsoring organizations: ACS, IUPAC, and RSC.

In addition, Herman Winick (U.S.), Peter Atkins (U.K.), and Charles Kolb (U.S.) gave keynote lectures. Workshops with oral and poster presentations by the participants were held on the following topics: Materials and Polymer Science; Cultural Heritage and Preservation of Antiquities; Environment, Water, and Renewable Energy; Research and New Methodologies in Science Education; Medicinal and Natural Products; Research and Technology Transfer for Economies in Transition.

Totally unexpectedly, two collaborative initiatives were announced at the end of the conference. Yitzhak Apeloig, president of Technion-Israel Institute of Technology, offered three scholarships for students from Middle East countries to study at that institution, and Yuan T. Lee provided three one-year fellowships for Middle East scientists to perform research at the synchrotron light source in Taiwan to support advanced training of young scientists at SESAME, the new synchrotron facility that was under construction in Jordan with UNESCO support.

The atmosphere of the conference, which at the start was rather tense, evolved soon into the camaraderie of a summer camp with many emotional goodbyes at the end. The participants enthusiastically endorsed the idea of holding a second conference in 2005, and it was clear that this experiment in science diplomacy had succeeded beyond expectation.

The site of the first meeting gave its name to the series: the Malta Conferences. Malta-I on December 6-11, 2003, was followed by Malta-II, also in Malta, on November 5-10, 2005 (*4–6*). Malta-III took place in Istanbul on December 8-13, 2007 (*7–10*); Malta-IV was held in Amman, Jordan, on November 14-19, 2009 (*11*, *12*). UNESCO invited Malta-V to its headquarters in Paris on December 4-9, 2011 to be one of the concluding events of the International Year of Chemistry (*13*, *14*).

In addition to the Nobel Laureates who were at Malta-I, the following have also attended, many of them more than once: Aaron Ciechanover (Israel), Richard Ernst (Switzerland), Robert Grubbs (U.S.), Tim Hunt (U.K.), Walter Kohn (U.S.), F. Sherwood Rowland (U.S.), Ada Yonath (Israel), and Dan Shechtman (Israel), who, interestingly, was a participant at Malta-I before receiving the Nobel Prize. Other distinguished keynote speakers have been HRH Prince Hassan (Jordan), Irina Bokova (Director-General, UNESCO), George Abela (President, Malta), Michael Grätzel (Switzerland), Heinz Hötzel (Germany), David Reinhoudt (Netherlands), and Omar Yaghi (U.S.).

Prior to 2011, the organizing committees of some of the Conferences included representatives from GDCh.

Malta-VI

Malta-VI, the most recent conference, took place in Malta on November 10-15, 2013 (*15–20*). Over the course of the past decade, scientists from five more countries have been added to the list of participants: Bahrain, Iraq, Libya, Qatar, and Syria. As the scope of the Malta Conferences has broadened to include countries in North Africa, the number of participants attending has swelled; more than 80 individuals were at Malta-VI, including 20 women (Figure 1). Interest in attending the Conference has remained very high despite the obstacles many have to overcome (*e.g.*, inability to get an entrance visa or an exit permit, unpredictable bureaucratic decisions, unanticipated hostilities); repeat participants often state that the experience is one of the high points of their professional and personal lives.

The workshop topics have also evolved over the decade with the change in the interests of the participants. At Malta-VI, the following workshops examined scientific, educational, and regional issues.

Chemistry and Bio-Medicinal Chemistry

A wide range of topics were explored in this workshop, including cancer therapy, tumor markers, HIV activity, and myocardial infarction, as well as chemical synthesis and computational studies. Of great interest was a presentation on clinical trials on the analysis of breath samples for the early detection of lung cancer in which chemical nanoarrays and GC-MS are used for the comparison of the signatures and compositions of the exhaled volatile organic compounds that are created as a result of the biological pathways that occur in the human body. The results show a clear distinction among 1) head and neck cancer patients and healthy controls, 2) lung cancer patients and healthy controls, and 3) head and neck cancer patients and those with lung cancer. Other clinical trials aimed to explore the difference in the breath print of the four most widespread cancers in the developed world (lung, prostate, colorectal, breast), which account for half of the cancer deaths; the results showed that each cancer has a unique pattern of volatile organic compounds when compared with healthy patients.

Figure 1. Participants at Malta-VI. (Courtesy of the Malta Conferences Foundation.)

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Analytical, Nanotechnology, and Material Science

The current trends in these areas that were described included the atmospheric measurement of pesticides, the extraction, separation, and analysis of lignans, and electron transfer in biological systems. The realm of complex functional bio-composites has attracted a good deal of interest, in particular plant cystoliths, which are mineralized objects formed by specialized cells in the leaves of certain plants, that scatter incident light. Cystoliths are regularly distributed in the epidermis of leaves and protrude into the photosynthetic tissue such that the photosynthetic pigments generate a steep light gradient in the leaf. Under most illumination regimes, the outer leaf layer is light saturated, rendering the photosynthetic apparatus kinetically unable to use the excess light for photochemistry.

Energy, Environment, Air and Water Quality

This workshop had many interlocking components. Inasmuch as collaborations that involve renewable energy among several Middle East countries are currently ongoing, this aspect of the workshop concentrated on current research activities; the hope was expressed that new collaborations could be established to lead to the further development of sustainable resources that do not impact adversely on the environment, particularly air quality. With regard to water, the shared resources are under heavy natural and human pressures in terms of quantity and quality, which affect every aspect of life from ecosystems and the environment to food security and health. Because of population growth and urbanization, and despite a general improved standard of living in the region, many communities still lack access to safe drinking water and basic sanitation. The problem of water scarcity provides important opportunities for cooperation and conflict prevention, and could be at the core of programs to promote peaceful coexistence and collaboration among people in Israel, the Palestinian Authority, and Jordan, to the mutual benefit of all the stakeholders.

Chemistry Safety and Security

The awarding of the 2013 Nobel Peace Prize to the Organization for the Prohibition of Chemical Weapons (OPCW) placed in clear focus the work of that group in the development of the International Chemical Weapons Convention (CWC) and the removal of chemical weapons from current areas of conflict in the Middle East. Especially relevant is the fact that some of the participants at Malta-VI were from the several countries that have not ratified or signed the CWC. It was pointed out that OPCW is working toward the creation of an international code of conduct for chemists, especially in connection with the problems created by the dual use of chemicals for both peaceful and terrorist purposes.

Science Education at All Levels

In addition to the presentations on innovative pedagogy, systemic assessment, and the use of technology, there were several that attracted particular interest. The talk on the ethics of scientific research emphasized the importance of stressing the basic values of honesty, reliability, and objectivity in all of science education. A representative from Saudi Arabia described the enormous progress made by women scientists in the Arab world with a particular focus on her own country where there has been a significant increase in the number of highly qualified women scientists although career opportunities remain limited. A speaker from Egypt reminded the audience that the use of gas weapons in North Africa and the Middle East against civilians engaged in peaceful political protests puts an ugly face on the public perception of chemistry.

Perspectives on the Conferences

So far, a total of about 500 scientists from the Middle East have participated in the six Malta Conferences with a few having attended every conference and a majority more than one. Increasingly, early-career scientists and students are represented (Figs. 2, 3), which offers hope that the efforts of the Conferences will one day bear fruit.

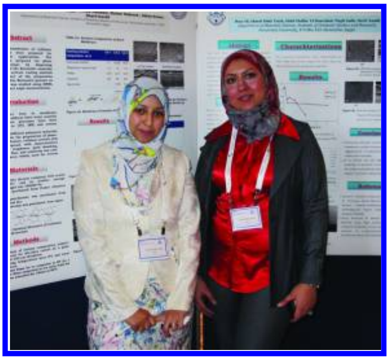

Figure 2. (left) Students from Egypt. (Courtesy of the Malta Conferences Foundation.)

Figure 3. (right) Students from Qatar. (Courtesy of the Malta Conferences Foundation.)

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The Malta Conferences have gotten the attention of members of the U.S. Congress, who have entered their support into the *Congressional Record* (*21*, *22*). The Conferences remain the only current platforms at which scientists from the embattled nations of the Middle East can meet in a nonconfrontational environment to discuss regional problems and seek solutions.

Collaborations as a Result of the Conferences

Through the personal interactions that have taken place at the Malta Conferences, a number of collaborations have developed. Palestinian students are pursuing Ph.D. studies at the Weizmann Institute of Science in Israel, and Hasan Dweik, Vice President for Science and Society at Al-Quds University in East

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ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

Jerusalem, recently spent a sabbatical year in the laboratory of Ron Naaman at Weizmann, developing biomolecular sensors (*23*). Hossam Haick, an Israeli-Arab professor of chemical engineering and nanotechnology at the Technion-Israel Institute of Technology who has been a participant in the Conferences (*24*), has designed massive open online courses (MOOC) in nanotechnology in Arabic and English that are being used by thousands of students in Egypt, Syria, Saudi Arabia, Jordan, Iraq, Kuwait, Algeria, Morocco, Sudan, Tunisia, Yemen, the United Arab Emirates, the Palestinian Authority, and Iran (*25*).

If there is one subject that draws the attention of everyone in the Middle East, it is water – its availability, quality, and distribution. Not unexpectedly, the most robust and potentially significant collaborations resulting from the Malta Conferences have developed around the issues of the quality and quantity of the water available for human use. In the forward of a compendium of papers on water quality and purification, the editor wrote, "Water is a significant component of the ongoing Palestinian–Israeli conflict and other regional disputes over water. However, these can be addressed through concerted regional efforts, lessening cross-border tension, contributing to cooperation and understanding in this politically volatile region (*26*)."

At Malta-III in Istanbul in 2007, Yousef Abu-Mayla, director of the Water Research Center at Al-Azhar University in the Gaza Strip, described the widespread degradation of water quality in Gaza and the especially urgent need for action. The attendees at the Conference unanimously adopted the following declaration, which was communicated to Tony Blair, envoy to the Middle East representing the U.N., U.S, Russia, and the European Union.

"There are some concerns that transcend politics. Among them are issues that have long-term consequences for civilization and affect the lives of individuals who simply lie in the way of events.

"As scientists from throughout the Middle East, with some of their colleagues from other parts of the world, we wish to draw immediate and urgent attention to one such issue. Water is of central importance to human life; water in the Gaza Strip is of particular concern in terms of quantity and quality, threatening the health of every inhabitant regardless of their political inclination.

"We urge governments to look beyond the present conflicts and disagreements that afflict the region. As with some other treaties, where difficult conflicts are set aside for future consideration, we urge that the interested governments and agencies ignore their current disagreements, and by, drawing on scientific expertise, urgently address the issue of water in the Gaza strip, taking into account the whole cycle from collection to reuse."

The clear and present danger of the water crisis, not only in Gaza but also more broadly throughout the region as described at Malta-III, led to the idea in Istanbul of establishing a working group with representatives from Egypt, Germany, Israel, Jordan, Kuwait, Palestinian Authority, U.K., and U.S. to write and submit a project proposal to the Division of Chemistry and the Environment of IUPAC. The project (#2008-003-3-600) was funded, leading to face-to-face meetings of the members of the working group at Malta-IV, -V, and -VI, participation in the workshops, and the creation of an action plan with specific recommendations to the governments of Israel, Jordan, and the Palestinian Authority:

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- Establish a uniform and comprehensive regional water information system and database;
- Create an integrated water resources management board;
- Promote the development of new water resources and conservation methods;
- Initiate regional water research and development;
- Assess the environmental and social impacts of water usage.

Details about this collaborative outcome of the Malta Conferences can be found in references (*19*) and (*27*).

In addition, scientists from Al-Azhar University in Gaza and the Technion continue to collaborate on testing the quality of the ground water in Gaza despite the difficulties involved in doing so. Bethlehem University in the Palestinian Authority and the Weizmann Institute of Science in Israel received a grant from the Yad Hanadiv Foundation <http://www.yadhanadiv.org.il/> for a water purification project. These examples demonstrate that when there is a will toward collaborative actions, there will be a way.

Comments from the Participants of the Conferences

The opinions of the participants matter the most. The consensus among attendees at each of the Malta Conferences has been that the achievements of the meeting far exceeded all expectations, prompting the participants to vote unanimously each time to hold another one in two year's time. Ten Middle Eastern chemists have agreed to serve on the Organizing Committee of the Malta Conferences, and the convictions of the attendees and the concrete results of these conferences have borne out the initial vision: "Collaborations between scientists of the region will be the bridge to peace in the Middle East."

- "I felt that we really created a community of people who enjoy being together and sharing ideas. For me, the education workshop, was very useful, and I dare to say, that this time I enjoyed it even better than during my last two conferences." (Israel)
- "Thanks a lot for your kindness, care and hospitality and all you did and do for peace all over the world. My deep hearty congratulations for you for the successful conference. Thank you for introducing new members in your conference, which increase our networking and good chance for more collaboration." (Egypt)
- "Many thanks for all that you have done to make Malta-V such a wonderful event full by success and happiness to such gathering from all the Middle East scientists. Congratulations and looking forward to seeing you in Malta-VI." (Saudi Arabia)
- "Thanks to your efforts, Malta-V was another success despite worldwide economic hardship. We all congratulate you. We hope that you are aware of the fact how much your hard work is appreciated to help the Middle East peace process through science." (Turkey)

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- “Now we are already sharing greetings and looking for deeper collaborations and support to each other.” (Saudi Arabia)
- “The conference should work towards creating a pressure group from among scientists in the area to work for enhancing harmony and peaceful coexistence.” (U.A.E.)
- “I came to help push peace forward.” (Palestine)
- “I believe the Conferences contribute to the mutual understanding of the people from different cultures, ethnic, religious, and political backgrounds, thereby opening the door for a lasting peace in the Middle East.” (Turkey)
- “We have only one nationality here – and that’s science.” (Egypt)
- “Despite the preoccupation of our lives, I am glad that we have occasions like these, which give us a chance to reconnect and express our warmth for each other.” (Palestine)
- “May we all have better times in our region. A dream starts with one little step. Let’s hope the Malta Conferences will inch eventually towards this step.” (Israel)
- “I think the conference represents a very important step in the way of cooperation between researchers in the Middle East away from the politics; it also removes the barriers between the people of this region left by politicians.” (Jordan)
- “It’s the first time for me and my friends from Iraq to have met Israel scientists and experts. I found them very friendly, kind, and active. I think the conference was very important, but more important was this opportunity that we met your people.” (Iraq)
- “Thank you very much for writing to me although you are always busy, working for more peace not only in Arab countries but for all the world.” (Egypt)
- “I am so pleased we had the chance of meeting each other in Istanbul. This made me find out that we are all looking for a happy and peaceful life. Thank you.” (Saudi Arabia)
- “I can only join the various messages of friendship that we all received from many of you. Personally, I felt this time that I was meeting again old friends and was making new significant friendships. We have created, thanks to all those who worked so hard to make the success of this initiative, a network of scientific communication that overcomes all other barriers. I am confident that this will bear fruit in the future, maybe well beyond what we expect and hope.” (Israel)
- “I deeply appreciate your endless efforts to attend and organize many conferences to transfer the idea to help humanity to have a good health and live in peace.” (Egypt)
- “Malta Conferences for me have always been the highest quality and the most enjoyable scientific activity. You did it again in Istanbul. Now Malta Conferences reached a point of no return. There is only one way and that is to continue the well-established tradition. I know how much time, energy and even spending your own money it takes. I appreciate all your efforts to put such a world-class scientific event together. I am certain,

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that some time in the future, when peace and prosperity comes to the Middle East, your efforts will be remembered." (Turkey)

- "Our great Middle East Chemistry meeting in Istanbul was for me – an elderly 'freshman' – a thrilling experience. The unfailingly friendly and cooperative tone, the excellent presentations, from basic science to urgent local and regional problems; the enjoyable banquets with opportunities for informally meeting colleagues with very different backgrounds and perspectives – yet all of us united by our love of science and commitment to its use for the benefit of mankind. I was a postdoc at Bohr's Institute for Atomic Physics in Copenhagen in the early 1950's. From Bohr, I learned not only many wonderful things about science as science, but also about the exceptional opportunity science offers to open up national, ethnic, political, and religious boundaries. His own Institute was, and is, a very successful example of these principles as was, and is, the great European (but in fact international) Research Center for High Energy Particle Research (CERN) in Geneva, to whose establishment he was passionately committed. Malta seems to me to follow in the same great tradition. May it continue to go from strength to strength." – Walter Kohn, Nobel Laureate (U.S.)

Funding and Sustainability of the Malta Conferences

The greatest challenge that must be faced is to raise enough money through grants, sponsorships, and personal contributions to cover the cost of each biennial conference, which can amount to $250-300K, for the support of travel and accommodations of the Nobel Laureates and the participants from the Middle East, meals and social events, conference facilities, technical support, and the expenses of the organizing company.

In order to provide fiscal responsibility, a mechanism for fundraising, and a structure for the organization of the Conferences, the Malta Conferences Foundation, a charitable organization under IRS Section 501(c)(3), was incorporated on June 1, 2011, in the District of Columbia. As such, personal contributions may be itemized and deducted on the federal income tax return, and the Foundation is tax-exempt. Over the course of the past decade, many hundreds of individuals have contributed personally to the Foundation.

The Foundation has a Board of Directors led by Officers, and an International Advisory Board; members of the latter are Nobel Laureates and other very distinguished scientists. All serve without any compensation whatsoever. Among the Board members are past presidents of the ACS and representatives from the U.S., Canada, Korea, Europe, and the Middle East. Information about the Foundation and the way to make donations to support the Conferences can be found at www.MaltaConferencesFoundation.org/.

Since the start of the Conferences in 2003, financial support has been received from many agencies, organizations, and foundations; without their generosity, it would have been impossible to sustain the effort. Acknowledgements and thanks go to the following: ACS, RSC, GDCh, IUPAC, UNESCO, OPCW, National

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Science Foundation (NSF), Columbia College Chicago, Civilian Research and Development Fund Global, U.S. Office of Naval Research Global, U.S. Army Forward Element Command-Atlantic, The Munin Foundation of Norway, Terrific Science, Google, Inc., The Camille and Henry Dreyfus Foundation, Skoll Global Threats Fund, Center for Global Science-Berkeley, Alexander von Humboldt Foundation, Nano Tech for Intelligent Solutions, Spectra-Physics (Newport Corp.), Committee of Concerned Scientists, Rockefeller Brothers Fund, Yad Hanadiv Fund.

Prospects for the Future

Among the ongoing challenges for the future of the Malta Conferences is the necessity to hold the meetings in a safe and secure location that is accessible via international air transportation in a country that will grant visas to all the participants from the Middle East without restrictions. As one can imagine, what is safe, secure, accessible, and restriction-free one day may not be the next.

Figure 4. The Middle East without borders. http://commons.wikimedia.org/wiki/File:Middle_East_geographic.jpg [accessed Nov. 1, 2014].

Nevertheless, despite (and because of) the terrible current conflicts within and between nations in the Middle East, and the political, societal, and humanitarian disasters that are unfolding, plans are being developed to hold the next Malta Conference (Malta-VII) in November 2015 in Rabat, Morocco. One can only

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hope that the next conference and subsequent ones can bring together scientists from the region who share the seemingly impossible dream of making international scientific cooperation and collaboration a border-free reality (Figure 4).

Perhaps the double rainbow observed during Malta-VI (Figure 5) is a harbinger of better things to come.

Figure 5. The double rainbow of hope. (Courtesy of the Malta Conferences Foundation.)

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Chapter 9

Pacific Polymer Federation: A Model for International Cooperation

William H. Daly*

Department of Chemistry, Louisiana State University, Baton Rouge, Louisiana, 70803-1804, United States
***E-mail: chdaly@lsu.edu.**

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The Pacific Polymer Federation (PPF) was conceived at Pacifichem 1984, when an organizing committee for PPF was formed, which drafted a constitution expanding the bilateral agreements between SPSJ and POLY to include RACI and outlined the objectives of PPF. The founding members (Jim O'Donnell and David Hill, RACI, Takeo Saegusa and Akihiro Abe, SPSJ, and Otto Vogl and Joe Salamone, POLY) became the first PPF council. The first Pacific Polymer Conference (PPC) meeting was held in Maui in December 1989, establishing a tradition of relating the PPC meeting to Pacifichem. Since 1989, PPF has grown to a membership of 17 societies from 15 countries bordering the Pacific Rim. PPC is hosted by one of the member nations and held biennially in venues selected by the host since 1991. In addition to the biennial PPC conferences, many smaller conferences have evolved, thanks to the interactions promoted by PPF membership. PPF is fulfilling the objectives of the founding committee of facilitating interactions among polymer organizations and promoting the exchange of scientific knowledge through specialized polymer meetings and visits by polymer scientists around the Pacific Rim.

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ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

History of PPF

In the early 1970's polymer scientists of Japan and the U.S. began to interact and cooperate with each other, both professionally and personally. Universities of both countries recognized similar interests on common subjects, and the polymer communities of Japan and the U.S. began communicating through their professional organizations, exchanging ideas and scientific knowledge. In 1974, these interactions were formalized through a cooperation agreement, signed by the President of the Society of Polymer Science, Japan (SPSJ), Yoshio Iwakura, and the Chairman of the ACS Division of Polymer Chemistry (POLY) Otto Vogl. Four years later, the two societies held their first joint symposium in Palm Springs, California, with Teiji Tsuruta and William Bailey as co-chairman. It was a meeting of broad implications and was considered a substantial success.

In 1984, during an ACS meeting in Hawaii, Jim O'Donnell, Chairman of the Polymer Division of the Royal Australian Chemistry Institute (RACI) was approached by Takeo Saegusa of the SPSJ regarding regional cooperation. It was believed that what could not be achieved by the SPSJ and POLY on a bilateral basis might be possible on a regional basis. This established the concept of the Pacific Polymer Federation (PPF), a regional organization of polymer scientists from the Pacific Rim countries. Together, the three organizations came to an informal cooperation agreement, which was drafted into a constitution for the PPF soon after (*1*).

A year later, the SPSJ-POLY cooperation held their second symposium in Kyoto, Japan, with Takeo Saegusa and Otto Vogl as co-chairman. The symposium was attended by the six founding representatives of PPF (Figure 1).

In July 1988, at the first PPF council meeting in Kyoto, Japan, seven more organizations were added to the PPF: the Macromolecular Science & Engineering Division of the Chemical Institute of Canada, the Polymer Society of Korea, the Polymer and Industrial Section of the Institute of Chemistry of Malaysia, the Polymer Division of the Chinese Chemical Society, the Plastics and Rubber Institute of Singapore, and the Division High Polymer Physics, American Physical Society. These additions expanded the PPF's representation to include six more countries and over 6,500 new members.

In December 1989, the first official Pacific Polymer Conference was held in Maui, U.S.A. (Figure 2). Pacifichem, a pan-Pacific conference focused collaborations in chemistry, was being held a week later in Honolulu. This established the tradition of linking the PPC meeting to Pacifichem

In 1993, two years after Takeo Saegusa became president of the PPF, membership grew to 17 organizations from 14 countries around the Pacific Rim and Pacific Islands. The 1993 additions to the PPF included the Macromolecular Division of the Chemical Society of Chile, the Hong Kong Chemical Society, the Indonesia Polymer Association, the Division of Polymers and Organic Materials, Mexican Academy of Materials of Sciences, the Polymer Society of Thailand, the Polymer Society of Taipei, and the division of Polymer Science, Chemical Society of Vietnam.

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The PPF Constitution

The name of this cooperative effort between Pacific Rim countries is the Pacific Polymer Federation, otherwise known as the Federation.

The Federation's objective is to advance polymer science and technology by facilitating interaction between Pacific polymer organizations, exchanging scientific knowledge, participating in national polymer meetings, and conducting visits by polymer scientists. The exchange of ideas between scientists of different backgrounds and different countries, in particular, is a great contributor the advancement of polymer science, and is indispensable for the development of new technologies. The objectives are mutually beneficial for both science and industrial technology.

Membership is open to all societies and associations of scientists and engineers, geographically situated near the Pacific Basin, which have part of their activities devoted to polymer science and/or technology. Member organizations are not committed by any action in conflict with their charters, constitutions, or bylaws – or those of their parent organizations.

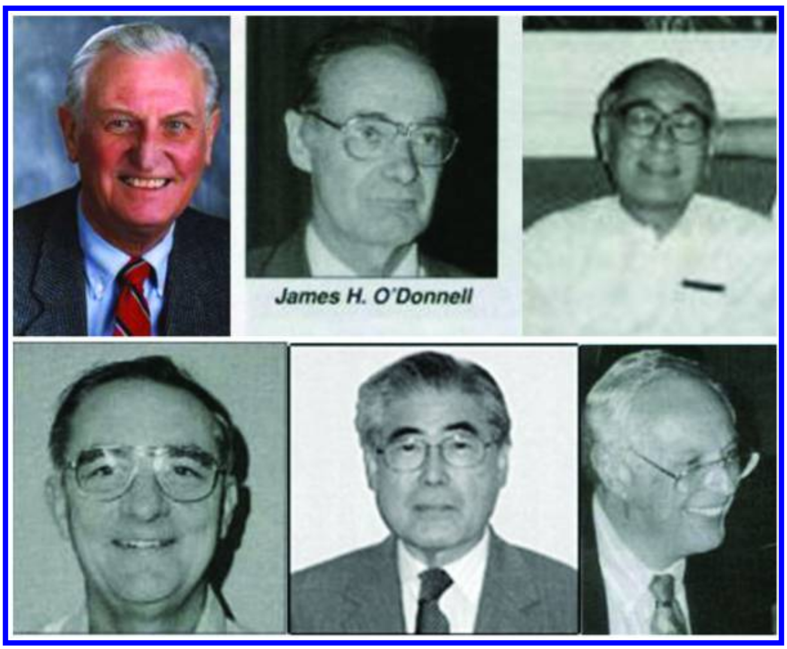

Figure 1. The founding representatives of the PPF. From the top-left, clockwise, Otto Vogl (President), James H. O'Donnell (Deputy Vice President, Membership Chair), Takeo Saegusa (Vice President), Joe C. Salamone (Secretary Treasurer), Akahiro Abe and David J.T. Hill. (Courtesy of the ACS Division of Polymer Chemistry, Inc. Used with permission.)

Meetings which garner international interest are conceived and promoted by the council. The meetings are organized by the council members of the chosen host country and may be financed (with the acceptance of profit or loss) by the participating body (or bodies) of the hosting country. Pacific Polymer Conferences, which are international meetings between the member organizations, are organized by the Council and held every two years.

Pacific Polymer Conferences have traditionally been held in a relaxed atmosphere at business facilities that offer recreational opportunities nearby. There have been 13 PPCs so far, which have been held in major cities in Australia, China, Japan, Korea, Mexico, Taiwan, Thailand, and the U.S.A. Participation in these conferences has been steadily rising over time, with the last three conferences gathering over 800 participants. The number of papers contributed for each program has followed a similar trend over time (Figure 3).

The Federation's policy towards publicizing the proceedings of its meetings is determined principally by the publication policy of the organizing national body or bodies. Prominent recognition of the Federation's sponsorship accompanies all such publications. For the first three conferences, extended abstracts were published after the meeting in "Progress in Polymer Science". The fourth PPC switched to a preprint book, and the thirteenth now makes the preprints available on USB drives.

Figure 2. PPF Members at PPC-1 in Maui, U.S.A., December 1989. (Courtesy of the ACS Division of Polymer Chemistry, Inc. Used with permission.)

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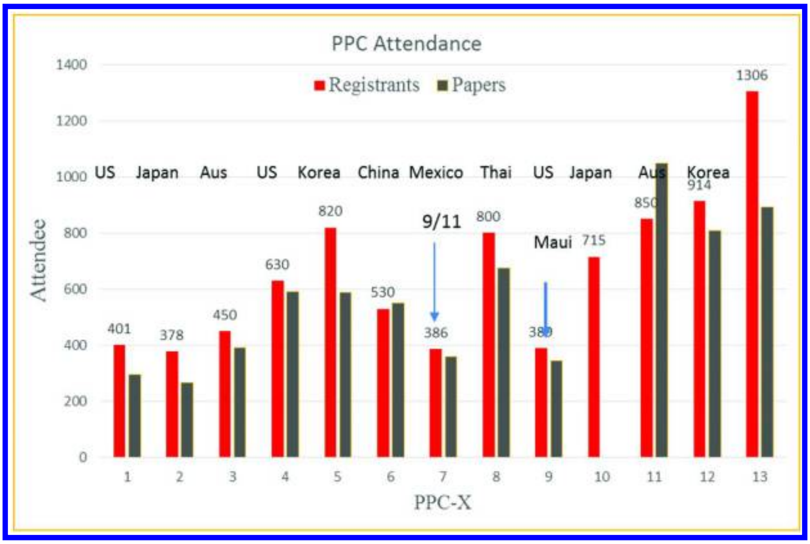

Figure 3. PPC registrants and contributed papers over time. (Courtesy of the ACS Division of Polymer Chemistry, Inc. Used with permission.)

The Federation may distribute a bulletin (or other forms of information) to its members and other interested organizations. These include newsletters as reports for each conference, minutes of Council meetings, Council member introductions, and upcoming workshops and symposia.

The members of the current PPF Council are shown in Figure 4. Professor Krzysztof Matyjaszwski, Carnegie Mellon University, currently serves as the President of PPF.

Joint Symposia

The PPF has held bi-national, U.S.-Mexico symposiums on advances in polymer science, known as MACROMEX. MACROMEX 2008 took place in Los Cabos, Mexico, and approximately 200 papers and posters were presented. This number rose to 250 in the second U.S.-Mexico symposium, MACROMEX 2011, which took place in Cancun, Mexico. MACROMEX 2014, which Canada is invited to participate in, is scheduled for December 3-6, 2014 at the Paradise Village Resort in Nuevo Vallarta, Nayarit, Mexico.

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PPC 14

The 14th Pacific Polymer Conference is scheduled for Wednesday, December 9 to Sunday, December 13, 2015 at the Grand Hyatt Resort and Spa in Kauai, Hawaii, U.S.A. (*2*). The Conference will take place immediately prior to the International Chemical Congress of Pacific Basin Societies (Pacifichem 2015), which will be held from Tuesday, December 15, to Sunday, December 20 in Honolulu, Hawaii, U.S.A. It will feature 21 symposia on macromolecules and 35 symposia on materials and nanoscience.

Figure 4. The current PPF Council. (Courtesy of the ACS Division of Polymer Chemistry, Inc. Used with permission.)

The objective of PPC-14 is to develop an outstanding technical program which features international intellectual diversity in polymer science, create a pleasant social atmosphere for all participants, and promote future productive interaction among members of the Pacific Polymer Federation.

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1. For more information on the history of PPF, see *Polymer Chemistry Division History Page*; http://www.polyacs.org/46.html (accessed Jan 27, 2015).
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Chapter 10

Perspectives from the Brazilian Chemical Society (SBQ)

Adriano D. Andricopulo*

Instituto de Física de São Carlos, Universidade de São Paulo, São Carlos, SP 13566-970, Brazil
***Email: aandrico@ifsc.usp.br.**

Since its creation, the Brazilian Chemical Society (SBQ, Sociedade Brasileira de Química) has been working with Brazilian scientific community to promote the progress of chemistry in all areas through a number of regional, national and international programs. SBQ has established a solid platform to become a scientific society of the future, with excellence in all academic and scientific activities, while contributing to the development of chemistry with growing political and social clout. SBQ is constantly committed to identifying and encouraging new international collaborations to build bridges for further development and improvement of the quality of life through chemistry. One of our most important activities is to build international collaborations with other scientific societies and promote a wide range of activities, including meetings, special programs, and large conferences in all areas of chemistry. An excellent example is the successful "Science Without Borders" program from the Brazilian Federal Government (via CAPES and CNPq). In 2017, Brazil will host for the first time the IUPAC World Chemistry Congress, on the occasion of the celebration of the 40th anniversary of SBQ. This initiative is expected to bring an entire contingent of chemists in Brazil closer to the global chemistry community.

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ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

Overview of the Brazilian Chemical Society

The SBQ was founded in July 1977 and is the leading chemical society in Brazil. It is also one of the largest scientific societies in Latin America, with over 5,000 members. The SBQ is devoted to the development and growth of the Brazilian chemical community, the dissemination of chemistry information, and the use of chemistry to develop the country and improve the quality of life.

The SBQ is governed by elected officials, currently comprising President Adriano D. Andricopulo (University of São Paulo - USP), President-Elect Aldo J. G. Zarbin (Federal University of Paraná - UFPR), Vice-President Luiz H. Catalani (University of São Paulo - USP), Secretary-General Luiz F. da Silva Jr. (University of São Paulo - USP), Secretary-Adjunct Silvio D. Cunha (Federal University of Bahia - UFBA), Treasurer Rossimiriam P. Freitas (Federal University of Minas Gerais - UFMG), and Treasurer-Adjunct José D. Figueroa Villar (Instituto Militar de Engenharia - IME).

The SBQ is also governed by an advisory board composed of Vanderlan da S. Bolzani (UNESP), Fernando Galembeck (UNICAMP), Marília O.F. Goulart (UFAL), Antonio L. Braga (UFSC), Maria D. Vargas (UFF), Hans Viertler (USP), and Vitor F. Ferreira (UFF). A majority of the SBQ's administrative activities are organized and carried out by the Executive Office, located in São Paulo.

The SBQ holds annual meetings, generally in the last week of May. It is the largest chemistry event in Latin America, attended by about 2,500 – 3,000 researchers, teachers and students. While most of the annual meetings have taken place in Águas de Lindóia – SP (Figure 1), the 34th meeting was held in Florianópolis – SC. The 38th Annual Meeting of the SBQ will take place on May 25-28, 2015 in Águas de Lindóia – SP.

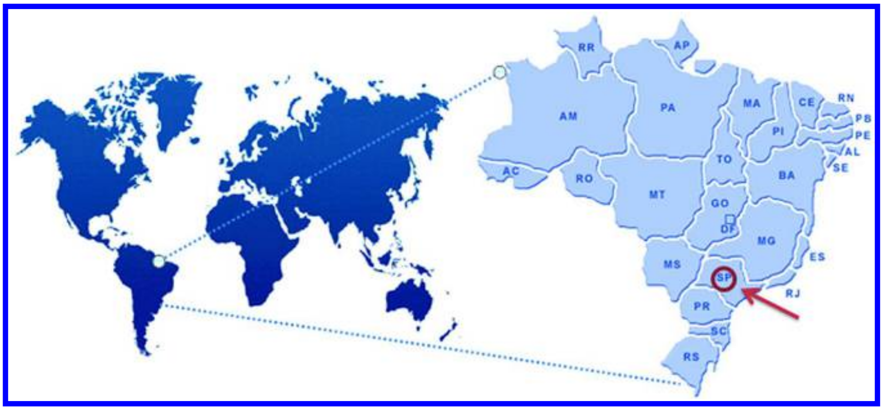

Figure 1. Águas de Lindóia is located in Sao Paulo State- Brazil. Reproduced with permission from Sociedade Brasileira de Química.

The SBQ has 13 scientific divisions to cater to a diverse range of member chemistry interests. These divisions are inorganic chemistry, materials, medicianl chemistry, organic chemistry, analytical chemistry, environmental chemistry, natural products chemistry, photochemistry, physical chemistry, education,

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catalysis, electrochemistry, and food & beverages. Several divisions promote international biannual meetings (e.g., BMOS, BrazMedChem, and BMIC). The board of directors for each scientific division consists of a director, a vice-director and a treasurer, who are elected by the full members every two years.

The SBQ has 22 regional offices located throughout Brazil. Each regional office has a board of directors with a secretary, a vice-secretary, and a treasurer. The regional offices offer a diverse and comprehensive collection of activities to serve chemists and other professionals in different regions of Brazil. SBQ Regional Meetings are hosted and supported by the Regional Offices to disseminate information to members.

SBQ Publications (*Publi*SBQ, Figure 2) is an organ of the SBQ used to communicate scientific activities, technical and educational interest articles, and related news. Its main mission is to produce publications of interest to the national and international chemical community: chemistry professionals from universities and industries and chemistry students at the high school, college, and graduate levels. It also serves as an outreach mechanisms for the layman and young people. SBQ edits and publishes four journals: The Journal of the Brazilian Chemical Society (JBCS), Química Nova (QN), Química Nova na Escola (QNEsc), Revista Virtual de Química (RVq), along with a weekly digital edition, Boletim Eletrônico, and Química Nova Interativa (QNInt), the latter of which is designed for teaching students at the middle and high school levels. In addition, QuiD^{+} is an interactive site which provides children and prospective students with information for the study of chemistry. These publications can be accessed by visiting http://publisbq.org.br/

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Figure 2. The SBQ Publications homepage. Reproduced with permission from Sociedade Brasileira de Química.

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SBQ International Activities

SBQ believes that education, science, technology and innovation are strategic drivers in ensuring the social and economic advancement of the country. During the last few years, the SBQ has become more and more active internationally, with conferences, workshops, and other activities. Globalization is increasingly connecting people and ideas across cultural, political, social, economic and geographic divides, and SBQ recognizes the importance of having a strong global network.

It is increasingly important to further international interactions with other chemical societies around the world and the chemical science community, as there are many common challenges, responsibilities and interests amongst these organizations. It is also necessary to be constantly open to new information and willing to listen to different perspectives. In addition, it is particularly important to stimulate and promote the creation and use of new scientific information to advance the health, prosperity, and quality of life for all people around the world. Chemistry will continue to be central to achieving these goals.

Relevant SBQ activities can be broadly grouped into three categories:

1. Innovation and international collaboration in areas of mutual interest
2. Joint conferences, symposia, workshops and related events (both in Brazil and abroad)
3. Education and training of students and young Brazilian scientists

Science Without Borders Program

Funded primarily by the Brazilian Government, the Science Without Borders scholarship program was launched in July 2011. The Science Without Borders Program aims to boost Brazilian science, technology, innovation and competitiveness through the promotion of international mobility. It increases the presence of Brazilian researchers and students at various education levels at academic and research institutions abroad. Additionally, Brazilian institutions provide similar opportunities for foreign scientists and students in Brazil. It increases the innovative expertise of personnel from technological industries and attracts young scientific talent and highly qualified researchers to work in Brazil.

The program follows the national development strategy of investing in people, i.e., developing the skills and competence needed to be successful in today's knowledge based economy. This strategy focuses on national challenges, such as expanding engineering and other technological areas. The program also promotes industrial research, development, and investment.

The priority areas for the program are engineering and other technological areas, natural sciences, health and biomedical sciences, computing and information technology, aerospace, pharmaceuticals, sustainable agricultural production, oil and gas, nuclear energy, renewable energy, minerals, biotechnology, nanotechnology and new materials, technology for prevention and mitigation of natural disasters, biodiversity and bioprospection, marine sciences, technologies for the green economy, new technologies for constructive engineering, and capacity building for technical personnel.

Presently in Brazil there are 2,377 higher education institutions, with 7.2 million enrolled undergrads, a million of which graduate annually. There are 190,000 graduate students pursuing Master's or PhD degrees, with 43,000 Master's program graduates and 14,000 PhD graduates annually.

PhD students participating in the Science Without Borders can enroll in a "Sandwich" Fellowship, where they earn a "sandwich" PhD. Students begin their academic and research activities in Brazil, continue their academic and research activities at an institution abroad, then finish their academic and research activities/PhD theses back in Brazil.

As part of the program, undergraduate students go abroad for 12 months, or possibly longer if an internship in a laboratory or industry is included. PhD students receive support for doctoral academic degrees abroad, either in full PhD programs or in 12-month "sandwich" stays. Postdoctoral fellowships at institutions abroad are also available for candidates with doctorate degrees, for a minimum of 6 months and a maximum of 24 months.

Young post-docs working abroad, who excel both qualitatively and quantitatively in their scientific or technological careers, are qualified to receive funding and resources to perform one- to three-year research projects in Brazil.

There are also opportunities for Brazilians or foreigners from abroad to come to Brazil for academic or research purposes. Senior researchers/leaders can receive support to perform joint projects with research groups in Brazil and can work in the country for up to three months every year over the course of three years. PhD students and post-docs are also encouraged to work on projects both in Brazil and abroad. The benefits of participating in this program include the coverage of travel and living expenses, post-doc and PhD fellowships, and funding for the local laboratory and the individual researchers.

The program aims to send 101,000 Brazilian students to study internationally by 2015. 64,000 of these students will be undergraduates in "sandwich" fellowships, 15,000 will be PhD students in "sandwich" fellowships, 4,500 will be full PhD students studying abroad, 6,440 will be postdoctoral fellowships abroad, and 7,060 will be fellowships for industrial scientists and engineers. In addition, Brazil aims to bring 2,000 talented, young individuals to the country to study and 2,000 leading scientists to visit Brazil. About 75,000 of these fellowships will be funded by the Brazilian government and 26,000 by the private sector.

Brazilian students are currently enrolled in fellowship programs in 30 different countries around the globe. The main travel destinations of these students include the United States, followed by the UK, Canada, France, and Australia (Figures 3 and 4).

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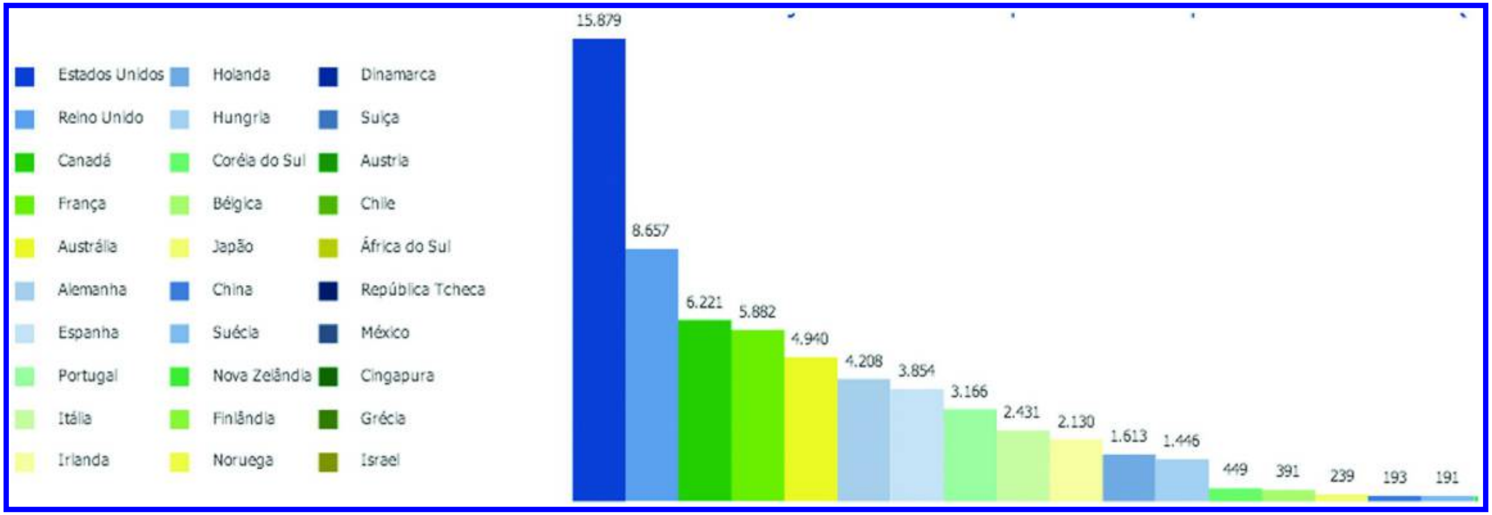

Figure 3. The distribution of Brazilian students abroad in the Science Without Borders program. Reproduced with permission from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

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Figure 4. Geolocations of Brazilian students studying abroad through Science Without Borders fellowships in the U.S. Reproduced with permission from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

IUPAC 2017

The 46th IUPAC World Chemistry Congress will take place for the first time in South America, July 3-11, 2017. The organizing committee for the 46th IUPAC consists of Adriano D. Andricopulo (Chairman), Vitor F. Ferreira, Fernando Galembeck, Vanderlan da Silva Bolzani, Jailson Bittencourt de Andrade, Luiz Henrique Catalani, Lui Fernando da Silva Jr., Aldo José G. Zarbin, Claudio José de A. Mota, Adriano L. Monteiro, Maria Domingues Vargas, Rochel Montero Lago, Fernando Figueiredo, and Paulo Coutinho. The organizing committee will work jointly with SBQ to oversee an international advisory board, IUPAC secretariat, the scientific committee, and the financial committee.

The venue chosen for IUPAC 2017 is the Transamerica Expo Center. This location features state-of-the-art technology and modern infrastructure, covering an area of 100,000 square meters, thus making it one of the best Convention and Exhibition Centers in Brazil. It offers a variety of services such as coffee shops, restaurants, convenience store, foyer, printing services, telephone/internet services, courier, beauty salon, cafeterias, and airline offices.

As part of the World Class Program, SBQ will conduct the IUPAC General Assembly, IUPAC Congress and SBQ 40th Congress in parallel. The logistics will be carried out by the Congress Organizing Committee and SBQ. The Transamerica Expo will easily accommodate the technical programs and the General Assembly running side-by-side.

The Brazilian Chemical Society will provide the IUPAC congress with interesting and valuable scientific programs. SBQ will invite prominent speakers from all over the world in academic and industrial fields of chemistry and related disciplines. Many international scientists will be invited to chair sessions in their specialties.

SBQ is expected to have eight to ten plenary lectures and around forty symposia in several scientific areas, and four poster sessions. Six to eight Nobel laureates will be invited to participate in the 2017 IUPAC Congress.

Conclusion

SBQ, with all of its activities and the challenge to host the IUPAC World Chemistry Congress 2017, has shown that it is not just a chemistry leader in Latin America, but a potential global chemistry leader of the future. SBQ's strong efforts to spur the scientific education and international collaboration of its youth, as well as its focus on research, development and investment, make it well positioned to take on the chemical and scientific challenges of the future. SBQ is a good example of how international collaboration and investment in the people can lead to successful research endeavors and a dynamic chemistry community.

Additional Reading

1. For more information on Science Without Borders, see the following link: http://www.cienciasemfronteiras.gov.br/web/csf-eng/ (accessed 8/14/15).

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Chapter 11

Towards A Sustainable Partnership Between ACS & FACS: What's Next?

T. S. Andy Hor*

President, Federation of Asian Chemical Societies (FACS)
President, Singapore National Institute of Chemistry (SNIC)
Executive Director, Institute of Materials Research & Engineering (IMRE), A*STAR, Singapore
Professor of Chemistry, National University of Singapore, Singapore
***E-mail: andyhor@imre.a-star.edu.sg.**

Today, the Chinese economy (GDP US$9 trillions) is bigger than those of Germany ($3.6 t), France ($2.7 t) & UK ($2.4 t) put together. The combined economies of China, Japan ($5.1) and India ($2.0) are matching that of the USA ($16.2). By 2018, the Chinese economy alone is expected to reach 70% of the U.S. economy. The accelerating growth of Asian economies has brought along immense opportunities not only in business but also in research collaboration, adoption of new technologies, and education exchanges. The emergence of Asia has presented exciting prospects in the chemical sciences – from education to technology, from environment to energy, from health to business. How do we grow the partnership between ACS and FACS (Federation of Asian Chemical Societies) amidst these vigorous developments and changes? What are the biggest opportunities that Asia has presented and the challenges that the strategic partnership will face? In this article, the author touches on these topics and gives his views on the way forward.

Introduction

The Asian economies have grown remarkably in recent years in chemical sciences, from education to technology, environment to energy, and health to business. This development opens up opportunities for collaboration between

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American Chemical Society (ACS) and Federation of Asian Chemical Societies (FACS). Indeed, FACS and ACS have agreed to enter a three-year collaboration alliance characterized by mutual benefit, impact and a commitment to cooperation in service to chemical scientists, engineers and professionals. This alliance serves to strengthen the shared interest of each organization in engaging the Asian and U.S. chemical communities in collaborations, research, education, and meetings (*1*).

In 2011 the Asia America Chemical Symposium (A2CS) was organized as a partnership between the ACS and the FACS. It was first held at the ACS national meeting in Anaheim in March 2011, where the theme was “Energy and Food.” The second symposium was held at the Asian Chemical Congress (ACC) in Bangkok in September 2011, and the theme was “Quality of Water.” These were followed by the next two symposia at the ACS national meeting in Philadelphia in August 2012 with the theme “Materials for Health and Medicine” and the ACC meeting in Singapore in August 2013 with the theme “Advanced Materials.” In the ACS national meeting in San Francisco in August 2014, the fifth A2CS was held, where the theme was “Global Stewardship and Chemistry Innovations for Sustainable Agriculture & Food Products.” The next meeting opportunity will come at the ACC meeting in Bangladesh in November 2015, which will focus on “Scientific Ethics.”

Whereas the A2CS is a fruitful collaboration between FACS and ACS, the question may be asked, “What’s next?” How do we grow the partnership between ACS and FACS? What are the biggest opportunities that Asia presents and the challenges that a strategic partnership will face?

Perspectives from FACS

The Federation of Asian Chemical Societies (FACS) is a federation of 28 chemical societies of countries and territories in the Asia Pacific (*2*). Membership of the Federation is open to all not-for-profit chemical societies whose membership consists largely of individual qualified chemists and which are national professional chemical societies of countries and territories in the Asia Pacific. Individual membership is open to individual chemists from the Asia Pacific. The general objective of the Federation is to promote the advancement and appreciation of chemistry and the interests of professional chemists in the Asia Pacific.

There are many challenges and opportunities facing FACS. Among the challenges, one issue relates to the differences that exist between the FACS member countries. On an economic level, there are countries at different stages of development, from third-world to first-world nations. There are also different and often contrasting cultures, practices, and priorities between these countries. The member countries’ divergence and occasional tendency towards fragmentation require prudent management. Furthermore, part of the chemical industry is being commoditized, resulting in lower commercial value. As for FACS itself, it has limited institutional and public resources, and there is a challenge to assure leadership continuity.

Despite these challenges, many opportunities for FACS can be envisioned. Many of the Asian countries have fast-growing economies and large populations. There is a substantial commitment to education and innovation in FACS member societies, and research output is increasing exponentially in several FACS member countries, with Singapore and China among the examples. The open innovation concept has been a positive driver in this growth. The member countries are also rich in diversity, and most of them have significant room for growth.

In any successful partnership, a number of factors need to be considered (Figure 1). First, there needs to be mutually beneficial outcomes due to the partnership. For example, these benefits may result from synergistic or complementary skills, services, or resources. Secondly, there needs to be mutual trust and respect. The partnership can agree to disagree and be willing to give and take. Thirdly, the partnership must be responsive to needs, changes, and opportunities. There should be regular reviews of activities, including efforts to look far and wide for opportunities – all guided by common, long-run goals.

In the case of FACS-ACS relationship, perhaps we can use the three-step process shown in Figure 2. A good starting point towards realizing the partnerships potential is through symposia. Symposia provide an opportunity to build on common themes, create networks and community awareness, help both partners drive for membership and allow them to share knowledge with each other. Indeed, we have started the A2CS as our first step in our interactions.

Figure 1. Key to a sustainable partnership.

The next logical step is collaboration. This means putting ideas such as faculty and student exchanges, collaborative projects, one-on-one society interactions, grant agency reach-out, and co-developments of emerging technology areas into action.

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The final step is propagation. This may involve catalyzing the development of chemistry in Asia, designing activities to specific country needs, introducing other societies into the partnership, and promoting industry and capability building.

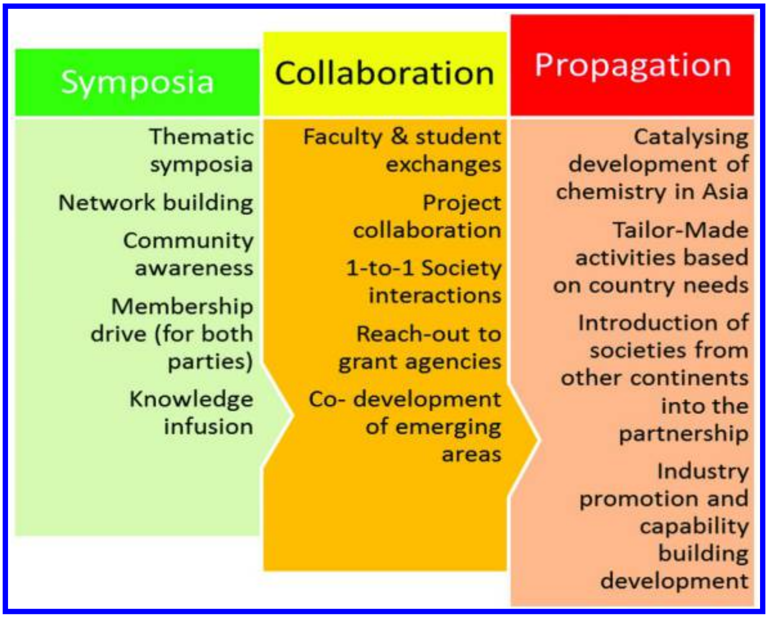

Figure 2. Possible steps and activities in the development of Asia-American partnerships.

What Does ACS Bring to the Table?

Like FACS, ACS is a professional organization that is focused on chemistry and allied disciplines. Meetings and publications are major parts of ACS activities. These are obvious areas for possible FACS-ACS collaborations. The A2CS (as mentioned above) is a good example

Over the years ACS has developed a wide array of resources and services for its members (*3*). Many of these resources are very useful to practicing chemists and students. For example, ACS has developed useful professional workshops (Figure 3). These workshops will be of interest to FACS and its member societies. Students can certainly benefit from workshops on resume writing, career opportunities, presentation and communication, and ethics training. Academics can learn how to better compete for grants, engage in emerging research fields and publications, and share experience with editors. Industrial professionals can learn more about laboratory management, quality control, technique development, and lab and process safety.

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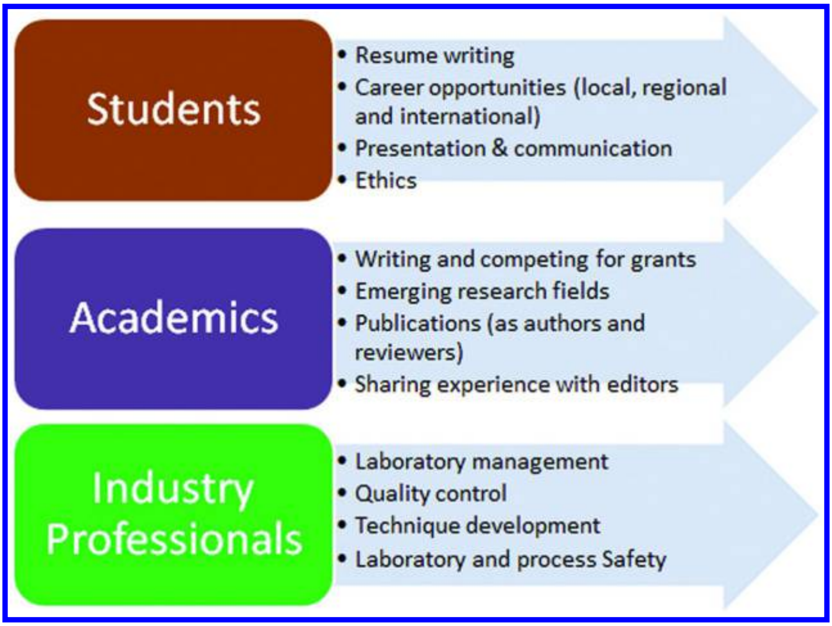

Figure 3. ACS workshops and some of the benefits for students, academics, and industry professionals.

ACS International Chapters are also important in the interactions with FACS. They provide visibility and stimulate local development through their scientific activities. ACS International Chapters can facilitate chemistry education, career and professional development, and present opportunities for partnerships with local chemical societies, networking, and regional outreach.

Further FACS-ACS Interactions

There are a number of possible areas for future FACS-ACS collaboration, such as faculty and student exchange programs, industrial consortia, trilateral agreements with a third party, and collaborative programs with individual chemical societies within FACS.

FACS-ACS Exchanges, Travel Grants, and Awards

One way for ACS and FACS to work together is to promote faculty and student exchanges; education and industry tours; conferences, symposia, and workshops. This may lead to joint conferment of FACS and ACS-styled awards, fellowships and lectureship opportunities, and global ambassadors, which may in turn propagate a new round of exchanges, tours, and workshops.

International Chemistry Olympiad

The International Chemistry Olympiad (IChO) is an annual academic competition for high school students. It is one of the International Science Olympiads. The first IChO was held in Prague, Czechoslovakia, in 1968. The event has been held every year since then, with the exception of 1971. In the IChO 2013 in Russia, there were 75 participating countries with 300 student contestants. Among the 34 gold medallists, 19 or 56% came from FACS member-countries. In the IChO in July 2014 held in Hanoi (Vietnam), the top student came from Singapore. This shows the advancement of a small country in FACS.

Over the course of three decades, Singapore started by joining the IChO, then started its own Singapore Chemistry Olympiad (SChO) for senior high school students, and later created the Junior Chemistry Olympiad (JChO) for junior high school students. This completed the education value chain for chemistry learning in an open environment in the entire secondary and pre-university space.

Of course, the U.S. has been active in IChO as well. What can we do together and learn from each other? If so, this would show the potential of cross-Atlantic and cross-Continental chemistry learning and exposure.

Catalysing Industry Engagement

Industrial engagement can be a fruitful activity for ACS and FACS. Of the top 20 global chemical companies, eight of them, or 40%, are Asia-based. These companies include Sinopec (China, 2nd), SABIC (Saudi Arabia, 4th), Formosa Plastics (Taiwan, 4th), Mitsubishi Chemicals (Japan, 11th), LG Chem (S. Korea, 13th), Mitsui Chemicals (Japan, 17th), Sumitomo Chemical (Japan, 19th), and Reliance Industries (India, 20th). These companies are key drivers of the knowledge-based economy that we are in. We should seriously consider bringing these industry partners on board to enrich the collaboration between ACS and FACS.

Opportunities for Single-Country Platforms

There are several chemical societies within FACS that are rife for collaboration with ACS. In each case, FACS can serve as a bridge to facilitate interactions. For example, ACS can work with individual chemical societies to form industrial consortia, to present professional workshops, or to collaborate on the organization of National Chemistry Week

A few suggested chemical societies include Institute of Chemistry Ceylon (IChemC), the Institute of Chemists, Papua New Guinea (ICPNG), the Chemical Society Located in Taipei (CSLT), the Chinese Chemical Society (CCS), Chemical Society of Thailand (CST), and the Singapore National Institute of Chemistry (SNIC). There are of course many others. Many of these societies are eager to work with ACS, may it be in educational projects or technical workshops, or cross-continental symposia. FACS can facilitate such partnership.

IChemC is a professional learned society with a membership of 1,500. Its activities include an annual session, international conferences, science

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popularization programs, and professional lectures among others. Its educational arm, the College of Chemical Sciences, offers a Graduate program in Chemistry and a Diploma in Laboratory Technology in Chemistry.

ICPNG, established in 2006, conducts several activities in promoting chemistry. It supports upper secondary chemistry education, including preparing syllabi and publishing two chemistry textbooks. ICPNG also supports tertiary education, with its members teaching bachelors' programs, conducting research, and supervising graduate level programs. The organization also holds chemistry conferences and publishes an annual Chemistry Journal. In addition, The President of ICPNG chairs the Chemical Standards Committee of Papua New Guinea.

The Chemical Society in Tapei has four regional divisions, 2,000 active members, three society publications, and a number of activities including annual meetings, workshops, a chemistry camp for high schools, a chemistry show truck for middle schools, and training courses for professionals.

The Chinese Chemical Society, founded in 1932, has over 50,000 members, 31 local branches, three overseas branches, and a number of discipline and working committees. CCS Congress is the largest meeting in the field of chemistry in China, with over 5,000 attendees, and is the co-organizer of CS3 (Chemical Sciences and Society Summit) with ACS and several other groups.

The Chemical Society of Thailand has over 3,000 members, hosts the PACCON International Conference, and runs the Standard Chemistry Test Project. It has also been involved in 11 FACS projects, as well as several ACS meetings.

The Singapore National Institute of Chemistry (SNIC) was formed in 1970. It organizes professional meetings, seminars, symposiums, talks, congress and exhibitions and publishes newsletters and a bulletin. SNIC promotes chemical education by organizing talks on chemistry and chemistry-related contests for secondary students. In 2013, it organized the hugely successful 15th Asian Chemical Congress with nearly 1,500 local, regional and international delegates. This was followed by another major meeting in 2014 in the 41st International Conference on Coordination Chemistry. In 2015, it will celebrate Singapore's 50th national birthday in hosting the Golden Jubilee Chemistry Conference in August.

Conclusions

There are several collaboration models that may be applicable to the relationship between FACS and ACS. The first relates to the ongoing A2CS meeings. The question is what we should do next. Also in consideration are the possible catalytic and propagating effects of this symposium. The Gobal Innovation Imperatives (Gii) bought to Asia under the partnership of ACS and SNIC held in Singapore in December 2014 was an example of such propagation. It created the Water Innovation Treatment & Solutions (WITS) to discuss innovative methods and technological solutions in water purification and desalination in an urban environment. Workshops of this nature could offer significant value to many developing countries in Asia where reliable fresh and clean water supply is still one of the national priorities.

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Another option is to establish a possible tri-lateral consortium involving ACS, FACS, and a third partner. Such consortium may also accept industry partners to join force to take on some of the global challenges. An example would be the cooperation between SNIC and ACS as well as a global giant such as Procter & Gamble (P&G) in raising the awareness of consumer care needs and R&G growth. P&G's recent establishment of a major research center in Singapire is a good example of public-private partnership that strives to raise the quality of life through science and innovation. FACS and ACS should participate in such a partnership.

A third option is for ACS to engage in the region with FACS acting as a facilitator. The engagement may involve regional workshops, meetings, and exchanges. The WITS forum in Dec 2014 in Singapore is just one of the many possibilities. Different types of engagement may be tailored for developing and developed regions.

Finally, a one-to-one partnerships with ACS and a local society (single country platform) may be considered. The FACS can act as a bridge to these partnerships to assist with industrial consortia, professional workshops, National Chemistry Week, and other activities.

Acknowledgments

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Chapter 12

International Research Funding in the Chemical Sciences: Latest Developments

Markus Behnke*

Program Director, German Research Foundation (DFG), Kennedyallee 40, 53175 Bonn, Germany
***E-mail: markus.behnke@dfg.de.**

International collaboration is common practice in the chemical sciences for a long time. Within a changing research world international collaboration has become even more important in achieving scientific success and the participants are forced to identify appropriate funding sources. Support for scientific research is mostly provided by the national funding organizations. Traditionally, the national funders are reluctant to support non-domestic researchers, and in practice, funding truly international research projects can be a real challenge for a variety of technical and bureaucratic reasons. This article will gives a short overview on the history of international funding initiatives to support collaborative research. It will shine some light on the most recent developments of bilateral international funding programs. The readers will also learn more about a prominent showcase of a first multilateral funding program. Under the umbrella of the IUPAC, the funding partners succeeded to overcome administrative hurdles to shape a really international research area that strengthens collaborative research in the chemical sciences.

German Research Foundation (DFG): Our Mission

The DFG is the self-governing organization for science and research in Germany. It serves all branches of science and humanities (Figure 1). The DFG is an association under private law. Its membership consists of German research universities, non-university research institutions, scientific associations and the Academies of Science and the Humanities. The DFG receives the large majority of its funds from the German states and the Federal Government, which are represented in all Grants Committees. At the same time, the voting system and procedural regulations guarantee science-driven decisions. The chief task of the DFG is to select the best research projects by scientists and academics at universities and research institutions on a competitive basis and to finance these projects.

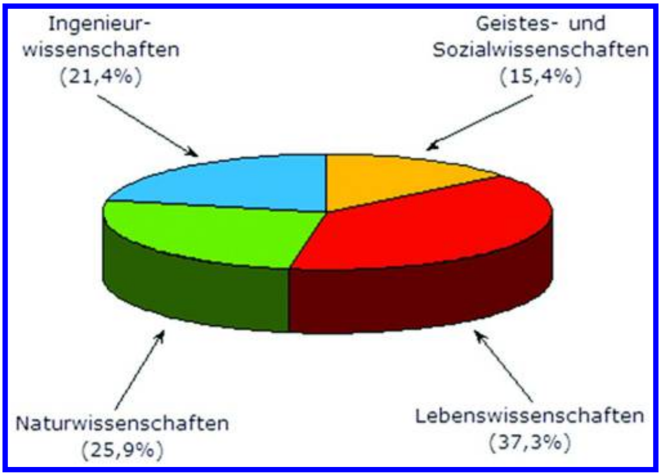

Figure 1. DFG has a budget of >2.7 billion euros, 21.4% in engineering sciences (blue), 15.4% in social sciences and humanities (yellow), 25.9% in natural sciences (green), and 37.3% in life sciences (in red).

One of the DFG's key objectives is the promotion of young scientists and researchers and it therefore offers them programs which provide appropriate support at every phase of their qualification. The DFG funds excellent science without regard to extra-scientific factors. Equal treatment of men and women and broad representation of the scientific disciplines in the self-government of the DFG ensure the diversity and originality required for outstanding research.

The DFG gives policy advice to parliaments, governments and public institutions on scientific issues. As the voice of science in political and social discourse, it counsels and partakes in political decision making processes with scientific expertise. For this purpose, its regulations on good scientific practice provide **internationally recognized guidelines**.

The foundation actively encourages **international research cooperation**: all of its programs promote cooperation between scientists and academics in Germany and their colleagues abroad. It places special emphasis on collaboration in the scientific community in the European Research Area and worldwide.

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Early International Collaboration in Chemistry (*1*)

Chemistry is an international science per se and one of the founders of the modern organic chemistry, Justus von Liebig (1803 – 1873), was known to have international students and colleagues visiting his lab on a regular base. Liebig was one of the first to establish teaching in laboratory classes with hands-on lectures. He invented quite a number of innovative instruments for the lab. The Liebig condenser is well known. Another instrument is called the five-bulb or kali apparatus which allowed 19th Century chemists to determine the nature of organic molecules and their reactions. In 1842 J.L. Smith visited Liebig's lab. Smith was one of the founders of the American Chemical Society and it is more than a coincidence to find the kali apparatus incorporated in the logo of the ACS (Figure 2).

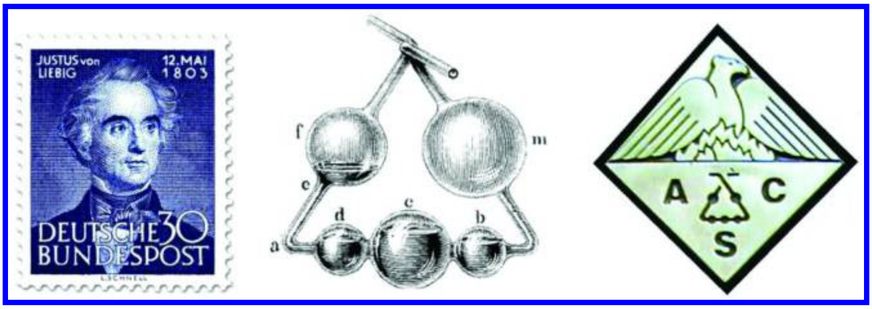

Figure 2. Left picture shows the likeness of Liebig on a German stamp. The middle picture portrays the kali apparatus designed by Liebig. The right picture shows the ACS logo, with the kali apparatus below the phoenix.

ERA-Chemistry (*2*)

The more recent history of collaborative research and research funding brings me to a network of European funding agencies. ERA-Chemistry was founded within the European Research Area Network scheme (ERA-NET) of the European Commission (EC). It started in the Framework Program 6 in 2004. ERA-Chemistry aimed at improving the coherence and coordination across Europe of research programs and projects considering the research field chemistry as a representative example. In order to attain this goal, the ERA-Chemistry consortium envisaged the establishment of an ERA in curiosity-driven chemical research (basic and applied chemistry including chemistry-based trans-disciplinary projects) without noticeable national, formal and research subject boundaries. ERA-Chemistry achieved a substantial list of goals within the previous years. Among them:

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- Setting up a common information system on reviewing and funding chemical research (including chemistry-based trans-disciplinary research) in all European countries.
- Providing simple, effective and jointly agreed processing and evaluation schemes for trans-national proposals.
- Setting up electronic infrastructure facilities for trans-national communication and for submitting and reviewing trans-national proposals.
- Encouraging chemists across Europe to combine their complementary expertise in joint trans-national projects.
- Developing and implementing sustainable joint European research programs in chemistry in all degrees of complexity, including joint management of these programs.
- Increasing the competitiveness of chemical researchers in Europe by developing and implementing a truly integrated European research conference scheme (Flash Conferences).
- Launching trans-national thematic calls for proposals with fixed budgets and deadlines.
- Launching trans-national open calls for proposals in all fields of chemical research.
- Providing a framework for jointly agreed, earmarked/commonly financed chemistry-based trans-national research programs and projects.

The Perfect Funding Program – List of Wishes

As part of their tasks the ERA-Chemistry partners did also surveys among scientists. One of the key questions was how to facilitate international collaboration. The result is a list of wishes for the "perfect funding program":

- Submission any time (no deadline)
- Free choice of collaboration partner
- Bi- and multilateral collaborations – benefit of "Global Research Area"
- No thematic restriction
- Joint proposal
- Joint review process
- Joint decision – avoid double jeopardy
- Short time line to funding decision (≤ 6 months)
- Less bureaucracy
- Full package of cost items (personnel, consumables, instrumentation, travel)
- Renewal proposals
- High success rate

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.;
ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

Bilateral DFG/NSF Proposals Collaborative Research in the Chemical Sciences

There is a long tradition of joint collaboration among the major funding agencies in the US and Germany. Starting in 2005 the National Science Foundation (NSF) and the German Research Foundation (DFG) seek to further enhance opportunities for collaborative activities in chemistry between U.S. and German investigators. Once a year both organizations accept new collaborative research proposals and renewal proposals between chemists from the U.S. and Germany. Projects must have clear relevance to areas supported by both NSF and DFG Divisions of Chemistry. The duration of the projects should be three years. These joint proposals pass through a joint review process with a joint decision. In this way, the usual drawbacks of international funding programs like double jeopardy are avoided. While working jointly on the review process, the program directors involved on both sides of the Atlantic Ocean gain experience and cultivate their friendship. On the average, seven grants on each side have been funded each year. Meanwhile the acronym for International Collaboration in Chemistry (ICC) is well known to many chemists around the globe and the program has been expanded to more and more countries. The program is evaluated at the moment to be further optimized and enhanced in the near future.

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IUPAC - Committee for Chemical Research Funding (CCRF) (*3*)

Starting in 2004 IUPAC was the host of two projects that focused on "International research funding in the chemical sciences" and "IUPAC's role in international research funding in the chemical sciences: a feasibility study". Members have been representatives of major funding agencies from more than 16 countries. Meetings and workshops took place along with IUPAC General Assemblies or other international conferences. Given the results of the previous projects that envisioned the need of a long-term involvement of research funders in the organizational structure of IUPAC the Committee on Chemistry Research Funding (CCRF) was established in 2008. It is reporting directly to the IUPAC Bureau (Figure 3). CCRF is a forum of representatives from research funders to improve the communication among their organizations and to help developing best practices for international research collaboration. The CCRF operates in a rather flat hierarchy. The immediate past president of IUPAC chairs the committee for two years. Members of the CCRF are nominated by any national organization that provides substantial funding to research in the chemical sciences. Each participating organization is expected to maintain its principal representative as a current staff member engaged in chemistry research funding. At the moment 14 national organizations are partnering within the committee. One of the nominated members is running a secretariat to support the chair and to ensure continuity of CCRF's actions.

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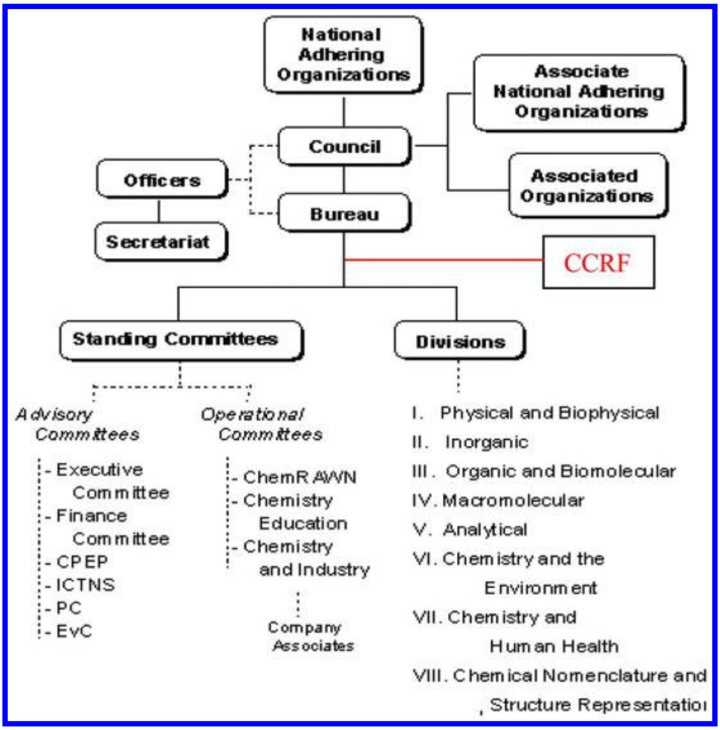

Figure 3. Schematic, showing how CCRF fits into the IUPAC organization.

CCRF's aim is to provide shared guidance, especially on mechanisms for review and support of research in the chemical sciences. The committee was engaged in the development of effective processes for multilateral funding programs on international level. The committee plays an important role is discussing open questions that are associated with the needs of small versus large countries and the needs of developed versus developing countries in an international scientific world with increasing interaction. Further topics are intellectual property issues, methods for tackling the "grand challenges" in the chemical sciences, ways to encourage greater participation and recognition of women in chemistry and the enhancement of the dialogue between scientists and program officers.

International Call for Proposals in Chemistry 2010 and 2013

Over the years the national members of the CCRF gained a lot of experience on bilateral calls for proposals. Knowing that the administrative obstacles are rather high, a core group of the CCRF members decided to work on a showcase for a first real multilateral call for proposals. The call was supported by the Polymer

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ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

Division of IUPAC and 7 national funding organizations that agreed to participate. It was announced in 2010 along with the preparation for the International Year in Chemistry (IYC) 2011. The goal of this pilot call was to establish an efficient transnational funding program in chemistry, without national boundaries, with a minimum of bureaucracy for the applicants, and the establishment of best practices for future calls of this type. An important key for achieving this goal was the establishment of a call secretariat as a central contact point for applicants, for the Polymer Division, and for the funding organizations. As a result 7 excellent joint projects out of 28 joint proposals were selected for support. Successful applicants reported on the results of their joint research efforts at a special session during the 44^{th} IUPAC World Polymer Congress in Blacksburg, Virginia, USA in June 2012.

A second call was conducted from October 2012 through September 2013. This was an initiative for joint proposals in the field of novel molecular and supra-molecular theory and synthesis approaches for sustainable catalysis. Based on a detailed evaluation the procedure followed the guidelines that were compiled and released under the IUPAC project for guidelines of multilateral calls. However, lessons learned and changing circumstances necessitated changes, especially in how the proposal review process was conducted. The Call was coordinated by the IUPAC Division of Chemistry and the Environment, and managed by a program manager through a Call Secretariat. Following the recommendations of an international review panel, again 7 joint projects have been supported.

Conclusion

The initial experiments with bilateral calls of national funders and the latest involvement of the CCRF led to a robust and mature tool for managing multilateral calls on international level. Key features are a central Call Secretariat for the call administration, the close interaction with one of the IUPAC divisions and the willingness of the funding partners to overcome administrative barriers to shape an international research area that strengthens collaborative research in the chemical sciences.

Coming back to the list of wishes, it may be said that quite a number of items have been successfully addressed. International calls for proposals with joint applications, joint review processes and joint decisions became more and more common practice. With the involvement of more funding agencies applicants are in the comfortable position to choose the most appropriate collaboration partner. On the other hand in the present situation it is still a difficult task to allow multilateral calls without thematic restriction. Also funding in response mode without submission windows and without deadlines is still a challenging task. It also seems obvious that in a funding world with budget restrictions, a high success rate will always be a dream.

The CCRF members will continue to further contribute to the international research area to enable international collaboration on the highest quality level. The next steps and future directions will be subject of the discussions during the next annual CCRF meeting.

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Chapter 13

International Collaborations in R&D: An Indian Perspective

Sanjeev Katti* and Ajit Sapre

Reliance Industries Ltd.,
Reliance Research & Development Center,
Navi Mumbai, India
***E-mail: Sanjeev.Katti@ril.com.**

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Reliance, one of the largest refining and petro-chemical companies in the world, is undergoing a major transformation with emphasis on research and development to support our businesses. We have embraced the open innovation concept. An integral part of our transformation strategy is sponsored R&D, including collaborations and joint development programs with appropriate Indian and international institutes and universities, National/CSIR Labs, start-up and established companies world-wide. While the U.S. is still the hub of innovation, R&D activities in the Asia Pacific are rapidly increasing. In the changing world, there should be more emphasis on international collaborations so that we can maximize the impact of innovations using the best facilities and the best minds. Yet, there are challenges in international collaborations, such as intellectual property (IP) issues, ownership and exclusivity. In spite of the challenges described above, we are open and committed to seek alliances and collaborate with centers of excellence anywhere in the world. We must do this to efficiently meet the aspirational needs of our growing world.

Introduction

As a major and still growing economic power in the world, India is looking at R&D and innovation with emphasis on implementation to make a difference in the lives of aspiring population. More specifically, we at Reliance, one of the largest refining and petro-chemical companies in the world, are undergoing a major transformation with emphasis on research and development to support our businesses. We have embraced the open innovation concept. An integral part of our transformation strategy is sponsored R&D, collaborations and joint development programs with appropriate Indian and International Institutes and Universities, National/CSIR Labs, start-up and established companies worldwide.

While the U.S. is still the hub of innovation with best eco-system, economic and hence R&D activities seem to be moving from West to East. Almost all major multi-national companies have or are planning to have their R&D centers in China and India. It has been claimed that India produces more scientists and engineers than the U.S. (*1*). According to World Intellectual Property Indicators for the year 2012, China ranks above the U.S. in both patent applications and application design counts (*2*). Even in the U.S. universities, more than half the PhDs granted in some engineering fields go to Indians and Chinese nationals (*3*). Science and engineering is seen as the career choice by the bright and talented young minds in India and China.

Another study shows that the number of doctorates awarded in China every year has constantly been increasing since 2002 whereas the U.S. has seen a comparatively smaller rise in the number of doctorates (*4*). China aims to increase its R&D spending to about 2.5% of its GDP by 2020 from the 1.1% of its GDP in 2013. On the other hand, the spending by the U.S. government has decreased to 0.8% of its GDP which is the lowest it has spent in 40 years.

In the changing world, there should be more emphasis on international collaborations so that we can maximize the impact of innovations using the best facilities and best minds. Certainly periodic face-to-face meetings are critical but with the use of advances in telecommunication and video-conferencing, initiating, monitoring and guiding the international joint R&D projects have become easier. Getting U.S. visa for attendance at scientific and business meetings takes a long time for chemical scientists and engineers from India and other developing countries. ACS has consistently brought up this issue with the U.S. government, but more needs to be done.

Some of the major challenges in international collaborations are intellectual property (IP) issues, ownership, and exclusivity. Each sovereign country has different patent rules and its own interpretations of the uniform WTO patent regulations. The companies would like to do sponsored research and in some cases get exclusive IP. The technology transfer offices of many universities insist on owning the IP and giving a non-exclusive or regional license to practice the technology. Also, the validity and interpretation of the international agreements is generally governed by the laws of an acceptable neutral third country. For example, an agreement between U.S. and Indian collaborators typically would be governed by the U.K. laws. However, there are some U.S. universities which are unable to agree on any jurisdiction other than their home state per their state laws. This creates unnecessary barriers for international collaborations.

We also need to evaluate innovative projects and collaborate with start-up companies, which are typically floated by post-docs and professors in incubation centers with financial support from venture capital (VC) firms. The VC model is effective in the IT and communication industry where the speed of development

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.;
ACS Symposium Series; American Chemical Society: Washington, DC, 2015.
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and deployment is relatively fast and the activities are not very capital demanding. Is VC funding the most efficient model for innovation in capital intensive industry such as ours (chemical, petro-chemical, industrial biotechnology, renewable energy, etc.)? In the capital intensive industry, incubation period is long and beyond the time horizons of VC return expectation. It took a few decades to go from the discovery of penicillin to a commercially available antibiotic product. Most of the start-ups have little experience in the scale-up and development process and they severely underestimate the time, cost, and efforts required to commercialize their discovery. Therefore, we need to promote a robust partnership culture between the basic scientists and experienced technology developers in our industry.

In spite of several challenges described above, Reliance is open and committed to seek alliances and collaborate with centers of excellence anywhere in the world.

Overview of Reliance

As a brief introduction to our company, Reliance is India's largest private sector enterprise. Our annual revenue is close to about $70 billion and about two-thirds of this revenue comes from exports. In addition, Reliance has a strong balance sheet and is essentially debt-free on net basis. Reliance has two of the world's largest and most complex refineries. We are able to process crude of any quality, from anywhere in the world, and manufacture various grades of products as per customer requirement. This is attributed to the latest equipment and control strategies that we employ. Our operating cost per barrel is amongst the lowest in the world.

Reliance aspires to be amongst the top 50 companies of the world within 3 years. We are investing about $30,000 million across businesses in the next 3 years, while our petrochemical expansion should be completed in the next 2 years. Reliance Jio, which is 4G technology, will be launched all over India next year. We also have a retail business with a couple of thousand stores which will double in the next 3-4 years. So we are expecting to double the revenue in the next 4-5 years with a compounded annual growth rate of 20-25% per year (*5*).

Reliance vision is to promote innovation as one of the drivers for growth. The company has grown so far by licensing technologies, building world scale and world quality plants, running them efficiently, and optimising and increasing their capacity. Now we want to become IP creator by developing our own technology and implementing it to build new plants and manufacture new products. And this is where the Reliance Technology Group which is the R&D arm of Reliance, that I am representing, comes into picture. We are trying to facilitate this jump from IP user to IP creator. Towards that, we have built a new state-of-the-art R&D Center in Navi Mumbai which is an investment of about U.S.$ 100 million.

In addition to internal R&D, an integral part of our transformation strategy is sponsored R&D and joint development programs all over the world. We want to collaborate with academic institutes and universities, government and national labs such as CSIR and PNNL, and with start-up and established companies. We are also open to take strategic equity positions in start-ups as long as it fits with our core strategies and businesses.

Why To Collaborate?

One important question that arises here is ‘Why to collaborate?’ and the main reason is to simplify or understand the complex nature of any scientific problem. Knowledge and resources from multiple disciplines such as chemistry, biology, and various branches of engineering are required to tackle any major innovative project. Collaboration is important to maximize the use of resources and to get the most out of it. National or international collaborations have become easier because of advances in the communication technology. It is feasible now to initiate, monitor, and execute global team projects in a seamless manner.

Let’s take the example of Industrial Biotechnology development. Consider a conceptual bio-refinery. To operate such a complex enterprise, first agricultural scientists will ensure the best biomass output from the available land by exercising the best combination of water, nutrients and other growth inducing factors for the given soil structure, sunlight, and weather. Then mechanical engineers are needed for aggregation, collection, and initial processing of biomass. Then we need biotechnology and enzyme technology expertise to separate the polymers into cellulose, hemicellulose and lignin. This can be followed by either a chemical route or a biological route to depolymerize the separated polymers into glucose, xylose, etc. Next, we require molecular biologists, fermentation technologists, and biochemical engineering experts, to obtain specific chemicals from these monomers. We need the aid of genetic engineering to come up with the appropriate organisms which will specifically make the required chemicals with high specificity. Thus chemicals such as ethanol, butadiene, pentene, BTX, FDCA, furfural, phenols, etc. are produced. Further they could be converted to plastics or polymers. This covers just the technical section at research level. To scale it up and commercialize further expertise from various field are required. This example signifies the need to collaborate due to the complexity of the project involved. It has become extremely important to promote this culture to ensure economic and industrial growth in nations.

Basic Research versus Applied Research

If we think of typical separation between fundamental or basic research and applied research, we can divide it into four quadrants as described in “Pasteur’s Quadrant” by Donald Stokes (*6*) (Figure 1). When you think of highly fundamental or basic research, names like Bohr, Einstein, Maxwell, Mendel, Planck, etc. comes to mind. On the other hand, Edison tried over ten thousand different materials to come up with one that worked and in a few years all the light bulbs were made using that filament material. This approach displays his lack of fundamental understanding, and even today this type of approach is called Edisonian approach. It is scientists like Louis Pasteur who exhibit exemplary work, which has high relevance in application while being

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based on strong fundamental concepts. Similarly, the advent of computers and development to its modern form, or advanced telecommunication based on fiber optics are all examples of research having high quotients of both fundamental concepts and applications. Unfortunately, today most of our research is far from Pasteur-inspired research. We lack fundamental understanding and applicability because researchers aim to make money with minimal understanding instead of focusing on new breakthroughs. This is another reason why we need collaboration between the fundamental and application people.

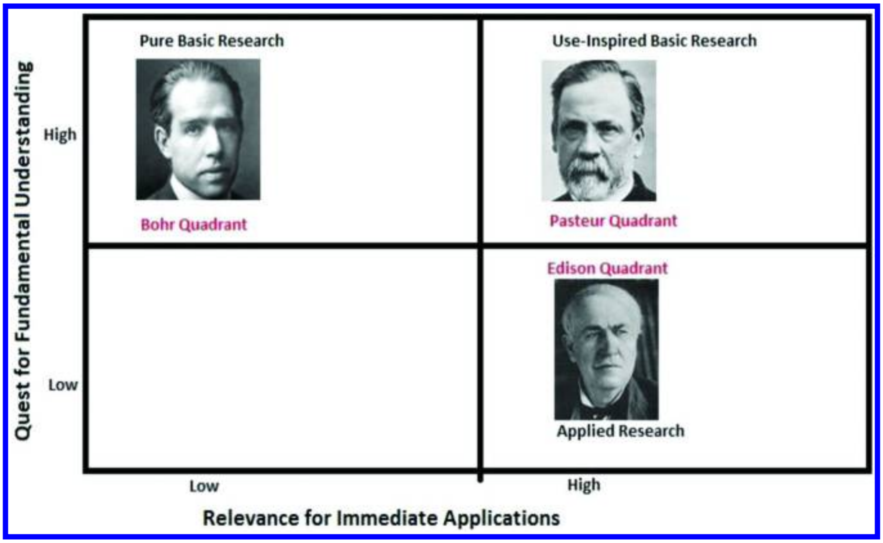

Figure 1. "Pasteur's Quadrant", describing researcher's fundamental understanding of research and it's relevance for immediate applications, at both high and low levels. (Source of insets: Wikimedia Commons, http://commons.wikimedia.org/wiki/Commons:Free_media_resources/Photography.)

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The Venture Capital Model

Venture capitalists work to bring a start-up company to the next stage by providing the required funding with the hope that it will flourish or be purchased by a larger company. Venture capitalists expect huge returns from their investment in a short time period. They invest in various startups and expect only a few to succeed, which would also make up for the losses incurred from the other investments. They would probably invest $5 million in ten startups expecting one or two to succeed, giving them returns of approximately $50 million each. This model has worked very well in the IT industry where capital expenditure is low and rate of deployment is very fast. Once an iPad is introduced, within three years it is deployed all over the world. In the year 2013, approximately 71 million iPads were sold globally.

Our industry, on the other hand, is capital intensive, the speed of development and deployment is much slower, and the returns are also lower. In the chemical technology development and commercialization, inventing a new technology (or chemical entity or catalyst or therapeutic protein) is only the first step towards its commercialization. The inventors (basic scientists) severely underestimate the time, cost and efforts required to commercialize their discovery. Once something is discovered, it takes two or three more phases of scale up before commercialization. You have to go from gram-scale to kilo-scale, pilot plant, demo plant and then large-scale production. This entire process takes approximately 7-10 years. As an example, the commercial production of penicillin took 35 years.

The cash flow for a typical project in our industry is shown in Figure 2. In curve I, 'a' is the point where the basic discovery is made. A typical pilot equipment and operating costs would run into several million dollars. After the kilo and pilot lab are a success we start building a commercial plant and more investment is required. Then after production begins, the curve slowly starts turning upwards and it takes about 7-10 years to achieve a net zero cumulative cash flow and then we start making profit. It is so possible that after scaling up, the technology might not prove to be commercially successful. Therefore many venture capitalists are not willing to fund such projects. On the other hand, in IT industry (curve II), this payback period is of 2-3 years.

Perhaps, a new funding approach should be developed where the start-ups could directly work with the established companies that financially and technically support them. While the VCs provide useful service for high risk projects, they typically seek near term financial profits and have limited interest in long term development of science and technology.

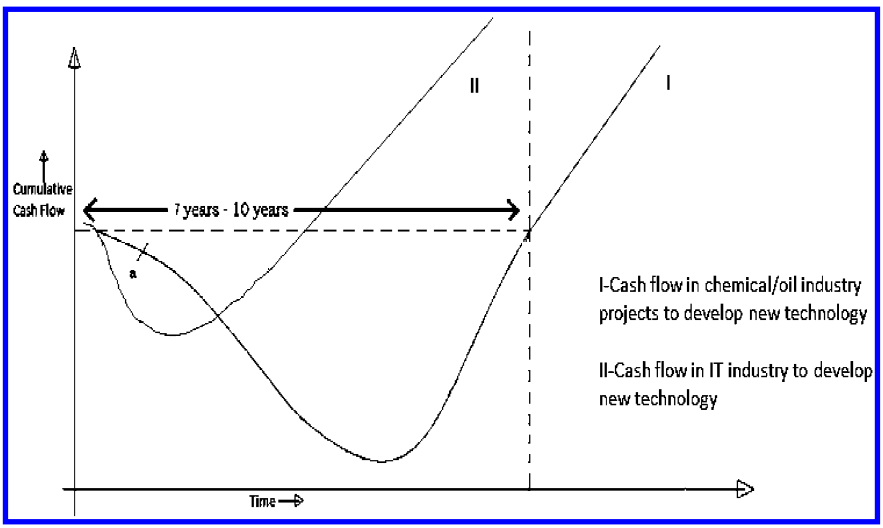

Figure 2. The cash flow in chemical/oil industry projects to develop new technology and the cash flow in information technology industry projects to develop new technology.

Several companies have venture capital as an investment arm. Dow Venture Capital, for example, has been investing in promising startups in North America, Europe and Asia for almost 20 years now. They invest in startups that provide innovation in areas of strategic interest to Dow businesses, or are pursuing new and disruptive technologies (*7*). The arrays of startups include several that address some of the most challenging problems faced by the world including clean water, renewable energy generation and conservation, and increasing agricultural productivity. Companies are capable of funding technologically driven projects dually beneficial to the investor and the startup company, eliminating the requirement of a mediating venture capitalist. Unlike venture capitalists, the large companies like ours are strategic buyers, we want to promote science and technology because we are looking for a long term business.

Challenges

Let's address some of the challenges that are encountered in international collaborations.

One of the major issues regards IP rights where there exist variations in the laws and differences in interpretations in each country. Each sovereign country has its own patent laws and its own interpretation of the uniform WTO patent regulations. Some of these laws are so stringent and archaic that it makes it difficult to work in international collaboration. The international agreements are generally governed by the laws of an acceptable neutral country. For example, the U.S. and Indian collaboration agreement would be governed by U.K. laws. However, some U.S. state universities do not agree to any jurisdiction other than their home state per state law. Technology transfer offices of institutions also sometimes bear hindrance to international collaborations. Companies would like to get exclusive rights for IP from sponsored research, while the institutions want to own the IP and only give license to practice.

In our experience, technology transfer offices of institutions or start-ups overestimate the value of their invention/IP and underestimate the risk and cost to commercialization. They demand high licensing fees or purchase prices which makes the project infeasible to commercialize since the gross margins in the chemical business is only 20-30% as compared to 70-80% in pharmaceutical, biotech, or IT industry. It should be noted that greater than 95% of the patents are never commercialized. There should be a need for realistic expectations and robust long-term partnership between basic scientists and experienced technology developers in our industry.

The laws governing IP rights and technology transfer are subsumed in the Bayh-Dole Act which was adopted on December 12, 1980. This act was established in order to obtain a better output for the nation from $75 billion a year that was being invested in research by the government. Prior to the enactment of Bayh-Dole, the U.S. government had accumulated 28,000 patents but fewer than 5% of those patents were commercially licensed. However, the laws were so coded and amended that it has curtailed the scope of international collaborations. According to this act, if the university elects to retain title, the university must provide the government, through a confirmatory license, a non-exclusive, non-transferable, irrevocable, paid-up right to practice or have practiced the invention on behalf of the U.S. throughout the world. Therefore, though the researching institute retains its title it has gotten no ownership of the invention. Universities cannot assign their ownership of inventions to third parties, except to patent management organizations. Also, any company that holds an exclusive patent license of product sale in the United States must substantially manufacture the product in the U.S. Since the cost of production in the U.S. is generally high, it is not economically feasible for companies to manufacture there and the Government has rights to implement the same technology elsewhere in the world (*8*). A direct implication of this act was observed in the famous case of Stanford versus Roche (*9*).

Another problem is the lack of commercialization knowledge. Many small companies and research organizations are able to find the breakthroughs but they do not know which direction to follow to commercialize their products. Thus these type of research gets stuck in the laboratory unless they find the right path. For example, Fritz Haber from BASF found the way to synthesize ammonia from air and water but Haber did not had knowledge to turn it into the process. The company purchased the rights to Haber's patent, and retained him as a consultant. Then under the direction of Carl Bosch, the company built the plants, sold the product to German government and financed the efforts. Likewise many startup companies are selling their ideas to large corporations instead of remaining independent and taking risk of getting bigger profits by self-manufacturing.

Another problem is getting the U.S. visa for chemical professionals. While we utilize latest communication tools such as video conferences to minimize travel, sometimes it is essential to have face to face meetings. Also, it is necessary to attend important conferences in person. After filing on-line U.S. visa application, the applicant has to be personally go to the consulate/embassy twice: first for fingerprinting and submission of documents and secondly for an interview. Most chemical professionals are told to submit a synopsis of all their activities, list of patents and research papers. This information is typically sent to Washington for further evaluation and the whole procedure takes a few weeks. Because of the delay in obtaining visa, many professionals are unable to attend business and professional meetings. I understand that ACS has consistently brought up this issue with the U.S. government, but more needs to be done.

Success Stories

Indian government and institutions have participated in a number of successful collaborations. Two such partnerships are highlighted below.

CEFIPRA-Indo-French Collaboration

Indo-French Centre for Science and Development (CEFIPRA) is a joint center for promoting collaboration between Indian and French scientists that has been functional since September 9, 1987. CEFIPRA supports research through

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‘Collaborative Research Programs’ and ‘Industrial Research Programs’, each having its own set of criteria.

SINCE 1988

- 1190 research proposals evaluated
- 406 research projects approved;
    - 315 completed;
    - 61 under implementation

The only eligibility criterion for availing benefits under this program is to have a permanent position in an Indian or French University /R&D Institution. The Centre supports the project by providing manpower (in terms of PhDs or experts in the field), purchase of consumables, travel (international and domestic), and small equipment to Indian partners. An industry from France or India and a research institution from the other country must be involved. Partnerships with more than one industry or one research institution are also possible. CEFIPRA is an excellent example of how nations can promote growth and innovation by overcoming complicated laws and regulations and setting up joint centers (*10*).

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IITB-Monash Research Academy

The Indian Institute of Technology-Bombay (IITB) is one of the top ranked technological institutes in India while the Monash University, which has various campuses in Australia, is a non-profit organization as endorsed by the Australian tax office. Supported by state-of-the-art technical facilities and high performance computing sources, the IITB-Monash academy aims to house around 250-300 PhD students at any time. They will be supervised by experts from both the universities and industry partners of the academy. Selected students (typically 40 per year) will get a dual badged PhD degree, from IITB and the Monash University, Australia. Each PhD project is funded mostly by industry and some by government. Each student is guided by three advisors: one from IITB, one from Monash, and one from an industrial sponsor. The academy aspires to deliver innovative solutions through collaborative, multi-disciplinary projects that are of importance to the Indian and Australian industries (*11*).

International Collaborations and Incubation Centers

All international collaborations need to meet three basic criteria to be successful: *Complementarity, Compatibility, and Continuity* (*12*). The participating members of the collaboration should be of equivalent statures intellectually and financially to avoid overshadowing of one of the members and to have a healthy continual collaboration. Also, their knowledge in their respective fields should be complementary towards the achievement of the common aim. Continuity in the sense that the collaborations should not last for just 1-2 years but at least for 5 years with mutual benefits. Incubation could be a good method for international collaborations. Incubating companies should not only provide financial support, but also intellectual support to commercialize some of the big inventions. A change in the Indian Law states that established companies should mandatorily spend a part of their net profits for innovation. For example, in India, any company having a net worth of rupees 500 crore or more or a turnover of rupees 1,000 crore or more or a net profit of rupees 5 crore or more is required to spend 2% of their net profits per fiscal on Corporate Social Responsibility (CSR) activities, in effect from April 1, 2014. This money could be spent in funding research activities through national as well as international collaboration.

To conclude, we believe that scientific progress is essential for better living, better health and better nation. We are open and committed to seek alliances and collaborate with centers of excellence anywhere in the world despite all the difficulties and challenges. We must do this to efficiently meet the aspirational needs of our global village. Global technology also needs to be developed faster to meet the demands of the growing population. Technology has leapfrogged its way into the 21^{st} century. However, now it needs to pole vault into the future to live up to the expectations of the people. These are all global issues that need to be attended by all nations in a unified manner, and all available intellectual resources from all nations have to be pooled together to address these challenges.

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Chapter 14

Building Global Capabilities and Delivering Continual Innovation at 3M

Peter Koelsch*

3M Company,
Building 223-6N-08, 3M Center,
St. Paul, Minnesota 55144, U.S.A.
***E-mail: pmkoelsch@mmm.com.**

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3M is a truly global company with a technical community in 85 locations working to innovate, support business growth in more than 70 countries, and apply science to life. Its innovation is driven by a system of principles, practices and infrastructure that harness the chain reaction of new ideas. Specifically, 3M specializes in colloboration between seemingly unrelated markets and technology platforms. Everywhere in the world, 3M strives to have more than 30% of its sales derived from products introduced during the past five years. In order to accomplish this, effective sharing of technology, capabilities, and customer insights around the globe is critical. This article describes some important practices and provides some examples of how a global technical network collaborates and fosters innovation.

Overview of 3M

3M Company strives to be a leader in technology and innovation. Our corporate vision is to have 3M technology advancing every company, 3M products enhancing every home, and 3M innovation improving every life (*1*). Our five market-leading business groups are: 1) Industrial, which handles industries from purification to aerospace; 2) Safety and Graphics, which protects people and information, and enhances visual and design communication; 3) Electronics and Energy, which enables tomorrow's lifestyle today with power, communications and electronics; 4) Consumer, for simplifying life at home and keeping you organized at work; and 5) Health Care, which helps prevent infections and makes smiles brighter.

Our annual sales are around $31.8 billion, of which $20.1 billion (or 63%) is from international sales in nearly 200 countries, yielding $5 billion in net income. $1.8 billion is invested in research and development. 3M operates more than 200 manufacturing factories across 71 countries and employs around 90,000 employees. Our laboratories are in several locations to keep us close to customers and aim to innovate to produce the best and the most relevant solutions to market needs. 3M developed more than 55,000 products, issued 3,300 patents in 2013 alone, and currently has more than 41,000 issued and pending patents.

Simply put, 3M is *the* innvoation company. We find solutions and develop products that permit customers to succeed and improve lives. Our approach, both internally and with our customers, is collaborative. We can make a big impact and solve tough problems by building on each other's ideas and uncovering new connections between seemingly unrelated markets across 46 diverse technology platforms. 3M's culture of intellectual curiosity and creativity is what allows it to continue to push the boundaries for more than a century.

Our innovation is focused on helping customers tackle challenges and enable progress in our fast-changing world. Innovation at 3M would not be possible without the contributions of many people, working together to share and reshape ideas on a daily basis. With multiple touch points among people, countries, technologies and businesses, the evolution of ideas and innovation is borderless. We invest significantly in R&D capability year after year to drive opportunity for the most productive collaborations possible. 3M's continual partnership with its customers yields tangible successes.

3M Global Challenges and Opportunities

The scope of 3M's operations presents many different challenges and opportunities. It can be difficult to disseminate common practices and culture across many countries. It can also be difficult to understand the market and customer needs in many different countries and regions. While 3M is able to share its technology around the world, converting that technology to products targeted to local markets and customs can be a challenge. Another challenge 3M faces is finding, growing, and retaining local talent in many different countries, and creating a global awareness among technical people. Nevertheless, 3M is constantly working to develop the most efficent solutions to these challenges.

3M is cognizant of the many business opportunities across a diverse global product and market enterprise. Everywhere in the world, 3M strives to have over 30% of its sales derived from products introduced during the past five years. In order to accomplish this, effective sharing of technology, capabilities and customer insights around the globe is critical.

Presently, 3M has 85 well-connected laboratories scattered throughout the globe. These labs have localized research and development foci, which represent Centers of Excellence (CoE) around the globe. For example, Korea has labs

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specializing in non-wovens, radio-frequency identification, electronics, energy, nano-technology, and tapes and adhesives. It is also home to the Asia Display Tech Center. Germany, France, and the U.K. together have CoEs in automotives, dental, telecom, specialty materials, polymers, consumer, oil and gas, and drug delivery. Brazil is working on expansion to safety/orthodontic products, nano and bio technologies, specialty materials, hooks/loops, molding, non-pvc films, and acrylic foam tape.

3M Innovation

3M innovation is planned, purposeful, and global. We apply science to life to consistently create new ideas. To do this, we maintain labs around the globe, host technical forums, staff customer tech centers, fosterg a culture of collaboration, promote e-connectivity, ensure no IP barriers, leverage capabilities, and share technology.

The innovative process at 3M typically begins with someone identifying a market opportunity. This can be an idea to develop a new product for a new market or application, a new product to satisfy an ongoing market need, or an improvement on an existing product for a current market. The scientist or scientific team then brainstorms and screens product concepts to derive the best solution. The next step in the New Product Introduction (NPI) framework is to develop the product and optimize its properties to satisfy the customers' needs. Once this is accomplished, the product is scaled up and then launched.

The key to the success of 3M's product development system is to understand the customers' needs. For existing businesses, there needs to be good interactions with the customers. The involved customers often are Spec-In/OEM Businesses, with both sales and R&D bench-to-bench engagement driving the interaction. In this way, there is a buy-in and ownership from the customers, thereby facilitating its product commercialization success.

For new opportunities in more-dispersed and/or distribution-based markets, 3M values "Insights To Innovation" (i2i). In such cases, good marketing and exploratory research may be needed, including end user ethnography, insight synthesis and validation. These processes have been documented in an article in *Harvard Business Review* by von Hipple, et al (*2*).

The yellow sticky note, called Post-it Notes™, is a good example of the combination of technical innovation and customer insight. In 1968 Spence Silver, a 3M scientist, tried to make a strong adhesive tape, but obtained a semi-sticky material. He suspected that this material might be useful, but did not know what to do with it. A few years later, Arthur Fry, a 3M colleague, needed weak glue that would stick to his hymn book at church, then could be removed without tearing the page. Thus, the Post-it Notes product family was born and became a big commercial success.

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Conclusions

Over the years, 3M has had an excellent track record for innovation. 3M specializes in collaboration between seemingly unrelated markets and technology platforms. The company has adapted well to the global trends and operates both its businesses and R&D worldwide. To be successful in the global products and markets enterprise, 3M has emphasized effective sharing of technology, capabilities, and customer insights around the world, and continues to foster the company's culture of intellectual curiosity and creativity.

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Chapter 15

Ingenuity in the Global Market: How To Leverage Open Innovation To Achieve Results for Your Organization

Eloise Young*

Senior Program Manager, NineSigma,
23611 Chagrin Blvd., Suite 320, Cleveland, Ohio 44122, U.S.A.
***E-mail: young@ninesigma.com.**

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Thanks to the interconnectivity of modern technology, the global market is accessible in ways never previously imagined. Open Innovation is a proven method for creating fruitful partnerships that reduce time to market and uncover innovation that often lies at the intersection of two industries, or two technical disciplines. NineSigma helps organizations 'connect with the world' to find new solutions, knowledge or partners to accelerate the innovation cycle. In this article, Dr. Eloise Young will share examples that show how successful international connections and discoveries have been made as a result of Open Innovation. Dr. Young will also address the fundamentals of building an Open Innovation program to help create competitive advantages for your organization and drive to superior results.

Introduction

In its broadest sense, open innovation is the act of going outside yourself to find the solution to a problem. Collaboration with another research lab, crowd-sourcing, and innovation contests are all examples of open innovation. The term open innovation and its use as a formal business tool are relatively new – it was promoted by Henry Chesbrough in his book (*1*) "*Open Innovation: The new Imperative for Creating and Profiting from Technology"* in 2005. However, the practice has been around for a long time.

300 years ago, the British government established the Longitude Prize in 1714. At that time, there was no way to accurately determine a ship's position

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.;
ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

if it was not within sight of land. This inability to reliably navigate on long ocean voyages had sometimes disastrous consequences and significant impact on the British economy. The British government offered £20,000 to anyone that could successfully determine longitude within 30 nautical miles. John Harrison won for his work on chronometers that would accurately keep time at sea.

This is a terrific example of open innovation for several reasons. The contest had a clear and urgent objective, and the prize of £20,000 (which is worth more than £20 million today) was compelling. Also, this example highlights a common NineSigma theme that great solutions sometimes arise from adjacent disciplines or sectors. In fact, given all of these similarities, this example could be looked at as an early predecessor of the modern day prize-based contests within the open innovation marketplace.

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NineSigma's Spin on Open Innovation

NineSigma's spin on open innovation is that we work with major, multi-national companies to help them expand their networks. To a greater or lesser extent, everyone has a network. It can start with colleagues down the hall and expand to colleagues in another business unit; it can include other universities or companies with whom you jointly collaborate. NineSigma works with companies and organizations to help them reach into geographies, industrial sectors, and research labs that are currently outside their known network (Fiure 1).

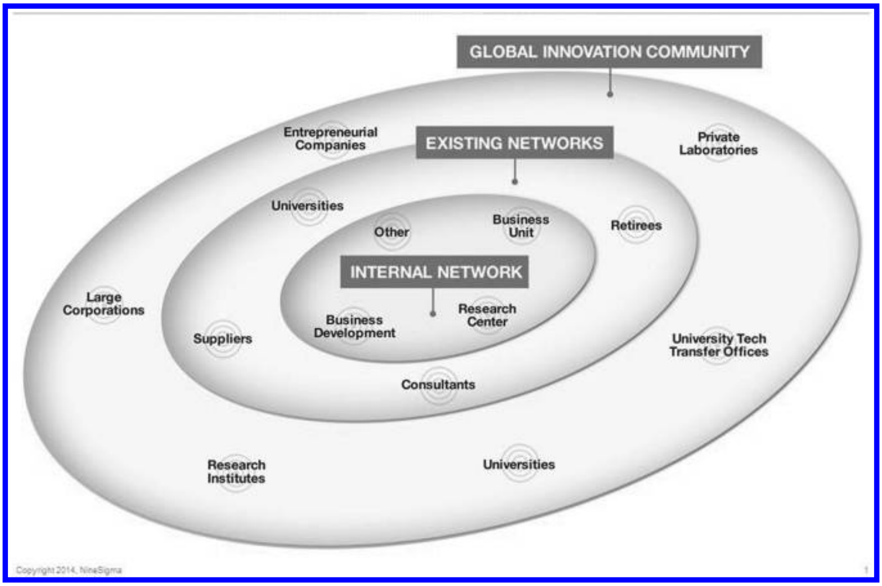

Figure 1. New solutions and ideas come from internal and external networks. (Courtesy of NineSigma.)

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.; ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

CCEMC Case Study

One example of how NineSigma, using its unique methodology, helps its clients is the continuing work done with the CCEMC. The Climate Change and Emissions Management Corporation (CCEMC) is a non-profit, grant-awarding organization based in Alberta, Canada, whose mandate is to fund the development and deployment of technologies that will reduce greenhouse gas (GHG) emissions and manage climate change. They have awarded tens of millions of dollars to research labs, start-ups, and companies to fund projects in the areas of carbon capture and storage, renewable energy, clean energy production, energy efficiency, adaptation, carbon uses, and biological initiatives. Although the CCEMC is well-known within Alberta, and to a lesser extent throughout Canada, the organization is virtually unknown outside of Canada. The CCEMC knows that there are many minds all across the globe working on different aspects of GHG emissions and climate change, but they didn't know how to get their message out to all of those groups and individuals. Additionally, much of the work they fund results in important but incremental advances. They were interested in helping to develop truly transformative technologies that will have significant impacts on emissions and on the environment.

NineSigma worked with the CCEMC to create and administer the CCEMC Grand Challenge: Innovative Carbon Uses (*2*). This multi-stage program spans 5 years and offers over $35 million to help develop and ultimately commercialize technologies that convert carbon emissions into valuable products. Round One of this Grand Challenge concluded in April, 2014 with the announcement of the 24 Round One winners. Each winner then received a seed grant of $500,000 to develop technologies that will annually convert at least 1 megaton of carbon emissions into valuable products. These winners were selected from 344 submissions that came from 37 countries around the world. This level of international outreach far exceeded CCEMC's previous geographic range for grants and shows the power of open innovation in the global market. This Grand Challenge is making significant strides towards CCEMC's goals for this project and showcases how open innovation can be an effective tool to help an organization to make the impact they want within the global marketplace.

Three Keys to a Successful Open Innovation Program

If this example is intriguing, and open innovation might be a tool worth considering, what are some things to keep in mind? There are three keys to a successful open innovation program (Figures 2-4).

First, make your needs known. This seems self-evident, but there are several levels from which to consider this statement. If you do not tell the world you have a problem, no one will think about possible solutions. When NineSigma successfully pairs a solution provider with a client, it is not uncommon to hear something along the lines of "I had no idea that this was an issue, or that my technology could be used as part of the solution." Without the Longitude Prize, who knows whether or not John Harrison would have made the connection between accurate time-keeping and navigation?

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Figure 2. Key #1 to a successful Open Innovation program. (Courtesy of NineSigma.)

Related to the statement "make your needs known," is the need to present the problem to the right audience, using language that is clearly understood. Asking a taxi driver in Shanghai for directions to the subway in English is unlikely to result in a successful outcome. Similarly, describing a problem using terms that are specific to a certain field or industry can deter someone from outside that specialty from seeing how his or her technology could be a solution.

Figure 3. Key #2 to a successful Open Innovation program. (Courtesy of NineSigma.)

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.;
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This leads into the second key for a successful open innovation program: frame problems differently. Sometimes a particularly intransigent problem can become so weighed down with constraints, conditions, and other boundaries that it appears impossible to describe clearly – let alone solve. Looking at things from a different angle can provide perspective and allow one to see to the heart of problem.

A great example of this is a project that NineSigma ran for Eastman Chemicals. Distillation at an industrial manufacturing scale is an extremely expensive separation technique; the associated energy costs are significant. Eastman wanted to identify a way to lower the cost of distilling water away from organic reaction mixtures. The heart of the problem is finding a low cost way to separate water from other organic components that can work at industrial scales. Whether this separation occurs by distillation or some other method is less important than its cost and scalability. We worked with Eastman to frame this issue succinctly in the following manner: separation of water from a mixture, without using the word distillation. As a result of this framing, Eastman received 20 proposals from 7 different countries. One of the most intriguing proposals was a separation technique developed by a Dutch company for refinement of mined natural gas. Freshly produced natural gas is contaminated with water vapor and other gases. The Dutch technology forces this feedstock through a narrow orifice at high pressure, then adiabatic expansion and cooling causes the water vapor to condense and separate from the natural gas stream. Eastman entered into discussions with this company and several other responding companies as a result of the project. By focusing on separation, rather than distillation, Eastman received a much wider range of proposals and possible solutions than they would otherwise have.

Figure 4. Key #3 to a successful Open Innovation program. (Courtesy of NineSigma.)

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The third key to successful open innovation is to be open to solutions that were not invented here. The world is a big place, and there are smart, talented, and creative people all over. Since this symposium is about "Innovations from International Collaborations", this audience embraces, or at least is interested in, working with groups outside your local geography. But how do you go about finding those potential partners and their technologies?

Innovation Contests and the GE 3D Printing Production Quest

One way is through an Innovation Contest (*3*). The case study provided here has a strong international component. GE is interested in the possibilities of using 3D printing to manufacture high performance, high precisions parts that might be used in a variety of end applications, including jet engines and/or medical imaging equipment. NineSigma worked with GE to develop and manage the GE 3D Printing Production Quest to understand the possible opportunities. This innovation contest was focused on 3D printing test coupons with high precision, using tungsten (Figures 5-6). The goal was to identify potential suppliers and development partners with cutting edge technologies and capabilities. Initial respondents were asked to submit a capabilities statement.

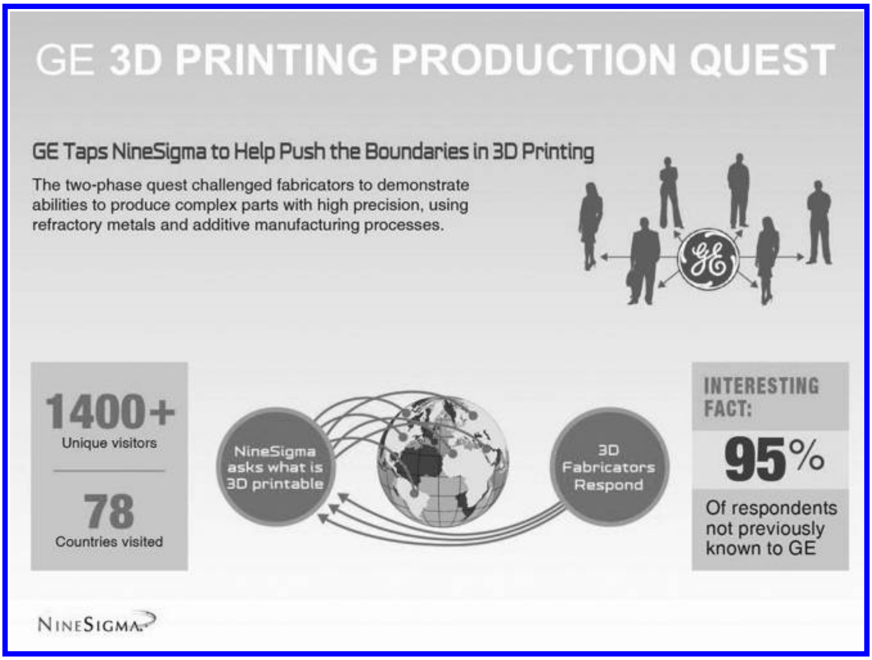

Figure 5. Information on GE 3D printing production quest. (Courtesy of NineSigma.)

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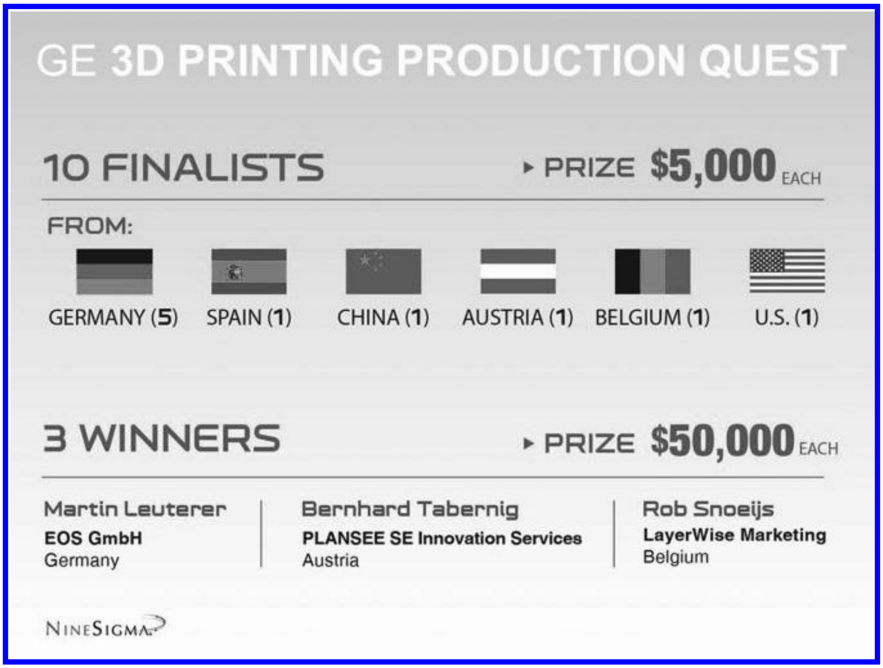

Figure 6. Results of the GE 3D printing production quest. (Courtesy of NineSigma.)

GE awarded the 10 most promising groups a token cash prize and invited them to demonstrate their technology using a GE-supplied test coupon development package. Three of the 10 groups were selected as contest winners, based on the quality of their submitted test coupons. One of the most interesting aspects of this innovation contest was the number of responses which came from outside of the United States. Only one of the 10 finalists was from North America; the other 9 groups were from Europe and Asia. The three winning groups were: EOS (Finland), Plansee (Austria), and Layerwise (Belgium). Each winning group received a $50,000 prize, but all finalists benefitted from the opportunity to interact directly with the GE technical team.

Conclusion

Open innovation is not about finding the perfect, drop-in solution. It's about finding new ways of defining a problem, assembling a solution from several component technologies, being open to new approaches, and/or identifying new potential collaborators. These new opportunities might be around the corner, or around the world. Using open innovation, solutions can be closer than imagined.

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Chapter 16

Seed, Foster, Believe, Dream and Act. Capacity Building in Kenya by Novartis Global Discovery Chemistry, Seeding Labs, the International Activities Committee, and the Computers in Chemistry Division of the ACS between 2010−2014

Lewis Whitehead,* Evans Ogwagwa Changamu, Nina Dudnik, Patrick McCarren, Rajiv Chopra, Rem R. Fazio, David Qualter, Vinod Patel, Ryan Haas, Khampoua Naovarangsy, Bhaveshkumar Gami, Christopher Harwell, Jeffry D. Madura, Heather Burks, Solomon Derese, Michelle Lynn Hall, Ralph Greenberg, Sean Ohlinger, Juliette Pradon, Bryan R. Henry, Linda Wang, Lucy Kiruri, Colleen Dionne, and Brigitta Tadmor

Computer Aided Drug Discovery, Global Discovery Chemistry, Novartis Institutes for Biomedical Research, 100 Technology Square, Cambridge, Massachusetts 02139, U.S.A.
***E-mail: lewis.whitehead@novartis.com.**

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Novartis initiated a Fellows program for African academic scientists in 2010 in partnership with Seeding Labs, providing a 9 week-long industrial immersion experience at the Novartis Institutes for Biomedical Research (NIBR) in Cambridge Massachusetts. Through their scientific projects and activities, the Fellows explored new laboratory techniques and improved their scientific communication and grant writing skills. A primary aim of the program was to influence the Fellows' time in the NIBR laboratories into promoting research of potential utility to their scientific and teaching activities on returning home to their academic institutions, thus building strength in scientific capacity in Africa. As chemistry is an essential discipline in the drug-discovery process, it has been

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an area of focus for several visiting African Fellows and their NIBR scientific mentors. In particular, computational chemistry has minimal laboratory requirements and is ideally suited as an area for scientific capacity building in Africa. In addition, extending drug-discovery capabilities in African laboratories to assist natural products research is of interest, particularly concerning development of treatments for malaria, tuberculosis, HIV and, of recent concern, the West African Ebola outbreak. An ACS International Activities Committee Global Innovation Grant, granted in 2012 added financial momentum to this capacity building project, spurring our efforts in capturing a Canadian Grand Challenges award and the pursuit of funding from IUPAC. In 2014, this initiative reached two significant milestones, creation of its first job, a computational chemistry academic faculty position in Kenya, and the launch of an *in-silico* database of Kenyan natural products named Mitishamba.

'It is vital for African scientists to enhance the drug discovery capability of the continent to address African health needs (1).'

Nairobi, February 2012. Believe

During a long, arduous late-afternoon journey between Kenyatta University and the center of Nairobi, I became overwhelmed by a sense of the tremendous energy, strength, determination and awe of the human spirit. As the sun set out in the distance to the West, visible outside of our Land Rover window, the ensuing darkness began to frame an eerily poetic scene. Unfolding on the road outside before me, the failing light filled with thousands of faceless, almost ghostly, souls wandering home in silence from the city through the choking cacophonous trafffic, their bodies flitting between the high and low beam headlights, as the exhaust smoke skirted around their limbs before vanishing into the atmosphere. Purveyors of bottled water and hazard-signs snaked through the narrow spaces between commuters' cars, motor-bikes and mutatus, looking for trade, melodically chanting in Kiswahili, sharing this backdrop with abandoned construction vehicles, parked dormant for the night, before their toil of earthly destruction would begin anew at the new dawn. I looked ahead to see Heather, in the front passenger seat, also immersed and transfixed in the scene, watching her eyes move from one brief human story to another, while our driver, Joseph Murigu, calmly traversed the human and vehicular obstacles placed in front of him. At that moment, within the vivid chaos of the ongoing Thika Road Superhighway road construction project, a Kenyan infrastructure capacity building effort, financed by overseas capital, our physical presence in the country helping to influence capacity creation in chemistry, no longer seemed so daunting. In fact, the desire to be involved and immersed in this theatre, was so strongly magnetic and intensely contagious.

Malaria, A Personal and Corporate History - The Seeds

During the closing stages of the Pacific Campaign of World War Two, Leading Aircraftman John (Jack) Harold Hill, shown in Figure 1, served in the Royal Air Force's Airfield Construction Squadron at locations in the Malay Peninsula between 1945-1946. Upon the reoccupation and liberation of Singapore from the Empire of Japan by Allied troops, while attached to RAF Station Changi, a major role played by the construction squadron was supervision of Japanese prisoners of war forcibly employed in the reconstruction of the runway and airfield infrastructure in Singapore. The squadron rebuilt the fighting capacity and capability of the British military base which would in later years become the main international airport. Aircraftman Hill contracted malaria while serving in his RAF squadron in South-Eastern Asia and was fortunate to survive. He would also suffer a relapse of the disease on his return to the United Kingdom. Hill was merely one of hundreds of thousands of military personnel directly affected by malaria in World War 2, which caused a significant death toll on all sides during the global conflict (*2*). Jack Hill is the grandfather of the corresponding author Lewis Whitehead, who is fortunate to be writing this document today as a result of the development of anti-malarial prophylatic strategies and therapeutics in the 1940's.

Figure 1. Photographs taken by and including Leading Aircraftman John Harold Hill (service number 1139644, grandfather of Lewis Whitehead) of the Airfield Reconstruction Squadron stationed in Singapore at RAF Station Changi and locations in the Malay Peninsula, 1945-1946. Scenes include images of the Raffles Hotel, Singapore Harbor, and Japanese prisoners of war. (Courtesy of Lewis Whitehead.)

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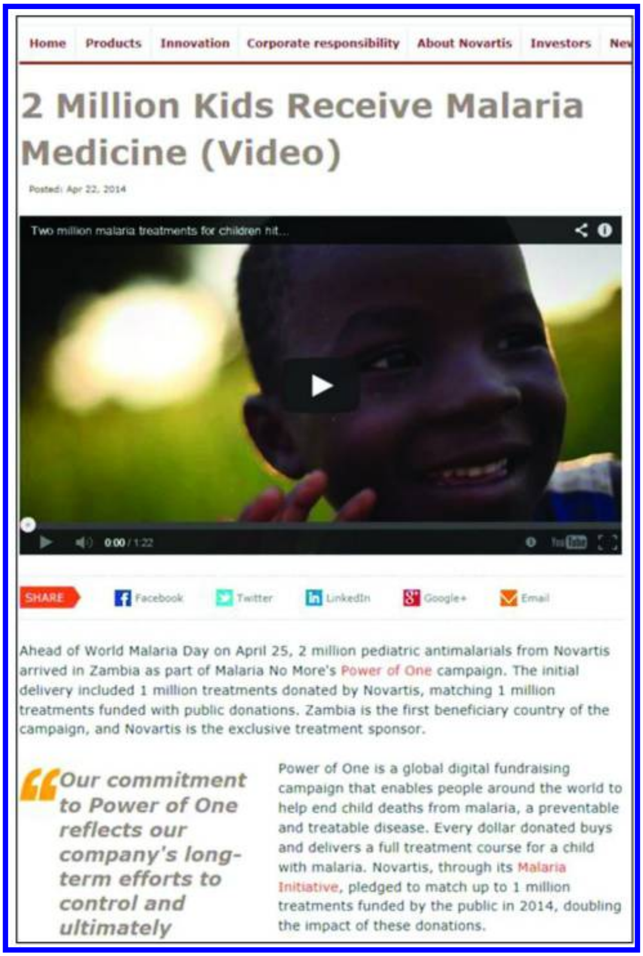

Figure 2. A story on the Novartis corporate website detailing World Malaria Day and the Malaria Initiative (6). (Courtesy of Novartis. Used with permission.)

Novartis has a prominent legacy in the fight against malaria. In 1939, Paul Hermann Muller, while working at the Geigy Chemical Company (a Novartis predecessor company), was to discover the pharmacological properties of 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane, which would become known as DDT (*3*). Muller was awarded the Nobel Prize in Medicine in 1948 for the discovery of the insecticidal qualities and use of DDT in the control of vector diseases such as malaria and yellow fever, recognizing his revolutionary contribution to reducing the death toll of malaria worldwide. In recent years the company has committed to supporting this legacy by providing not-for-profit, Coartem (*4*), an artemisinin based combination therapy for the treatment of acute uncomplicated *Plasmodium falciparum* malaria. Coartem access is widespread in countries within the Sub-Saharan Africa region and forms the foundation of Novartis' malaria intiatives, as shown in Figure 2. Recently the development

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of a new synthetic spiroindolone analogue at the Novartis Institute for Tropical Disease in Singapore was disclosed (*5*), further demonstrating the company's long term commitment and determination to the fight against this disease.

The Novartis Institutes for Biomedical Research in Cambridge Massachusetts focuses on diseases of unmet clinical need. One particular example is in the oncology field, with the development of small molecule therapeutics as inhibitors of histone deacetylase (HDAC). Our work detailed the optimization of a third generation of chemical analogues following in the medicinal chemistry design footsteps of the company's development of dacinostat and panobinostat (*7*, *8*). During a retrospective period of manuscript preparation detailing our study of an alternative novel small molecule with an interesting binding motif (*9*), our attention was diverted by a discussion of the use of HDAC inhibitors for the treatment of parasitic diseases (*10*). On digesting the information presented in their study, the team contacted our colleagues in Singapore at the Novartis Tropical Diseases Institute for additional consultation. The ensuing actions from our initial discussions lead to a six-month long collaboration on the study of our inhibitors, designed as potential anti-cancer drugs, against malarial and trypanosomal parasite strains. This work terminated in the spring of 2010, and prior to our final decision to publish our medicinal chemistry endevours to the outside world, a request for volunteers from within the NIBR research scientist population, to mentor academics from Africa, for a short time over the summer was posted within an internal corporate e-mail. The corresponding author of this manuscript reached out to volunteer as a mentor, providing him an opportunity to work with, and learn from, a scientist from a country where malaria is an immense health challenge.

A Call to Action - Reseed and Foster

'...the development of computational chemistry research in Sub-Saharan Africa tertiary institutions is realistic and feasible within the current circumstances of the institutions. The most important requirement is the training of new specialists that can initialize and conduct research activities. The drawbacks from the current scarcity of specialists can be overcome through innovative ways of sharing the experts currently available (11).'

Professor Evans Changamu, of the Department of Chemistry at Kenyatta University, from Nairobi in Kenya, requested a 9-week-long secondment to the computer-aided drug discovery (CADD) group at NIBR, working with Lewis Whitehead to acquire an understanding of the approaches, techniques and scientific problems faced by a computational medicinal chemist in a pharmaceutical company, and within the industrial setting. During his time in CADD, Changamu concentrated on structure-based and ligand-based drug-discovery methods, and became aware of the use of cheminformatics on medicinal chemistry project teams. He rapidly noticed the breadth of scope within the computational chemistry field within routine drug development activities. Initially, the HDAC structure-based design work (*7*–*10*) provided an introduction

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into the interpretation, manipulation and management of three-dimensional protein-ligand structures, and how a computational chemist attempts to rationalize structure-activity data, communicating the information to chemistry teams and engaging proactively in the design process. The professor continued with an investigation of quantum mechanical methods, particularly in reference to prediction of ligand toxicity (*12*). His work progressed with a study on the use of the Cambridge Structure Database (*13*) as a resource for understanding molecular shapes and discussions about using this resource in future for the teaching of chemistry, not only as a centerpiece of research. The placement concluded with experiments involving *in-silico* compound screening efforts (*14*, *15*), as a way to understand a commonly used 'hit-finding' protocol to discover novel chemical matter. During the closing stages of Evans' visit to NIBR's laboratories, as shown in a frame of a video-clip in Figure 3, he summarized his time in the following way.

'We may not have the resources to do it in the lab, chemicals are expensive, equipment is expensive, but we can do it on computer, giving [to] those who can do it chemically. Now I can visualize proteins on the screen, with molecules in there they call inhibitors, which we speak of abstract, they are there, but when you can see the molecule, turn it around, turn it around, see how and what part is interacting with what part. Seeing is believing they say, seeing is believing. So that is something I will carry back with me to the students. And not only the students, but with myself. Because now it is something I have picked, I can do it with my own hands.' Evans Ogwagwa Changamu commentary from video produced at the end of his fellowship, August 2010.

Figure 3. Professor Changamu discusses his 9 week visit to NIBR, August 2010. (Courtesy of Lewis Whitehead.)

In the fall of 2010 the NIBR CADD and X-ray crystallography groups were undergoing a computer hardware refresh cycle, retiring Linux workstations that had been used for over 4 years and replacing them with up-to-date models. NIBR

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worked with Seeding Labs and Kenyatta University to ship the retired machines to Nairobi in order to construct a computational chemistry laboratory within the Chemistry department at Kenyatta University. The 16 Linux workstations were delivered to the university in February 2012, with their hard-drives wiped clean of corporate information, allowing the university to install Linux and Windows operating systems and begin downloading freely accessible computational chemistry and molecular modeling software.

Innovative Project Grants – Believe, Dream, and Act

During an evening meal with friend and former Novartis computational chemistry colleague Chris Harwell, of New York City based D.E. Shaw Research, at the Hilton Short Hills hotel in New Jersey, the progress of the Kenyan computational chemistry initiative was discussed. Harwell is the current treasurer of the Computers in Chemistry (COMP) division of the ACS, and on hearing about the Novartis hardware donation to Kenya, and our desire to find funding for scientific software purchasing, he suggested an application for financial support to the ACS divisions via an Innovative Project Grant award. A grant was subsequently written and submitted in January 2012 by Whitehead and Changamu requesting financial support of $7500 to purchase sophisticated computational chemistry software for the new computational chemistry facility. A decision on the Innovative Project Grant was received in the spring, informing us that we had failed to be awarded the grant. This came as somewhat of a surprise to Whitehead, who was confident in the quality of the proposal documentation, although this was the first grant proposal he had written for financial support, because at Novartis this is not a job requirement. To Professor Changamu, a rejection of a grant proposal is routine, as many African academics are all too familiar (*11*). Although the rejection did serve as a reminder that there are many worthy causes in need of financial support, over the subsequent weeks a plan to resubmit the grant proposal to another funding agency was targeted. In an unforseen development, the COMP division chair and treasurer reached out to inform our effort that the International Activities Committee (IAC) of the ACS had recently launched a call for its first Global Innovation Grant Award for the financial support of overseas collaborations (*16*). Our previous grant proposal was modified slightly and resubmitted to the IAC for review. On September 28th, 2012 in a letter from the ACS Committee on International Activities, news was received that a $5000 Global Innovation Grant was successfully received for our computational chemistry laboratory building effort (*17*).

The $5000 Global Innovation Grant allowed the purchase of technologically superior computational chemistry software from Wavefunction (*18*), and the Cambridge Crystallographic Data Centre (*13*) to be installed on the workstations within the new computational chemistry facility shown in Figure 4. In addition, an Apple iPad for use in research and teaching was acquired to demonstrate the mobile nature of computational chemistry. ACS membership for Profesor Changamu was also acquired and the remaining funds were used to purchase academic text books for the Kenyatta University library (*1*, *11*).

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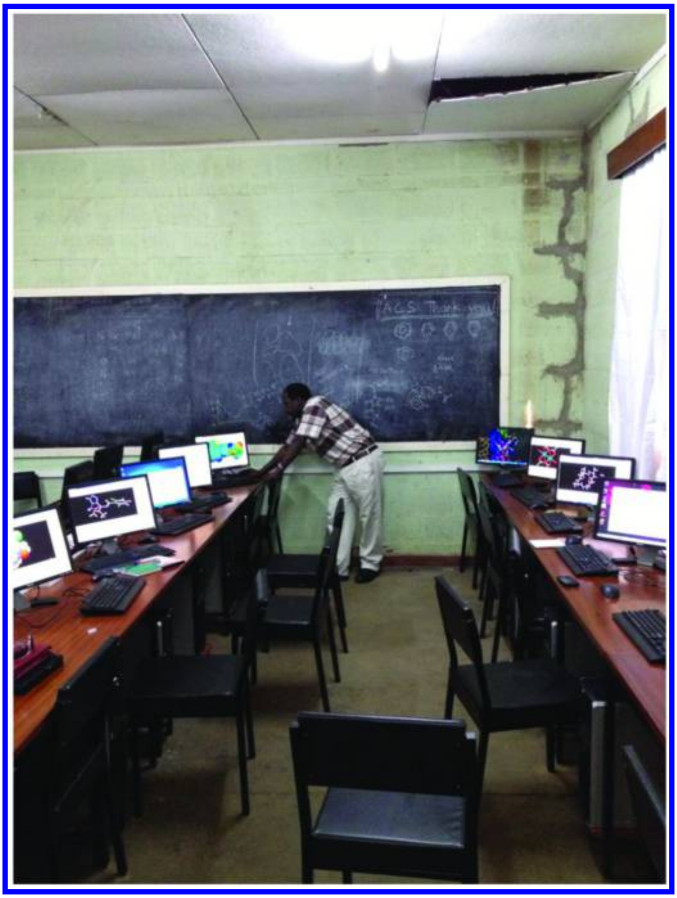

Figure 4. Professor Evans Ogwagwa Changamu in the Kenyatta University Computational Chemistry laboratory. February 2013. (Courtesy of Lewis Whitehead.)

Seed, Foster, Believe, Dream, and Act, Again

Our first visit to Nairobi in February 2012 to follow the initial donation of Linux workstations to Kenyatta University and the construction of a computational chemistry laboratory, involved a visit to the University of Nairobi. As well as performing a drug-discovery seminar on the Chiromo campus at the Department of Chemistry (Figure 5), Seeding Labs would select the 2012 African Fellows from the university, one of the candidates, Professor Solomon Derese, would co-host our visit.

Figure 5. Lewis Whitehead presents a medicinal chemistry seminar on the development of the EF-Tu inhibitor NVP-LFF571 (19) at the University of Nairobi, February 2012. (Courtesy of Lewis Whitehead.)

Professor Solomon Derese was selected as a NIBR-Seeding Labs African Fellow 2012, and he decided to share his time in the USA between the CADD laboratory of Lewis Whitehead, and the synthetic chemistry laboratory of Heather Burks. As an organic chemist by training, focusing on the purification and characterization of natural products from Kenyan plants, Derese began his computational chemistry project at NIBR beginning to construct three-dimensional molecular representations of natural products using the CSD modeling system (*13*). With focus particularly on the molecules characterized at the University of Nairobi, an *in-silico* database of natural products could then be used to perform structure-based drug discovery and launch of a drug-design laboratory at the University. The 'Mitishamba' database would also form the central *in-silico* repository for natural products isolated in Kenya. The database name is derived from the Kiswahili word for medicinal plant, *miti shamba*. During Professor Derese's fellowship he prepared a grant proposal document for submission to the Canadian Government's Grand Challenges Stars in Global Health competition (*20*, *21*), using his initial work at NIBR planting the seed of Mitishamba.

Derese was awarded $(CAN)110,000 to support the Mitishamba project, which would be used to finance several M.Sc. Chemistry studentships with the aim of constructing a web page allowing global access to the chemical information derived from the Department of Chemistry's knowledge of natural products isolated in Kenya.

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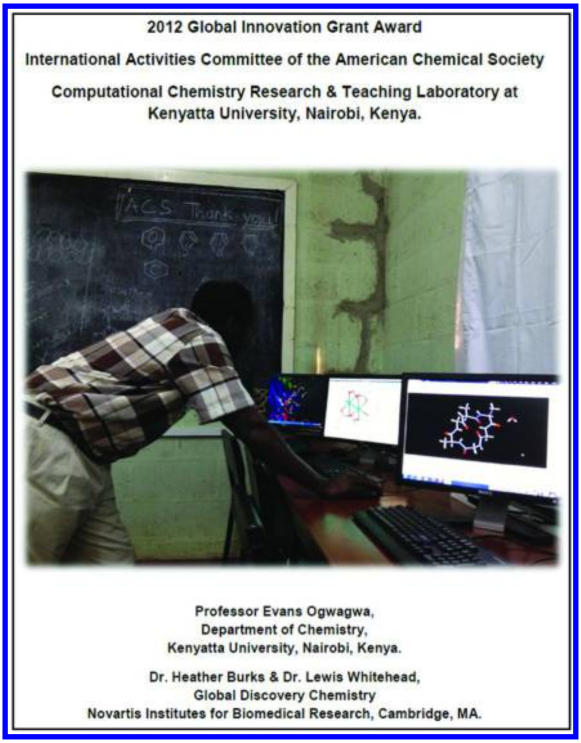
The End of the Beginning

At the spring ACS National Meeting in New Orleans in 2013, during the International Activities Committee subcommittee I: Africa and the Americas meeting on Saturday 6th April, the details of the 2012 Global Innovation Grant Award report document were discussed. The front page of the report is shown in Figure 6. An action item was minuted by Professor Bryan R. Henry, chair of subcommittee I, to inform scientific reporters at the *Chemical and Engineering News* (C&EN) journal of the actions and activities of the Kenyan computational chemistry effort.


2012 Global Innovation Grant Award
International Activities Committee of the American Chemical Society
Computational Chemistry Research & Teaching Laboratory at Kenyatta University, Nairobi, Kenya.

Professor Evans Ogwagwa,
Department of Chemistry,
Kenyatta University, Nairobi, Kenya.

Dr. Heather Burks & Dr. Lewis Whitehead,
Global Discovery Chemistry
Novartis Institutes for Biomedical Research, Cambridge, MA.

Figure 6. Frontispiece of the report delivered to the IAC Subcommittee I: Africa and the Americas. The picture shows Professor Evans Changamu within the Kenyatta University computational chemistry suite. (Courtesy of Lewis Whitehead.)

Within a few weeks C&EN reporter Linda Wang reached out to our team and produced an article published in the journal entitled ‘Computers Aid Chemistry in Kenya’ (*22*). The article, shown in Figure 7, launched online on Monday 23rd of September 2013, and during the afternoon of the 23rd, postgraduate student Lucy Kiruri, of Louisiana State University in Baton Rouge, contacted Lewis Whitehead via e-mail to inform him that she had seen the story. Kiruri informed Whitehead in discussions over subsequent weeks that as a chemistry graduate of Kenyatta University several years before, she left Kenya for graduate work in the computational chemistry and EPR research fields (*23*). As she was finishing her Ph.D studies in Louisiana in the laboratories of Dellinger and Lomnicki, on completion she was returning back to her home country and would be seeking a faculty position. The department of Chemistry at Kenyatta University hired Dr. Kiruri to faculty in January 2014. Kiruri, a former student had trained in computational and physical chemistry overseas, and returned to a fully functioning computational chemistry laboratory in Nairobi. On Friday 1st August, 2014, Dr. Kiruri wrote, *'All is well here and we have many graduate students undertaking research in computational chemistry.'*.

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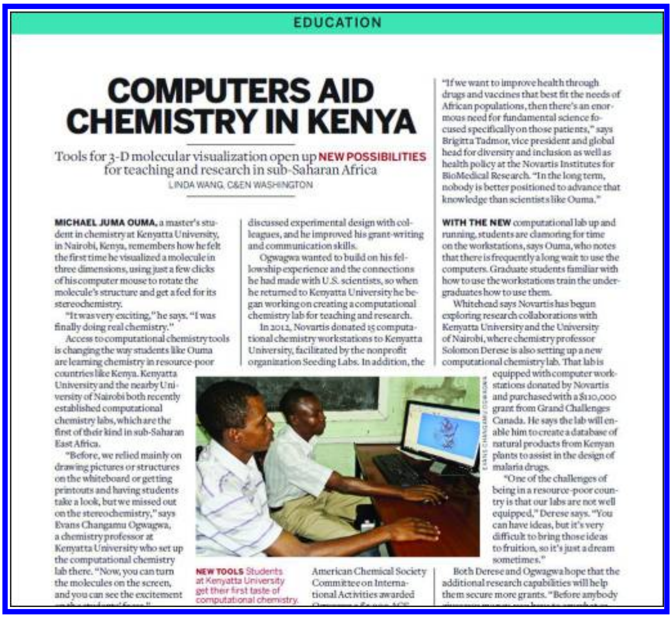

EDUCATION

COMPUTERS AID CHEMISTRY IN KENYA

Tools for 3-D molecular visualization open up NEW POSSIBILITIES for teaching and research in sub-Saharan Africa

LINDA WANG, C&EN WASHINGTON

MICHAEL JUMA OUMA, a master's student in chemistry at Kenyatta University, in Nairobi, Kenya, remembers how he felt the first time he visualized a molecule in three dimensions, using just a few clicks of his computer mouse to rotate the molecule's structure and get a feel for its stereochemistry.

"It was very exciting," he says. "I was finally doing real chemistry."

Access to computational chemistry tools is changing the way students like Ouma are learning chemistry in resource-poor countries like Kenya. Kenyatta University and the nearby University of Nairobi both recently established computational chemistry labs, which are the first of their kind in sub-Saharan East Africa.

"Before, we relied mainly on drawing pictures or structures on the whiteboard or getting printouts and having students take a look, but we missed out on the stereochemistry," says Evans Changamu Ogwagwa, a chemistry professor at Kenyatta University who set up the computational chemistry lab there. "Now, you can turn the molecules on the screen, and you can see the excitement

discussed experimental design with colleagues, and he improved his grant-writing and communication skills.

Ogwagwa wanted to build on his fellowship experience and the connections he had made with U.S. scientists, so when he returned to Kenyatta University he began working on creating a computational chemistry lab for teaching and research.

In 2012, Novartis donated 15 computational chemistry workstations to Kenyatta University, facilitated by the nonprofit organization Seeding Labs. In addition, the

NEW TOOLS Students at Kenyatta University get their first taste of computational chemistry.

American Chemical Society Committee on International Activities awarded

"If we want to improve health through drugs and vaccines that best fit the needs of African populations, then there's an enormous need for fundamental science focused specifically on those patients," says Brigitta Tadmor, vice president and global head for diversity and inclusion as well as health policy at the Novartis Institutes for BioMedical Research. "In the long term, nobody is better positioned to advance that knowledge than scientists like Ouma."

WITH THE NEW computational lab up and running, students are clamoring for time on the workstations, says Ouma, who notes that there is frequently a long wait to use the computers. Graduate students familiar with how to use the workstations train the undergraduates how to use them.

Whitehead says Novartis has begun exploring research collaborations with Kenyatta University and the University of Nairobi, where chemistry professor Solomon Derese is also setting up a new computational chemistry lab. That lab is equipped with computer workstations donated by Novartis and purchased with a $110,000 grant from Grand Challenges Canada. He says the lab will enable him to create a database of natural products from Kenyan plants to assist in the design of malaria drugs.

"One of the challenges of being in a resource-poor country is that our labs are not well equipped," Derese says. "You can have ideas, but it's very difficult to bring those ideas to fruition, so it's just a dream sometimes."

Both Derese and Ogwagwa hope that the additional research capabilities will help them secure more grants. "Before anybody

Figure 7. Linda Wang's report Computers Aid Chemistry in Kenya. Chemical and Engineering News, 23rd September 2013. (Reproduced with permission from ref. (22). Copyright 2013 American Chemical Society.)

In September 2014, the Mitishamba database (shown in Figure 8) was launched via the internet, marking a substantial stride forward in the documentation and dissemination of information on natural products from Kenyan plants (*24*). Another significant milestone is that this initative was completed by M.Sc. chemistry students, undertaking research in the cheminformatics sub-discipline of computational chemistry at the University of Nairobi.

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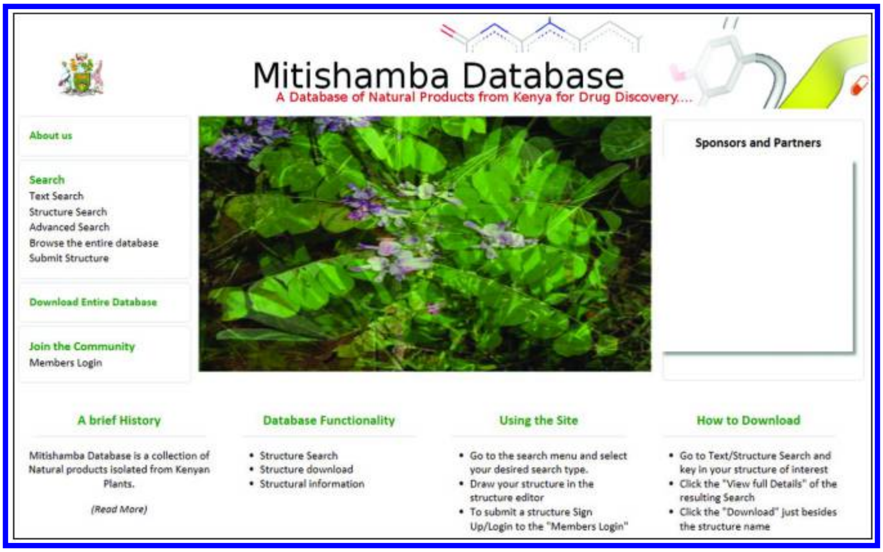

Figure 8. The online Mitishamba database of Kenyan natural products.

Conclusion

Through a series of historical coincidences and a willingness to volunteer, mentor and learn, Novartis' Global Discovery Chemistry team, together with Seeding Labs, the International Activities Committee and the Computers in Chemistry (COMP) division of the American Chemical Society have successfully constructed first of its kind computational chemistry resources in partnership with academics at Kenyatta University and the University of Nairobi in Kenya. To emphasize the importance of creating these educational and research resources in Sub-Saharan Africa, this manuscript concludes with the story of an event concerning Prischa, shown in Figure 9, a chemistry graduate of Kenyatta University, and teacher of high school science in Western Kenya, who is interested in pursuing her education in the chemical sciences further with an additional M.Sc. qualification focusing on computational chemistry.

During the laboratory visit to Kenyatta University in February 2012 Whitehead met a prospective Kenyatta University M.Sc. graduate student for two hours to discuss the importance of computational chemistry. After the meeting concluded, Whitehead learned that the student, Prischa, had travelled 6 hours, on three buses, leaving home at 3.30 a.m. that day to travel 200 miles for the meeting. Prischa would then return home that afternoon, completing a 400 mile day trip, for two hours of discussion with a trained British computational medicinal chemist from a research laboratory in the United States. That evening, from the Fairmont Norfolk hotel in central Nairobi, Whitehead wrote the following e-mail back to colleagues at NIBR in the USA.

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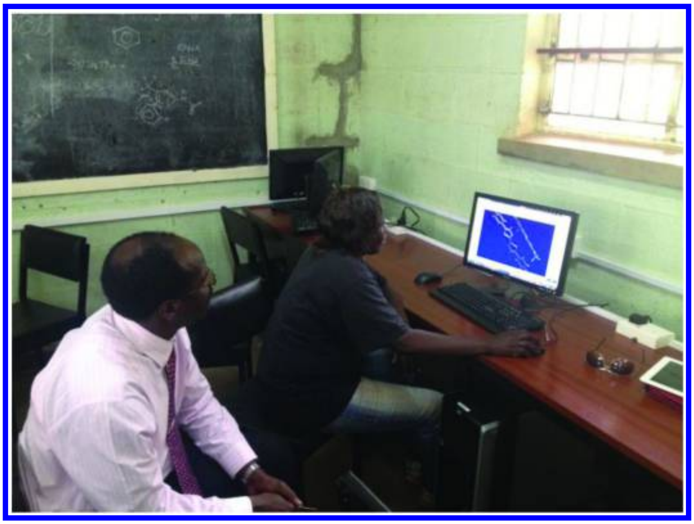

Figure 9. Prischa and Professor Changamu using the Cambridge Structural Database in the Kenyatta University Computational Chemistry Laboratory. (Courtesy of Lewis Whitehead.)

'I've just returned from two days at KU and effectively 2 days of radio silence. Before I go to the gym and dinner, and send you an update on other KU/UON information in 2 hours, I thought you'd like to hear this, because I still, 10 hours later, can't quite believe it, and I'm at the point of tears every time I think about this. Yesterday Evans said that 2 graduate students were wanting to speak to me for a time today. This morning, Evans received a telephone call from Prischa, a 2012 chemistry graduate at KU, telling him that she'd just got on a mutatu in Nairobi and that she'd be about 45 minutes. One hour later, Prischa arrives and we make formal introductions. At this point Evans asked her about her journey today….which I thought was a bit odd…I'm thinking, 'she's just come up from Nairobi by bus.' Prischa left home at 03.30 a.m. this morning to take a bus from her home into central Kisii, caught the 05.00 a.m. bus to Nairobi, where she arrived around 10.00 a.m., then taking a mutatu to KU. Just to see me, and get an idea about computational chemistry. I spent 2 hours with her while Evans was teaching, she shared lunch with us, before leaving KU around 3 p.m. to make the return journey. A 708 km round trip journey. I'm going to the gym now, Prischa will be on the Nairobi – Kisii bus, getting home tonight around midnight. I'm truly stunned, humbled, inspired and still finding it hard holding back my emotions….it's just truly unbelievable.'

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Chapter 17

Science for Haiti: International Collaborations To Advance Haitian Science and Science Education Capacity and Innovation

Jorge L. Colón*

Department of Chemistry, College of Natural Sciences University of Puerto Rico, P.O. Box 70377 San Juan, Puerto Rico 00936-8377
***E-mail: jorge.colon10@upr.edu.**

The magnitude 7.0 earthquake that struck Haiti on January 12, 2010 killed over 220,000 people and injured over 300,000 (United Nations Office for the Coordination of Humanitarian Affairs, Where We Work, Haiti Page: Haiti: One Year Later. http://ochaonline.un.org/tabid/6412/language/en-US/Default.aspx (accessed Jan 7, 2011)). In addition, it also damaged most of the science and science education infrastructure at Port-au-Prince and all areas near the epicenter. The Inter-university Institute for Research and Development estimated that 87% of Haiti's higher education institutions were impaired or completely demolished (The Challenge for Haitian Higher Education: A post-earthquake assessment of higher education institutions in the Port-au-Prince metropolitan area. http://www.inured.org/uploads/2/5/2/6/25266591/the_challenge_for_haitian_higher_education.pdf (accessed Dec 22, 2014)). In this article, I review the general context of the institutions of higher education (IHE) in Haiti before and after the earthquake and give a few examples of efforts by the international community to advance Haitian science and science education capacity since the 2010 earthquake. These initial efforts offer inspiring examples of science collaborations in Haiti that will allow this country to advance capacity in areas crucial to its sustainable development and innovation. Finally, I also present the situation of chemistry in Haiti and some

efforts aimed at improving higher education science capacity in the future and finish with some recommendations for possible involvement of the ACS in this endeavor.

Introduction

Dr. Evens Emmanuel of Université Quisqueya and Dr. Guy Etienne of the College Cats Pressoir-High School, both educational institutions in Haiti, presented an overview of the higher education situation in Haiti before and after the 2010 earthquake (*1*). Of the close to 200 institutions of higher education (IHE) in Haiti, only 50 were authorized by the Ministry of Education. However, most of them did not have the conditions (infrastructure, human qualifications) to operate at the university level.

In 2010, eight of the IHE were members of the *Agence Universitaire de la Francophone (AUF)*, the biggest university and research center network in the world. Those eight institutions were considered the "elite" higher education academic centers in Haiti with about 60% of student body approximating 60,000 students. Those eight IHE are: the State University of Haiti (UEH), the Ecole Supérieure d'Infotronique d'Haïti (ESIH), the Université Quisqueya (UNIQ), the Université Notre Dame d'Haïti, the Université Caraïbe, the Institut Universitaire Quisqueya Amérique (INUQUA), the Ecole Nationale Supérieure de Technologie (ENST), and the Centre de Techniques de Planification et d'Economie Appliquée (CTPEA).

The governance of the IHE in Haiti is assured by the Ministry of Education, with a specialized service run by three (3) people. No legal provisions are in place for accreditation, evaluation and certification of programs. Public funding is insufficient to run the State University, is almost non-existent for the other public institutions, and is not available for private IHE (including the non-profit institutions).

There are few regular professors; only 15% of professors have a doctorate (e.g., Ph.D.), 65% have a master's degree and 20% have a bachelor's degree. Scientific research is very rare and almost done in a voluntary basis. There is an absence of procedures of accreditation of research laboratories. In elementary, middle, and high schools there is a need to train a critical mass of science teachers. Since schools lack laboratories, there have been calls to at least install school laboratories by regions that might by used by several schools.

The capacities to perform scientific research were limited, with only the following research centers in place: the Laboratories of the School of Agriculture (FAMV – UEH), the School of Medicine (FMP – UEH), the Laboratory of Virtual Reality (ESIH), the Laboratory of Water and Environment Quality (LAQUE – UniQ), and the Centres GHESKIO (Prof. J. W. Pape).

The January 2010 earthquake devastated the institutional capacity and infrastructure of Haitian science. Some photos of the damages inflicted to IHE that provide examples of the widespread devastation that occurred and taken from an assessment of the damages performed by Professor Patrick Attie of ESIH and Daniel Lamaute in February 2010 are available (*2*).

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The State University of Haiti (UEH) (*3*) had around 15,000 students in Port-au-Prince and 10,000 students in the provinces divided in 11 faculties. Three hundred of those students and 20 professors died during the earthquake, most of the faculties were destroyed or irremediably damaged, and only the Faculty of Odontology remained operational.

The Ecole Supérieure d'Infotronique d'Haïti (ESIH) (*4*) had 1,000 students in Port-au-Prince and two undergraduate programs: Bachelor in Computer Science and Bachelor in Business Administration. The earthquake resulted in thirteen students and one professor dead, a rented building destroyed, the energy infrastructure destroyed (around U.S. $60,000), and 250 computers destroyed. However, the Virtual Reality Laboratory was saved. At the moment a team was developing a complete 3D immersive model of the Citadel near the city of Cap Haitien. That work was stopped by the earthquake until funding could be resumed from a donor that was hurt by the earthquake (around U.S. $30,000 in funding).

The Université Quisqueya (UNIQ) (*5*) had 2,600 students in Port-au-Prince divided in seven (7) faculties. Sixteen (16) students and three (3) professors died in the earthquake and a newly built building was destroyed.

After the earthquake new collaborative efforts were initiated between Haitian scientists and international scientists, and existing ones were strengthened. I will start by presenting the one that I am more familiar with, since it is an effort co-led by the Caribbean Division of the American Association for the Advancement of Science (AAAS). I was President of the AAAS-Caribbean Division when the massive Haiti earthquake occurred on January 12, 2010. Then I will present other significant efforts as examples that can be used as models for other scientific collaborations that can be established in Haiti. I will finish with efforts centered in chemistry, advances in science higher education in Haiti, and a personal goal.

Science for Haiti Project (AAAS-Caribbean Division)

A month after the 2010 earthquake, at the AAAS Annual Meeting, Professor Gary Machlis (University of Idaho) and I convinced the AAAS Board that an effort should be done to help Haitian scientists get back to conditions that would allow them to contribute to the rebuilding and sustainable development of their country. In July 2010 workshops titled *Advancing Capacity for Haitian Science and Science Education* were conducted in San Juan, Puerto Rico and Port-au-Prince, Haiti, with Haitian scientists, scientists from the Haitian diaspora, and scientists from Puerto Rico, United States, Canada and Rwanda on how to advance scientific and science education capacity in Haiti following the earthquake and prepare a set of strategies, recommendations and proposed actions directed to the government of Haiti, the U.S. government, the scientific community and development, donors and aid organizations (*6*).

The workshop in Puerto Rico was attended by nine Haitian scientists and twelve scientists from Puerto Rico, United States, Canada and Rwanda. The workshops in Haiti were attended by about 70 Haitian scientists, teachers and principals, and members of the Presidential Commission for Education and the Presidential Commission on Information and Communication Technologies (*7*).

The report that resulted from these workshops, *Science for Haiti: A Report on Advancing Haitian Science and Science Education Capacity* (*8*), coauthored by Gary Machlis (University of Idaho), Jorge Colón (University of Puerto Rico), and Jean McKendry (Association of American Geographers), contains an executive summary in English, French, Creole, and Spanish, a first for a AAAS report. The report has seven strategic goals to advance science and science education in Haiti, including (1) Advance Haiti's scientific capacity to link Haitians scientific expertise to Haiti's development objectives; (2) Invest in science education, research and technological innovation to generate sustainable development and prosperity for Haiti (3) Developing Haitian scientific capacity and expertise to promote scientific management and sustainability of Haiti's natural resources, and (4) Support existing scientific and educational organizations and institutions, and if needed, establish new ones to promote the role of science in Haitian society.

To support the achievement of the seven strategic goals, the workshop participants identified specific recommendations, policies and actions to advance science in Haiti. The report includes 17 recommendations for advancing science capacity, such as: establishing a national science and technology policy, conducting specific human capital studies, including inventories of existing and/or needed scientific expertise, and developing creative approaches to increase recognition of science within Haitian society, including national awards for outstanding Haitian scientists and science students. The report also includes 15 recommendations to advance science education capacity emphasizing that science education, both formal and informal, is essential at all levels of Haitian society - preschool, K-13, higher education and among adults. Among the recommendations on advancing Haitian capacity in science education are: constructing regional "learning laboratories" and community gathering places and training more teachers and faculty to provide quality science instruction. The report concludes with 11 recommendations to advance science governance in Haiti. These include clear and constructive science policies (and where necessary, rules and procedures), effective governing bodies, well-supported institutions of higher education and research, and organizations to provide Haitian scientists with research opportunities, scientific interchange, and recognition. Participants stressed the need for the Haitian government to increase its level of support for science and science education, and urged the international scientific community to provide encouragement and assistance in developing "good governance" institutions for science.

The report containing the results of these workshops was presented in Haiti in September 2011 to scientists, science educators, primary schools principals and members of the private sector. The first official presentation in the U.S. took place in October 2011 in the AAAS Auditorium in its offices in Washington, D.C. and was attended by representatives of the U.S. State Department, USDA, USAID, the National Academies; and non-governmental organizations such as the Haitian Ocean Project, Ciencia Puerto Rico (CienciaPR), American Society for Microbiology, and National Institute of Building Sciences. The reaction to the workshops and the report in both countries was extremely positive.

In Haiti, the scientific community came together and created in 2011 the Haitian Association for the Advancement of Science and Technology (HAAST) with Professor Fritz Deshommes, Vice-Rector for Research, UEH, as its first President. The HAAST was officially recognized by the Haitian government in 2014. One of the first events held by the HAAST was a workshop on science reporting held in Port-au-Prince, Haiti in February 2013 with the participation of Lisa Friedman from ClimateWire and 2009 AAAS Kavli Science Journalism Awardee for Online Reporting. The workshop was attended by over 25 journalists, who then created an association of science journalists.

Counselors of the President of Haiti met with us to better understand the details and recommendations of the report and expressed interest in implementing several of the recommendations soon. Several scientific and aid organizations from the United States and abroad expressed their support and shared with us and with the Haitian scientific community possible avenues of collaboration and monetary support to begin implementing some of the ideas suggested.

All our efforts in the *Science for Haiti Project* were based on the following premises: (a) the January 12, 2010 earthquake impacted the institutional capacity and infrastructure of Haitian science and science education; (b) the recovery planning had not yet included science and science education as a priority; (c) Haitian science and science education is critical to rebuilding Haiti for long-term sustainable development and economic prosperity; (d) the Haitian scientific community must lead this effort; the international community can provide assistance; (e) A first step was to develop policy and action recommendations through a collaborative partnership among scientists from Haiti and around the world. We were inspired by seeing the temporary classrooms in tents that the UEH has established in Port-au-Prince for students to attend classes and complete the semester. We also saw the temporary classrooms at Collège Catts Pressoir (High School), and we were invited to attend their graduation ceremony on July 16, 2010, in Port-au-Prince, Haiti. The resilience of the Haitian people and their passion for knowledge were beautifully demonstrated before our eyes.

Other Scientific Collaborations in Haiti

There are many other scientific collaborations in Haiti. Several of them are given below.

Haitian Bioscience Initiative

Professor Ilio Durandis is the founder of the *Haitian Bioscience Initiative*: *Science Education and Training for Sustainable Development in Haiti* developed in collaboration with Dr. Phil Gibson, the Bioscience Program Director at Gwinnett Technical College in Athens, GA (*9*). The Haitian Bioscience Initiative's aim is to train young Haitians in the basics of bioscience laboratory techniques that can be helpful in environmental and water/food safety testing, including PCR. In addition, it aims to help make young Haitians employable as professionals, laboratory technicians, and future researchers who can eventually become leaders in creating new industries in Haiti.

A pilot project was held in Haiti in May-June 2014 in collaboration with the Ecole Supeérieure d'Infotronique d'Haïti. Professor Jim Dekloe, Ph.D. from Solano Community College and Professor Durandis were the instructors for the 5-day hands-on workshop. Twenty three people participated in the pilot, including professionals, high school and university students. They learned techniques and discussed topics such as extraction of DNA, the polymerase chain reaction using miniPCR, microbes and the environment, wastewater treatment, and buffers in biological systems. A video of that first pilot project can be viewed on the Internet (*10*). Participants later visited the Tamarind National Laboratory and the Laboratory of the University of Florida in Gressier, Haiti, where they were able to see work being performed by technicians working on the *V. cholerae* bacterium that has recently killed thousands of Haitians.

The Haitian Bioscience Initiative hopes to be able to collaborate with existing Haitian institutions to promote scientific technology and practical experience in their curriculum through a public-private partnership with the ultimate goal for Haiti to have a biotechnology and biopharmaceutical industry to meet its population needs, create new jobs that guarantee a living wage and help in the development of the country. The participants of Phase I of the Pilot Project of the Haiti Bioscience Initiative received their certificates on November 14, 2014 at a ceremony held at the ESIH.

Professor Durandis also founded *Haiti 2015* in 2009 as a social movement for a just and prosperous Haiti..

Haiti Biogas Project (University of Maryland)

Dr. Stephanie Lansing, from the Department of Environmental Science and Technology of the University of Maryland, is the Director of the *Haiti Biogas Project* aimed at providing low-cost anaerobic digestion facilities for human waste treatment that will produce methane-enriched biogas (*11*). Haiti faces acute sanitation, energy, and food security challenges. Seventy percent (70%) of the population has no access to sanitation facilities. Energy, in the form of wood and charcoal, require 25-50% of daily income ($1/day). In this collaborative project, anaerobic digestion is being used to treat human waste, produce energy, and provide fertilizer for agricultural production. The project site is being also used to test a business model around the innovation, with a strong focus on capacity building (*12*). Three research activities and four education activities were conducted by Dr. Lansing's team as part of a one-year NSF RAPID grant.

Six senior students in a capstone ecological design and technology course designed a sustainable anaerobic digestion system for Cange, Haiti and made presentations about it to school groups, farmers, and professional societies. The wastewater and energy needs of critical medical infrastructure in a post-earthquake environment were compared to data from pre-earthquake conditions to determine the resiliency of the existing system in responding to natural disasters. The project site in Haiti was the site of the Partners in Health (PIH) hospital in Cange. Five sustainable technologies appropriate for Haiti have been incorporated into teaching curriculum in a new ecological design class at the University of Maryland.

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VT-ESI Haiti Project: Capacity Building in Computer Science (Virginia Tech - Ecole Supériore d'Infotronique d'Haiti (ESIH))

The Office of International Research, Education, and Development and the Computer Science Department of the Virginia Polytechnic Institute and State University (Virginia Tech) partnered with the Ecole Supériore d'Infotronique d'Haiti (ESIH) to strengthen ESIH's computer science program. The *VT-ESI HAITI PROJECT* (*13*) started before the 2010 earthquake and was part of a USAID initiative to build capacity in Haiti's IHE. They developed distance learning courses for STEM teaching in Haiti, with three online courses already used by 11% of the student population from the start of the 2011-2012 academic year. The program trained ESIH faculty and provided funds for ESIH students to complete undergraduate work at Virginia Tech. In addition, Virginia Tech was able to secure a donation from IBM of 50 laptops for ESIH.

Haiti Ocean Project

Jamie Aquino founded the *Haiti Ocean Project* with the purpose of protecting Haiti's valuable marine mammals and other important marine life (*14*). Haiti has 1600 kilometers of coastline and many fishing villages, so a marine science/ education curriculum should be facilitated in classrooms throughout Haiti. The *Haitian Ocean Project* involves Haitian kids in creating a simple and informative classroom curriculum specifically for Haiti students. The *Haiti Ocean Project* is sponsored by the Guy Harvey Ocean Foundation.

Haiti-Chemistry Team (Purdue University)

The Haiti-Chemistry Team was a collaboration between the Université de Antenor Firmin (UNAF) in Cap Haitien, Education in Science for secondary education program and the Purdue University Departments of Animal Science, Agriculture and Engineering (*15*). The goal of the Haiti-Chemistry Team was to design a "Purdue Chemistry Lab" for UNAF, which they were able to do.

Zanmi Lasante (Partners in Health/Haiti)

Zanmi Lasante (Partners in Health/Haiti), operates clinics and hospitals – including the 205,000 square foot, 300-bed national teaching hospital Hôpital Universitaire de Mirebalais – at 12 sites across the desperately underserved Central Plateau and beyond, serving an area of 1.3 million people with a staff of 5,400 Haitians (*16*). The University Hospital in Mirebalais, Haiti, is a public-private partnership between the Haitian government and PIH to provide a level of care never before available at a public facility in Haiti and to provide high-quality education to the next generation of Haitian nurses, medical students, and resident physicians. In 2013, the government of Haiti supported the hospital's operating budget with $8 million sourced from multilateral post-earthquake relief funds. The Hôpital Universitaire de Mirebalais is the world's largest solar hospital (with 1,800 solar panels).

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Situation of Chemistry in Haiti

Chemistry courses were given by around 10 professors at the following programs: (a) Licence en Chimie at the Faculté des Sciences (FDS) to two groups of 50 students; (b) Faculté d'Agronomie et de Medecine Veterinaire (FAMV) to two groups of 50 students; (c) Ecole Normale Superiore (Natural Science diplomat with an option in Chemistry) to one group of 25 students; and (d) UEH School of Medicine and Pharmacy to one group of 40 students and UEH Faculty of Dentistry.

Of the four laboratories (three in chemistry and one in medicine), all were destroyed by the earthquake, but some of the materials and equipment were recuperated.

In 2011 I became aware of a group in Haiti aimed at developing Chemistry in Haiti called *Groupe de recherche et de développement de la chimie en Haiti*. (GRDCH) (*17*). The motto of GRDCH is: "La chimie au service du developpement" (chemistry in service of development) and it planned activities to celebrate the International Year of Chemistry and the "global water experiment". Some Haitian schools received kits for the water experiment through the national commission of UNESCO in Haiti. GRDCH was able to held some conferences for the youth who really appreciated learning more about chemistry. Unfortunately, a lack of financial support prevented them to run the projects as planned (including the contest). I have been unable to contact GRDCH officials since 2011. However, in their website they have an assessment of Chemistry in Haiti relevant to our topic, which highlights the following problems (*18*): (a) lack of awareness of the importance of chemistry from the leaders and the population; (b) lack of higher education schools offering major in chemistry; (c) lack of interest for a career in chemistry among the high school students; (d) lack of qualified teachers and resources such as laboratories in the schools; (e) Chemistry is an issue not on the agenda in Haiti; and (f) actions need to be taken to improve the situation of this field for the benefits of the local industry, the secondary schools, and IHE in order for chemistry to help in the development of Haiti.

In contrast, GRDCH presented some good indicators for the future of Chemistry in Haiti: (a) the undergraduate program in Chemistry at the Faculty of Sciences of the State University (FDS/UEH) had been launched in 2003 (this program had been closed since the 1980's); (b) several students were currently enrolled in advanced studies in chemistry outside the country; and (c) nowadays Haiti is globally more open to technology and science.

The GRDCH website states that they believe in the future and believe that chemistry must play a key role in the development process of Haiti. So do I.

Future of Science and Science Education in Haiti

A new university campus of the State University of Haiti in Limonade (Université Henri Christophe) was inaugurated in 2012, a $30 million facility which plans to have a strong science component. In addition, a new US $150 million UEH main campus in 60 hectares of land is planned to be built in Damien, a district of Port-au-Prince 15 km from downtown, with buildings for classrooms,

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libraries, laboratories, dormitories, and restaurants to house 15,000 students and 1,000 professors, although funds for this project have not yet been approved.

The Clinton Foundation, in collaboration with the Government of Haiti and the Faculty of Sciences (FDS) at the State University of Haiti (UEH), announced $7.3 million in funding to rebuild the main building at the Faculty of Sciences in Port-au-Prince. The funding comes from the Qatar Haiti Fund, as well as from a grant with the Inter-American Development Bank (IDB). According to the Clinton Foundation "The reconstruction of FDS will focus on creating a top quality, environmentally friendly building that will serve as an anchor for the FDS campus. The building will include classrooms, lab space and lecture halls and will benefit FDS students as well as the faculty and staff." (*19*).

Other Encouraging Proposals

In a recent article on science diasporas Willian J. Burns stated: "Diaspora networks, like nongovernmental organizations, civil society groups, and multinational corporations, are increasingly important and influential actors in international relations. Science diasporas are vital to a new architecture of cooperation that will allow us to invent, create, innovate, and solve problems together." (*20*).

Ciencia Puerto Rico (Ciencia Puerto Rico Home Page. http://www.cienciapr.org (accessed Aug 8, 2014) is an expert and resource network for all who are interested in science and Puerto Rico and currently has with over 7,000 members. They published in September 2011 a book called *¡Ciencia Boricua! Essays and Anecdotes of the Puertorrican Scientist* with 61 essays by 24 Puerto Rican educators and scientists. Its essays are written in simple language with the general audience in mind, while covering important and fundamental scientific concepts with precision and veracity. The book is already used in many Puerto Rican schools after CienciaPR held workshops for teachers (*21*). Ciencia Puerto Rico was initially established as a way to maintain contact between the Puerto Rico science diaspora and scientist in Puerto Rico and have developed a model for how online diasporas and communities can work together to advance science. Ciencia Puerto Rico learned of the AAAS-Caribbean Division *Science for Haiti* project and has started discussions with the HAAST to try to transfer the web resource to establish a similar platform for the Haitian science diaspora and scientists in Haiti.

Three other examples of successful engagement with science diaspora communities are: the Turkish American Scholars and Scientists Association (TASSA) (*22*), the Wild Geese Network of Irish Scientists (WGNIS) (*23*), and the Ethiopian Physics Society-North America (EPSNA) (*24*). Meanwhile, the Networks of Diasporas in Engineering and Science (NODES) was developed in 2012 as a partnership between the AAAS, the U.S. Department of State, the National Academy of Sciences and the National Academy of Engineering (*25*). Furthermore, the International Diaspora Engagement Alliance (IdEA) promotes and supports diaspora-centered initiatives in investment & entrepreneurship, philanthropy, volunteerism, and innovation in countries and regions of diaspora origin (*26*). IdEA engages global diaspora communities, the private sector, civil

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society, and public institutions in collaborative efforts to support economic and social development. The CienciaPR and HAAST Proposal for Collaboration to establish a similar online network between Haitian scientific diaspora and Haitian scientists currently only needs to secure funding to be implemented.

COLLÈGE DOCTORAL D'Haïti

The *COLLÈGE DOCTORAL D'Haïti (CDH)* is a collaborative project between UEH, Université Quisqueya and AUF for the creation of a Doctoral College of Haiti that will allow professors and research professors without a doctoral degree to conduct research on issues relevant to the country. The CDH is a resource center supporting the different Ph.D. programs of the universities affiliated to the CDH, with academic and administrative management remaining the responsibility of these universities. The CDH project was established on the firm belief that the future of Haiti requires quality higher education and research that is both innovative and competitive (*27*). The Working Group for the COLLÈGE DOCTORAL D'Haïti expects to train 100 Ph.D.s in 5 years, produce and publish theses of high scientific quality, and provide effective scientific tools to meet national and regional needs. Students would register in one of the graduate schools of CDH members. The CDH promotes female candidates in all the member universities. The scientific council of the college will determine the thematic priorities. Student will produce international joint theses (dual degrees). In June 2014, the Doctoral College in Telecommunications of the ESIH also applied to become a member of the CDH. During its first year (2013-2014 academic year) CDH obtained AUF funds to provide financial assistance to 20 doctoral students; 24 are being supported in the 2014-2015 academic year. In addition, during the current year there will be a scientific evaluation of the four (4) university laboratories and the international evaluation of the application for the Doctoral College of ESIH, among other projects.

Possible Roles for ACS

In 2012 I published an article in which I made a call for a response from the international chemistry community to the efforts to advance Haitian science and science education capacity (*28*). Once again, I encourage the ACS to take a leadership role in this endeavor. The ACS and its Committees, Divisions, and Local Sections can play important roles, and individual members can become engaged in this effort. The International Activities Committee (IAC) may be involved as well, probably through a Global Innovation Grant. Perhaps a Festival de Química should be held in Haiti. I firmly believe that assisting the advance of science capacity in Haiti is both appropriate to ACS mission and a moral imperative; science in Haiti is a foundation for human rights in the country.

My Personal Goal

Since 2011 I have been involved in a collaborative research and science outreach effort with the California Institute of Technology NSF Center for

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Chemical Innovation called *Powering the Planet: A Chemical Bonding Center in the Direct Conversion of Sunlight into Chemical Fuel* (now *Center for Chemical Innovation in Solar Fuels*) (*29*). Our Caribbean Brigade for the CCI Solar Army objective is to introduce concepts of solar energy as a suitable energy source to underrepresented groups in middle and high schools in Puerto Rico. Two teams, one from the University of Puerto Rico-Río Piedras and one from UPR-Mayagüez have been giving workshops on constructing dye-sensitized solar cells using the Juice-from-Juice (JfJ) kit sell by Arbor Scientific (*30*) and on research to identify new catalysts for hydrogen generation using the Solar Energy Activity Laboratory kit sell by Caltech. Over 20 schools and 800 people were impacted in the first two years of the program; 19% were teachers, 67% students, and 14% others (professional scientists, etc.). Many of these teachers receive a free JfJ kit to repeat the workshop in other academic years under the auspices of the NSF support. Four graduate students (2 in each site) participate in the workshops and eight undergraduate students (4 in each site) have been collaborating with the graduate students in the program. A graduate students and an undergraduate student were able to do summer research internships in 2013 and 2014 on solar catalyst development at the University of Wyoming and Caltech, respectively, under the auspices of this program.

My goal is to bring these workshops to Haiti to help advance solar energy science and science education related capacity building. Our efforts will join current solar energy efforts in Haiti such as those from the Clinton Foundation and its Global Initiative (*31*).

Conclusions

To address the innovation needs of developing countries such as Haiti, strong collaborative engagements with foreign science institutions, professional scientific organizations, and governments need to be established. In 2011 I was part of a AAAS Delegation with Prof. Jessica Wyndham of AAAS Science and Human Rights Program that gave testimony at the Public Hearing *Right to Enjoy the Benefits of Scientific Progress and its Applications* held by the Inter-American Commission on Human Rights (IACHR, an organ of the Organization of American States), in Washington, D.C. In my testimony (*32*) I shared my strong belief that access to the benefits of science is a human right as important as any other. Scientists must be committed to help communities sharing their knowledge and information and working together to allow them to solve their problems. I strongly believe that the public, including poor and disadvantaged groups, has the right to enjoy the benefits of scientific progress and its applications, but that right can only be fulfilled if science and technology are broadly available and accessible so that all members of society can appreciate them and understand their significance.

Scientific capacity is required to advance technological innovation and economic opportunities in Haiti, improve medicine and health care, create access to drinking water, improve disaster preparedness and mitigation, develop sustainable agriculture and reduce hunger, sustainably manage natural resources, educate citizens, and promote human rights. Science is an essential foundation for the future of Haiti, but must be led and directed by Haitians, with the valuable assistance of the international scientific community. The role of science in reconstruction, recovery and development of Haiti will depend on the development of scientific capacity integrated into the full range of local, regional, and national efforts to rebuild the nation. I urge the ACS to monitor these collaborative efforts and encourage new ones that are being made between Haitian and international scientists through the *Science for Haiti Project* and its report which provides an initial "road map" for progress. The establishment of a national science and technology policy in Haiti is a priority and should include specific ways to coordinate these international collaborations. These collaborations can lead to the advancement of science, science education, and other benefits of scientific progress in Haiti.

Acknowledgments

Thanks are due to Dr. H. N. Cheng, Chair of the American Chemical Society International Activities Committee (IAC), for including me in the IAC Symposium on "Innovation for International Collaborations" in San Francisco on August 11, 2013 and giving me the opportunity to share my thoughts on scientific collaborations to help advance science and science education capacity in Haiti. I also thank my present and former graduate and undergraduate students who share with me the commitment to science, science education and outreach, and the human right to the benefits of scientific progress.

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Chapter 18

A Retrospective View of My 70 Years in Chemistry

Darleane Christian Hoffman*

Faculty Senior Scientist, Nuclear Science Division, Lawrence Berkeley National Laboratory, Professor Emerita, Department of Chemistry, University of California, Berkeley, Berkeley, California, U.S.A.
***E-mail: darlhoffman@gmail.com.**

In this article, some of the people and events that helped shape my long career in chemistry are recalled. The status of women has changed dramatically over these years as have chemistry and my specialties of radiochemistry and nuclear chemistry. When I entered Iowa State College in 1944 as an Applied Art major, freshman chemistry was a required subject. It was my first course in chemistry and was taught by a woman chemistry professor. She emphasized chemistry as a basic science with opportunities in both fundamental and applied research and told of Marie Curie's discovery of radium as well as practical applications in everyday life. Because of her inspiring lectures, I soon decided to change my major to chemistry! Subsequent undergraduate research in nuclear chemistry exposed me to the thrill of discovering new isotopes. I earned my B.S. (1944), Ph.D. (1951) in Chemistry (nuclear) and married fellow graduate student Marvin Hoffman (1951). I quickly learned that "you can't do it all by yourself"! I had outstanding help at home and a husband who understood that I must continue my career even after we had two children. The opportunity to travel, attend international conferences, pursue sabbaticals abroad, accept lectureships in many different countries ranging from North and South America, to China, Japan and Europe helped broaden my horizons and understand the potential 'uniting power' of science in the solution of world problems.

The status of women has changed dramatically over my 70 years in chemistry, and there have been many changes in my fields of nuclear chemistry and radiochemistry. My experiences highlight and re-emphasize the tremendous influence of our teachers and mentors.

I graduated from High School in West Union, Iowa in May 1944 and could not decide whether to major in mathematics or art. I finally chose to enter Iowa State College, Ames, Iowa as an Applied Art Major which was in the school of Home Economics. Fortunately, chemistry was a required course and because of my inspiring chemistry professor, Dr. Nellie M. Naylor (Fig. 1), a "spinster" - a more polite word for what we used to call an 'old maid'- I switched to chemistry. When I told my Applied Art counselor—also a woman and a spinster, she asked if I thought chemistry was a suitable profession for a woman? I replied, "Of course, my chemistry professor is a woman!" *At that time women teachers at all levels had to resign if they married so I proclaimed I would never teach!*

Figure 1. Nellie Naylor. Courtesy of the Special Collections Department, Iowa State University Library.

I vowed to follow Marie Curie's model—marry if I wanted to and have children if I chose to. However, to make a long story short, WW-II changed everything! Women successfully took over jobs formerly designated as "men's jobs". After the war, 'The Jeannie was out of the bottle' and couldn't be put back!

In the summer of 1947, I obtained a position as an undergrad research assistant at the Institute for Atomic Research at Ames, Iowa with young Prof. Don Martin and continued part-time during my coming senior year. I split mica for Geiger counter windows, learned micro ion-exchange techniques for rare earth separations, and pursued research on Szilard-Chalmers reactions and the production of new radioactive isotopes. In June 1948, I received my B.S. in Chemistry and was then ***officially a Nuclear Chemist—nearly 66 years ago****!*

In Fall 1948, I stayed on to pursue my Ph. D. in Chemistry, and my husband-to-be Marvin Hoffman entered graduate school in Physics. *Both Marvin & I studied photonuclear reactions at the new 68-MeV synchrotron being built near the Iowa State University campus.*

In Dec. 20, 1951, I received my Ph. D. My dissertation was entitled, "High Specific Radioactivities of Cobalt, Platinum, and Iridium from Photonuclear Reactions".

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I had also vowed not to marry until I finished my Ph. D. and so on December. 26, 1951, Marvin and I were married!

In January, 1952, I left Ames to take a position at Oak Ridge while Marvin finished his Ph. D. This was .most unconventional, and his major professor told him: "You've made a terrible mistake—you should have married some nice girl who would stay home and take care of you!" That didn't sound like me!

December 1952

Marvin decided to take a position at Los Alamos National Laboratory (LANL) where he had been earlier as a summer student so I resigned my position at Oak Ridge to join him for a promised position in the Radiochemistry group there which I eventually manage to join—a long story! My clearance was somehow lost between the two laboratories, and I missed being a co-discoverer of the new elements einsteinium (99) and fermium (100) which were discovered in the debris from the LANL first thermonuclear test in the Pacific that the group was busy analyzing.

We were to remain in Los Alamos for ~ 30 years (Fig. 2)! The following are some highlights from that time.

Figure 2. Darleane, Marvin, Daryl (age 15), and Maureane (age 17) Hoffman around the piano in our home in Pajarito Acres, Los Alamos, NM; 1974. Courtesy of the author.

1953-78: Los Alamos Scientific Laboratory

Staff Member, Project Leader, Associate Group Leader: And, yes, I did choose to have children! Daughter Maureane was born on Easter Sunday, 21 April, 1957 and son Daryl was born on Labor Day, 2 September 1959 so I took

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very little time off! I found a wonderful woman whose husband brought her to our home every morning and picked her up in the evening. It was too difficult to take them somewhere else! Marvin had a position in the Test Division that often required him to be gone for extended periods of time.

In later years, after our children were in school, my Mother came to live near us and they went to her home after school. And I learned a very important lesson—You can't do it all yourself—you need help!

Los Alamos

We were to remain in Los Alamos for ~30 years from March 1953-August 1984 (Figs. 3-5). From 1953-1979, I was in the Radiochemistry Group as *Staff Member, Project Leader, and Associate Group Leader.*

The following sabbaticals proved to be *vital in shaping my career:*

1964-65: *NSF Sr. Postdoctoral Fellowship, Kjeller, Norway.*

1978-79: *Guggenheim Fellowship, Seaborg's Group, LBL.*

I returned from this Fellowship to become the first woman Division Leader of a scientific division at Los Alamos National Laboratory.

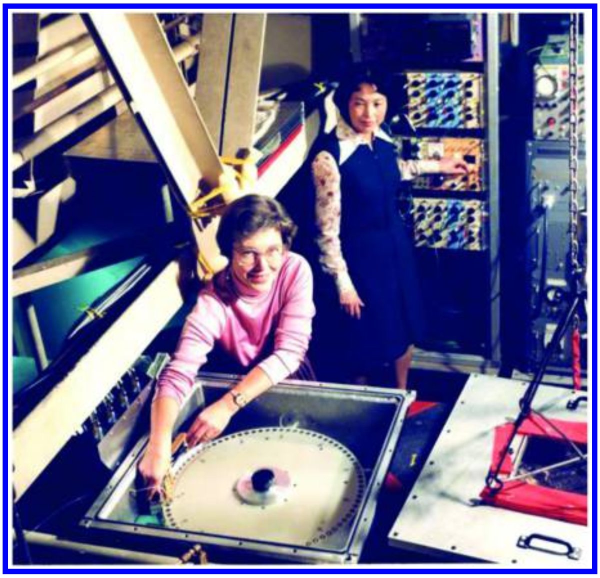

Figure 3. Sabbatical year 1978-1979: Lawrence Berkeley Laboratory; Darleane Hoffman & Diana Lee with "Merry-Go-Around" (MGA) for collecting and characterizing short-lived isotopes produced at the 88-inch cyclotron. Albert Ghiorso helped design and build this sample collection and detection system. We called it the MGA since he had a vertical wheel system called the VWA so he had a VW and we had an MG. (Courtesy of Lawrence Berkeley National Laboratory.)

Figure 4. Farewell party August 1979. Cake says: "It was SHEer pleasure knowing you!". (Courtesy of Lawrence Berkeley National Laboratory.)

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1979-1982*: Division Leader of Chemistry-Nuclear Chemistry Division.* Los Alamos National Laboratory.

Figure 5. Glenn Seaborg presenting ACS Award in Nuclear Chemistry, March 1983, Seattle, WA. There were no other women recipients of this award until Joanna Fowler (2002) followed by Silvia Jurisson (2012). Courtesy of the American Chemical Society.

1982-1984: *Division Leader of Isotope and Nuclear Chemistry Division* Los Alamos from 1982-1984 when I returned to Berkeley as tenured Professor of Chemistry and Group Leader of the Heavy Element Nuclear and Radiochemistry Group.

30 Years: September 1984−Present (Figures 6−12)

University of California, Berkeley, Chemistry Department

1984-91: 2nd woman tenured Professor, 1991-93 and 2012 to present: Professor Emerita: 1994-2011: Professor of Graduate School

Lawrence Berkeley National Laboratory (LBNL) (Figure 6)

1984-2001: Nuclear Science Division: Faculty Sr. Scientist, Group Leader, Co-Group Leader.

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Figure 6. 1990 collaboration group, 88-inch cyclotron, Berkeley, CA. German, Russian, Swiss, U.S.A. collaboration. (Courtesy of Lawrence Berkeley National Laboratory.)

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Figure 7. Professor Darleane Hoffman showing the then "new" lab computer systems for data control and display to University Professor Glenn Seaborg in Building 70, Room 210, LBNL, 1991. (Courtesy of Lawrence Berkeley National Laboratory.)

Figure 8. Faculty, Department of Chemistry, University of California, Berkeley, 1991. Darleane Hoffman and Birgitta Whaley are the only women. (Photograph by Michael Barnes. Used with permission.)

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Figure 9. Hoffman Research Group together with Glenn Seaborg, Albert Ghiorso, and Matti Nurmia. LBL, Fall 1993. (Courtesy of Lawrence Berkeley National Laboratory.)

Lawrence Livermore National Laboratory (LLNL)

1991: Co-Founder, Seaborg Institute for Transactinium Science, Charter Director 1991-1996. Sr. Research Advisor 1997-2007.

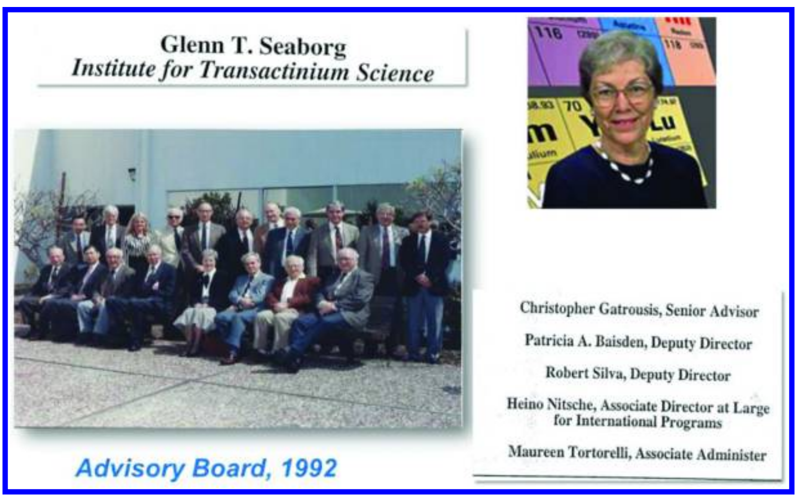

Figure 10. Institute for Transactinium Science Advisory Board members, 1992. (Group inset reprinted with permission from Lawrence Livermore National Laboratory; other image courtesy of the author.)

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Figure 11. Darleane and Marvin Hoffman, Priestley Award Banquet San Francisco, March 2000. Courtesy of the American Chemical Society.

Figure 12. (from left) A.Ghiorso, D. C. Hoffman, G. T. Seaborg, published by Imperial College Press, London, 2000 (1). (Reprinted with permission from ref. (1). Copyright 2000 Imperial College Press.)

Conclusions

After this brief account of my nearly 70 years in chemistry, I have summarized and commented on some of the significant events and dramatic changes I've witnessed.

- The status of women and women teachers has changed dramatically, primarily due to the influence of WWII when women did "men's jobs." However, the fraction of women on the faculties of prestigious universities still needs to be increased.
- The importance of one's spouse, or significant other, and family, and the influence of teachers and mentors, both male and female cannot be overestimated!
- Undergraduate research is invaluable.
- Both the fundamental and applied aspects of chemistry should be emphasized.
- Sabbaticals and travel abroad are invaluable in broadening one's horizons and understanding the role science can play in helping to solve world problems.
- Recognize that "you can't do it all by yourself".

Acknowledgments

Special thanks to my long-time friend and illustrious colleague, 2013 ACS President Marinda Li Wu, who conceived of and organized this Symposium, and invited me to participate. It is also a pleasure to thank graduate student Jennifer Shusterman without whom I would never have been able to adapt my talk to book format.

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Chapter 19

Ten Lessons from a Lifetime of Science

Madeleine Jacobs*

Executive Director and CEO, American Chemical Society, 1155 16th Street NW, Washington, D.C. 20036
***E-mail: madeleine.susan.jacobs@gmail.com.**

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Drawing on nearly 45 years as a communicator and leader in the chemical sciences, I describe herewith my life's journey, from a young girl growing up in my grandmother's house in Washington, D.C., to becoming the chief executive officer of the world's largest scientific society. At each transition in my personal and professional career, I realized that I had learned a lesson, even if I had not realized it at the time. Students to seasoned professionals should be prepared to nod with recognition, laugh, and even cry, from my first lesson, "Never do anything just to please your mother," to Lesson Number 10, "Experiment!" This article will provide insights on how to build a satisfying career and personal life.

This article originated in 2002, when I was asked to give a brief—that is, 20 minutes— biographical sketch on the occasion of receiving the Women's History Month Award from the New York Academy of Sciences. I realized after I wrote out my 20 minutes that I had learned something at each transition step of my career. I titled that talk "Ten Lessons from a Lifetime of Communicating Science" and as my career progressed I retitled it "Ten Lessons from A Lifetime of Science"…and, of course, the talk also got longer. It is a very personal journey, and probably very different from the other articles in this book which deal perhaps more about scientific research. However, I hope there will be a few valuable insights on how to build a satisfying and enduring career and life.

It is probably self-evident just by looking at me that I'm a full fledged member of the baby boom generation. I was born in 1946, a little more than a year after World War II ended. Indeed, I will be 68 on November 11. Of course, through the miracles of modern chemistry, I still have brunet hair—and not only that, it's a bit like a Starbuck special: mocha on the bottom and caramel on the top. I grew up in Washington, D.C., in a comfortable lower middle class home with my extended family that included a grandmother and an uncle, as well as my parents and a brother. My father was a bassoonist—from a long line of bassoonists—my mother was a housewife and later a secretary who became the executive assistant to the President of Geico, which in the 1950s was just starting out. I never had a chemistry set to play with, and my parents were totally uninterested in and unaware of science.

However, I always had the sense that I could do anything I wanted. And my favorite television program was "Watch Mr. Wizard"—that was my first exposure to science—and Mr. Wizard made it seem magical. For those of you who are too young to remember this show and have not seen it on the Internet, let me tell you a little bit about it.

Don Herbert, also known as Mr. Wizard, was a World War II pilot and a radio and television actor before he gained his greatest fame as Mr. Wizard. Every Saturday morning, from 1951-1965, he appeared live on NBC--in black and white, of course. Mr. Wizard covered everything from air travel to sound speed to chemical reactions and much, more. The key to this show was the experiments he conducted.

Sometimes, the experiments went awry or didn't do anything of interest, which could have been the cause of major embarrassment on live TV. But Mr. Wizard never got discouraged. He would repeat the experiment week after week until it behaved as he knew it should.

Part of the show's success was the fact that everyday household items could be used to conduct the experiments. Since Mr. Wizard was a teacher, he needed students, and so the show gathered a group of "neighborhood kids," who were actually young actors hired to be inquisitive. I was pretty naive in those days—I thought they were real kids! Although Mr. Wizard had file cards with "one word reminders" on them, most of the dialogue was improvised, although the audience could always count on the kids saying in unison, "Gee, Mr. Wizard!"

"Watch Mr. Wizard" demonstrated that science was something tangible and accessible to everyone. The philosophy worked, and many people whom I've met over the years have credited Mr. Wizard with their career choices in science and engineering.

So with the help of Mr. Wizard, I became increasingly aware of science in my daily life. I grew up with DuPont's once-famous slogan—"Better Things for Better Living through Chemistry." I was probably only 10 years old when it became crystal clear to me that science in general and chemistry in particular made possible the food, medicines, housing, furniture, clothes, and transportation that I enjoyed. Then, in 1957, Sputnik was launched, and the U.S. government began pouring money into science education and training—from kindergarten through graduate school. By the time I was ready to go to college in 1964, I had benefited from several excellent general science, chemistry, physics, and biology teachers. These teachers not only had a deep love of their subject matter, but they also had the ability to communicate that love.

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Science was a hands-on activity, and like Mr. Wizard, those teachers made it come alive.

Majoring in science, in chemistry, was encouraged, not necessarily by my parents, who, as I mentioned, had no particular interest in science, but by the overall cultural environment. I believed strongly and still believe that being a chemist was a ***noble calling***. Scientists were widely respected, and they also earned a respectable salary. The message to youth was: You could live well and do good by becoming a scientist. For my part, I wanted to get a Ph.D. in chemistry and design drugs that would cure cancer. At the age of 17, I understood that it was chemists, as well as biologists, not physicians, who developed the drugs that made our lives healthier.

As a senior in high school, I had very little guidance from my parents or from my guidance counselors, as my graduating class had 900 kids. We were indeed the baby boom generation! Many of my classmates were from affluent families and had parents who were scientists and physicians—there were few lawyers back then.

My family only had enough money for me to apply to four universities, and when I received a full tuition scholarship for four years from George Washington University, I was elated, even though it meant I wasn't going to an Ivy League school like my friends, or even going away from Washington, D.C.

I lived on the George Washington University campus, and immersed myself in chemistry. GW had a very small graduate department but prepared a lot of kids for medical school, so its undergraduate chemistry and biology departments were excellent. I took every possible course I could, including a graduate course in organic chemistry, which cemented my love for that field.

To earn money so I could live on campus, I worked two summers at the U.S. Department of Agriculture Agricultural Research Center in Beltsville, Maryland, catching and dissecting cockroaches. I still have nightmares from that job, but it paid well. The summer between my junior and senior year I had an NSF fellowship to work in my organic chemistry professor's lab. It was a great experience, despite my one and only experience with an explosion. But that story is for another time.

I was completely in love with chemistry and wanted to go to graduate school. Moreover, I had achieved straight A grades (except for three B's in physical education) and outstanding GRE's to make it possible to go to the best graduate schools. My father was enthusiastic; my mother, on the other hand, had only one goal for me: To see me married—and to someone who could keep me in the style to which she wanted to see me become accustomed.

So Here Is Lesson Number 1: Never Do Anything Just To Please Your Mother—or Your Mother's Friends or Anyone Else for That Matter.

However, in those days, I was always anxious to please my mother and so I dutifully married a high school boyfriend, the son of a very wealthy family, a month after college graduation in 1968. My husband, a physics major at Yale, graduated first in his class. We had a dream of getting our Ph.D.s in physics and

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chemistry, doing brilliant research, having our 2.5 children, and winning the Nobel Prize. We were going to be a modern day Pierre and Marie Curie.

The marriage worked out well in two ways: My mother got to plan the big wedding she had always dreamed of, and I didn't have to even think about where I wanted to go to graduate school. Since my new husband was a physics major at Yale and wanted to go to graduate school, I let him choose the place we would go. We applied to the top 10 universities in physics (which fortunately coincided with the Top 10 in chemistry). He got into all of them; I got into nine of them but was rejected by Harvard. Later, in life, as I became more familiar with women's issues and discrimination, I wondered whether my rejection at Harvard had to do with my marital status, since the Harvard application asked if the applicant was married, and if the answer was no, it asked, "Are you planning to get married." I answered it honestly. I guess Harvard figured it wouldn't waste time to educate a woman who might get pregnant. Anyhow, of the nine universities where we both got in, my husband chose Stanford.

My first husband and I were headed to Stanford for graduate school when he learned that he was going to be drafted into the Army—it was the height of the Vietnam War and there were no deferments for graduate school. His wealthy father pulled some strings and my husband received a commission in the Public Health Service. As it turned out, his father owned the building that housed the Public Health Service's computers. He and I got deferments from Stanford, and that settled life for the next two years—at least for him.

But I was then in a quandary because I hadn't applied to any local universities for graduate school since none of them were of the caliber of Stanford. I ended up going to the University of Maryland, figuring I'd get a master's degree and then be just that further ahead when I got to Stanford. So I completed my course work at the University of Maryland and began working on my thesis in the spring of 1969. I chose as a mentor a young assistant professor who had the worst lab space—it was on the fourth floor of an un-air-conditioned building. I was in the field of organic chemistry, and by the middle of May, I had to come in at 6 a.m. and leave by 11 a.m. because the lab was 110 degrees.

Also, at that time, my husband's mother had succeeded in making life miserable for me. She had signed me up for tennis lessons so I wouldn't embarrass her at the country club where we played doubles on Saturday mornings, and it meant I had to commute 30 miles twice a week from University of Maryland to make the lessons.

After a few months of suffocating heat in the laboratory and a boring master's degree project, not to mention lousy tennis, I tossed in the towel and decided to get a job. Everyone was horrified.

This leads me to the next lesson.

Lesson Number 2: Follow Your Intuition. It Is Often Better than Looking Only at the Facts.

From a factual viewpoint, I should have finished my master's degree. After all, it was only a year. But I knew in my gut that completing my master's degree at the University of Maryland was not the right thing to do for me. I figured I was going to go to Stanford. And there was a nagging doubt in my head at the time. I began to wonder whether I was smart enough and cut out to do research.

At this stage, I only had a year before I was to head off to Stanford. I had always enjoyed writing—-indeed, at one point my English literature professor in college asked me to switch majors—and I loved *Chemical & Engineering News*, which I read as an undergraduate and in graduate school.

So I thought to myself, why not get a job at *Chemical & Engineering News*? I had no idea whether or not there was an opening. I simply thought, that would be interesting. One day in July 1969, I called Dr. Richard Kenyon, then the publisher of C&EN, and asked his secretary for an appointment. She informed me that "Dr. Kenyon is at lunch and he is busy all afternoon. I suggest you send a résumé." I didn't know what a résumé was, so instead, I got on a bus and went to the headquarters of the American Chemical Society, took the elevator to the publications floor—there was no security back then—and walked into Dr. Kenyon's office. I told the secretary I was there to see Dr. Kenyon. She looked up and said, "Didn't I just talk to you on the phone?" "Yes," I admitted. "And didn't I tell you that he's at lunch and he's busy?" "Yes," I replied, "Do you mind if I wait?" She shrugged, and said "You can wait but he won't be able to see you."

I positioned myself in the office so I could see the elevator and when he got off, I raced over to the elevator door, introduced myself and asked for a job.

You can't imagine the look of horror on the secretary's face as we breezed past as Dr. Kenyon said to me, "Come right in."

Lesson Number Three: Never Take No for an Answer. (And by the Way, I'll Always See Anyone Who Walks in off the Street, although It Is a Lot Harder Now with Security.)

I was very honest at this interview. I told Dr. Kenyon I only had a year to give the magazine because I was going to graduate school at Stanford.

He asked me if I had any writing experience. Proudly, I replied, "Yes, I've always gotten an A on my lab reports." I even pulled one from my briefcase.

He took me to see the editor, Pat McCurdy, and because I always read the magazine carefully, I told him everything that was wrong with the magazine and how I could contribute. I told him which editorials I liked and which ones missed the mark. Remember I was 22 years old.

Incredibly, Pat offered me the job. That's why today, I will see any young person who calls and I will always answer their letters and emails.

Lesson Number Four: Believe in Yourself.

I didn't have this much self-confidence again for another 25 years! A short digression here: A lack of self-confidence and a lack of self-esteem are nearly universal problems that haunt women at some stage in their development. Girls and young women in particular suffer from a lack of self-confidence that holds them back. But all of us know *women* well into their 40s who are very successful

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at what they do who still think they aren't good enough, smart enough, thin enough, or pretty enough to succeed. One thing that each of us in this room who are older can do is be sure that we help young women known their own worth.

After my first year at C&EN, it was time to go to Stanford, but I had found my calling: Writing about chemistry. I loved this job. It nourished my love of learning and my myriad interests in science. So instead of going to graduate school, I moved with my husband to California where he went to graduate school and I worked for C&EN.

However, the marriage broke up for two main reasons: My mother died in January 1970, just a year and a half into our marriage, and I no longer had to please her, and my husband and I had very little in common because I had moved into the adult world and he was still in the world of graduate school.

So I left him and moved back to Washington, D.C., where I continued working for C&EN. I also met and married my husband of more than 42 years, Joe.

I loved my work at C&EN. Besides writing about every field of chemistry, I became the expert on women's issues in chemistry and science. But I had a step son who would soon be going to college and I needed more money. I left C&EN in 1972 when I discovered that my salary was 30% below a benchmark for my position. This may or may not have had anything to do with the fact that I was the only woman on the staff, but later ACS did have a class action suit brought by the women at ACS for underpayment of salaries. ACS lost the suit.

Back in 1972, I asked for a raise and was told that the economy was in a recession, which it was, and that since eight people had just been fired, the magazine was not in a position to give me a raise. Although I was the youngest staff member, and the only woman, I was then the highest producer on the staff.

With no hard feelings, I found a better job, at the National Institutes of Health writing about allergies and infectious diseases. It was a great fit with my chemistry training, and also broadened my knowledge of science tremendously to include immunology, molecular biology, and medicine.

Lesson Number Five: Never Burn Bridges, but Know When It Is Time to Move on, and Then Do It.

No one can make these choices for you. Be open to change.

One of my favorite books is by Dawn Marie Driscoll and Carol R. Greenberg. It is titled "Members of the Club: The Coming of Age of Executive Women." Though it was published in 1993, it is still a wonderful book. Driscoll and Greenberg speak of the 5 R's that define a culture of success: respect, responsibility, resourcefulness, revenue development, and risk taking. Women are a part of this culture of success only to the extent that they explicitly embrace and deal with the five Rs.

I had a rewarding time at NIH, and certainly learned about allergies, immunology, and infectious diseases. But after three years working at a weekly magazine, I found the pace of a government agency excruciatingly slow. Fortunately, after just 15 months working at NIH, I got a call from a friend of a friend, and I went to work at the National Bureau of Standards, since renamed the

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National Institute of Standards and Technology, as a science writer. This was a new function at the National Bureau of Standards and I was soon like the kid in the candy shop.

The Bureau, as we called it then, worked in so many basic research and applied science fields—everything from fundamental research in materials, nuclear energy, and particle physics to dental research, fire prevention, and energy conservation. I wrote about all of those areas and became one of those individuals who could talk about almost anything for three minutes at a cocktail party.

Seriously, if you have broad interests as I do, this was a fabulous job. Almost every day I got to work with interesting scientists and engineers and learn something new about important fields with practical applications. Chemistry, I found, was an underpinning for many of these fields and I used my knowledge of chemistry and the scientific method to gain credibility with the scientists and engineers as I interviewed them and wrote about their complex research.

But, and there's usually a but….I was about to face my next major career challenge. That occurred when my boss was promoted to division head and I was promoted into my first job in management—to head the media and general publications unit he had previously directed.

My boss and I had always gotten along well, when I was one of 14 people reporting to him. Interestingly, most of the other people who reported to him did not like him at all. They saw him as a bully and a mean-spirited micro-manager. I soon found out why he wasn't liked, when I took over his old job and began doing it differently. All hell broke loose. He would come into my office and stand over my shoulder while I was working. He once called me at home when I was sick with 104 fever and screamed at me, demanding to know where a certain report was. I told him it was on his desk. Instead of mentoring me and supporting me, he spent most of his time trying to teach me how to do the job the way he did it, micromanaging everything I did, and yelling at me. Constantly. I had to act as the buffer between my staff and his outrageous bullying behavior.

My work, which I had always loved, started to become unbearable. I hated getting out of bed in the morning to go to work. I knew that he would never change and that I could not and did not want to change to become like him. I thought, if this is what it means to be a manager, I want no part of it. Thus, I quietly let the word out that I was interested in finding a new job.

Knowing that I was eventually going to leave enabled me to tolerate the situation. It took a year, but I received that magic call from a friend of a friend who told me that the Smithsonian Institution was looking for a science writer to start a news service for daily and weekly newspapers. He asked if I knew anyone, I said I did, and that's how I landed a new and wonderful job at the Smithsonian Institution as chief science writer in the Office of Public Affairs.

Lesson Number Six: Never Allow Yourself To Become a Martyr or To Be Victimized by Anyone.

My experience at the National Bureau of Standards taught me never to allow anyone to bully me. It taught me to take control of my career and make it happen.

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I found being a martyr very unpleasant. It meant that someone else had control of my life.

So my advice is: Never stand for a situation in which someone is acting the way my boss acted. And by the way, this can happen with women bosses too. More about that in a moment.

I tell young women to construct a personal agenda with a series of five-year plans focusing on your objectives, goals, and career aspirations. Revise these plans regularly so they are up to date. Ask yourself: "Where do I want to be in five years and what must I do to get there?" Don't wait for others to define this agenda for you. It won't happen.

And now we come to a long stretch in my career—14 years at the Smithsonian Institution. The Smithsonian was a wonderful place to work between 1979 and 1993, the years I was there. I was hired to write and launch a news service about research at the Smithsonian, which in the pre-internet days was distributed by mail to daily and weekly newspapers. It was a very popular service, and once again I expanded my knowledge base to include the arts and humanities. The Smithsonian conducted research on everything from American art, astrophysics, and anthropology to zoology and Zen Buddhism. I traveled with biologists, physicists, and animal behaviorists around the world and wrote about their research. Almost immediately, my wonderful boss, a former foreign correspondent for newspapers and networks, promoted me to assistant director of the office. After seven years, I moved from being assistant director and chief science writer to head of the Office of Public Affairs and was also the chief spokesman for the institution. I oversaw the public affairs activities of 16 museums, the national Zoo, and many research institutes ranging from astronomy to zoology. It was a dream job. I built a wonderful staff of writers and media specialists, and we were considered the best museum public affairs staff in the world. And it was there that I successfully made the transition from being an individual contributor to being a manager and a leader. I found the rewards of creating an environment where very bright people could do their best work. It was a revelation to me that management could be as rewarding as being a single contributor. It also taught me the value of teamwork and collaboration.

But the Smithsonian job was incredibly time consuming and stressful. Essentially, I was on duty 24 hours a day, and it was not uncommon for the press to call me at 3 a.m. about the birth of a panda at the National Zoo or the havoc wrought by a tornado at one of the storage facilities of the National Air and Space Museum. Although the Smithsonian was an endlessly fascinating place and fed my love of art, history, and the humanities, I had no personal life at all. I worked, ate, and breathed the Smithsonian.

And, once again, I found myself dealing with a bully—only this time it was a woman. I reported directly to the head of the Smithsonian, who had the title of Secretary, but he brought in an undersecretary who decided that she would hold daily staff meetings at 7:30 a.m. every day—whether there was anything to discuss or not. She began micromanaging everything in the purview of the Secretary's direct reports.

One day in 1991, I had a Eureka moment. I was standing in front of the mirror getting dressed and I realized that although I was very good at my job, I

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was unhappy. I am a person who likes to be in control of my life, and I was in a job where I was never in control. I realized that I hated going to work in the morning because at the end of the day I had not accomplished any of the things I had set out to do. And then I spent every weekend at work. And I had a boss, who wasn't really my boss, who thought she was!

Lesson Number Seven: Get a Life! That Is, a Life in Addition to Your Work Life.

Balancing a personal life and professional career is difficult—but it can be done by carefully setting priorities and not getting distracted by those things which don't fit on your list of priorities.

And remember, if you don't enjoy going to work every day, ask yourself why. Be honest with yourself. Decide what gives you satisfaction in life, and then make it happen.

I thought about what had given me the greatest pleasure in my career, and I realized it was my love of chemistry—I had moved away from that over the years—and my love of writing and journalism. I had never lost touch with *Chemical & Engineering News*, and one day I bumped into the then editor, Michael Heylin, at a black tie dinner. We agreed to meet for lunch. At that lunch, I asked him why he didn't have a managing editor. He explained that the managing editor had died 10 years before and he just hadn't gotten around to filling the position.

I was shocked, because when I had been at C&EN, the managing editor was a co-captain of the ship. I couldn't imagine how Mike could produce a quality publication without a managing editor. He took my comments to heart, and asked if I were interested in the job. I said yes and he said he would try to get funding for the position. But in the fall of 1991, he reported back that ACS would not fund the new position. It was in the middle of a recession and funding was not available. I began looking elsewhere, methodically targeting those publications that might provide the kind of environment that would fulfill my goals.

I was still looking in March 1993 when an executive search firm called to say that ACS was looking for a managing editor for its flagship publication. By that time, I wasn't sure I was still interested. After all, any organization that would take two years to make up its mind didn't strike me as the kind of organization I would like. But I met with the recruiter anyhow, and returned to C&EN in 1993 and became Editor-in-Chief in 1995.

I loved being Editor-in-Chief of *Chemical & Engineering News*. When I came back to the American Chemical Society in 1993, I was told C&EN was a family, but what I found was a dysfunctional family. But in the 10 years I worked there as managing editor and editor-in-chief, we truly became a family. It was a joy to go to work every day. I know I made a difference in the quality of the publication and also in the quality of the lives of the people who work there. I was able to mentor an entire new generation of writers and reporters and prepare my successor, Rudy Baum, for the job.

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As Editor-in-Chief, I deepened again my knowledge of chemistry. Every day I learned something new about the exciting research going on in the field. Since chemistry is a central science, I was able to ensure that C&EN covered the most exciting fields at the interface of chemistry and multiple disciplines—biology, materials, engineering, physics, medicine, to name a few. I also enhanced our coverage of industry, making sure that our stories covered the important research that went on in industry.

Shortly after I became Editor-in-Chief, I had a series of personal crises. First, my beloved father became ill with lymphoma and died within five months. We had always been very close, I talked to him nearly every day, we saw each other every week for lunch. Fortunately for me, he lived near me. From the day of his diagnosis until he died five months later, I left work every day promptly at 5 p.m. to visit him. I found a way to balance the demands of the job with my need to see him as much as possible. I learned that nothing suffered at work, and I cherished that time with him.

Barely a year after he died, when my life had returned to its normal hectic pace, I was diagnosed with breast cancer. I was 50 years old and had never felt better or been fitter. I was completely taken by surprise. When I received the diagnosis and the oncologist laid out the possible courses of treatment for my estrogen positive, stage-one cancer, I compiled a list of 30 technical questions for him to answer. I had read about all the options and the chemotherapeutic agents, the side effects, the clinical trials, and so forth. I understood the chemical structures and asked very detailed questions. He had never before had a patient who wanted to know so much. But I was simply following my own advice to take charge of my life and construct an agenda for myself. He patiently answered everything, and in the end, I had two surgeries, six months of chemotherapy, and daily radiation for 7 weeks.

I am so grateful to all the researchers who worked tirelessly over the years—the chemists, biologists, doctors, and others—who developed the drugs and treatments that saved my life. My course of treatment was CMF—cytoxan, methotrexate, and 5-fluorouracil. When I had completed all of the treatments, I also took Tamoxifen, whose mode of action was binding estrogen, and Femara, an aromatase inhibitor whose mode of action was interrupting the synthesis of estrogen. It helped me to understand what the mode of action and side effects of each of these drugs were.

Fortunately, except for the two weeks involving the surgery, I never missed a day of work. I knew I was fortunate because the only real side effect I had was fatigue and weight loss—25 pounds in all. I really liked being a size 6!

Of course, the size 6 didn't last long, but fortunately for me, the remission did. It's been 17 years and I count myself very fortunate.

It was exciting leading the C&EN team which had a weekly mission: produce the best possible publication covering the chemistry universe. I could have gone on forever as Editor-in-Chief of *Chemical & Engineering News*. There are few positions as satisfying as having a weekly product—and an excellent one at that! But when I learned that the Executive Director of the American Chemical Society was going to retire at the end of 2003, I decided to apply for the position. There were more than 250 applicants, and I went through five interviews, including two with the full board of directors.

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In these interviews, my confidence never wavered. I didn't have a Ph.D. in chemistry, and my career was perhaps a nontraditional one to become the head of an organization. I was managing a group of 75 people, and the ACS has 2,000 employees. How did I know I could transfer my skills as a leader from 75 to 2,000? I just knew. Because in my heart, I believe that all good things come from the power of people, and I am the ultimate people person.

Apparently the Board of Directors agreed and I became the first woman, non-Ph.D. to head the American Chemical Society. ACS was at the time at an important crossroads in its 138-year history. From my vantage point as C&EN Editor-in-Chief, I saw what needed to be done to ensure that ACS was positioned for the future. I worked diligently and patiently with the ACS Board of Directors, our 161,000 members, and our staff to bring the Society to a new level of excellence, just as I did at *Chemical & Engineering News*.

These 11 years as Executive Director and Chief Executive Officer have been a great learning experience. Working with a volunteer Board of Directors is not the same as working with a single boss.

I always love reading articles in the *Wall Street Journal* about CEOs who get fired because invariably they are fired because they have a run in with the Board of Directors or the chair of the Board. And that fate almost befell me. I ran into a rocky patch after two years as Executive Director/CEO, and found it was indeed lonely at the top. So I hired an executive coach to help me negotiate the way. First, he advised me that the care and feeding of a board of directors requires considerably more time than you can imagine. He was right. He gave me lots of invaluable advice. "Stay calm, listen carefully, pause before speaking, and be strategic when you speak." He talked to each member of the Board of Directors to find out what they liked and didn't like. He reported back that the Board thought I was too glamorous. "Men are distracted, women are jealous," he told me. So I threw away my patterned stockings and bought St. John knit suits. I tossed out my contact lenses and began wearing glasses. Suddenly, I was more intelligent looking and the Board of Directors began to see me differently. Though this was the right approach with the Board of Directors, it turned out to be deadly advice. St. John suits have elastic waist bands, and without even knowing it, I quickly gained 20 pounds on the job.

But seriously, I sought advice from others I respected. My first chair of the board advised, "It's better to do it right than to do it fast." Another colleague whom I admired told me, "You can get credit for things or you can get things done, but you rarely can do both." I utilized my scientific training and always thought about options, what would happen if I approached a problem from multiple perspectives. Every day, I put into operation my analytical thinking skills and the patience I had learned in doing research.

The outcomes have been great for the ACS and for me. I won't bore you with a list of accomplishments, but I will just say this: My career journey has been a wonderful one, fulfilling my love of lifelong learning and of working with people. I can honestly say I've never been bored a single day of my life. I've learned many lessons—I've shared some of them with you today. As I conclude, I have a few words about embarking on or changing courses in a career.

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Lesson Number Eight: No Matter What Career Pathway You Choose, You Should Do It for Something Other than Money. You Should Do It Because You Love It with a Passion and Because You Believe in It.

A career is like a love affair. It has its ups and downs—but overall, it must be rich and rewarding. It must be bursting daily with possibilities and promise, or why bother? It must provide an environment in which you can constantly grow and learn. It must make you want to get up every day and go to work. It must be fun.

I can't imagine staying in a relationship that didn't have these qualities, and what else is a job except a relationship where you spend anywhere from eight to 16 hours a day? I can't imagine spending even a minute at work without feeling passionate about it.

It's not always easy to find the right person—or the right career. Sometimes we simply don't choose wisely the first time; presumably, we learn from that experience and move on. Making that transition can be painful, but it can also open up exciting possibilities. So it is with a career. The important thing to understand is that there are alternatives--that there might not be a single right choice that will give a lifetime of satisfaction. Fortunately, there's a veritable cornucopia of career possibilities for people trained in the sciences at all degree levels.

Lesson Number Nine: Carpe Diem!

I am a firm believer in seizing the day. Don't let a day slip by without doing something to advance your career. As Dale Carnegie used to advise people taking his public speaking course, "Today is the first day of the rest of your life." Make the most of it.

My career has been an exciting adventure, and I have many people to thank for my success, if indeed I have been successful.

When I was still Editor-in-Chief of C&EN, *Chemistry and Industry* magazine featured me in its publication in a column they call "Personal Chemistry." They asked me, what do I like most about my job. And I answered, "The opportunity to create an environment where bright, intellectually curious people can do their best work—which is writing about events in the chemical enterprise for a global audience." They asked me who my biggest influence is, and why, and I answered "My father, who gave me an optimistic outlook on life, some pretty decent genes, and wise advice for dealing with life in general and people in particular." But the no-brainer for me was the question, "What is my biggest success?" The answer to that is "My marriage to a wonderful and talented artist." Indeed, we celebrated our 42nd wedding anniversary in March 2014. And he turns 90 on October 31.

In my life, I am especially pleased to have been able to balance my personal and professional lives. My husband and I were not able to have our own children, but I have a wonderful stepson who is 59 years old today and two fabulous grandsons, ages 30 and 25. Since I was there at their births and babysat for them every week while they were growing up, they really do see me as their

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grandmother. Do I wish I had children of my own? Absolutely, but I have many children in my life—and my friend's children and their children as well.

The fact is, I count myself lucky. And yet I also know that hard work is what helped get me here today.

So I Have One Final Lesson, Lesson Number Ten, I'd Like to Leave You with.

I want to reinforce the idea of science as a noble calling. I believe that the best and the brightest are desperately needed in the sciences, and I hope that those of you who are on your way in this career will see it through to the end. To help you take this message to heart, I'm going to give you the lyrics of a wonderful Cole Porter tune from 1933—-it was in a musical called "Nymph Errant." It's called "Experiment," and it is Lesson Number 10 (*1*). Here are the lyrics:

Before you leave these portals,
To meet less fortunate mortals,
There's just one final message
I would give to you.
You all have learned reliance
On the sacred teachings of science,
So I hope, through life, you never will decline
In spite of Philistine
Defiance
To do what all good scientists do.
Experiment.
Make it your motto day and night.
Experiment.
And it will lead you to the light.
The apple on the top of the tree
Is never too high to achieve.
So take an example from Eve,
Experiment.
Be curious,
Though interfering friends may frown.
Get furious
At each attempt to hold you down.
If this advice you always employ
The future can offer you infinite joy
And merriment.
Experiment
And you'll see.

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1. "Experiment" (from "Nymph Errant"). Words and Music by Cole Porter. Copyright © 1933 (Renewed) WB Music Corp. All rights reserved. Used by permission of Alfred Music.

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Chapter 20

From Building Roads To Building Peace: A Woman Chemist's Odyssey

Zafra Margolin Lerman*

President, Malta Conferences Foundation, 1911 Grant Street, Evanston, Illinois 60201, U.S.A.
***E-mail: zafra@zafralerman.com**

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 plans. Upon graduating from high school, I was drafted into the Army, and in the evenings, started my college education and majored in chemistry. While 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, and drama, 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. This work led me to use chemistry as a bridge to peace in the Middle East by organizing conferences which bring together chemists from fifteen Middle East countries with six Nobel Laureates for six days. 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. I started my career by building roads and through chemistry, moved to building a bridge to peace in the Middle East.

Building Roads

I was born and grew up in Israel, which was a developing country at the time. We did not have toys, after-school programs, sports, or any sort of guided activities while growing up. This demanded that we develop our own creativity to build toys and to develop our own activities so we could socialize with each other. Leadership was vital in order to develop these sorts of skills. Because the homes in Israel did not have hot showers, a center of our activity was a central bath made up of many showers. All of the children loved the gathering and this was like a community center for us. I remember coming home one day and my parents announcing that we now had a shower with running hot water at home. I started to cry and blamed them for trying to spoil my social life, so that instead of going together with a group of children to the central bath, I would now have to shower alone.

From the age of ten, we all spent the summers in a kibbutz, a sort of commune that was built on the borders of the country. The main activity was agriculture. During the harvest, these communes needed more hands and we, the children, volunteered to work in the fields and help the members of the kibbutz. We would go out at 4AM to pick grapes because by 10AM, it would already be too hot to work in the fields. We would get forty bee stings a day. The adults promised us that these stings would help us avoid arthritis later in life. (As a matter of fact, these days there is research on the effects of bee stings on arthritis). In the evenings, we would gather together and have discussions about agriculture and living in a commune. There is no doubt that this experience helped us to build character and leadership skills.

In high school, we were already required to choose majors. I had chosen science and math, which landed me in a class with all boys. I had to prove to them that I could be as good as they when it came to science and math. Socially, it was an interesting time. At an age when girls find their best girlfriends, my best friends were boys.

During the junior year of high school, every student was required to spend four weeks in the desert, close to the Red Sea, building roads going from the south to the north of the country. It was a wonderful experience. We lived in tents, stood guard at night, and spent all day building the roads (Fig. 1). After four weeks, there was an exchange of groups, and another group of juniors would arrive to continue the task.

Upon graduating from high school, we all were drafted to the army, male and female alike. This was a new experience for all of us. Suddenly, I had to share my room with fifty other girls I had never met before for two months during training (Fig. 2). Leadership was a very important characteristic for success in the army.

All of these experiences taught the importance of giving to your country. The famous John F. Kennedy saying, "Ask not what your country can do for you, ask what you can do for your country," was practiced in Israel by everybody starting from a very young age.

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Figure 1. The tents in the desert ca. 1953. (Reprinted with permission from Ref. (3). Copyright 2013 American Chemical Society.)

Figure 2. Entering the army. The picture shows everyone wearing their berets on opposite sides, not knowing the uniform rules yet ca. 1955. (Courtesy of the author.)

We all entered college after serving for two years in the army. I received my bachelor's and master's degrees in Chemistry from the Technion - Israel Institute of Technology and my Ph.D. in Chemistry from the Weizmann Institute of Science. I was very proud that my son attended the three ceremonies for my Bachelor's, Master's and Ph.D 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 in Decarbonylation Reactions. As a graduate student, I was invited to the U.S. 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 receiving my Ph.D., I moved to the U.S. with my son to continue 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 about Science and Society, Arms Control and Disarmament, and Human Rights.

From Cornell, I moved to Northwestern University and then continued my research at the Swiss Federal Institute of Technology in Zurich (ETH). While at the ETH, I had to overcome two challenges, one to learn German so I could participate in lectures and seminars, the other one, to learn to ski because we had skiing seminars for a week at a time in the Alps. I overcame both challenges.

Education

I decided that in order to make the world a better place for humankind, I would like to develop methods of teaching chemistry, which would make it possible for everybody to master the subject.

My tenet in life is that equal access to science education is a human right that belongs to all. In order to guarantee science education to all, I developed methods for teaching and assessing students, which took into account students' talents, interests, and cultural backgrounds. There is no one method that can fit all. If we don't develop different methods for different students, we will not be able to make science accessible to all (*1*). This will result in a two-class society, not divided by royalty and wealth, but divided by knowledge of science.

I first developed chemistry courses for students majoring in art, music, dance, drama, poetry, and computer animation. The class was student-centered. In the world of education, a known saying is, "A teacher can be a sage on the stage or a guide on the side." In this method, the teacher is a guide on the side.

The central piece of this method is that the students show their knowledge through projects, which they produce alone or in groups, through the use of different media to present their projects to the class (Fig. 3). For example, a group of theater students showed their understanding of the concept of the ionic bond 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 and in order to follow Shakespeare's tragedy, water came along and separated

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

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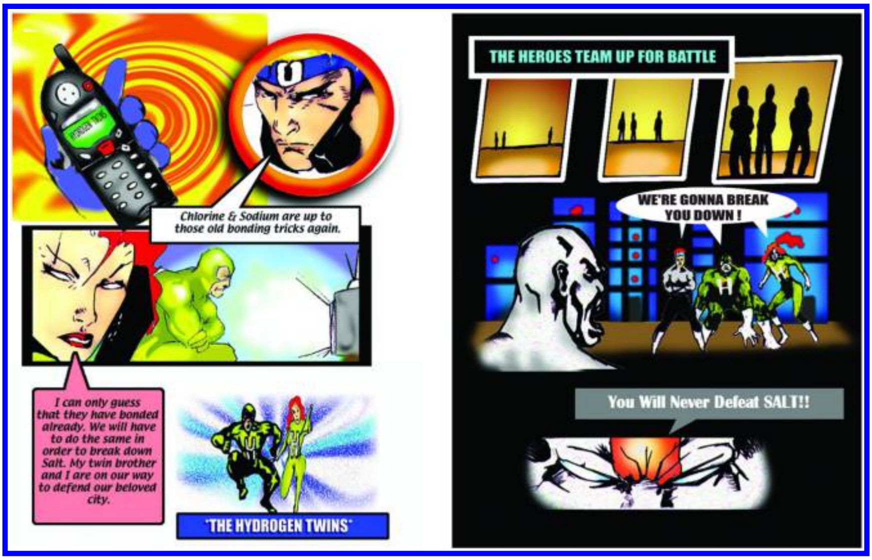

Figure 3. Student's cartoon strip. (Art by Joe Nelson. Used with permission.)

As a result of the success of this method, the National Science Foundation funded a project in the inner city of Chicago to bring this method of teaching to the Chicago Public Schools. An old African proverb says, “It takes a village to raise a child,” therefore, we ran workshops for teachers, parents, and the students. In these workshops, we mixed together students from diverse cultural backgrounds, which helped the students to learn, not only chemistry, but also appreciation for other religions and cultural backgrounds.

We showed the teachers, parents, and students how the arts can be a wonderful vehicle for learning, teaching, and assessing science (*2*). We always brought undergraduate students who represented the cultural demographics of Chicago to work with the group. These students presented their understanding of different scientific concepts to the teachers, parents, and students through different media: paintings, sculptures, songs, dances, drama, poetry, rap, and film. For example, two students in the same class visualized the fission reaction, where a neutron bombards the nucleus of the atom, but they presented it using the media that each felt most comfortable using. One presented it as a computer animation, and another student choreographed it as a dance (*3*). 16,000 students participated in this program and many of them went on to pursue careers in the sciences and in science-related fields. More than 1,000 teachers participated in the program over 20 years and during those years influenced hundreds of thousands of students.

Figure 4. Science education at a dance studio ca. 1997. Photograph by David Morton. (Reprinted with permission from Ref. (3). Copyright 2013 American Chemical Society.)

In a very poor neighborhood of Chicago, we partnered with a dance studio where at night, students, many of whom were from homeless families, came to learn dance and we took the opportunity to teach them chemistry through dance (Fig. 4). We encouraged these students to obtain high school diplomas and to continue onto college. Several of them went on to pursue a PhD. in Biochemistry. 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

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in the conference. They demonstrated to the scientists their understanding of scientific concepts through dance. The audience reacted with a standing ovation and a chorus of "bravo!" which contributed to the students' self-confidence and self-esteem (*3*, *4*).

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 United States and around the world.

Human Rights

For 25 years, I chaired the subcommittee on Scientific Freedom and Human Rights of the ACS International Activities Committee. During these 25 years, the subcommittee worked on behalf of many scientists around the world whose human rights were abused. We were very successful in securing the release of prisoners of conscience from prison, bringing dissidents to freedom in the United States and joined campaigns to prevent executions in several countries. The written letters for these activites were always signed by the Presidents of ACS during these 25 years.

The first success of the subcommittee was the release of chemist Yuri Tarnopolsky, who spent three years in hard labor in Siberia in the Soviet Union. We were involved in a writing campaign and joined other human rights groups who worked on his behalf. He was released in 1987 and with the effort of the human rights groups, came to the U.S. Yuri's first address was at an ACS meeting in New Orleans, where he described his experience and thanked the subcommittee for its efforts on his behalf. He emphasized very strongly that without the help of the human rights group, he would still be spending time in Siberia. 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 (*5*)."

After reading Yuri's statement, I understood why I risked my life several times for the benefit of people whom I had never met. In order to help dissidents in the Soviet Union, I took a crash course in Russian and went to the Soviet Union several times (*6*). I met with dissidents after midnight in dark alleys and conducted

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seminars in attics in the middle of the night. During these meetings, I distributed copies of C&EN and other scientific magazines so that these scientists would be able to read about scientific discoveries. In addition, I collected information and CVs from them so that I could bring the information back to the states and help facilitate their immigration to the U.S. It was against the Soviet law to take this information out of the country and I had to find ways to hide it in order to protect my freedom. We managed to bring several of these scientists to the United States and help them to find jobs. I was lucky enough to be able to meet with Andrei Sakharov and discuss with him the work of the subcommittee on Scientific Freedom and Human Rights (Fig. 5). He emphasized that continuous pressure on the governments from the outside was the best way to help the victims. When the victims learned of this outside support, it gave them courage to persevere, despite their terrible circumstances, because they knew others cared.

Figure 5. Andrei Sakharov and Zafra Lerman ca. 1988. (Reprinted with permission from Ref. (3). Copyright 2013 American Chemical Society.)

After the incidents in Tiananmen Square in China in 1989, the subcommittee worked very hard on behalf of dissidents in China, including physicist Fang Lizhi, who was the father of the prodemocracy movement in China (*7*). During the incident in Tiananmen Square, he managed to escape to the American Embassy where he lived for a year. We worked very hard on his behalf and when he arrived to the U.S., he addressed the ACS members in a National meeting in San Francisco. In addition, his first speech in Chinese to China was made from my office in Chicago through the Voice of America Radio. I visited China several times, and risked bringing letters from Fang Lizhi to dissidents who were under house arrest and their letters back to him. When I was invited to deliver a plenary lecture in Beijing in the International Conference on Public Understanding of Science, I dedicated my lecture to the scientists who still were in jail, which made the Chinese authorities quite unhappy. Following this lecture I was closely watched when I tried to visit different dissidents. As a result of my lecture and the dedication, I appeared on China's national television.

Cuba was another challenge for the Subcommittee for Scientific Freedom and Human Rights. Because of the American embargo on Cuba, Americans cannot freely visit Cuba without a license from the Treasury Department, a process that takes a long time and does not guarantee that the license will be given. We felt that in order to have scientific freedom, the Subcommittee must arrange for a delegation from ACS to go to Cuba and attend the Cuban Chemical Society Meeting to deliver lectures; therefore, we went through the complicated process of receiving a 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. During one of these conferences, the Cuban Chemical Society made me an honorary member, and Cuba National Television interviewed me.

Another responsibility for Human Rights groups is the work on AIDS in Africa. In 1999, I received the Presidential Award for Excellence in STEM Mentoring from President Bill Clinton. I used the award money to take African American students with me to Kenya and South Africa to work at AIDS orphanages and produce a documentary on the experience.

Building Bridges to Peace

Since September 2001, the eyes of the world have been on the Middle East. The Subcommittee on Scientific Freedom and Human Rights believed that it might be possible to use science as a bridge to peace in the Middle East. The idea was to bring together chemists from 15 Middle East countries (Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Palestinian Authority, Qatar, Saudi Arabia, Syria, Turkey, and United Arab Emirates) with six Nobel Laureates to work toward solving scientific problems of importance to the region and to the world. The Subcommittee brought the idea to the Board of ACS, which enthusiastically supported it and spearheaded the project. IUPAC (International Union of Pure and Applied Chemistry), RSC (Royal Society of Chemistry), and the GDCh (Gesellschaft Deutscher Chemiker) joined later as co-sponsors (*3*, *8*).

The First Conference referred to as “Malta I” was held in 2003 on the Island of Malta. The title of the Conference was “Frontiers of Chemical Sciences: Research and Education in the Middle East – A Bridge to Peace.” The first conference was a big success, despite the initial hesitation of the Middle East participants to interact with each other. At the end of the five days, it looked more like a family reunion than a gathering of scientists from countries whose governments do not have diplomatic relationships with each other. The conference was composed of plenary lectures by the Nobel Laureates and workshops. The Middle East participants presented their work orally in workshops or in poster sessions. The workshops included the following subjects;

- Environment: Air and Water Quality
- Sustainability of Resources, Energy and Materials
- Science and Technology Education at all Levels
- Nanotechnology and Material Science
- Medicinal Chemistry and Natural Products
- Chemistry Safety and Security

As a result of the Malta Conferences, collaborations on the important issue of water became very strong. The region’s severe poor air quality and insufficient high quality water can be successfully assessed and addressed by environmental science. However, the solutions have to be international because the badly polluted air sheds and watersheds are regional in nature and cross many national boundaries.

A working group on Regional Water Quality Assessment in Jordan, Palestine and Israel was conceived at the Malta III conference and received funding from IUPAC to continue the assessment. During Malta IV, this group defined and launched an ambitious research program, involving hydrologists and environmental chemists from Jordan, Palestine, Israel, Egypt and Kuwait (with advisors from the U.S. and EU). Reports of the work of the group were given in Malta V and Malta VI. The working group plans to expand their activities to include Syria and Lebanon.

There is no clean drinking water in Gaza. As a result of the Malta Conference, 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 (*9–12*).

The Malta Conferences were recognized by Senator Dick Durbin (*13*) with a speech on the floor of the U.S. Senate and by Congresswoman Jan Schakowsky (*14*) with a speech on the floor of the House of Representatives. The two speeches are in the permanent Congressional Records. The Civilian Research and Development Foundation (CRDF) recognized the work of the Malta Conferences with the George Brown award (*15*).

As President of the Malta Conferences Foundation, I was invited to deliver a lecture on Malta at the Nobel Peace Institute in Oslo, Norway (Fig. 6). The American Association for the Advancement of Science (AAAS) recognized the Malta Conferences with the AAAS Science and Diplomacy Award.

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At the end of every Conference, the participants unanimously voted to gather again two years later. There have been six conferences to date. In 2003 and 2005 the conferences took place on the Island of Malta; 2007 in Istanbul, Turkey; 2009 in Amman, Jordan. In 2011, the Malta Conference was invited to be held at UNESCO's Headquarters in Paris as one of the last events for the International Year of Chemistry. The Director General of UNESCO, Irina Bokova, opened the Conference and His Royal Highness Prince Hassan of Jordan gave the first lecture (Fig. 7). In 2013, in celebration of the tenth Anniversary of the first Malta Conference, it returned to the Island of Malta and was opened by his Excellency Dr. George Abela President of the Republic of Malta, where he stated, "In 2003, a great idea was born in Malta, this idea being the use of Science as a Bridge to Peace in the Middle East. At first, there were only slender hopes of it surviving, yet it has thrived, grown and returns home to Malta to celebrate the tenth anniversary of its inception (*16*, *17*)…"

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Figure 6. Lecturing at The Nobel Institute in Oslo, Norway, 2009. (Reprinted with permission from Ref. (3). Copyright 2013 American Chemical Society.)

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Figure 7. HRH Prince Hassan of Jordan and Director General of UNESCO Irina Bokova. (Photograph by Cynthia Mentz. Used with permission.)

The Malta Conferences contribute to encourage women leadership in the chemical enterprise. The number of women in the conference is continuously growing with every passing conference. The only woman with a Nobel Prize in Chemistry, Ada Yonath, is a participant in the Malta Conferences and is a role model to the young women from the Middle East. The women formed very strong bonds and consider themselves a sisterhood.

The Malta Conferences are the ONLY platform in the world 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, serving as a bridge to tolerance, understanding and peace between the Arabs, Iranians and Israelis, and between the Muslim world and the West (*18*).

My personal odyssey of moving from building roads to building peace is an example of how education, human rights, and peace are intertwined.

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Chapter 21

The Magnificent Journey

Ann Nalley*

**Clarence Page Endowed Chair of Math and Science Education,
Department of Chemistry, Physics and Engineering,
Cameron University, Lawton, Oklahoma 73505
*E-mail: annn@cameron.edu.**

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This article describes the journey of a young girl born to poor cotton farmers in the early 40s who grew up to become a chemist and then to become the President of the World's Largest Scientific Society, the American Chemical Society. It describes the obstacles she had to overcome as a woman as she earned a Ph.D. in Chemistry and the successes she celebrated along the way. It also features undergraduate research success stories and how these have contributed to her success. Hopefully it will inspire women to follow her footprints in a journey that reached many corners of the world.

This article resulted from an invited lecture, which I gave at the ACS national meeting in San Francisco in August 2014. I am pleased to be able to share my thoughts with you about my life and the role of women as leaders today.

The Early Years

First of all, I would like to acquaint you with who I am and how I earned a Ph.D. in Chemistry and became a Professor of Chemistry. I was born to parents who were not educated. My father graduated from the eighth grade and my mother attended school up to eleventh grade. They were farmers, and to them, the odds that I would grow up and get a Ph.D. in chemistry were probably zero. I went to a one-room school. I never saw a woman science teacher in my entire 12 years of schooling, from elementary to high school. In college, I never saw a woman professor in chemistry as an undergraduate or graduate student, despite attending

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and earning a Ph.D. in chemistry from a women's university. As a result, I had no female scientific role models or mentors. Fortunately, there are now women at all levels of science and academia, but we still have a long way to go.

I was born in Catron, Missouri near New Madrid, Missouri. New Madrid is located in southeast Missouri, in the part of Missouri known as the "New Madrid Fault" and the home where I was born is only about a half-mile from the Mississippi River (Figure 1). In those days most babies were born at home. My mother gave birth to 5 babies all of which were born at home.

Shortly after the picture in Figure 1 was taken, my father rowed in a small row boat in the middle of the night and rescued us from a flood when the Mississippi River flooded. My family spent the next ten days in a one room school house with ten other families. When we moved back into the house, my father scooped out the mud which was left behind after the flood waters receded and my mother scrubbed the floor with wood ashes to clean the wooden floors. There were few commercial cleaning supplies available at the time. We did not have to worry about carpets then. Our floors were covered with linoleum and we simply picked it up and threw it out. My mother had stacked the beds on top of the table before the flood, but the mattress' were made of chicken feathers and had mildewed. We threw them out and made new ones from corn shucks, because it takes a very long time to collect enough feathers to make a feather bed.

Figure 1. Photo of Ann Nalley, 9 months old, in a stroller on the back porch of the home where she was born, July 8, 1942. Note the modern water facilities on the back porch, a pump which was connected to a cistern. Nalley's mother would add bleach to the water to kill bacteria. (Courtesy of the author.)

My father was a farmer and we grew almost every crop you can imagine. Since most of the plowing was done with horses until the early 1950s, the fields were small. I learned to pick and chop cotton, haul hay and work in the fields at a very early age (Figure 2).

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The fields were fertile but the floods were discouraging to my parents. When I was three years old, we moved to higher ground to a farm near Dexter, Missouri. I started school there in a one-room schoolhouse, known as the Acorn Ridge School, when I was four years old. In those days, we already knew about headstart. I started school so my mother would have more time to work in the fields and take care of my younger brother. By the time I was five years old, I had read 27 books. Those were hard times. During my father's service in World War II, he parachuted out of a plane and broke his leg. This had made farming very difficult for him, because he had to walk behind a plow. Everything was rationed during the war. We survived only on what we grew in our garden and fields, including our pigs, cows, and chickens.

Figure 2. Ann Nalley with her two grandfathers, father and uncle. On the left is her grandfather, King, the son of a Cherokee Indian. The middle man is her father. The man on the right is her grandfather, Frazier, whose father came to the U.S. from Scotland. We are standing in a cotton field and the tall cotton is the result of the fertile ground left behind after the floods. (Courtesy of the author.)

In 1947, my uncle who lived in Checotah, Oklahoma, asked my father to move back to Oklahoma. I think we were having a hard time with finances in Missouri, but my parents never talked about it. We did not have a car, so we drove a wagon to

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the store to get ice for the ice box and we walked to school. I had an older brother and sister (both of whom were born during the depression). They always shared their books with me and helped educate me. We had no electricity or modern conveniences in our homes until the mid-1950s.

When we moved back to Oklahoma, we bought a 160-acre farm. At that time, the bank carried us with no collateral, only on my father's word and an agreement that we would make each payment at the end of harvest. I was five years old then, but Oklahoma Laws required that I had to be six years old to start school. So I took my first sabbatical at the age of five. The one-room school (Elm Grove, located about eight miles from Checotah, Oklahoma), which my older brother and sister attended, was one half-mile from our home. There was a small store and gas station across the street from the school. The owner's wife had severe, crippling arthritis and I worked as an attendant for the owner's wife. I carried water to her, read to her and sat with her each day during the school hours. I earned 10 cents per day. This was a great experience for me. She taught me to crochet and tat. I soon became an entrepreneur (Figure 3). I would crochet doilies and chair covers, then set up a table on the street corner in Checotah and sell my wares. I also raised rabbits and sold them.

Figure 3. Ann Nalley as an entrepreneur at age 8. She started her own business, selling wares on the street corner in Checotah, OK. This photo appeared on the cover of the Muskogee Daily Phoenix. (Courtesy of the author.)

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Now, back to my science education and inspiration. As I mentioned earlier, I never saw a woman science teacher. My role models came from books. My role model and mentor was Marie Curie, the only woman to win two Nobel prizes, one in chemistry and one in physics. I read her biography at least five or six times when I was going to school in the one room school at Elm Grove. For three of my four years there, I was the only student in my class. I had lots of time to read and listen to older students present their lessons. We learned mostly out of workbooks. We didn't have television then. We didn't have many stories about women scientists, because there weren't many stories to tell about women scientists – they just did not exist at that time. At the end of my fourth year at Elm Grove, the school closed and I was transferred to a larger, rural school, Victor Public School. It had over 100 students spread over eight grade levels. I rode a schoolbus to school each day along a route that was more than 30 miles long, which meant I spent about two hours on the bus each day. Life changed drastically for me, as I now had to compete with 20 other students in my classes.

As I look back over my life, I believe I began to formulate my leadership philosophy at a very early age. To me, leadership meant performing at my best and setting a high standard for others to follow. I read more books than any one in my school. I had perfect attendance. I won more math contests. I entered personality contests in the 4-H Club; I sewed and entered dress-making contests, and I ran for offices in the 4-H Club and won. When I graduated eighth grade in 1956, I started high school at Checotah High School, in Checotah, Oklahoma. The school was only eight miles from my home, but this meant another 30 mile bus ride both morning and night.

As I entered Checotah High School (population of 250 students), I signed a petition with 16 boys requesting that a physics class be offered at the high school. As a result, I was in the first physics class ever taught at my high school. While in high school, I won award after award.

They launched Sputnik in 1957, and at that time, I was a sophomore in high school. The U.S. government said it was time to get more young people involved in science and technology. The National Science Foundation developed wonderful programs in the U.S. to encourage young men and women, like myself, to study science. I took chemistry when I was a junior because I wanted to take physics in my senior year. At the beginning of the chemistry class, my instructor chose two students to study extra-hard to complete the book by the Christmas break so that they would be able to compete in the state chemistry contest. My high school chemistry teacher, a man, of course, was great. His name was Jackson Emerson, and I could not have had a better mentor. I took the test in January and won the state chemistry contest at Southeastern Oklahoma State University. As a result, my high school teacher nominated me for one of the summer National Science Foundation programs in chemical engineering. I was selected to participate in the program, spending 6 weeks at Oklahoma State University in a chemical engineering program, learning about careers in engineering and participating in advanced studies and research (Figure 4). This summer changed my life forever. I came home that summer with a slide rule with my name engraved on it and a determination to go to college to become a scientist or engineer.

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Figure 4. Ann Nalley while participating in the chemical engineering program at Oklahoma State University. (Courtesy of the author.)

My College Education

I started college in the fall of 1960 at Connors State Junior College in Warner, Oklahoma. Scholarships helped finance my education. I also worked as a lab assistant for the chemistry instructor. I majored in chemistry and completed an Associate's Degree in Science in two years, then transferred to Oklahoma State University (OSU) in fall of 1962 to begin a degree in chemical engineering. I was the only girl in all of my engineering classes at OSU. My classes did not go well. I decided to change my major to become a chemistry teacher and transferred to Northeastern Oklahoma State University, where I could complete both education and chemistry courses in a year-and-a-half in order to graduate on time.

I completed my undergraduate degree in chemistry and taught high school for a year at Muskogee Central High School, where I had done my practice teaching for my education courses. Dr. J. E. Dunn was my mentor during my practice; he was a wonderful mentor. Upon completion of my BS, the school offered to hire me full time. However, that led to a horrendous year. I taught one course section on chemistry, one section on physics, two sections on modern abstract algebra and one section on remedial math. I had never had a course in modern abstract algebra. When I reported for duty at the school, the faculty parking lot was full and I was assigned to the student lot. The discipline at the school was very poor, and the students continually harassed me. They stole the spark plugs from my car, my distributor cap, let the air out of my tires, and filled my gas tank with sand.

Discipline in my classes was non-existent. I was driving home from school in April and was about a mile outside the city limits of Muskogee. My car started smoking and I stopped the car, grabbed my books and purse and started running

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away from the car. When I was less than a hundred feet from the car, it exploded and burned up very quickly.

That day I began to wonder if teaching high school was the right career for me. My chemistry, physics and modern algebra classes went well, but the remedial math class turned out to be the class that all the students with discipline problems were placed in. Near the end of the spring semester, a student threw my chair out the fourth floor window (the window of my classroom) and threatened to throw me out. I went down to the first floor to the Principal's office, but he told me discipline was very difficult to enforce. A week later, the Principal had a nervous breakdown and was hospitalized. He never returned to the school for the remainder of the year. So much for discipline at that school at that time.

In the summer following my first year of teaching, I went back to school at Oklahoma State University. I intended to pursue a MS degree in mathematics that summer and return to teach at Muskogee in the fall. Near the end of the summer, I decided to stay at OSU and continue my graduate education. I applied for a teaching assistantship in mathematics, but none were available. I walked across campus to the Chemistry Department to visit with the Department Chairman and inquire about the possibility of pursuing graduate study in chemistry. The Chair, Dr. Otis Dermer, handed me a form which extended an invitation for me to apply to graduate school and a graduate teaching assistantship. I signed the form, called Muskogee High School and resigned my teaching contract.

That fall, I entered graduate school at OSU to pursue an advanced degree in chemistry. There were 42 students in my graduate chemistry class, of which only two others were women. I began my graduate courses that fall and selected Dr. Paul Arthur as my research advisor. Dr. Arthur was an analytical professor specializing in polarography. At the end of my second year, he passed away and left sixteen students in his research group with no research advisor. There was only one other analytical chemist in the department, and he did not feel comfortable taking on that many graduate students. He also did not do research in polarography. Dr. Tom Moore, an inorganic chemistry professor discussed a possible research project with me. I chose to study with him and started on a completely new research project.

My Career

In spite of this setback, I was able to complete a research project and write a thesis in one year. I was scheduled to graduate with a Master's Degree in chemistry in August of 1969. In the spring semester of 1969, I began to search for a position in industry. I sent out 40 letters and resumés, but did not receive a single interview invitation. The economy was at a low point, and industry just was not hiring anyone. I was in the office of the professor with whom I worked as a teaching assistant. He asked me what I was going to do after I completed my degree, and I told him my story of my applications to find a position in industry. He told me I should teach; he received many positive comments regarding my work as a teaching assistant. He said, "As a matter of fact, I am a former President of Cameron University and I think they have positions. The Regents have changed their mission from a two-year to four-year college, and they are expanding their faculty." He picked up the phone and called the President of Cameron University, Dr. Don Owen. He inquired about a possible teaching position in chemistry for me. Dr. Owen responded well, and transferred me to the Department Chair of the Department of Physical Sciences at Cameron. It turned out to be Dr. Bob Vowell, whom I had served as an instructor in his organic lab at OSU the previous summer. He told me that he had three openings and would drive up to OSU (168 miles) the next day to interview me. He came to the interview with a contract in hand. I signed the contract without ever seeing the town of Lawton and the Cameron Campus. This was near the end of April, three months before I was scheduled to graduate with a Master's Degree. I reasoned that if I did not like the position I could continue my search next year. I accepted the position as instructor of chemistry at Cameron University, and began my career as a college teacher in August of 1969.

In the summer of 1975, I went back to school at the Texas Women's University (TWU) to earn a Ph.D. in chemistry. Another first: I was my research advisor's first Ph.D. Student. He was a great mentor and role model for me.

> Throughout my career, I had many opportunities to be the first: I was the first woman to be promoted to full professor at Cameron, the first person to be named a distinguished professor by Phi Kappa Phi at Cameron, the first faculty member at Cameron to receive the Student Government outstanding teacher award, the first professor at Cameron to be inducted into the Alumni Faculty Hall of Awards, the first faculty member at Cameron to receive the Distinguished Service Award, and the first woman to be honored as the Oklahoma Chemist of the Year.
> As the years passed, I worked harder and harder to earn my firsts. I had opportunity to be elected as the National President of the Honor Society of Phi Kappa Phi (the largest interdisciplinary Honor Society in the world). I was the third woman in 100 years to serve as the President, and I served on their National Board of Directors for 21 years from 1980 to 2001. I was the National President of Phi Kappa Phi during its Centennial and chaired its National Centennial Convention, which was held in New Orleans. During those 21 years as a member of their National Board, I spoke at over 100 Universities.

This led to many opportunities for leadership at the national and international level. In 1997, I was elected to the National Board of Directors of the American Chemical Society, the world's largest scientific society. Then in 2000 I was appointed to be on the governing board of Pacifichem, an organization of the chemical societies which border on the Pacific Ocean. The governing board consisted of representatives from Japan, Korea, New Zealand, Australia, Canada, China and the U.S. I was the first woman to be appointed, and I was told that the ACS was hesitant to appoint me because the Japanese did not like working with women. I told them I would make the Japanese like me. I think I did, because I became a hero for the Japanese women and now regularly visit the country to speak.

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My greatest opportunity for leadership came when I was elected President of the American Chemical Society in 2004 (Figure 5). I was the fifth woman to serve in this position, and I soon learned that I was essentially the only woman in the world to lead a chemical society of its magnitude at that time. As I traveled around the world, I became determined to change this. I continually challenged my male colleagues to elect women to leadership positions. I traveled to 15 countries and gave more than 25 international presentations, including a presentation to Putin's governing board in Russia; remarks in Havana, Cuba; presentations in London; Seoul, Korea; Taipei, Taiwan; Budapest, Hungary; Tokyo, Japan; Hiroshima, Japan; Kobe, Japan; Kyoto, Japan; Singapore; Malta; Frankfort, Germany; Petra, Jordan and many others.

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Figure 5. Ann Nalley's induction as the the American Chemical Society President, at the New Officers Reception in Washington, D.C., January 2006. Pictured with Ann Nalley are Dr. John McArthur (left, President of Cameron University) and Dr. Danny McGuire (right, a former student and now my department chair). Photograph by Nancy Thomas; used with permission.

During all this time, I taught at Cameron Univeristy, and my courseloads ranged from 9 to 21 hours per semester. It was difficult to find time or space to conduct research, so my research activities were severely curtailed. Our building was very small until 1997, when we moved into our present-day facility. Our research lab in the old building was the organic lab, which we could only use when classes were not in session. Despite this, I served as a research mentor for more than 100 undergraduates. Much of my research has been applied research.

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Early on, I contacted local industries and arranged for my students to do research for different companies. I negotiated for students to be paid or receive scholarships. This was formalized when in 1989, I received an Oklahoma Applied Research (OARS) grant through the Oklahoma Center for the Advancement of Science and Technology (OCAST) to set up an intern program with local industries. This enabled my students to work in industries during the summer as interns, and receive monetary compensation – or to work at Cameron either in the summer or academic year as interns for local industries. These grants continued for eight years until I was elected to the ACS Board. More than 50 industrial interns benefited from this program.

My advice to young faculty and undergraduates striving for a successful career is to take advantage of every opportunity to enhance your career through professional development. The professional development opportunities which helped me enhance my career included a summer at Argonne National Laboratories studying Nuclear Chemistry, eight summers at the University of Oklahoma Department of Chemistry and Biochemistry conducting research, two summers at the University of Southern Mississippi as a Poly Ed Scholar (a program funded by NSF learning polymer chemistry), three summers at the University of Texas at Dallas conducting research in Laser Photochemistry and 12 courses at the University of Oklahoma Department of Environmental Engineering in Environmental Chemistry and Engineering helping me to enhance my skills in teaching environmental chemistry. I developed the first undergraduate environmental chemistry course at Cameron in 1972. Over the years, I also attended numerous workshops on instrumentation and computer molecular modeling.

Leadership Opportunities

At a small university, opportunities for leadership are plentiful. Over the years at Cameron, I served on most of the academic committees and served as the Chair of the Cameron Council and the Faculty Council (both were the highest leadership positions available to faculty). I also served as chair of seven other committees. I also served as the sponsor to the Chemistry Club beginning in 1971, and helped the students prepare their petition to establish it as a student affiliate chapter of ACS. In 1982, the ACS Regional Director traveled to Cameron to install the chapter.

The way I lead is by example. I spent many hours with members of the club, building homecoming floats, doing demonstrations and hands-on activities for local elementary, middle, and high school students. Under my mentorhip, the clubs won many awards including 14 ACS National Awards. I also served my local section in all capacities, and continue to serve as the program chair. My department was always supportive of my activities.

During this time, the number of female students in the Department grew as well, with as many as 70% of the graduates being women in some years. I initiated Chem Quest, a program involving hands-on activities for sixth grade students in 1981, a career open house for high school students in 1982, wrote grant proposals to conduct summer science academies for high school and middle school students and wrote grant proposals to fund workshops for K-12 science teachers. These activities continue to this day and have helped to encourage thousands of students to choose STEM careers.

Over the years, I have received many awards for my activities, but the two most meaningful highlights of my career are an American Chemical Society award named after me, the E. Ann Nalley Award for Volunteer Service, and being inducted into the Oklahoma Higher Education Hall of Fame in 2010 (Figure 6). I was also elected as an ACS Fellow in 2010 (Figure 7), a AAAS Fellow in 2013 and a DaVinci Fellow in 2013.

Figure 6. Induction of Ann Nalley into the Oklahoma Higher Education Hall of Fame, 2010. Pictured with Dr. Nalley are Chancellor Glen Johnson (left), Chancellor of the Oklahoma State Regents for Higher Education and Dr. Earl Mitchell (right), President of the Oklahoma Higher Education Heritage Society. Photograph by Robert L. Mullican; used with permission.

Even though I have tried to make changes throughout my life, there continues to be a problem with the employment of women in the field of chemistry. Now is the time to focus on change, because the next decade offers a great opportunity for us to diversify academia. There are a lot of faculty members in the U.S., like me, that are getting ready to retire, and many who will be stepping down. This is the time for us to give women the opportunity to move into the work force and up into the ranks of professor and increase diversity in our universities. In order to do this, we have to be leaders. Those of us who have made it through these difficulties before have to be the leaders. What is leadership? I love the description given by General Colin Powell: "The art of accomplishing more than the science of management says is possible."

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The five practices of leadership I like are the way you model and lead by example. You inspire a shared vision and you challenge the processes. You enable others to act – something that many women should do better. Unfortunately, I've seen this many times where women tend to be jealous of other women instead of helping them. It's our responsibility as women to not only lead the way and challenge the process, but to enable, help, and encourage other women. This is what I try to instill in my students. I call it encouraging the heart, or instilling self-confidence. The poem below is an example of how I have accomplished this. Cynthia Ignaszewski read this poem during her acceptance speech for the Overcoming Challenges Award at the Women Chemist's Luncheon.

Dr. Nalley,
You gave me encouragement when I was down
And ready to quit.
You kept me smiling in times of my life
When I had nothing to smile about.
You had more faith in me than
I had in myself.
Because of you, not only me,
But also my children are better off.
You touch so many lives in your daily life—
If I touch one person's life as much as you have touched mine,
Then I will know for sure that God has a purpose for me on this earth.
You will always be my friend, my family, and my mentor.
I hope one day to be as good a scientist as your are.
Love,
Cindy Ignaszewski

Cynthia completed an MS Degree and is now an AP high school chemistry teacher at John T. Hoggard High School in Wilmington, NC.

My Philosophy of Life

Workplace culture changes when women are in power. Women have different leadership qualities, including integrity, character, sympathy, and knowing that people are the principal asset of any organization. If we can instill confidence in our young women, they will become leaders. I think that women have to be there for other women, but men also have to be there because it takes a combination of both men and women working together for success.

We are all equal in our uniqueness, and because we are unique, we tend to see things differently. This includes how we develop solutions to our problems. We, as teachers, have to help our students develop in diverse ways and lead them to find the best way to succeed. My philosophy for life is: "I will not go where the path may lead, I will go where there is no path, and my path out of that cotton field in Missouri was no path at all because there was not a prayer that I would ever go

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on and accomplish anything in my life, but I found the way. I will go where there is no path and I will leave a trail for others to follow." That's what I've tried to do with my life and I encourage all other women to do the same.

Figure 7. Ann Nalley elected as an ACS Fellow in 2010. (Courtesy of the author.)

What does the future hold for women in chemistry? I see women in leadership positions, dominating in the field of chemistry. What about the men? The trend in the U.S. over the years has been that as the number of women goes up, the number of men goes down. Men are not choosing scientific careers. We need to encourage all talent in the U.S. to maintain its position as a world leader. It is everyone's responsibility to be leaders, for both sexes.

One of the most important decisions I made in my life was to marry my husband, Robert Mullican, who has supported me in all of my activities. I believe in order for a woman to be successful in life, she must work harder than anyone, work longer than anyone, be blessed with good health and choose the right husband.

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I want to thank Marinda Wu for inviting me to be a part of the symposium and the book which resulted from it. I am pleased to be able to share my thoughts with you regarding my life and the role of women as leaders today.

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Chapter 22

Partners for Progress and Prosperity: A Personal and Professional Journey

Marinda Li Wu*

2013 President, American Chemical Society,
1155 Sixteenth Street, N.W., Washington, D.C. 20036
***E-mail: marindawu@gmail.com.**

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Because of the Korean War, I was born in Pasadena, California instead of Beijing, China. Growing up in a traditional academic Chinese family influenced my life direction. I am still the only chemist in my family and the first nonacademic. I once dreamed of becoming a scientist or ambassador. Today in the ACS Presidential succession, I am a global "ambassador" advocating for science and education.

Challenges as an Asian American woman strengthened my leadership skills. I tell my story of how destiny and determination impacted where I am today in my journey to getting elected as the 8th woman and first Asian American President of the world's largest scientific society. I have shared my message with chemistry and science & technology communities around the world on how we can all "Partner for Progress and Prosperity."

Early Background

This chapter about my personal and professional journey begins with the story of how both of my parents left China to travel to the United States in order to pursue their graduate studies. My father came to America in 1945 to work on his Ph.D. in Aeronautics at California Institute of Technology in Pasadena, California. My mother arrived in the USA in 1947 with a graduate fellowship and conducted graduate research in genetics and plant breeding at the Horticulture Department of the University of Illinois in Urbana-Champaign. She had been inspired by a biography of the famous woman scientist, Madame Curie, that was translated into Chinese and given to her by a college professor who believed my mother had great potential.

Both of my parents were courageous pioneers because in those days, it was a long rough journey by boat to travel across the ocean from China to America. I still remember hearing stories of how some passengers got so sea sick that they would throw themselves overboard to end their misery! I have always been very thankful that neither of my parents ever got that sea sick.

I also feel fortunate that my paternal and maternal grandfathers knew each so my father learned that my mother was also in graduate school in America. Although my mother had other suitors, I am so glad she ended up choosing to marry my father back in 1949 on the campus of the University of Illinois, eventually my Ph.D. alma mater! It was quite a thrill to go back to see the Methodist church on the UIUC campus where my parents were married. I was honored to be invited as the commencement speaker for the Chemistry Department of the University of Illinois after getting elected as President of the American Chemical Society over six decades later.

I have always believed that both *destiny* and *determination* have played major roles in my life. See Figure 1 that depicts my story of "Pasadena versus Beijing" with accompanying photos of my parents when they first came to America almost seventy years ago.

My family name before I got married is Li, and it was often a Li family tradition to name the children after the city in which they were born. When my father was awarded his Ph.D. from Cal Tech back in 1950, he actually bought the boat tickets for my parents to return home to Beijing.

It was fate that I ended up being born in Pasadena instead of Beijing because the Korean War broke out the summer of 1950. My mother was so pregnant with me at that time that my parents decided it was too dangerous to cross the ocean with the war. So I have always been very happy to be named Marinda Pasadena Li.

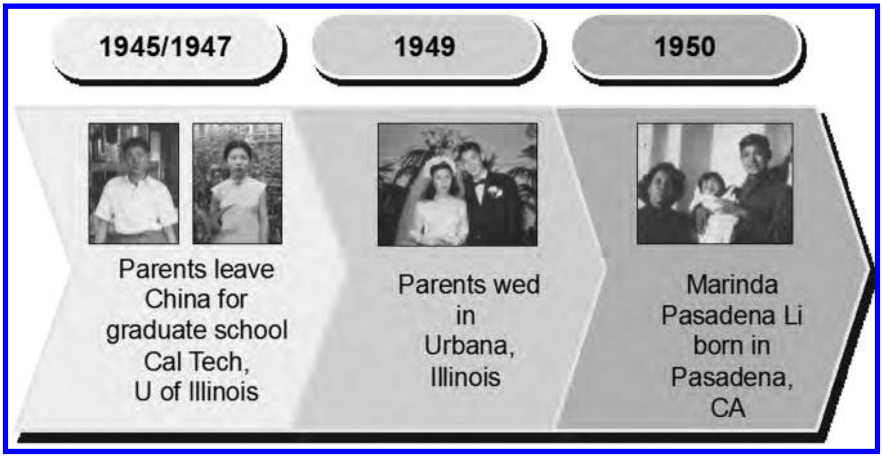

Figure 1. My story of Pasadena vs. Beijing. (Courtesy of the author.)

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I am the oldest of four children and the only chemist in my family. I have two younger sisters and a brother, all of whom are accomplished professors in their own fields. My parents were great role models. I remember always wanting to excel and never felt pushed but simply supported and encouraged by my parents.

At my mother's 90th birthday party, which we celebrated in Beijing where she had been born, I made a speech about how my mother was truly the best Mom ever, raising four children who earned five Ph.D.s with her unwavering love and support to help our entire family thrive. My youngest sister ended up earning two Ph.D.s -- the first from Harvard University and the second from Stanford University in two different fields she later combined very effectively in her work.

My mother had always wanted to pursue her own Ph.D. but encountered many barriers. First in 1949, after marrying my father and earning a masters degree from the University of Illinois, she went to talk with a UCLA professor who asked her, "What do you need two Ph.D.s for in a family?" After raising four children, she again tried to return to graduate school in the 1960s but again met great resistance. She was told by the university that she would not get credit for her undergraduate or graduate studies and needed to start over! Although she never had her own career, she raised three daughters and a son who all have highly successful careers. I remember our mother telling us that ***a family is important, but never give up your career.***

I have very fond memories of my childhood and am fortunate to have lived in various parts of the USA. I was born in Pasadena, California but attended elementary school in Troy, New York. After Cal Tech and a postdoc at JPL (Jet Propulsion Lab), my father became a very successful professor of aeronautical engineering at RPI (Rensselaer Polytechnic Institute) and eventually Director of Hypersonics Research. I enjoyed intermediate school in Greenhills, Ohio when my father was recruited to the University of Cincinnati. My father was then recruited to The Ohio State University in Columbus, Ohio. Due to the advanced math classes I already had taken, it was recommended that I learn French II on my own over the summer and skip a grade in high school at Upper Arlington High School.

Although we lived in Ohio, I grew up loving California because my father spent every summer consulting for Rand Corporation in Santa Monica, California. I feel fortunate growing up to have spent my summers enjoying the California beaches near Santa Monica. It was also quite educational for our family to explore the many scenic national parks and historic monuments between Ohio and California taking different routes each year. My father preferred driving instead of taking an airplane so I have wonderful memories of our fun and educational family car trips traveling across the USA each summer.

In contemplating my life experiences, I will also comment that I got excellent early leadership training with my childhood activities. I grew up in the days before much TV or video games. Being the oldest of four children, I was always the "leader" playing the father or the king when we played "make believe" with other kids in the neighborhood. Inventing "make believe" games was so creative, fun, and stimulating! I recall quite a happy and idyllic childhood.

Thus, while very young, I dreamed of becoming a scientist when I grew up. Later in high school, I also considered becoming an ambassador someday.

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See Figure 2. That was due to my love of foreign languages and learning about different cultures. Although I skipped a grade and completed high school in three years, I always enjoyed and excelled in all my subjects.

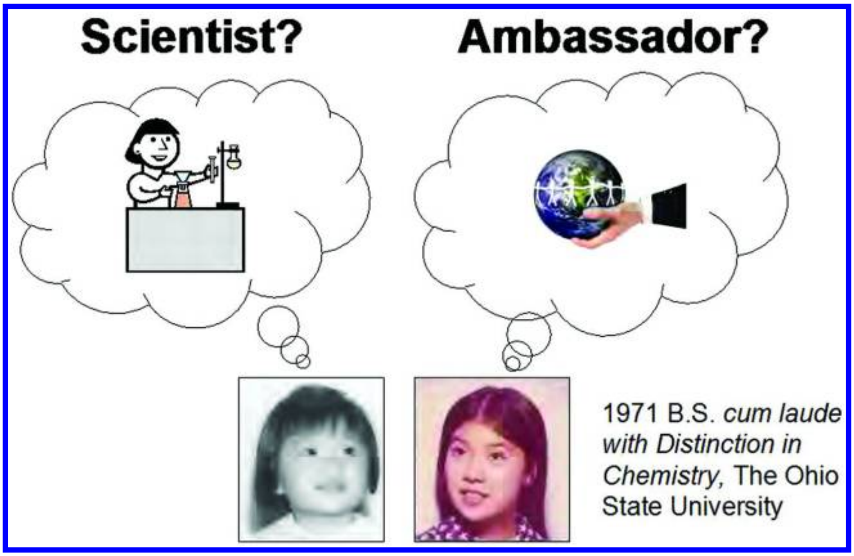

Figure 2. Early dreams. (Courtesy of the author.)

I was also always active in extracurricular activities and was elected to leadership roles including Student Council at Upper Arlington High School. Graduating as valedictorian from a high school class of 600, I gave my first speech ever on "*A Time for Work and A Time for Play*" for an audience of almost 2,000 at Mershon Auditorium at The Ohio State University.

There was not much diversity growing up in the Midwest. The only non-whites in my high school were my own sisters, and we Li girls all graduated as class valedictorians three years in a row.

I have always been so glad that I decided to major in chemistry in college. Chemistry and the American Chemical Society (ACS) have enabled me to realize the dreams of my youth by allowing me to become a global ambassador for science!

College and Graduate School Days

I was fortunate to be named an OSU Freshman Honors Scholar which enabled me to take small honors classes taught by well known famous professors at The Ohio State University. During my freshman year, I worked for the Analytical Chemistry Department. The following summer, I was fortunate to be awarded a National Science Foundation undergraduate research grant to conduct research in X-ray crystallography. Starting my sophomore year, I received OSU undergraduate research grants and conducted undergraduate research with my

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wonderful research mentor, Professor Devon Meek, for the next three years until I graduated. I was able to not only publish my undergraduate research (*1*) and present a research poster at a national ACS meeting, but also defended my undergraduate thesis research. I graduated in 1971 with a B.S. *cum laude with Distinction in Chemistry* from The Ohio State University.

Although I was a hard working chemistry major in college, I never fit any stereotype but lived in three very different worlds. This diversity helped me later in life to readily get along with all kinds of people. My first world was the world of chemistry where I spent many hours a day in the research lab. There were not many women in my honors chemistry, physics, and math classes. I was used to having classes with only one or two other women students at that time and never had a single female professor for any subject.

My second world, quite different from chemistry, was my sorority. I find it surprising today that as a freshman, I got into a very popular campus sorority, Kappa Kappa Gamma. I lived in the sorority house all four years in college where my sorority sisters were often Homecoming Queens. I was the only chemistry or science major in my sorority and was voted my senior year as "Most Dedicated and Likely to Succeed."

The third world I explored in college was the Chinese Student Association. I met other Chinese students, mostly from either Hong Kong or Taiwan. I had never met many Chinese until I went to college. Because I was interested in learning more about my roots, I fulfilled my non-chemistry requirements by taking classes to learn more about China. I enjoyed studying Chinese Mandarin language, Chinese history, Chinese literature, and Chinese art history. To this day, I am glad to have some of that background. Fortunately, my parents raised me with Chinese traditions, so I appreciate both the cultures of America and China.

I also enjoyed participating in various campus activities and got elected as an officer of several honor societies. It was fun joining the Block "O" cheering squad for the top ranked OSU Buckeye football team under the legendary coach Woody Hayes. How exciting it was to attend the Rose Bowl game the year that OSU beat USC when O.J. Simpson was running! I was also an active officer in my Kappa Kappa Gamma sorority, and am still in touch with some of my college sorority sisters today.

It was such a thrill to revisit my old undergraduate alma mater campus at OSU as a member of the ACS Board of Directors attending the 100th Anniversary celebration in 2007 for Chemical Abstracts Service in Columbus, Ohio…it brought back warm memories of my college days! I also saw many changes on campus like a Woody Hayes Drive. That did not exist when I was there as a student. I also feel fortunate to have had the opportunity to hear Neil Armstrong speak as the commencement speaker when I graduated from OSU in 1971 after he landed on the moon.

The next phase of my life after college was graduate school. At the time, I only applied to two graduate schools to pursue my Ph.D. in inorganic chemistry. I was accepted by both the University of California at Berkeley and the University of Illinois at Urbana-Champaign. Although I would have loved returning to California (my ultimate goal), I made my choice at that time based on the chemistry I wished to pursue.

At that time in 1971, I wanted to work for a very famous professor in Inorganic Chemistry, Professor Russell Drago, well known for his textbook on "Physical Methods in Chemistry." I had read many of his papers as an undergraduate. Imagine my surprise and disappointment when I arrived on campus at the University of Illinois after turning down UC Berkeley. At the new graduate student mixer for the Chemistry Department at UIUC, the older graduate students came up to ask me whom I was interested in working for. When I replied, "Professor Drago," every single one of them told me that I could not join his research group because he did not accept women! There are still many men today who find this shocking and hard to believe, but it was quite true and prevalent in other chemistry departments too at that time. What a change in 40 years!

So people ask, " How did I succeed in joining this all male Drago research group?" First, I do not believe in taking no for an answer. I thought I should at least try and explore the possibilities. It turns out that when I went to talk to Professor Drago, he allowed me to join his research group. I am convinced that he took me because I had been awarded the Chemistry Department's three year NDEA (National Defense Education Act) fellowship. Later another woman tried to work in the Drago group but ended up leaving with a masters degree.

I worked hard as I do with everything in life. I was quite happy to be voted as the Chemistry Department's "Outstanding Teaching Assistant" one year in teaching General Chemistry. I also was able to get along with not only Professor Drago but his entire research group of over twenty guys. They all played basketball together with "Doc" (Professor Drago), but I let them play basketball while I did my chemistry (since women in those days did not play much basketball). I ended up graduating with my Ph.D. in Inorganic Chemistry in 1976 as Professor Drago's 65th Ph.D. but only his second woman (*2–4*). I learned years later that there were a few guys in the Drago group who made the first woman who earned her Ph.D. from Professor Drago work in a laboratory by herself! I cannot imagine that and consider myself lucky.

Life After Graduate School in Industry

I then had to decide whether to pursue a career in academics or industry after getting my Ph.D. in Inorganic Chemistry. Although I come from an academic family where my father and all my siblings are successful professors, I am still the only chemist in my family and the only non-academic. At that time, although I was accepted for two excellent post-doctoral fellowships from UCLA and UC Berkeley, I started getting great job offers from almost all the major chemical companies across the country. To me, becoming the first in my family to venture into a career in industry seemed quite exciting! It was also wonderful doing basic research in Central Research Laboratories in industry at that time.

When I was offered a job from the Dow Chemical Company in Midland, Michigan at the end of my day of interviews, I asked them about the possibility of visiting their research center in the San Francisco Bay Area. Thus, I was sent out to interview at the Dow Walnut Creek-Central Research Laboratory (associated with Dow's Western Division R&D) and also got a job offer there.

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I ended up with several other job offers in the San Francisco Bay Area but chose Dow's offer due to a Professional Projects Program the first year. It was a great recruiting tool (also called the Special Assignments Program in Midland). I was offered the opportunity to take on four different research or technical service and development assignments my first year. That was ideal because I learned a lot that first year about four different areas of the company before deciding which area I wished to join long term.

To this day, I still love Dow Chemical and cherish the memories of a wonderful career where I enjoyed working there for almost two decades. I worked for Dow in the 1970s, '80s, and '90s. I even got to spend an entire day with Herbert Dow (the grandson of the original founder of Dow who was a Board member visiting Dow Western Division R&D in 1987). It is still amazing to me that the Director of Dow Western Division R&D chose only me to greet Herbert Dow at his corporate jet and accompany him to all the R&D presentations for the entire day. It is still quite an unforgettable memory how attentive and caring a person that Herbert Dow was to a young research scientist like me, as well as to all the researchers he met! ***Throughout my Dow career, I was always chosen as the "ambassador" or liaison for all my research projects when Dow needed to interact with external companies, universities, or organizations.***

Although I started out in basic research in the Dow Central Research Laboratory of Walnut Creek outside of San Francisco, Dow was very good to me and transferred me to work at the Dow Central Research Laboratory in New England outside of Boston when my husband got accepted to Harvard Business School. Although my husband and I both had great job offers in Boston and San Francisco, we finally decided to return to California. I returned to Dow Western Division R&D in Walnut Creek and Pittsburg, California when my husband, who had been an electrical engineer, graduated from Harvard. However, I very much enjoyed my research at CRNEL (Central Research New England Lab) working in the area of metal zeolite catalysis and have kept in touch with friends I made at CRNEL and Boston.

Over the years, I progressed from basic to more applied research, gaining leadership and project management responsibilities. See Figure 3 for a snapshot of my Dow career. Dow believed in hiring people for their problem solving skills. I conducted research (*5*) and earned seven patents (*6–12*) in a number of very interesting areas but mostly in polymers and membrane separations research. The Dow Western R&D Labs developed the hollow fiber membrane technology that led to the first artificial kidney and also the reverse osmosis membranes for water purification.

Eventually I was recruited to join Dow Plastics marketing after getting known for my early research in recycling plastics. I was on loan from R&D, so I had two offices at that time, one in research and the other at the Dow sales office. This was truly a time when I learned many more skills and gained new experiences while working with Dow Plastics Marketing and Sales. ***Although I always enjoyed research, I decided to try expanding my horizons by accepting the exciting offer from Dow Plastics who was interested in my technical background in recycling plastics.***

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Dow Chemical

- **Central Research - Walnut Creek Laboratory**
  - Advanced electrochemical batteries
  - Polymer research in medical plastics
- **Central Research - New England Laboratory**
  - Metal zeolite catalysis
- **Western Division Research**
  - Gas separation membranes
  - Plastics recycling
- **Dow Plastics Sales & Marketing**
  - Worked with senior executives of top customers
  - Forged strategic alliances with business, government, education and local communities

Figure 3. Snapshot of my career at Dow Chemical.

Dow Plastics created an exciting new position for three of us appointed as Environmental Advisors. Marketing first considered calling us Environmental Ambassadors, but later decided to call us Environmental Advisors. I was based at the San Francisco sales office while my two counterparts were based at the Dow sales offices in Chicago and New York City. I had responsibility for both the Western and South Central zones for sales for Dow Plastics. We developed and launched a wonderful new program for Dow Plastics called "Partners for Environmental Progress" (PEP).

We worked with the CEOs and senior executives of Dow Plastics' top customers, forging strategic alliances with business, government, education and local communities. In more recent visits with Dow Chemical after getting elected as ACS President, I have been told this PEP program in the late 1980s and early '90s was the precursor to today's programs on sustainability.

Although I enjoyed a wonderful and exciting career at Dow for almost two decades, there are times in life when one needs to make difficult choices and decisions. Figure 4 shows different personal and professional values to consider where one must determine the relative priorities depending on where you are in life. Choices one makes at an early career stage will differ from those one makes much later in life.

When I joined Dow Chemical out in California back in the early to mid- 1970s, Dow was planning to expand. Most of my Dow colleagues have retired, but some old timers recall that as well. Although Dow R&D at Western Division did well and wanted to expand, California unfortunately would not let Dow expand. As a result, Dow finally decided to move the very successful Dow Agricultural Products R&D from Western Division in Walnut Creek, California to Indianapolis, Indiana where Dow Agro is quite successful today.

Very few chemists living in the San Francisco Bay Area working at the Dow R&D labs in Walnut Creek, California chose to move to Indianapolis. A few did move to Indianapolis but then later left Dow. Once the Agricultural Products

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division left, that left only the Polymers and Membranes R&D division where I worked. Although I had an office in both R&D and Dow Sales, both the Dow R&D facility and sales office in Walnut Creek were closed. When the Dow Vice President for R&D flew out from Midland to make the announcement of closing the R&D facility in Walnut Creek on Friday, I returned to work on Monday with the decision to leave Dow rather than move to its facilities in Midland, Michigan or Freeport, Texas where I had frequently visited on Dow business.

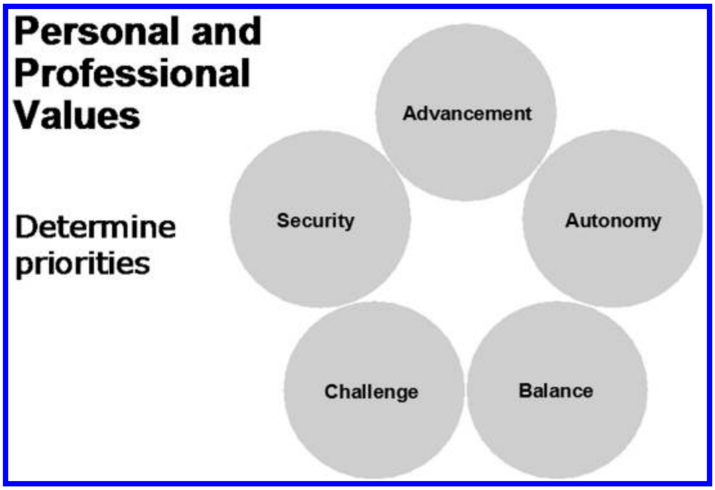

Figure 4. Personal and professional values to prioritize for career decisions.

I was quoted on the front page of the local newspaper that I am part of a dual career family and cannot move because my husband is not a chemist. Thus, he would have had little opportunity in Midland or Freeport where Dow Chemical still has large facilities. ***It is one of those tough decisions which I have never regretted.*** I gave up a fabulous career at Dow to start the next phase of my career. Last year as ACS President, I was delighted to meet Dow's CEO Andrew Liveris when he won the Society of Chemical Industry Award at the Waldorf Astoria Hotel in New York City, and we enjoyed a pleasant chat. He knew how many years I had worked for Dow, and I knew we started the same year.

Small Business and Entrepreneurial Experiences

I was fortunate that I had already started getting involved with my local ACS California Section a few years before I ever knew that Dow Chemical was going to close its research facility and sales office in Walnut Creek, California where I worked for so many years. Thus, I had a good network when I needed it after leaving Dow. ***Networking and career opportunity leads are a very valuable benefit for ACS members!***

I was already on the ACS California Section Executive Committee when I chose to leave Dow. Soon after, one of the other local section Executive Committee

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members approached me at our annual December Social for the California Section. This CEO and founder of a small chemical company let me know he needed an experienced polymer chemist and encouraged me to apply for an opening with his company. I interviewed at this small company and was offered a job where I worked in both R&D and marketing.

This small company, called March Instruments, employed about a hundred with only a few in R&D working on high energy plasma instrumentation primarily serving the medical and electronic industries. Among many other responsibilities, I enjoyed traveling to conferences with the CEO and sales representative as the R&D representative to work as an exhibitor at trade shows. It was another great learning experience to adjust to the contrasts of working for a very large company like Dow Chemical to working for a small company of only a hundred employees.

After some time, this small company got acquired by a larger company and changed direction. Another Ph.D. chemist from March Instruments and I decided to start up our own new venture called Atometrix. I was the President and co-founder while my partner was the Chief Technology Officer. We also had a lawyer advising and helping as we dealt with raising money and making plans as a fledgling startup dealing with novel technology for polymer surface modifications.

However, the small business that brought me the most satisfaction was one I founded called "Science is Fun!" I had been inspired by my daughter one day when she came home from elementary school before she started middle school. She came home and said, "Mom, I think science is SO boring!" That was because she had never experienced what we scientists would consider real science in elementary school. Most elementary school teachers are not well equipped or trained to teach real science.

Thus, I was inspired to create and develop teaching materials for after school hands-on "Science is Fun!" classes targeting young students at local community centers. I strongly believe that children are never too young to start learning science as long as you teach concepts appropriate for their age level. Young minds are like sponges, and children love learning if you make it "hands on" and fun.

It is better to instill interest and enthusiasm for science in children at a young age rather than waiting until later when students often get turned off to a subject by an ineffective teacher in middle school or high school. I always thank our K-12 teachers for the important job they do. ***Teachers have an important responsibility and can either inspire or bore their students with any subject they teach***. Because there was a void in our local community at that time for exciting elementary school age students about science, I created and developed hands-on activities to engage young students with "Science is Fun!"

My "Science is Fun!" classes were always filled to capacity with parents asking me to expand and teach more classes. I initially designed the classes for students from ages 4 to 7, and later up to age 9. My classes included all kinds of science, not just chemistry, with engaging topics like *Sound and Music*, *Stars and Planets*, and much more. After school classes and week long summer camps for "Science is Fun!" were very popular with young students and their parents for many years. See Figure 5 for a photo of one of my classes.

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My “Science is Fun!” evolved over the years. I founded it to help improve science education by providing hands on “Science is Fun!” enrichment classes to engage young students. Outreach to young students to show them how much fun science can be was my initial goal. That was certainly accomplished. Mothers told me their children would talk excitedly at dinner about the science they learned and how they continued to play with whatever they made and brought home from classes. Thus, parents even learned some simple science from their children sharing what they learned!

My goal was to engage young students in the excitement of science and enhance public awareness of the importance of supporting and improving science education. I received commendations from the local school district, the President of the School Board, and even the mayor and other community leaders.

Figure 5. Teaching “Science is Fun!”. (Courtesy of the author.)

Because misperceptions and often “chemophobia” still exist with the general public, I also initiated various public outreach programs for our local communities working with my local section of the American Chemical Society, the California Section. Such successful public outreach programs still enjoyed by hundreds today include “Family Science Nights” in partnership with local school districts around the San Francisco Bay Area, and popular “Science Cafes” in partnership with a local public library.

Why Get Involved with ACS?

I have been a member of the American Chemical Society since 1971 when I started graduate school. I started my journal subscriptions to both the Journal of the American Chemical Society (JACS) and Inorganic Chemistry**.** I have now been a member of ACS for 44 years, but my first two decades as a member were as a research scientist with interest primarily in the journals and technical ACS meetings. ***Over the past twenty plus years, I have steadily been getting more and more involved with ACS as my professional society for life. I believe in giving back to my profession and society and want to make a difference!***

In the early 1990s, before I ever knew that Dow Chemical would close its Western Division research and sales facilities, I attended my first local ACS program. It was an interesting program offered by the Women Chemists Committee (WCC) of the California Section of ACS. I enjoyed the program and very much liked the people I met. I am fortunate that the California Section of ACS has one of the oldest and most successful WCCs in the country. I continued to attend all the programs of our local WCC. Within a year, I was pleasantly surprised and honored to be asked if I would consider becoming their next WCC Chair.That was back in 1994, when I chaired the WCC for my local California ACS Section the first time.

I then joined the Executive Committee of the California Section and became an integral and active member of the governing body for our local ACS section. Over the last twenty years, I have chaired the California Section WCC four times—in 1994, 1997, 1999, and 2009. The first time, I chaired the Women Chemists Committee and helped organize all the WCC programs on my own. After that, I began recruiting and mentoring other women chemists to join our WCC. The second time I chaired the WCC, I recruited a co-chair.

To this day, our local WCC runs quite well with two WCC co-chairs. ***I have always believed in "partnering."*** It makes the job much easier, more enjoyable and more effective. It is also easier to recruit a WCC co-chair each year if they realize there are two people who can help each other with the responsibilities. With the help of Dr. Elaine Yamaguchi, who has also co- chaired our California Section WCC for many years, I put together a presentation many years ago shared at ACS regional meetings on *"How to Start and Grow a Successful WCC for Your Local Section."*

After joining and chairing the WCC of the California Section of ACS, I got involved in other local section activities. Because of my interest in public outreach, I volunteered enthusiastically to help our local section with National Chemistry Week activities. After volunteering and contributing for a couple of years for NCW, I was recruited to be the NCW Coordinator for our local California Section. I did this for many years and also got trained by the national ACS at a "Sparkle" workshop on how to be a good chair for Public Relations and learn about writing press releases and handling the news media. ***Volunteering for ACS activities offers excellent training and opportunities for developing leadership skills.***

As the NCW Coordinator for the California Section of ACS, I was able to initiate two exciting new programs—Family Science Nights and Seaborg Tributes-- for our local section that resulted in several ACS awards and recognition at the national level (earlier Phoenix Awards and later ChemLuminary Awards from national ACS). Figure 6 shows a photo from "Family Science Night" at a local San Francisco Bay Area school.

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Figure 6. Family Science Night stage show. (Photograph by Alex M. Madonik. Used with permission.)

Figure 7 shows photos from a Seaborg Tribute celebrating National Chemistry Week in honor of Glenn Seaborg, Chemistry Nobel Laureate and former Chancellor of the University of California at Berkeley (*13*, *14*)

Figure 7. Seaborg Tribute at University of California Berkeley (13, 14). (Photographs by Alex M. Madonik. Used with permission.)

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What an amazing thrill we enjoyed marching out on the football field at a UC Berkeley game in front of about 50,000 cheering football fans for many years to celebrate NCW! The announcer proclaimed over loud speakers the celebration of National Chemistry Week in honor of former UC Berkeley Chancellor Glenn Seaborg and Chemistry Nobel Laureate.

Glenn Seaborg is the only person who was still living when the element his research group discovered was named after him, element 106 – Seaborgium (*14*). I always also mention that the Nuclear Chemistry Division of ACS is raising money for donations to support the Glenn T. Seaborg Award for Nuclear Chemistry. Visit www.donate.acs.org.

Figure 8 shows photos from the first Family Science Night back in 1997. It was a very successful partnership between the California Section of ACS and my local school district. Its success exceeded all expectations because this first program attracted over a thousand participants with 200 volunteers. I partnered with other science organizations in the Bay Area and recruited scientists from local universities, colleges, companies, and government laboratories like Livermore National Lab and others. I had a main helper or "partner" from both the local ACS and a parent from the Orinda Union School District.

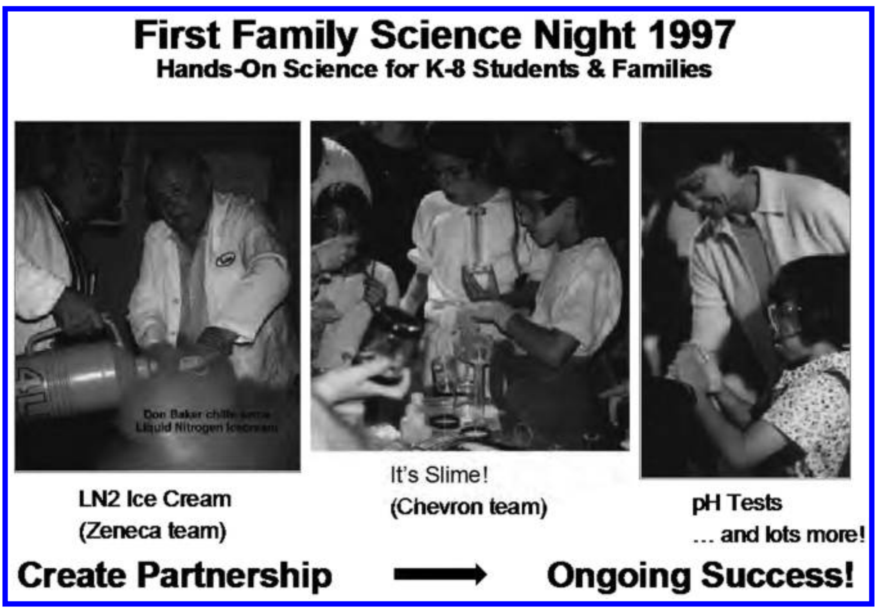

Figure 8. First Family Science Night creating a successful partnership between local school district and ACS, 1997. (Courtesy of the American Chemical Society.)

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Attendance had to be limited to only three stage shows of maximum capacity for the school auditorium that first Family Science Night in my home town of Orinda, California. Family Science Nights continue to this day. Orinda has continued to follow the model of that first successful program. The parents now organize a Family Science Night for the Orinda Intermediate School every few years to expose the students to the fun and excitement of science. We got lots of excellent publicity in local newspapers and received commendations from the California State Superintendent of Education and an elected State Assembly representative who attended that first “Family Science Night,” praising it as a “model for other school districts” in the local newspaper. The Orinda Union School Board President acknowleged the value of Family Science Night to the local community as follows:

> *"Marinda Wu’s wonderful vision for Family Science Night has brought hands-on science with real scientists to the families of our local community. This goes beyond improving our science curriculum for students in the classroom. Due to popular demand, our school district has continued the Family Science Night tradition since its first success in 1997. The excitement of science now reaches the entire community!"*
> Sue Severson
> School Board Past President
> Orinda Union School District

This successful public outreach activity is still practiced today by the California Section of ACS for various school districts around the entire San Francisco Bay Area. It has reached tens of thousands of students and families since 1997. I have started many programs in various areas over the years and then recruited others to take over and continue so as to be able to move on to do more in other areas of importance. In this case, when I retired as the NCW Coordinator for the California Section after doing so for a number of years, I recruited one of my original enthusiastic helpers, Dr. Alex Madonik, who has ably served as the NCW Coordinator for the California Section to this day.

Another very successful public outreach program that I helped start for the California Section of ACS is our popular Science Cafe program which helps to improve science literacy and appreciation for science. The concept of Science Cafes originated in Europe. A scientific expert will chat with the general public about some scientific topic of interest in layman terms while the audience enjoys food and drinks in an informal setting. For the first several years, I was able to recruit a different ACS colleague each year to help me to organize, publicize, and conduct the Science Cafe programs in local Orinda restaurants. Topics ranged from the *Chemistry of Chocolate* to *How not to get too Shook up about Earthquakes* to *Searching for E.T. (Extra Terrestrials).* Oftentimes, the topics were so popular that the restaurants were filled to capacity for the Science Cafe.

I again resorted to *partnering* to solve the challenges encountered. I ended up meeting a scientist, one of my Science Cafe speakers, who happened to be a board member of a local library. Together we piloted a very successful first Science Cafe program at this local public library. ***Today Science Cafe programs***

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are a very successful partnership between the California Section of ACS, our local WCC Women Chemists Committee, and the Lafayette Library and Learning Center (LLLC). The ongoing popular monthly Science Cafe program is publicized by both ACS and the Lafayette Library where it is very much appreciated and enjoyed by the general public of our local communities. I have inspired others to start up Science Cafes in their own local communities. It is also great to continue meeting interesting speakers and scientists willing to speak for Science Cafe programs.

It was personally rewarding to receive the following endorsement:

> *"Marinda is a visionary, enthusiastic, collaborative ambassador for the American Chemical Society, working with us to think outside the box for programs that demonstrate how science, and chemistry in many cases, is such an integral part of our lives."*
> Kathy Merchant
> Executive Director
> Lafayette Library and Learning Center

I was elected in 1996 as an ACS Councilor to represent my local California Section and have been an active member of the national ACS Council ever since. I have served on various national ACS Committees since getting elected to ACS Council and chaired the Committee on Economic and Professional Affairs (CEPA) from 2003-2005. I was honored to become the 100th Chair but only the third woman to Chair the California Section during my local ACS section's Centennial Celebration year in 2001.

Over the past twenty years, I have worked passionately in various areas of importance including *career assistance* and *government affairs* at both the local and national levels. I have addressed such topics of importance in various presentations as well as in my ACS Comments for *Chemical and Engineering News*. Since 1998, I have authored 27 ACS Comments in *C&EN*. Not only do I stress the importance of public outreach, but also the importance of *advocacy* by scientists in talking with legislators and public policy makers. There is still work to do in terms of getting the general public and policy makers to appreciate the benefits that chemistry and science bring to society. See my most recent ACS Comment on *"Partners for Progress and Prosperity"* (*15*).

Years ago when I first chaired the national ACS Committee CEPA in 2003, I began writing ACS Comments in C&EN on topics of importance to our members (*16*, *17*). I continued writing ACS Comments on ideas I strongly believe and promote when I got elected to the ACS Board of Directors as a petition candidate in 2006. I have long had a vision of how we scientists can all work together as "*Ambassadors for Science, Technology & Education in the 21st Century"* (C&EN, August 6, 2007) (*18*). See Figure 9.

I believe in not passing up opportunities, so I have always published as many ACS Comments as allowed in C&EN (two per year for a national ACS Committee Chair or as an ACS Board member). I later published an ACS Comment on *"Chemistry Ambassadors Go Global"* (*19*). I am happy now to see that indeed this vision is becoming reality. Progress has been made step by step.

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Getting Elected as ACS President

Past Presidents and other ACS members began urging me to run for ACS President once I had been active on the ACS Board for a few years. Eventually, because I had long had a vision depicted in Figure 9 which I had shown in many presentations over the years and I felt an urgent need to help our members when the unemployed chemists figure reached a record high, I decided to take on the challenge of running for ACS President.

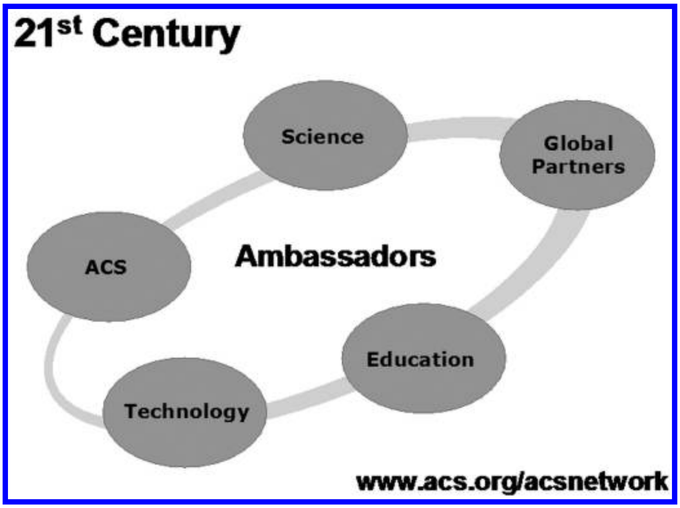

Figure 9. My vision of ambassadors for science, technology, and education working as global partners.

Unlike many of our sister chemical societies whose presidents may be selected by its governing Board members, the ACS president is elected by all its members after the ACS Council (composed of approximately 500 elected Councilors representing 187 Local Sections and 32 technical Divisions of ACS) selects two candidates from four nominees put forward by the Nominations & Elections Committee. The ACS Council votes for two candidates at every national ACS meeting in the spring after hearing a Town Hall debate where the four nominees answer questions submitted by members of the Council and then a speech from each nominee. Candidates also can run by petition.

I was told by one Councilor just prior to the Town Hall debate that I did not have a chance because I was running against three other ACS Board members who were all senior to me. However, I did not let that bother me and kept my self confidence during the debate. When the debate was over, that same Councilor came back up to me after hearing my answers to the many questions from the audience, and he said to me, "Now I believe you have a chance!"

It is important to believe in yourself and have confidence against all odds in life. I have always believed in turning challenges into opportunities!

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In spite of running for ACS President-elect against another candidate who was my senior on the ACS Board and worked at the National Academies in Washington D.C., I just continued to work hard on what I believed important and focused on the challenge at hand.

Having run for ACS President-elect as a "*Catalyst for Positive Change,*" I want to thank countless supporters from my over 40 years as an ACS member. Many scientists from my various endeavors provided tremendous support with enthusiastic endorsements. However, I only have space to share two of many wonderful endorsements:

> *"I have known and worked with Dr. Marinda Wu for thirty-five years, starting with our times as colleagues at The Dow Chemical Company. I have the greatest respect for Marinda's capability to do any job she sets her mind to do."*
> Dr. Jerry Moseley
> Former R&D Director
> Dow Chemical, Western Division
> *"Not only is Marinda eminently qualified to serve as ACS President, but she is one of the hardest working, most enthusiastic, and energetic persons I have ever known. In addition, she has a real "passion" for helping to improve our Society and better serve its members. She understands diversity of all kinds."*
> Dr. Darleane Hoffman
> ACS Priestley Medalist
> Professor Emerita, UC Berkeley

When I got elected, I received countless wonderful personal notes. One in particular stands out in my mind. I received a congratulatory email from the retired Director of Central Research (then 81 years old) for all of Dow Chemical in Midland, Michigan. He told me he remembered me well and believed that "ACS was in good hands" having elected me as ACS President.

I was greatly honored to be elected in November 2011 as the first Asian-American and only the 8^{th} woman in the 137 year history of ACS to become ACS President. See Figure 10 for the C&EN cover for my presidential article on "*Partners for Progress and Prosperi*ty" (*20*).

I have always believed in *excellence* and worked tirelessly these past three years in the ACS presidential succession. It has been an honor and privilege making many new friends and meeting with chemistry communities worldwide. See some of my summary thoughts in my last ACS Comment as Immediate Past President (*15*). I feel good about what has been accomplished through *partnering* with dedicated volunteers, ACS staff, and many others including my Vision 2025 Presidential Task Force (*21*).

As 2013 ACS President, I authored six ACS Comments (the maximum allowed for an ACS President) for C&EN. I wrote about the following topics of great importance that I am passionate about:

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- "*American Chemical Society-Chinese Chemical Society Alliance*" (Jan.7, 2013)
- "*Partners For Progress & Prosperity*" (March 11, 2013)
- *"Helping Members Thrive In The Global Chemistry Enterprise"* (June 3, 2013)
- *"Time To Partner And Speak Up For Science"* (Sept. 2, 2013)
- *"Looking For A Job? Check Out These Tools For Chemists"* (Oct. 21, 2013)
- *"Promoting World Peace through Science Diplomacy" (Dec. 9, 2013)*

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Figure 10. Cover story on partnering for progress & prosperity as 2013 ACS President, Chemical & Engineering News (January 7, 2013). (Reprinted with permission from ref. (20). Copyright 2013 American Chemical Society.)

My presidential symposia at the two 2013 national ACS meetings when I was ACS President are now available both in hard copy and also online at www.pubs.acs.org as two ACS Symposium books (*21*, *22*). They cover important areas on which I promised to focus:

1) Concentrating on members' needs and interests
2) Collaborating to enhance the global chemistry enterprise
3) Communicating the value and benefits of chemistry to society
4) Celebrating diversity and inclusivity.

ACS members can use their ACS membership benefit of 25 free downloads of journal articles or book chapters per year from ACS Publications to access the valuable information and perspectives shared in these two ACS Symposium books:

1) "*Vision 2025: How to Succeed in the Global Chemistry Enterprise,"* and
2) "Careers, Entrepreneurship and Diversity: Challenges and Opportunities in the Global Chemistry Enterprise."

The first book, "Vision 2025: How to Succeed in the Global Chemistry Enterprise," shares perspectives from ten presidents of chemical societies representing Europe, Asia, Africa, and the Americas as well as thought leaders from academia, industry, government, and small business from the USA. See Figure 11 for a photo of the front cover of the first ACS Symposium book (*21*).

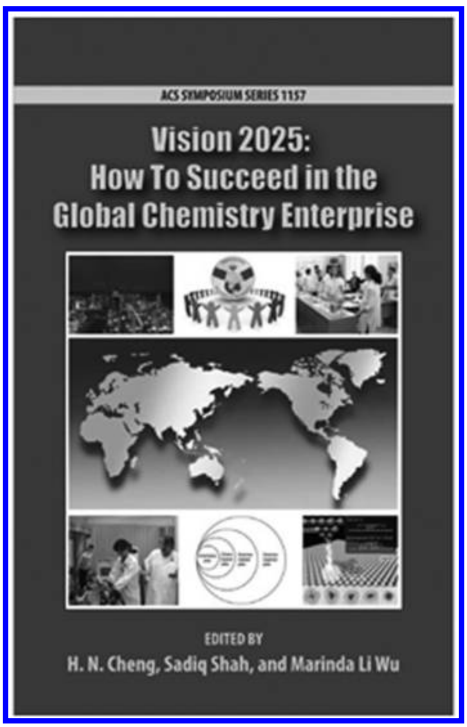

Figure 11. First ACS Symposium book based on 2013 presidential symposia 245th ACS National Meeting, New Orleans, April 2013. (Reprinted with permission from ref. (21). Copyright 2014 American Chemical Society.)

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I had invited eleven presidents to attend our national ACS meeting for a Global Collaboration Round Table discussion. See Figure 12 for a photo of Presidents of Chemical Societies from around the world.

Figure 12. Presidents of chemical societies around the world, 245th ACS National Meeting, New Orleans, April 2013. (Front row from left to right: Livia Sarkadi, Vitor Ferreira, Marinda Li Wu, Cathleen Crudden, Barbara Albert; Back row from left to right: Han-Young Kang, Sorin Rosca, Xi Zhang, Kohei Tamao, Chien-Hong Cheng, James Darkwa). (Photograph by Norm Wu. Used with permission.)

The second ACS Symposium book, *"Careers, Entrepreneurship and Diversity: Challenges and Opportunities in the Global Chemistry Enterprise,"* (*22*) shown in Figure 13 should be especially helpful for students, job seekers, and those contemplating career transitions. It shares the experience of many successful chemists starting at the lab bench and then going on to various different types of careers.

This third ACS Symposium book covers "*Jobs, Collaborations, and Women Leaders of the Global Chemistry Enterprise.*" It includes fascinating and inspiring chapters by former ACS CEO/ Executive Director Madeleine Jacobs, Priestley medalist Darleane Hoffman, and many others as well as a report on the Supply and Demand of Chemists and Jobs in the USA. Most of the authors were speakers from symposia at the 248th national ACS meeting in San Francisco in August 2014. See Figure 14 for a photo of most of the speakers from the symposium on "Women Leaders of the Global Chemistry Enterprise." Figure 15 shows photos of the two speakers missing from the group photo shown in Figure 14.

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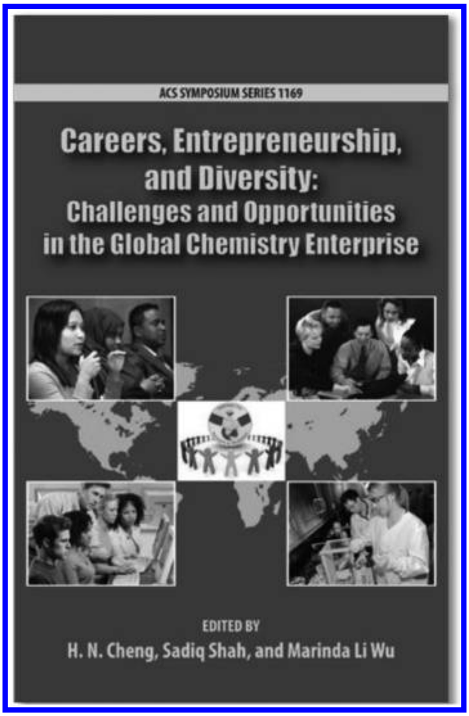

Figure 13. Second ACS Symposium book based on 2013 presidential symposia 246th ACS National Meeting, Indianapolis, September 2013. (Reprinted with permission from ref. (22). Copyright 2014 American Chemical Society.)

I am also happy to help raise awareness and promote excellent partnerships and collaborations through a new ACS P3 (Partners for Progress and Prosperity) award. Please help encourage nominations that demonstrate impact in the following important areas:

1) Improving the public perception and appreciation for chemistry
2) Promoting career advancement opportunities and/or supporting entrepreneurship in the chemistry enterprise
3) Advancing advocacy efforts with government and other thought leaders
4) Supporting STEM (Science, Technology, Engineering & Mathematics) education and/or research

Please visit www.acs.org/regionalawards or www.acs.org/chapters for more details on these awards available to local sections, international chapters, technical divisions, universities, government labs, other professional societies, nonprofit organizations, and much more.

Let's continue to work together as "*Partners for Progress and Prosperity*" to make advances in critical areas and to collaborate to solve global challenges! Let's partner to work as *catalysts* for positive change (*15*).

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Figure 14. Symposium speakers, Women Leaders of the Global Chemistry Enterprise, 248th ACS National Meeting, San Francisco, August 2014. (Front row from left to right: Samira Ibrahim Islam, Kazue Kurihara, Mannepalli Lakshmi Kantam, Vanderlan da Silva Bolzani, Marinda Li Wu, Supawan Tantayanon, Zafra Lerman, Darleane Hoffman, Hui Cai; Back row from left to right: Noemi Walsoe de Reca, Mamia El Rhazi, Lydia Galagovsky, Barbara Loeb, Bice Martincigh, Kimberly Woznack). (Photograph by Norm Wu. Used with permission.)

Figure 15. Additional symposium speakers, Women Leaders of the Global Chemistry Enterprise, 248th ACS National Meeting, San Francisco, August 2014. (Left photo: Madeleine Jacobs, CEO and Executive Director of ACS at the time of the symposium in San Francisco (23); Right photo: Dr. Ann Nalley, 2006 ACS President). (Courtesy of the American Chemical Society.)

Life Lessons Learned

I will conclude this chapter on my personal and professional journey by sharing a few life lessons learned.

Destiny and Determination have played a huge role in my life. There are some things like fate and history that one cannot change. However, determination and focus on what you wish to accomplish will take you far.

Excellence and Equity have always been part of my strong personal belief. I have always believed in excellence and do not like mediocrity. If a task is worth doing, I believe it should be done very well. Recently at a wonderful National Historic Chemical Landmark celebrating the achievements of Dr. Rachel Lloyd, I was pleased to learn that I share this same belief regarding excellence with Dr. Lloyd (*24*). She was a remarkable pioneer chemist who became the first woman to be hired as a chemistry professor in the USA by the University of Nebraska in Lincoln back in 1887! See www.acs.org/landmarks. I have given presentations on celebrating diversity of all kinds and encouraging equity without sacrificing excellence.

Having ***Confidence and Courage*** will also help you tackle difficult challenges in life. You may not always succeed or make the right decision, but you can always make course changes if needed. Having self confidence and courage to take risks for what is important is critical to success.

Passion and Perseverance are also two necessary ingredients in all that I do. I have passion for not only work but also for play, fun and whatever I do! Life balance is important which is why my first valedictory graduation speech in life was "*A Time for Work and A Time for Play.*" I also never give up but keep persevering at whatever I am focused to accomplish. This was a common theme among all the speakers of my wonderful symposium at the 248th national ACS meeting in San Francisco on *"Women Leaders of the Global Chemistry Enterprise."* Hard work, perseverance and passion were mentioned many times by these inspiring women leaders. I share and practice a favorite quote from Confucius (552-479 BC):

> *"Choose a job you love, and you will never have to work a day in your life. Wherever you go, go with all your heart."*

Lastly, I have always believed in partnering and collaborating to get things done throughout my career and personal pursuits. Hence, my presidential theme has been ***"Partners for Progress and Prosperity."*** It embodies my long time personal beliefs and has resonated well with chemistry communities wherever I have gone. This book covers many examples of outstanding international collaborations. I have also always believed in *diversity and inclusivity* which are core values of ACS. Many of the speakers of my international symposium are leaders of global alliances with ACS.

In closing, I wish to thank not only countless volunteers and colleagues, dedicated ACS staff, many others both in the USA and overseas, but also my wonderful family for their unwavering support. See Figure 16 for a photo of my family taken nearby in Sonoma wine country. Extra special thanks are due

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to my husband Norm, my daughter Lori and her husband Evan, my son Will, and my dear mother Tsun Hwei Li. I am planning a fabulous family reunion to celebrate my mother's 95th birthday in March 2015. See Figure 17 for a photo of my mother attending a family wedding with some of her grandchildren at Amelia Island, Florida in May 2014.

Figure 16. Marinda Li Wu and family. (Courtesy of the author.)

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Acknowledgments

Many thanks are due to my Presidential Task Force "Vision 2025: Helping ACS Members Thrive in the Global Chemistry Enterprise" for their help with my ACS presidential initiatives. Please see biographies of the 22 outstanding members of this diverse Presidential Task Force chaired by Dr. H.N. Cheng and Dr. Sadiq Shah with the able assistance of ACS staff liaison, Dr. Robert Rich in my first ACS Symposium Book (*21*). Extra special thanks are due to my long time colleague and ACS Symposium books co-editor, Dr. H. N. Cheng.

I also gratefully acknowledge financial support from the following individuals and organizations that helped make my international symposium on "Women Leaders of the Global Chemistry Enterprise" and other presidential initiatives possible:

- Madeleine Jacobs, CEO and Executive Director of ACS
- Brian Crawford, President of ACS Publications
- Manuel Guzman, President of Chemical Abstracts Service
- Denise Creech, Director of Membership & Scientific Advancement, ACS
- Hui Cai, Vice President of Corporate Alliances, WuXi App Tec
- Joe Stoner, Chair of Division of Professional Relations
- Ann Nalley, Global Innovation Grant from International Activities Committee
- Tao Guo, President of Doering Foundation
- Elaine Yamaguchi, Co-chair of the Women Chemists Committee, California Section, ACS

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Figure 17. Tsun Hwei Li with some of her grandchildren at a family wedding in May 2014 at Amelia Island, Florida. (Courtesy of the author.)

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Chapter 23

Two Decades of Research on Natural Products Chemistry from Brazilian Biodiversity: Inspirations and Motivations

Vanderlan da Silva Bolzani*

Institute of Chemistry, São Paulo State University, Araraquara, São Paulo, Brazil, CEP 14800-900
Natacha Carvalho Ferreira Santos, National Council for Scientific and Technological Development, CNPq, Brasília, DF, Brazil, CEP
***E-mail: bolzaniv@gmail.com.**

Although the author is a distinguished scientist and natural products researcher and has an impressive list of accomplishments to her name, achieving these was not easy. In recounting her journey, she describes the hurdles that not only she had to overcome, but all women scientists, both in Brazil and in the scientific community around the world, must overcome. While society has progressed significantly over the last century to include more women in the scientific community and other professions, disparities still persist. The author provides strong insight into these disparities and what might be considered a sobering reality of the progress that has been made. However, in reflecting upon her own progress over the course of her career, she has proven that with enough passion and dedication, it is never impossible to achieve one's dreams.

Introduction

When asked to write this chapter, I had two feelings, the first being happiness from being invited to participate in this fantastic ACS initiative dedicated to worldwide women in science. The second was concern to write about myself and at the same time to provide a perspective of the Brazilian women in science, emphasizing the contributions Brazilian women have made to natural products chemistry and to science and technology in general in Brazil.

It is very difficult to separate the personal life from the private life of a scientist. As I realized while writing this chapter, our stories and accomplishments interact in such a way that my career as a researcher and my role as a housewife, mother, professor all contribute to what we, as women, can do for our country and our society.

Thus, writing this chapter was an excellent opportunity to reflect upon our role as women throughout the evolution of humankind. This chapter is divided in two sections. The first gives a brief overview of the role of women in the Brazilian science, showing some statistical data, especially in the area of natural products. The second section covers the major steps I took in my career, my inspirations and motivations to become a scientist in natural products chemistry.

It is heartwarming to see the growing participation of women in various parts of the society today. In particular, the efforts of women who work in the so-called "hard sciences", which have traditionally been considered men's world (*1*, *2*). It is encouraging to see the national and international statistical indices increasingly containing women's scientific production, as women increasingly assume positions and jobs traditionally held by men in these fields.

Science and technology has always been the domain of men since the fifteenth, sixteenth, and seventeenth centuries. The world has witnessed many fantastic events and discoveries which have paved the way for understanding the universe, culminating in the recent advances in science we know today. Many of these events, including those that occurred in the seventeenth century, were marked by a long history of struggling women who ventured into the world of men to achieve balance among their various roles as wife, mother, and professional in a world of constant change.

Today, the involvement of women in all activities is central to the social and economic development of a country, and women are becoming an increasingly active part of the workforce in strategic sectors: universities, research institutes, technology, service industry, and production jobs. Women are building a new social dimension worldwide.

In the scientific world, the female journey has been long and trying. When looking back over centuries of scientific achievements, the contributions of women have been few when compared to men. It is impossible to not mention Marie Sklodowska Curie, who was denied a seat in the French Academy of Sciences for being a woman. Marie Curie, a disciplined and brilliant scientist, was the first woman to win a Nobel Prize in Physics, which she shared with her husband, Pierre Curie, for their discovery of polonium and radium, in partnership with Henri Becquerel (*3*). At the time, Marie Curie appeared to be only an assistant to her husband. She was rewarded again in 1911 with the 11th Nobel Prize in Chemistry for her personal research on radioactivity (*4*). She was the first scientist in history to receive the Nobel Prize twice. Her career was recognized by IUPAC and UNESCO in 2011, the centenary of her Chemistry Prize, and a celebration of the International Year of Chemistry. She has become a symbol of Chemistry, and the world recognizes her great achievements in science and human development. Since her recognition, we have witnessed a noticeable shift in many countries, where the number of women scientists, and the number of professional women in general, have increased radically.

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Despite the increased number of women in academic and research activities, they are still underrepresented, particularly in so-called hard sciences, and in leadership positions. Recent data collected in several continents reveal that there are more female than male undergraduate and graduate students in many countries; however, there are relatively few female full professors, and gender inequality in hiring, earnings, funding, patent authorship, and career satisfaction still persist (*5–7*). As for authorship of publications, globally women account for less than 30% of fractionalized authorships, whereas men represent slightly more than 70% (*8*). Similarly, women are underrepresented when it comes to first authors (*9*). For every article with a female first author, there are nearly two (1.93) articles first-authored by men. Therefore, it is important to welcome the actions that ACS has done to recognize the scientific work of women scientists in chemistry and chemical engineering.

Overview of the Brazilian Women in Science and in Natural Products Chemistry

"*Despite improvements, female scientists continue to face discrimination, unequal pay and funding disparities*" -- this was stated by Helen Shen in her article in the news feature of *Nature* in 2013 (*10*). When we study the Brazilian scientific workforce, women are fairly represented according to the 2010 statistics released by the National Council for Scientific and Technological Development (CNPq) (*11*). Of the 22,797 research groups, 49% involve women, representing a very promising development. Note that the equivalent data in 1993 gives 39%. However, this is not the total picture! While 49% of women are involved in research, only 27% of these groups are actually led or coordinated by women (Figure 1).

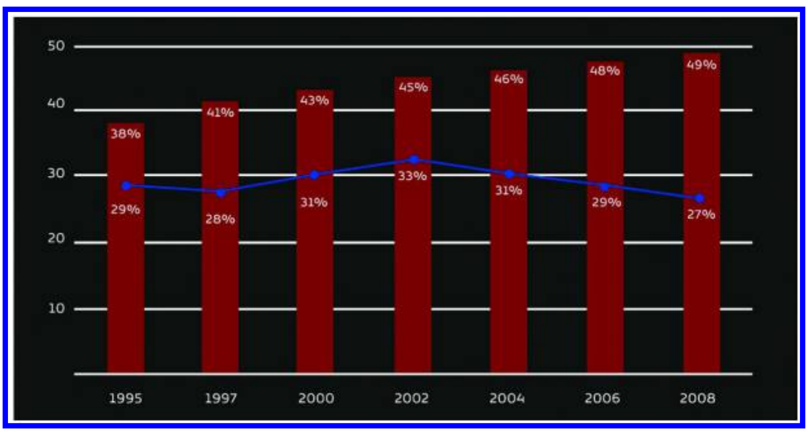

Figure 1. Statistical data of women researchers in Brazil have shown increasing numbers of women involved in research teams (red bars), but fewer women leading research teams (blue trend line). (Source: DGP-CNPq (11)) (see color insert)

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Another interesting aspect of the gender question in Brazilian science is the area of research (Figure 2). The so-called *hard sciences*, including engineering, natural and earth sciences, and agronomical sciences are dominated by men, whereas research in the humanities, linguistics, literature, arts, and health sciences is predominantly done by women. Looking at the data, one may conclude that a major workplace issue in Brazilian scientific research is to increase the demand of women for *hard sciences,* and the new gender equity would be very favorable to the current scientific and technological developments of Brazil because there are currently many outstanding women scientists in chemistry, engineering, and agronomy.

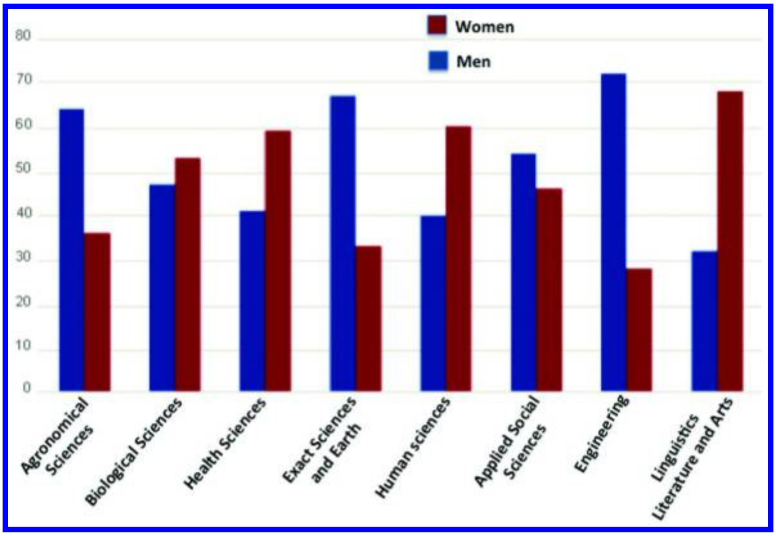

Figure 2. The distrubution of men and women researchers across different academic areas according to the Conselho Nacional de Pesquisa, reported in the census in 2010 (from CNPq database, Brazilian Council for Scientific and Technological Development). (see color insert)

We need to create a scientific environment free of gender discrimination for the future generations of women pursuing careers in science, especially in chemistry, where the number of female "research productivity fellows" recorded in the CNPq database is disproportionately smaller than that of men[11] (Figure 3). As Figure 3 shows, women are underrepresented in all areas of chemistry: organic (71 women, 28.29% of total organic chemists), analytical (50, 29.24%), inorganic (51, 40.80%) and physical chemistry (49, 27.84%). Special attention should be paid to organic and physical chemistry which have the largest disparity. Even in inorganic chemistry, which has a large female representation, women are still underrepresented.

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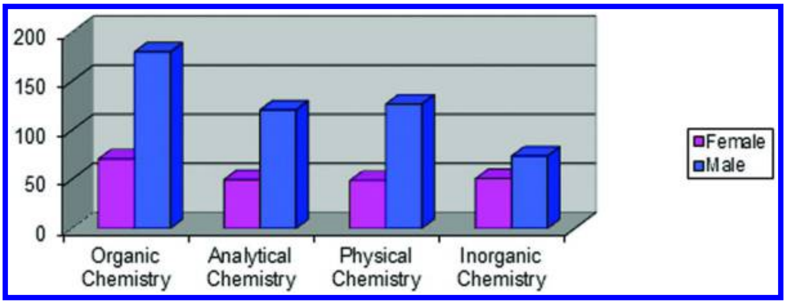

Figure 3. The distribution of women and men "research productivity fellows" across different areas of chemistry in Brazil, according to the National Council for Scientific and Technological Development (CNPq) database in 2010. (see color insert)

Even though more female scientific researchers are emerging in Brazil, the number of distinguished researchers, rated as 1A level researchers, is significantly less than their male counterparts, according to CNPq (Figure 4). This disparity is more serious in chemistry and deserves more attention. The last CNPq survey of the total number of "research productivity fellows" [male 502 (69.43%) and female 221 (30.57%)] shows a great disparity between the number of male and female CNPq "research productivity fellows." These fellows are distinguished Brazilian scientists who have been nominated on the basis of their excellent track records at different stages of their careers.

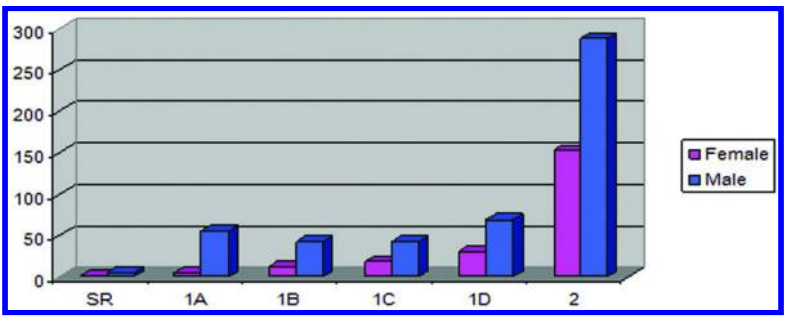

Figure 4. Distribution of "research productivity fellows" by gender according 2012 National Council for Scientific and Technological Development (CNPq) survey (SR=retired outstanding senior researchers; 1A = internationally excellent scientists; 1B = exellent, 1C = very good; 1D = junior excellence; level 2 = starting career). (see color insert)

At the early stages of their scientific careers, women are well represented among the "fellows", totaling 153, which represent 65.3% of the male "fellows."However, at the senior retired (SR) level, there are 6 "fellows", among whom only one is female, corresponding to 16%. At the next level (1A), the total number of "fellows" is 61, and the number of women amounts to 5, which

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corresponds to 8.2% only. In natural products chemistry, the number of women "fellows" at the 1A level is low, only 1 woman versus 4 men. Thus, while the total number of women within chemistry has increased in 2014, the majority are only at the lower career levels, which is unfortunate, because in Brazil there are several renowned female scientists who could be rated at the 1A level.

Where the funding for research in Brazil is concerned, CNPq is the main distributor of grant money. An annual national project funding program called Universal is the most important due to its wide range. It distributes its funding according to three categories: A (starting career), B (intermediate) and C (for renowned scientists). The percentage of women participating in CNPq Universal calls is noteworthy, as shown in Figures 5 and 6.

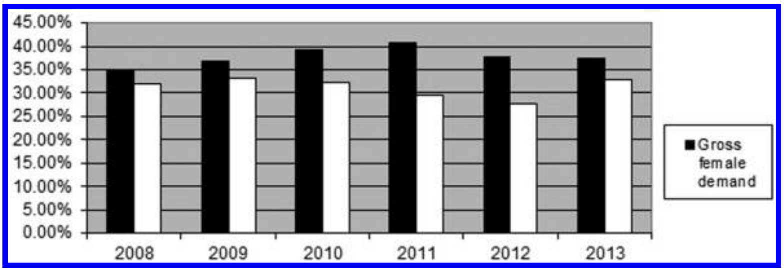

Figure 5. The percentage of women applicants participating in the CNPq Universal funding program in Chemistry. Applications, black bar; awarded, white bar. (see color insert)

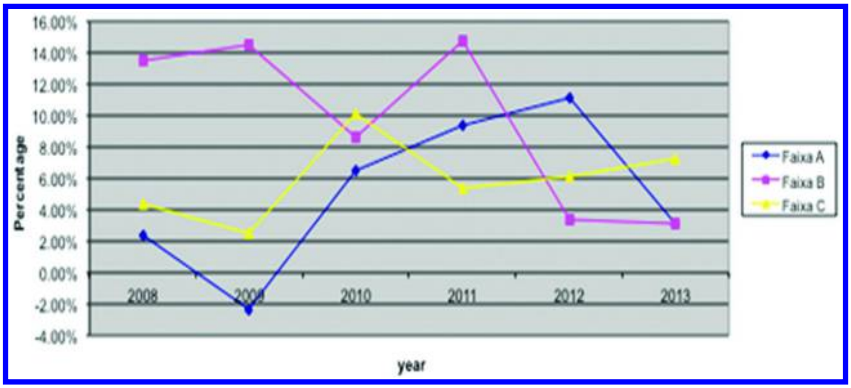

Figure 6. The difference between female participant gross demand and proposals approved at the Universal/CNPq calls for three categories (A, B, C) over the past 6 years. (see color insert)

When we look at the gross demand of women applicants and the number of approved projects, these numbers indicate high women participation in all categories (Figure 5). However, when compared with the approved projects for men and women, the results for women are in the minority (Figure 7).

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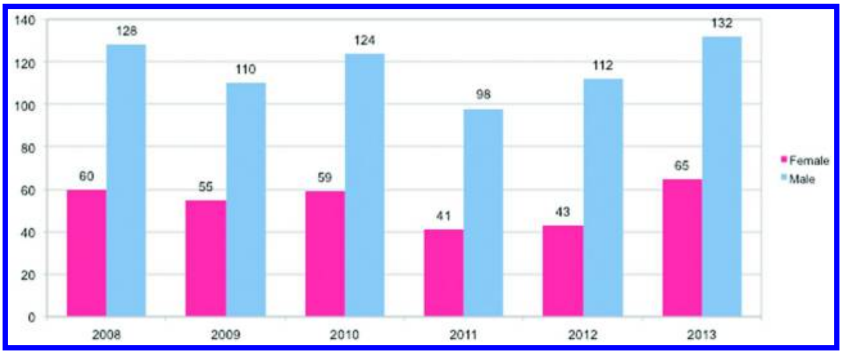

Figure 7. Male and female distribution for current CNPq financial support for research under "Universal Projects" (2008-2014). (see color insert)

If we analyze long-term projects, such as the ones funded by National Institute of Science and Technology (INCT) in Brazil, 125 projects have been approved, where 108 (or 86.4%) are coordinated by men, and only 17 (13.6%) are coordinated by women (Figure 8). This trend is also seen in the membership of Brazilian Academy of Sciences, where women are in the minority.

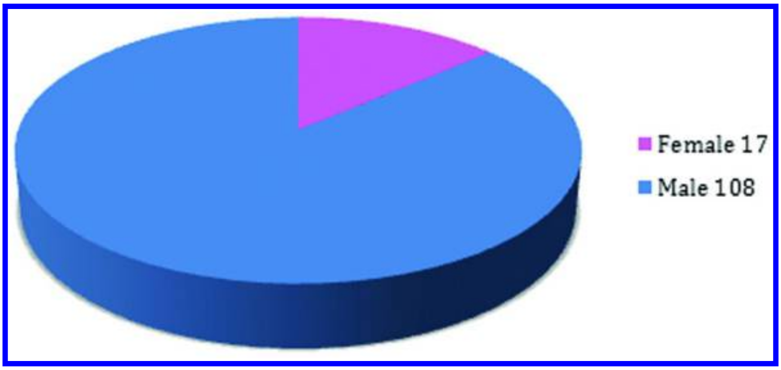

Figure 8. Distribution of male and female as project coordinators in INCT (for long-term national science and technology projects). (see color insert)

The Brazilian culture is a large factor in this gender disparity. For years we have witnessed discrimination in the workforce. 2014 is marked by a substantial change, with more women pursuing scientific careers and professional work in general. Since Brazil instituted a federal republican government in November 15, 1889, replacing the old imperial regime, women have made great progress. Brazil has even seen a woman achieve the presidency. Despite these developments, women are still largely underrepresented in professorships in the hard sciences, including chemistry and natural products chemistry research. This hierarchical (or vertical) segregation is not exclusive to developing countries like Brazil, where consolidation of academic and scientific activities is fairly recent. However, there have been several efforts in the direction of greater gender equity.

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The 14th edition of the CAPES-Elsevier Award that honors ten Brazilian women who made significant contributions to science is a good example of these efforts. As chemistry researchers, we can look at these developments with optimism. Seven of these women work in the chemical sciences and related areas. As a CAPES-Elsevier awardee, I stated in my acknowledgment speech, "*Science is predominantly male, even with all the advances we have made over time. Hopefully this award will encourage women. I grew up in an environment where books had no female characters. I believe that throughout this process, women with much struggle, high performance, intense vigor, and, above all, passion are writing a new story, where books begin to have female characters*."

A Brief Overview of the Research on Natural Products Chemistry from Brazilian Biodiversity

Summarizing more than three and a half decades of work in natural products chemistry into a few pages for this chapter might be one of the most difficult tasks of my career to date. It is not easy for me to write about my career, pick out certain events from the many things I have done, and identify those which have guided or marked my career paths. Obviously the events are all interconnected, and they intertwined with my personal lives.

Praia Formosa, Cabedelo, João Pessoa, Paraíba. The house is surrounded with a terrace that looks out over an immense coconut grove, beyond which lies the sea. A wonderfully green sea, emerald, as sung in the verse and prose of poets from my native land. It was in this enchanting place that I learned to read and write (Figure 9), at the age of four. It was a short but significant period, which undoubtedly laid the foundation, albeit unconsciously, for my love of nature and natural products.

Figure 9. 11/19/54. Vanderlan Birthday, 4 years old. (Courtesy of the author.) (see color insert)

My first years of study were at a Montessori school, known for its rigorous training program. The excellent marks I achieved made my parents proud, as I

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was then able to go to Liceu Paraibano, which was considered at that time the best public school in João Pessoa – and where I studied for two years in high school. I was one of the 50 students fortunate enough to be selected to finish the last grade at the Colégio Universitário, an innovative model of State High School, with a teaching staff composed of professors from the Universidade Federal da Paraíba (UFPB). At this school, I had a year of intense activity, preparing to go to the university. In 1966, at the age of 17, I began studying medicine at the UFPB. The reality of my classes on anatomy and physiology led me to reconsider medicine as my dream profession. Two years after starting medicine, I stopped and took an entrance exam for the faculty of Pharmaceutical Science at UFPB. I went on to take classes in pharmacy and immediately identified with organic chemistry. I thoroughly enjoyed the course, and finished with excellent marks.

This discovery, the exciting work which combines constant learning, teaching and research, came when I participated in a symposium on natural products chemistry, while still studying as a pharmacy student.

When I ended my undergraduate curriculum in pharmacy, I opted to pursue a Master's degree in chemistry at the University of São Paulo, one the most prestigious public universities in my country, located in the city of São Paulo, capital of São Paulo State, known as the economic center of Brazil (41 million inhabitants; 34% of Brazil's GDP, 50% of Brazilian science, 13% of state budget to HE and R&D, and 1.6% of GDP for R&D). In order to move to São Paulo to study in a very expensive city, I needed to get my parent's permission, mainly because I would have to leave my place of birth and travel 3200km to go to live in São Paulo. At the time it was a great adventure, because at that time only rich families left northeast Brazil to go study in the country's developed, urban poles. Three months after I finished my undergraduate studies, I arrived at the Instituto de Química da Universidade de São Paulo (IQ-USP). I began my scientific career by joining a phytochemical study of *Mikania hirsutíssima*, a species of Asteraceae under the supervision of Professor Mario Motidone, an assistant professor in Otto Richard Gotllieb's group.

Gottlieb was one of Brazil's greatest scientists, and the only Brazilian to be nominated for the Nobel Prize of chemistry twice. After receiving good training in natural products chemistry, I began my graduate studies under Prof. Gottlieb's supervision, studying *Croton diasii*, a species of plant from Amazonia. The studies with *C. diasii* were the first scientific challenge I faced. Prof. Gottlieb was a specialist in the chemistry of lignans, and had an international reputation for his work on the chemical diversity of Myristicaceae and Lauraceae from Amazonas (*12*).

Researching this distinct class of natural products at the time was an immense challenge, taking into account the fact that from *C. diassi* we had isolated a labdane type diterpene with a very complex structure, which had never been seen before. I proposed a new diterpene structure, which even at that time in Brazil was a challenge, and the correct molecular structure was confirmed by the collaboration with Professor Hugo Gottlieb of the Weizmann Institute of Science, Rehovot, Israel, who undertook all the ^{1}H and ^{13}C nuclear magnetic resonance (NMR) studies, which was not yet possible in Brazil. This research gave me the Master's degree and my first research publication in *Phytochemistry* in 1978 (*13*).

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During my Master's, I met Jorge Bolzani Neto, a student in social sciences at USP whom I went on to marry. My emotional life became intertwined with my grad courses and lab work. At the age of 27 in the midst of all that was going on, I became pregnant. My eldest child, Mariana, arrived on the 4th of March, exactly 2 months and 17 days after my dissertation defense for my Master's (Figure 10).

Figure 10. Vanderlan, her husband and children Mariana and Tiago. (Courtesy of the author.) (see color insert)

Having a Master's degree, I returned to my birthplace and was hired as an assistant professor in the department of chemistry at UFPB. This return meant contributing to the development of the university I graduated from. I became a member of the professional staff in May of 1978. The first classes I taught were in general and organic chemistry, within the basic cycle of courses in chemistry and pharmacy. The difficulty of continuing research in natural products chemistry at UFPB led me to return to São Paulo, which has an excellent infrastructure in all areas of study. An invitation from the Faculdade de Ciências Farmacêuticas, UNESP in Araraquara to be an assistant professor provided an excellent opportunity to begin my scientific career as a researcher and a great opportunity for my husband, Jorge, who began his Master's in rural and urban sociology at the Instituto de Filosofia Ciências e Letras at UNESP.

We moved to Araraquara with the same objective: to build a career in science and – in my case – to work in the department of pharmacognosy, which fascinated me, as it was a chance to establish a line of research in chemosystematics, focusing on indole terpene alkaloids as markers in the order Gentianales – the theme of my PhD, and a subject that had not been explored much at the time. It was also an opportunity to move my career as a scientist forward, continuing my PhD at IQ-USP, which I had begun in 1978 under Professor Gottlieb's supervision.

Studies of chemosystematics of indole alkaloids accumulated in Apocynaceae, Loganiaceae and Rubiaceae contributed to the establishment of some Rubiaceae phylogeny trends based on chemomarkers and also led to the

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phytochemical studies of Brazilian Rubiaceae plant species, which was still relatively unknown. It is interesting to note that research on indole alkaloids provided valuable input to the Rubiaceae taxonomy proposed by Robbrecht (*14*), a botanist who is recognized worldwide. Research with chemosystematics was a promising step towards the expansion of laboratory work and training at the Núcleo de Bioensaios, Biossíntese e Ecofisiologia de Produtos Naturais (NuBBE), which, today, is known throughout the world. It consisted of four researchers working in natural products chemistry, Professors Alberto José Carvalheiro (analytical methods) Angela Regina Araujo (endophytic fungi), Dulce Helena Siqueira Silva (bioprospection and dietary supplements), Ian Castro Gamboa (metabolomics) and Maysa Furlan (biosynthesis). During this time, in 1981, while research in natural products at the IQ-UNESP was bearing fruit, my second child, Tiago, was born, further closing the gap between my professional and personal life with my family.

One of the greatest challenges a female scientist faces is reconciling the roles of mother and scientific professional. As incredible as it may seem, we women have been able to orchestrate this dichotomy with great mastery. Mariana (designer, age 35) and Tiago (economist, age 34) are now respected and responsible professionals.

The research with Brazilian plants was becoming increasingly far-reaching and, as a result, we began collaborating with researchers from other areas, and initiated biodiscovery research at UNESP, which included studies with Aristolochiaceae, Verbenaceae, Piperaceae, Celatraceae, and Fabaceae, among others of medicinal interest, with a view to identify compounds exhibiting antitumor and antifungal properties.

As I have already mentioned, private life is often inseparable from professional life, and at times misfortune occurs without any way to prevent it. Jorge, my husband, suffered a serious stroke at the age of 38. This tragic and unexpected event completely changed my domestic and all to the end of profession life, and altered all the professional plans that had guided the research I had been doing at IQ-UNESP. I distanced myself from academic activity to stay in São Paulo, caring for my husband, who for several years was completely dependent on nursing care and our constant attention. During this period, I managed to do some research at IQ-USP in São Paulo with Professor Massayoshi Yoshida, in order to be close to Jorge and to re-acquaint myself with plant science. The brief phytochemistry experimental work resulted in a paper entitled, “Benzylisoquinolines Alkaloids And Eudesmane Sesquiterpenes from *Ocotea Pulchella”*, which we published in *Phytochemistry* in 1993 (*15*) and proved to be highly interesting. Over time, I learned to cope with my husband’s illness, and I returned to academic work. It was a rich period in which a number of papers on the chemistry of Aristolochiaceae were published (*16–18*).

In 1989, I returned to study species of Rubiaceae with the aim of searching for antifungal substances in species native to the Cerrado and Atlantic forest. The Rubiaceae family had been part of my studies for my PhD. It is a taxonomic group with great chemical diversity. For this new project I counted on the helpful collaboration of Dr. Maria Claudia M. Young of the Institute of Botany, located in the city of São Paulo.

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The research with Rubiaceae family created many opportunities in my career as a researcher. It was also important in establishing collaborative research with cosmetics and pharmaceuticals companies aimed at the development of lead molecules from Brazilian biodiversity. *Calycophyllum spruceanum*, a species of Rubiaceae from Amazônia, was the first project of technological innovation that I coordinated, together with Natura, a national cosmetic company, in an academic-private partnership with Financiadora de Estudos e Projetos (FINEP).

A postdoctoral study aimed to study marine organisms under the supervision of Prof. John Faulkner of the University of California in the U.S. was abandoned due to my husband's illness. Around 1991, I began looking again for a place to carry out my postdoc. A research post overseas was fundamental for my scientific career as a professor and researcher, and also in establishing international collaborations. I had lost interest in researching marine organisms in Professor Faulkner's laboratory and in 2002 he passed away, a great loss for the area of natural marine products.

In a workshop carried out by the Instituto de Pesquisa da Amazonia (IMPA) in Manaus, Amazonas, I met, among other renowned North American scientists in the area of plant science, Professor David G. I. Kingston, of the Virginia Polytechnic Institute and State University, VA. He was already famous for his research with anticancer biodiscovery and several medicinal chemistry studies on taxol. With a research grant by FAPESP, I went to work in his laboratory with the objective of finding antitumor substances in Brazilian plants. This research training experience in the U.S. broadened my perspective in terms of modernising the research for the searching of new biologically active compounds from Brazilian biodiversity at IQ-Ar. With strong financial support from FAPESP and CNPq for the project: "Phytochemical Study of Species of the Cerrado and Atlantic Forest Bio-guided for Mutant Strains of *Saccharomyces Cerevisiae*", a number of species were subjected to biological and chemical studies. At the end of this project, we obtained our first patent, registered at the INPI: "Process for obtaining *Casearia sylvestris* extracts, and of obtaining active fractions, use of extracts and active fractions, composition, units of dosage, preventative methods, treatment, combat or suspension of gastrointestinal disorders, medicine and active ingredient", Protocol DEINPI/SP 006358. The casearin diterpenes of *C. sylvestris* had shown potent anti-inflammatory and anti-tumor properties, which provided molecules for further pharmacological and toxicological studies aimed at new anticancer and anti-inflammatory drugs (*19*, *20*).

My recognition in the international scientific community marked this research phase. I was also engaged in a lot of supervision at all levels, and I found out that human resources represent an important aspect of my work. Since then, I have supervised many undergraduate and postgraduate students who, today, are professionals at various universities, research institutes and companies in Brazil and overseas as well. I continue to supervise the research of PhD students. To attract PhD students from several places is a goal of Brazilian universities, and I have accomplished this goal. In fact, the NuBBE lab has accepted several PhDs for training in several fields of plant sciences.

São Paulo, given its status as a state with a highly organised infrastructure for research, was the ideal location to create a long-term research program for the

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study of remaining biodiversity in the Atlantic Forest and Cerrado biomass. In 1998, the first activities of the Biodiversity Research Program of the State of São Paulo - Biota-FAPESP began. From the beginning, I was an active participant in this program, which is ideal for bioprospecting studies and the sustainable use of our fantastic biodiversity. With the coordination of two long term thematic projects "Conservation and Sustainable Use of the Plant Diversity from Cerrado and Atlantic Forest: Chemical Diversity and Prospecting for Potential Drugs – Phase I and II", we formed an internationally recognised group through our studies of pharmaceuticals, cosmetics and/or agrochemicals lead compounds from Brazilian plants.

As a result, we now have a library of plant extracts and a database of natural substances with potential for cosmetic and pharmaceutical sectors, and one of the most well-equipped phytochemical laboratories in Brazil.

Today, as a member of the coordination of the Biota-FAPESP program, I feel happy, as I had always believed that the development of excellent basic research, the training of highly qualified human resources, and the prospect of using nature for useful products would be feasible in Brazil, a country that is known for its huge biodiversity.

Some patents and research projects involving Brazilian companies, such as Natura and Apsen, on plant species have sparked innovation as a result of Brazilian biodiversity. I can say that the experience continues to be enriching, gratifying, and constantly provides opportunities to witness the fruits of academic work, which have been accumulating over the past 20 years of research on Brazilian flora. It is also gratifying to watch the work leaving the academic sphere and potentially going on to produce a drug and/or cosmetic based on the natural products isolated.

It is typically said that academic leadership can be measured by the number of collaborators a scientist is capable of engaging with. In these years of academic life, the collaboration with national and international research colleagues, have been, and continue to be, incredibly valuable for the research of natural products in Brazil. The collaborative research functions like a great orchestra, or, in other words, each individual complements the research of the other and produces more wide-ranging results.

Over the years, the members of NuBBE, Alberto, Ângela, Dulce, Ian, Márcia and Maysa, and Maria Claudia M. Young at Ibt-SMA have become more than collaborators; they are also my friends. Brazilian researchers Claudia do O' Pessoa, Letícia Lotufo, (Laboratory of Pharmacology at the Faculty of Medicine at UFCE), Eliezer J. Barreiros, Carlos Alberto M. Fraga, (LASBIO-UFRJ) Newton G. Castro and Magna S. Alexandre-Moreira (Departament of Pharmacology-UFRJ), Ricardo L. N. Souza and Maria José at FCF-Ar, Norberto Peporine Lopes (FCF-USPRP), Carlos Joly (UNICAMP) and the international researchers Robert Veerporte (Leiden University, Holland), Leslie Gunatilaka (Arizona State University, USA), David G. I. Kingston (VPISU-VA, USA), Jean-Luc Wolfender and Emerson Queiroz Ferreira at Geneve University and Michele Ravoux-Reboud from Université PMC, Paris VI, are all collaborators. With these scientists, we have established a solid national and international network of contributors.

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There was not much administrative activity at the beginning of my career by choice. The consolidation of a scientific career, particularly in the area of chemistry, demands a great deal of dedication to study and research, and this was difficult to do alongside management roles at the outset of one's career. Experimental research requires dedicated time, particularly at the beginning of one's career, making it difficult to be involved in management and administration. Over 40 years of research, I have attempted to collaborate, especially as a committee member, in various sectors of the University and principally at the national and international institutions that seek to advance chemistry around the world.

Scientists have a commitment to the society at large, and chemistry is the science of life. As such, it is incredibly important to make use of the knowledge we acquire to show the general population, and younger generations in particular, the fascinating and enchanting aspects of chemistry present in everyone's daily lives.

During my Master's, at the age of 24 I became a permanent member of the Sociedade Brasileira de Química and the Sociedade Brasileira (SBQ), as well as the Sociedade Brasileira para o Progresso da Ciência (SBPC) with a mind to participate more closely in the process of raising awareness of chemistry as a central science and of science in general in Brazil. I have participated in various committees and, while I was young, became Director of the Division of Natural Products for SBQ, which was important in consolidating a position of leadership in the Brazilian scientific community – evidenced in being elected to the position of General Secretary, Vice President and President in 2008 – becoming the first woman president of the (Figure 11).

Figure 11. Vanderlan elected president of the Brazilian Chemical Society and became the first woman to get this position. (Courtesy of the Brazilian Chemical Society. Used with permission.) (see color insert)

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I am currently part of the Consulting Council for the SBQ and the SBPC and set a goal to expand awareness of science in society with a particular focus on high school students, attempting to reveal the beauty of chemistry in people's lives and the role it plays in the economic and social development of countries. A sustainable future, founded on a green economy, by necessity involves chemistry. It is a science capable of solving problems associated with the environment, nutrition, health and energy, among others that affect humanity.

Participating in international scientific organisations such as the American Chemical Society (ACS), Fellow of the Royal Society of Chemistry, (FRSC), International Union of Pure and Applied Chemistry (IUPAC), American Society of Pharmacognosy (ASP), American Society of Phytochemistry (PSNA), and Society for Medicinal Plant GA – Europe, has been fundamental in my life as a scientist who aims to be connected with the global scientific community. Being a full member of these important societies, which bring together distinguished professors and researchers from around the world, has also been incredibly important for my international recognition as a Brazilian scientist. In 2012, became member of the L'Oréal Scientific Advisory Board (Paris), composed of nine eminent scientists, including myself, from different scientific areas and of wide-ranging nationalities, whose mission it will be to bring ideas to the L'Oréal Research's fields of interests.

Figure 12. Vanderlan elected to the Brazilian Academy of Science (2011). (Courtesy of the Brazilian Academy of Science. Used with permission.) (see color insert)

Taking stock of my national and international awards, which include being made an elected member of the Academia Brasileira de Ciências (ABC) (Figure 12), Academia Paulista de Ciências (ACIESP) and recently, member of The World Academy of Science (TWAS) for Developing Countries, I am immensely proud of my scientific activities. So many years of work have left marks on the body and soul that cannot be hidden. Yet this fascinating world of research, which requires daily inquiry, and the compelling desire to contribute to a better world are what

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guide our collective intellectual and experimental work. Though immeasurable, this is what always leads us to take flight again. In my case, there have been many flights, but not enough yet that I feel it is time to stop.

I could have been a physician, but I chose to give up on that. I chose to leave my place of birth behind, but not my ancestral and cultural roots, which I so strongly identify with, and to research natural products chemistry, which in reality is also a daily exercise in art, exemplifying the beauty of the chemical diversity that reflects the biodiversity of Brazil.

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Chapter 24

Portrait of a Professional Life: Work, Challenges, and Satisfaction, All Achieved in Small Steps

Lydia R. Galagovsky*

President of the Chemical Education Division, Argentine Chemical Society; Center for Educational Research and Training in Science Teaching, University of Buenos Aires, Faculty of Exact and Natural Sciences, Ciudad Universitaria, Pabellón 2, 2do piso 1428 Buenos Aires, Argentina
***E-mail: lydia.galagovsky@gmail.com.**

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A dual career in educational research and scientific research is always a challenge. If you work on educational research in a world of chemists, or do chemistry in a world of educators, the result may be a devaluation (or even disqualification) of your work when you are evaluated by specialists in one area only. When I was a secondary school student, I had two dreams: to become a teacher and to succeed as a medical scientist. As it turned out, I chose chemistry in college and obtained a Ph.D. in organic chemistry, thereby opening career pathways towards both research in medicinal chemistry and in chemical education. Thirty years later I have attained a fair amount of achievements and also realized my dreams. I have written three successful single-authored books and edited three more books in Spanish on chemistry, science, and pedagogy. In collaboration with four coworkers, we have applied for an international patent and licensed it to an Argentine pharmaceutical laboratory involving specific compounds with the unique ability to be simultaneously antiviral and anti-inflammatory for use against epidemic ocular conjunctivitis. From my own experience, I would provide two pieces of advice for a researcher: work hard and persevere in face of setbacks.

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Introduction

It is very encouraging to be a chemist in a world where chemists´ skills and knowledge are needed to make significant contributions to solve problems. However, it has always been challenging, all the more if you are a female chemist.

We are all familiar with the well-known female chemists and their struggles in history. The symposium "Women Leaders from the Global Chemistry Enterprise" held at the 248th national ACS meeting in San Francisco, California allowed us to reflect on the current situation and share our setbacks and challenges that we encountered either when we were learning to become chemists or when we had already become chemists. The challenges continued also when we were developing our professional careers. During the symposium, it was wonderful to hear many success stories from all over the world. They confirmed that determination and self-confidence can help overcome the obstacles.

Our personal stories represent just a few examples among thousands of female chemists. I am sure we all found these personal stories deeply moving. I hope that female chemists will feel inspired and comforted after reading these chapters. In addition, I wish that male readers can fully understand and appreciate the unique challenges facing female chemists due to their gender.

I suggest that you follow me on a trip down memory lane to become familiar with my personal story. This journey has some stops where I will introduce you to important points of my life, all set against the social and political situations in Argentina.

Argentina and Buenos Aires

Argentina is a large country full of beautiful landscapes, and Buenos Aires is its splendid capital city.

The University of Buenos Aires (UBA) is the largest university in the country with more than 200,000 students in total. Researchers based here produce almost 20% of the international scientific publications from Argentina, chemistry being an important area of contribution.

Three Argentine scientists have won Nobel Prizes: Dr. Alberto Houssay (Physician & Pharmacist, UBA), Nobel Prize in Medicine 1947; Dr. Luis Federico Leloir (Physician & Ph.D. in Chemistry, UBA), Nobel Prize in Chemistry 1970; and Dr. César Milstein (Chemist & Ph.D. in Chemistry, UBA), Nobel Prize in Medicine (1980) working at that time in Cambridge, UK.

The current Pope, Francis, studied Chemistry as a teenager at a renowned Technical Secondary School in the city of Buenos Aires.

My Family Origin and Childhood

My father´s parents had immigrated to Argentina as children with their parents from Grodno (now Belarus) in 1895. My mother´s parents had immigrated alone as teenagers – they met on the ship to Argentina- from towns near Kiev (now Ukraine) in 1912. Both grandparents' weddings took place in Argentina in 1913 and 1923, respectively.

They emigrated to Argentina to escape from the *pogroms*, which were cruel riots against Jewish people carried out by the Russian Tzar´s army. The Argentine government had generously opened the doors to all immigrants because the country was completely underpopulated.

My parents got married in June 1952 and went to live in a hamlet in the countryside, near a steel factory where my father worked varying shifts. The social context surrounding my parents´ wedding and my birth is given below.

Around 1950 the President of Argentina was General Juan Peron. His wife, Eva Peron was a young movie actress, who became very popular amongst the working class because of her social initiatives, particularly so amongst women because she supported the cause and enabled the vote for women. People affectionately called her Evita (little Eva). In August 1951, after a huge demonstration supporting General Peron, two million people shouted and begged Evita to become the Vice President in the following election. After two hours of private deliberation, she informed the waiting crowd that she had to decline. Her main reason for declining was that she was gravely ill, but this was kept secret from the public.

Evita died at age 33, just a month after my parents' wedding. There were seven days of national mourning during wintry, cold, rainy days. The whole population felt terribly sad and my young mother was no exception. In addition she missed her parents who lived far away and she felt lonely. My father told me a secret: he comforted her… to make her smile again. Then nine months later I was born!

Evita's story has been recreated in a musical (written by Webber & Rice). The most famous song says "*Don't cry for me Argentina. The truth is I never left you"*. There is also a movie version of *Evita* featuring Madonna.

Primary School

I went to an excellent, public primary school at no cost to me or my family amidst turbulent national politics. In 1955 a military coup overthrew Peron. He was exiled and banned from politics. Then the newly elected President (Dr. A. Frondizi) did not finish his term (1958-1964) because another military coup overthrew his government. Again, newly elected President Dr. A. Illia (1963-1969) did not finish his term either, as he was overthrown by another military coup in June 1966.

Dreams of a Teenager

I began my public, girls only secondary school (also at no cost) in March 1966. As I previously mentioned, in June a military government took power. One month later –on July 29- a politically motivated attack was carried out against intellectuals, in particular against professors and students of the Faculty of Exact and Natural Sciences (FCEN), UBA. This event is remembered as the "Night of the Long Sticks." The ideology of the military government clashed with the liberal ideas of many intellectuals; consequently many of them left the country and became important scientists abroad (*1*).

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Whilst the country languished during this period, I experienced happy years at secondary school. My love for chemistry blossomed when I was astonished looking at a volcano reaction (*2*) performed at the lab. I was also inspired after hearing about the Argentine Nobel Prize in Chemistry won in 1970 by Dr. Federico Leloir.

So, I finished my secondary school having two dreams: to become a good chemistry teacher and to succeed as a medical scientist.

My Time To Study at the University of Buenos Aires

University Degree

To achieve my dreams I decided to study Chemistry at FCEN-UBA. Studies here were and still are free of charge. The first university degree, “Licenciatura” -in Spanish- usually lasts six years; however, I completed it in five, between March 1971 and December 1975.

I was a highly motivated student and, in addition, I gave private lessons to earn some money. I got married in the middle of my studies on June 20, 1974. I was such an enthusiastic student that we decided not to go on a honeymoon because I had examinations shortly after my wedding day and a second semester packed with challenging courses! However, as it turned out, I found myself with lots of free time shortly after my wedding because of the political situation.

A new election took place in March 1973, but Peron was still banned from running as a candidate. Dr. H. Cámpora won and called immediately for a new open election in June which Perón won. In September, he took over the presidency accompanied by his third wife Isabel Peron as the vice president. Unfortunately, Peron died on July 1, 1974.

This meant that 10 days after my wedding, there was a week of mourning. These were wintry, cold, rainy days, and people were very sad. It was a situation nearly identical to the one 22 years earlier after my parent’s wedding. Everyone was worried about the uncertain future: many different groups fought each other claiming to be Peron´s successor. From that moment on, the political and social situation was a mess with much infighting and violence. In addition, universities were closed for a three-month period, and all the faculty members were laid off including a Nobel Prize winner. Some staff members were reappointed three months later and classes resumed. Many artists, intellectuals and scientists left the country due to the political situation.

Despite that unstable period, I continued my studies and was awarded my degree in December 1975. After the summer holidays, in February 1976, I began my Ph.D. studies in the Organic Chemistry Department of FCEN-UBA. But just a month later, in March 1976, a new military coup took over the government.

Ph.D. Studies

My Ph.D. studies lasted as long as that bloody time when the last military government ruled. I finished my Ph.D. the day before a newly elected President

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Dr. R. Alfonsín started (December 10, 1983). This event marked the beginning of a democratic period, which is fortunately still on-going.

Under the dictatorial government, thirty thousand people went "missing", including almost 90 undergraduates, graduate students and assistants from FCEN. Their names are depicted on inner walls in the buildings as a reminder of those frightful seven years.

My thesis dissertation title was "Biosynthetic studies on the bufadienolide ring of cardiotonic compounds in *Scilla maritima*, L." (natural products area). *Scilla maritima* is a plant consisting of a huge bulb that develops leaves during winter and blooms in summer - January in South America - with a flower nearly two meters high. Scillirosid is the steroidal compound (cardiotonic) that contains a singular doubly unsaturated lactone ring. My task was to investigate which small metabolites could form that typical ring. So I had to prepare radioactive (^{14}C) and ^{13}C precursors –like oxaloacetic and pyruvic acids - and inject them into different bulbs. A couple of days after injections, bulbs should be dried and Scillorosid could be obtained. Purification and careful chemical breakup of scillirosid was required to isolate parts of its structure and measure the possible intake of each small metabolite that has been injected.

Why would a motivated Ph.D. student need seven years to achieve these tasks? Simple answer: Injections with precursors can take place only during January because scillirosid is rapidly biosynthesized and degraded by the plant before blooming starts. However, the military government forbade us from entering the faculty (and the green house) during the months of January from 1977 to 1979. This meant having to conduct the experiments in different months with non-reproducible results.

During my Ph.D. studies, my family grew! My son Gabriel was born in September 1978 and my daughter Daiana, in April 1983.

Three important factors helped me during that time: tuition-free Ph.D. studies; a nursery with child care provided for children aged between 45 days and 5 years old; and the opportunity to gain employment as a teaching assistant.

Thirty-One Years of Working under Democratic Governments

General Background

In Argentina there were and still are political and macroeconomical instabilities, such as cycles of inflation and hyperinflation, which means that national economic priorities are focused away from science most of the time and, as a consequence, there are low salaries for scientists.

To help me when I started my post-doc career in 1983, my boss, Dr. E. Gros, gave me some pieces of advice:

- He stressed the importance of belonging to a strong, traditional research group in order to be promoted. But I wanted to choose my own research subjects, and I didn´t like the topics he suggested to me!
- He highlighted the importance of individualism and "publish or perish." But I love to work in teams and to share knowledge!

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- He recommended that I should focus on Organic Chemistry. But I love interdisciplinary work!
- He stressed the need to do a postdoc abroad to be promoted. But I already had a family and would not leave them even for a short period!

That meant that I was a rebel. Actually, after being a student under the many military goverments, I was anxious to play my own game as a chemist! I wanted to be free to choose and find my own challenges, follow my interests, decide on my own priorities, and enjoy doing research, instead of just accepting other people´s rules.

Achieving the Dream of Being a Good Science Teacher

At the beginning of the democratic period (since 1984), the Dean Dr. G. Klimovsky introduced pedagogical and philosophical topics as optional courses at the FCEN. I took those courses and I was fascinated. I realized that we were using antiquated methods for teaching and that there were no books available in Spanish on lab issues. So, after my experience of ten years as a teaching assistant, I decided to write a lab textbook "*Organic Chemistry: theoretical and practical fundamentals*" (*3*). Since 1986, it has been republished seven times! Thousands of Argentine students used my textbook and are still using it!

In 1988 I became the sole professor in the Science Education area of FCEN. Since then, this area has grown to be like a department. Nevertheless, at that time my boss Dr. Gros continued to warn me highlighting that "Chemical Education is not a scientific issue." He insisted "You must work and publish solely in the area of Organic Chemistry to make a successful career!"

But I persevered…

During 31 years of working in the area of Science Education, I have guided three Ph.D. theses dissertations, and three more are in progress. I have published 58 papers, most of them in collaboration with friendly colleagues working in the disciplines of Physics, Biology and Chemistry (*4*). My solo projects and co-authored work have received several awards.

Furthermore, I have also written two other popular books: "*Towards a new role for teachers*" (*5*); and "*Conceptual networks. Learning, communication, and memory"* (*6*). I have edited two other books renowned in Latin America: "*What is "natural" in natural sciences?*" (*7*), and *"Didactic of natural sciences. The case of scientific models"* (*8*). In addition, I have contributed chapters to other books.

Since 2005, I have been the Chair of the Chemical Education Division of the Argentine Chemical Society, and as such I was able to develop two important events. First, I edited two magnificent books, entitled *"Chemistry in Argentina"* and *"Chemistry and Civilization"*, respectively, to commemorate the International Year of Chemistry and the Centennial Anniversary of our Society (years 2011 and 2012, respectively). These books are in Spanish and available for download for free from our website (*9*, *10*). In total, both books contain 78 chapters written by 110 Argentine chemists, aimed at young readers without any background in chemistry. The publication of these books received the support of the Argentine government. The main aim of these books is to promote a contextualized vision

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of Chemistry, including social, political, economic and personal backgrounds, to change the negative image that (unfortunately) most teenagers have of Chemistry. Figure 1 shows the covers of the books mentioned above.

Figure 1. Covers of books. Compiled with permission from: Editorial Troquel, Lugar Editorial, Editorial Biblos, University of Buenos Aires, Argentina Chemical Association.

Secondly, I have had the opportunity to host many important international guests. In particular, I have had the great honour to receive and listen to Dr. Zafra Lerman (2006 and 2012) and Dr. Marinda Wu (2013) who generously shared their knowledge with Argentine teachers.

Achieving the Dream of Being a Medical Scientist

Since 1983, I have continued doing research in the field of synthesis of steroids by guiding three Ph.D. theses about plant hormones (brassinosteroids). We have published 23 papers on this subject in international journals, and we have written chapters in three international books (*11–13*).

In 2003, junior Ph.D. colleagues Dr. J. Ramírez and Dr. A. Bruttomesso joined me in working together as co-PIs in a new laboratory of our own: "Lab #10 team" of the Organic Chemistry Department at FCEN, UBA. Since then, we

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continue to work on organic synthesis. New enthusiastic young graduate students have enlarged our team, doing research and working on Ph.D. theses. Figure 2 shows all the team members during a national meeting.

Figure 2. Lab #10 team (2011), Organic Chemistry Department (FCEN, UBA). Senior investigator: Lydia Galagovsky; junior investigators: Andrea Bruttomesso and Javier Ramirez. Photo courtesy of Lydia R. Galagovsky.

We widened the focus of our research and were able to test antiviral properties of our synthetic steroids. Working collaboratively with Dr. M. Wachsman, Dr. L. Alché and Dr A. Berra, we have published 16 international papers on this topic. While guiding F. Michelini´s Ph.D. thesis, we discovered that some of our new molecules exhibited the unique effect of being simultaneously anti-inflammatory and antiviral compounds. These results allowed us to apply for international patents (*14*) in agreement with the National Scientific and Technical Research Council (CONICET) and an Argentine Pharmaceutical Company (Instituto Massone S.A.). It means that we are creating new molecules which have the potential to be used as drugs!!

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Final Remarks

A dual career in science education and chemistry research is a challenge. If you work in science education in a world of chemists, or do chemistry research in a world of educators, the results may be the devaluation (or even disqualification) of your work, when you are evaluated by specialists in one area only. That is the reason why I wrote in the title of this chapter "work, challenges, and satisfaction, all achieved in small steps".

From my own experience, I hope to encourage young female chemists with the following words:

- Our youthful dreams may appear unrealistic when they first form. However, believe in your dreams!
- In life so many different paths may be followed that a person never knows if those selected are the right ones. However, follow your enthusiasm!
- Only a few topics may be explored at any time such that a chemist may feel that his/her understanding is an infinitely small part of the total knowledge. However, trust your abilities to open new doors for knowledge to enter.
- Trust your dreams, enjoy your work, work hard, and persevere in face of setbacks.

Acknowledgments

Thanks are due to Dr Marinda Li Wu, 2013 President of the American Chemical Society for inviting me as a speaker at the Symposium "Women Leaders of the Global Chemistry Enterprise" in the ACS National Meeting in San Francisco in August 2014.

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Chapter 25

Academic and Personal Evolution through Thirty-Eight Years: Two Parallel Tracks?

Barbara Loeb*

Dean, Faculty of Chemistry, Pontificia Universidad Catolica de Chile, Vicuna Mackenna 4860, Santiago, Chile
***E-mail: bloeb@puc.cl.**

The kind invitation of Dr. Marinda Wu to give a talk at the "Women Leaders of the Global Chemistry Enterprise" Symposium" was the starting point for a long reflection about my nearly forty years devoted to academia, while facing the challenge of bringing up a family in a safe and nourishing environment. Ups and downs in both personal and academic life characterized this journey, which in essence was not really a trip in two parallel tracks, but two tangled routes that continuously crossed themselves, mixing and influencing each other. Looking back at the end of the road, I can see how everything fitted together and had a reason to occur. I am grateful to all that helped on this road. They pushed me up when everything seemed to slide down. The words of the Mexican poet Amado Nervo in his golden creation "In Peace" (Nervo, A.: "En Paz" in "Obras Completas, Tomo II Prosas-Poesías", Editorial Aguilar, Madrid, Spain, **1967**, p.1733) best reflect my present feelings at this stage of my life:

Close to my sunset I bless you, Life,
Because you never gave me unfulfilled hope,
Unfair work, or undeserved sorrow.
……….
Life, you owe me nothing. Life, we're at peace!

Introduction

To fulfill the task of giving an account of what these years have meant, and what have occurred during them, I am dividing the story in three parts: "The Beginning", the starting point that was arbitrarily set in the mid-seventies, when I was hired at the Catholic University of Chile, the place where my whole career has taken place. At the same time these were the years when I got married to Eduardo, my husband for more than forty years now, and undoubtly a key person in this story. The second part, called "The Middle Age", represents the long years of struggle and effort in order to grow as a teacher and as a scientist, while trying to balance these time-consuming activities with the necessary time needed to be a caring mother and wife. In parallel to my children growing up steadily, a scientific "family" was built, through dozens of students that performed their graduate or undergraduate theses under my guidance. The last part of this story, "The Present", represents what is occurring in these days, when management and administration have overtaken the space of scientific life, and where an increasing number of grandchildren have joyfully invaded the personal spaces. The common thread through these three stages is the challenge of being a woman in a Latin-American country, trying to develop an academic career in the last decades of the twentieth century and the first decades of Century 21.

Regarding the contents of each part, the focus has been positioned on four main points:

- To give a context through some facts.
- To give an account of my feelings during each stage.
- To give an overview of women in chemistry at the Catholic University of Chile.
- To give some tips on how the society perceived a woman scientist during the time being analyzed.

Finally, although the different academic activities developed during the years and my main research goals will not be treated in detail, some insight about them will be given throughout the text.

The Beginning

In September 1976 I succeeded in fulfilling the requirements of the degree of Master in Science with concentration in Chemistry. A couple of weeks afterwards, I signed my first contract as an Assistant Professor in the then Chemistry Institute of the Catholic University of Chile. Two years before, I had been married to Eduardo, and at the moment of obtaining the Master's degree, our eldest son Michael was already eight month old. Figure 1 is a momento of the celebration party for obtaining the degree: in the upper photo appears my supervisor, Fernando Zuloaga, and in the lower photo I am preparing a toast accompanied by a young Eduardo.

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Figure 1. Celebrating my Master's degree accompanied by my supervisor (upper photo) and my husband (lower photo). (Courtesy of the author.)

Everything seemed to be blooming at that time, and an extremely optimistic feeling guided those days. Family life seemed to be running on wheels, and dreams appeared easy to fulfill. Academic positions were very scarce, and I had gotten one. I felt that things could only develop one way, and that was upwards.

The research for the Master's thesis was related to cobalt complexes and their studies in the ground and the excited state. It contained also some theory, based on traditional Ligand Field Theory, developed mainly to interpret ground and excited state behavior (*1*). To conduct luminescence studies in Chile was extremely difficult, mainly because of the lack of instruments and the difficulties to get research resources. The experiments took very long and the equipment used contained a lot of hand-made parts.

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In the year of my appointment, 1976, about 25% of the chemistry faculty were women. Among them, only one, professor Ligia Gargallo, was a full professor. University regulations seemed rather "soft" concerning permanent positions, giving therefore some stability, but difficult in regard to promotion. While the opportunities for a woman to be hired seemed to be equivalent to those for men, women in leadership positions were very scarce.

4—LAS ULTIMAS NOTICIAS—Sábado 18 de Septiembre de 1976

Unica Magister en Química También Es Mamá y Esposa

* Para que ella estudie, su marido prepara las mamaderas.

* Bárbara Loeb tiene 25 años.

Una mujer de veinticinco años, colorina, y madre de un niño de ocho meses, tiene en sus manos el título de la primer Magister en Ciencias Exactas con mención en Química, que hay en el país.

Se llama Bárbara Loeb. La conocimos en su laboratorio en el Campus San Joaquín de la UC, donde habitualmente hace clases.

Aquel día iba a leer su tesis ante las autoridades de su departamento. Estaba nerviosa, excitada, alegre, esperanzada. Nos habló como corresponde a una científica. Con términos exactos, duros, pero suavizados por un par de ojos castaño-verdosos y una nariz respingada.

Bárbara Loeb no parece ser quien es. Podría pasar por colegiala —con su falda escocesa y su suéter marrón— o por una de sus alumnas universitarias. ¿Quién se va a imaginar que sus veinticinco años le han servido para tener marido, hijo, y el único título de su especialidad en Chile?

Empezó a los cinco años. En vez de acunar muñecas, dibujaba signos químicos que copiaba de un libro en el jardín infantil. Un poco mayor, se cambió a las leyes. Pero supo que había nacido para brillar en la química. Y se quedó. Y entró a la Universidad de Chile, cambiándose a la UC en 1972, en el tercer año de su carrera. A fines de 1974 —después de casarse con Eduardo Boys, técnico electrónico—, se recibió de licenciada en química. Empresa difícil, desde ya. Y todos pensaron que se emplearía en alguna industria, para cuidar mejor a su hijo Michael.

Pero Bárbara dijo que nada de eso. Y se puso a estudiar firme y decidida, para sacar su magister. Dos años de carreras, insomnios, nerviosismo y mamaderas apuradas, dieron su fruto. Hoy, es la única mujer magister en química que hay en nuestro país.

Y su marido tendrá que seguir ayudándola con la guagua, porque ahora piensa optar al doctorado. En síntesis, seguir estudiando e investigando en la materia. Sencillita...

ANTE TODO, MUJER

—Ante todo, soy madre de Michael y esposa de Eduardo. Mi familia me interesa por sobre todo. Les dedico cada minuto libre. "En los fines de semana la química se queda en la Universidad. Bárbara Loeb se convierte en amiga de sus amigos y madre de familia.

—¿Es difícil tener tu grado y cuidar de una casa?

—Por supuesto. Afortunadamente, cuento con la colaboración de mi marido,

La sonrisa de una mujer realizada.

Figure 2. Magazine article appeared after obtaining my Master's Degree. (Reprinted with permission from ref. (2). Copyright 1976 Las Ultimas Noticias.)

Regarding the view of the Chilean society about a woman in chemistry in the mid-70's, an anecdote can be illustrative. In the 70's graduate programs were just starting to emerge in our country. As I was the second person who graduated from the Chemistry Master's program and the first woman, some journalists came to interview me. I was extremely careful in detailing different aspects of the Program's curricula, about its rigor, and in general about all type of opportunities and demands involved. In one of the magazines a long and exhaustive article appeared (*2*) (Figure 2). None of the points mentioned above was cited, making my efforts to make some "propaganda" for our Master's program useless. Instead, sentences such as "for her to study, her husband prepared the milk bottles….", or statements such as "already at the nursery school she drew chemical symbols…" were written. Although my husband did help me a lot, amongst other things preparing milk bottles if necessary, of course I did not draw chemical symbols at that age, nor did I ever attend a nursery school. Roughly, the article reflected the feeling the society had at that time about a woman in chemistry: a very weird case, ideal to build a sensational story.

The Middle Age

In the following years, my academic and personal lives continued their paths, with ups and downs, good moments and more difficult ones. At the beginning of 1980 I started my graduate studies, obtaining in September 1985 the Doctor in Science degree from the University of Chile, under the guidance of Dr. Carlos Andrade. When I started the program, my daughter Maureen was already born, so my father gave me as present an old 1963 Citroen, to travel back and forth from the Catholic University, were I taught, to the University of Chile, where I was pursuing my graduate studies, and in between to rush home to feed the baby. Busy times!

Dr. Andrade was a former student of Nobel Prize winner Henry Taube. In this way, through my graduate studies, I got to be Taube´s "scientific granddaughter." The main field of my thesis was related to bioinorganic models, specifically binuclear and mixed valence copper complexes as models for hemocyanin (*3*). Mixed valence chemistry ended being a passion of my scientific life, and therefore, when an opportunity emerged for a 3-month UN research abroad program, I chose to spend one month at Dr. David Hendrickson labs at the University of Illinois at Urbana-Champaign, and two months at Dr. Tom Meyer´s lab at the University of North Carolina at Chapel Hill. Notable growth, as a person and as a scientist, was the consequence of these 3 months. Leaving two children of 8 and 11 years behind was very difficult, specially in times when internet was not available and telephone was prohibitively expensive. My husband did a great job taking care of them and running the house. Although already a grown up woman, I was rather shy, and afraid of being alone and by my own.

I arrived at Illinois on Saturday, January 1, 1987. Firstly, my luggage did not arrive. Secondly, I was located in a dorm in a student area, but there were no other students in the building, nor were they in the next building, nor in any buildings around. Everybody was spending their holidays at home. As an easily frightened person absolutely alone, with no luggage, no food, in a dark and snowy day, I had two possible choices: to jump out of the window from the eighth floor or to learn to survive. My option was to survive, to mature, and to grow up. After a month, I moved to Chapel Hill. The blue skies of Carolina received me at the airport, predicting a good stay. I remember the two months spent at UNC-Chapel Hill as one of the most spectacular periods of my scientific career. More than 30 very nice people were part of Dr. Meyer's group, lots of equipment to do different experiments with, great scientific discussions and challenging ideas. I worked enthusiastically and hard all days of the week, leaving just some free time for Sunday´s mass. The impact this period had on my career was equivalent to having done a second PhD. Even for being a short time, the research carried out permitted a paper to be written (*4*). I learned a lot, and got introduced to Ruthenium, Osmium and Rhenium polypyridinic compounds, a chemistry that opened new possibilities for research after travelling back home. I returned to Chapel Hill quite a few times in the years afterwards, and collaborative projects were undertaken involving graduate students' exchange in both directions. A good friendship with Dr. Meyer has remained with time. The 2014 San Francisco ACS meeting was a new opportunity to meet again and to recall memories of old times.

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The decade after this three-month postdoctoral stay was diverse in activities. The struggle to establish scientifically was hard. The resources for research were available but very competitive, and it took time to convince the peer reviewers that our scientific ideas had some value. Polypyridinic d^6 metal complexes started to be the focus of my research, mainly from a fundamental point of view. The current Faculty of Chemistry had been funded at that time, and a periodic evaluation of its faculty established. The aforementioned period of drought in getting funding put my permanent position at risk. This rather stormy period in my work was contrasted with my personal life, where children filled our days in a very cheerful way. Both of my children, Michael and Maureen, were good students, enjoyed sports, and had lots of friends. Close to my forties, I was pleased that little Henry came along, bringing fresh air and new challenges to our family. At the same time that my personal family was growing, a scientific "family" was building up. Graduate and undergraduate students came in and out throughout these years, some with more success than others, but always leaving contributions that helped to bring our ideas further. I am very grateful to all of them, for what they meant to me, not only for their scientific contributions, but also for the excitement they brought to the lab.

Compared to the 70's, had something changed in the 80's and 90's as regard to the possibilities women had to develop their scientific careers in our country? The percentage of women in academia continued to be about one-fourth of the total, and in our Faculty of Chemistry still only one woman full professor was present. University regulations had gotten stricter, and a maximum period of nine years to advance from an Assistant to an Associate Professor (in certain sense the equivalent of getting tenure) was established. The leadership positions at the University were still mainly reserved for men. A similar situation was observed in industrial companies, where management positions were also mainly occupied by men.

The Present

When bringing up memories to write about a whole career, I have the overwhelming feeling that time passed by too quickly. As shown in Figure 3, children are not children any more. Moreover, they have their own children, conferring on us the title of grandparents, the best and most enjoyable title ever achieved. I have also become a "scientific grandma"; furthermore, Eduardo and I are godparents of former students' children. The most impressive part of this portion of the story occurred some years ago, when among the freshmen students present in the official ceremony that the University prepared for their reception, I recognized the daughter of one of my former students. In this way, as seen in Figure 4, the dining table at our house needs to be enlarged when hosting my personal family, encompassing from my 95-year-old mother to 3-year-old Emilio, or when receiving my "scientific family", e.g., to celebrate the graduation of one of the members of the group.

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Figure 3. Family growth and evolution. Michael, a sports journalist, joined Marcela, and is the father of Emilio. Maureen, an actress and university teacher, married Andrés, and has three children: Pedro, José and Laura. Henry, on his way to be a lawyer, is still single but has lots of "children" through his social activities. (Courtesy of the author.) (see color insert)

University life has changed a lot. The beginning of the new century saw an active and more successful development of my scientific career, reaching its high point with my promotion to Full Professorship in 2003. Soon after, leadership opportunities emerged, first as Academic Director at the Faculty of Chemistry, then as Academic Development Director of the University, and presently as Dean of the Faculty of Chemistry. These are intense, interesting and challenging duties, putting a good dose of adrenalin to my daily life, and unavoidably changing the focus of my activities. Research is slowing down, and the time left to spent with my family reduced. My research continues to center on polypyridinic complexes but is now more oriented to applied goals: photoelectrochemical solar cells, Oled materials, and substances with non-linear optical response (*5–7*).

At this point it is interesting to have a look at what has occurred with women at academia nowadays. Figure 5 shows the percentage of men and women at the different academic categories for all the faculty members at the Pontifical Catholic University of Chile (*8*). It is impressive to notice that from about 50% of women in our undergraduate programs, the percentage drops dramatically to close to 17% of women being full professors. University regulations have become even stricter, with a seven-year maximum period of time to be promoted to the Associate Professor category. Nevertheless, importantly, if an Assistant Professor gets pregnant, a longer period of time can now be allowed.

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Figure 4. Extended dining table to accommodate family (upper picture) or group members (lower picture). (Courtesy of the author.) (see color insert)

The situation at the Faculty of Chemistry has changed lately. Dr. Gargallo, who was for a long time the only woman in the category of full professor, retired some years ago. In the mean time, she received two important prizes: the UNESCO L'Oreal Prize for Women in Science, and the Chilean National Prize in Natural Sciences. At present, 50% of the full professors of the Faculty of Chemistry are women, as well as the Dean and two of the four Faculty Directors. Although probably not the norm for the university, this situation at the Faculty of Chemistry can be considered a good sign for the future.

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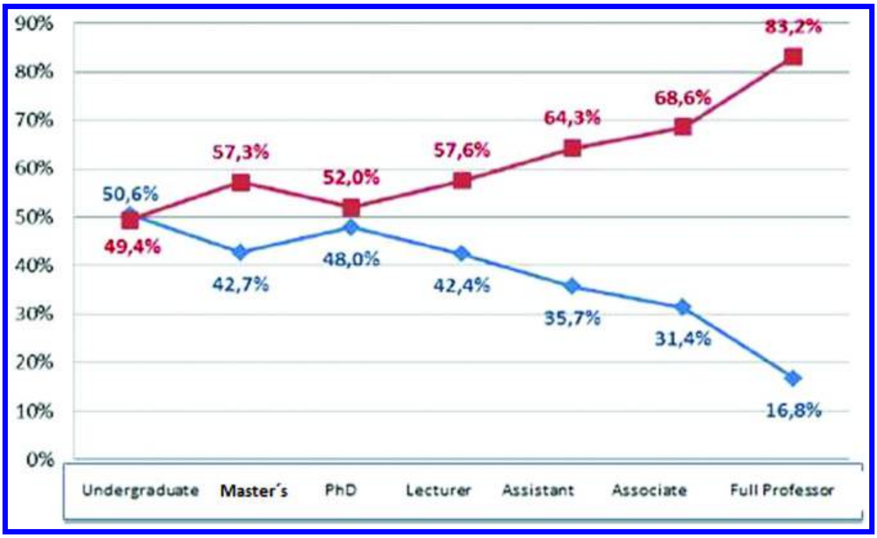

Figure 5. Percentage of men (in squares) and of women (in diamonds) at the Pontifical Catholic University of Chile at different stages of the academic career in 2013. (see color insert)

Conclusion

Being a woman scientist during the last decades of the 20th century and the first decade of the 21th century is, by itself, a challenge. If additionally the career is performed in an underdeveloped or developing country, the challenge is even more severe. To raise a family while trying to thrive in an increasingly demanding academic environment might at first glance seem to be difficult. Yet, as mentioned before, it was not really a trip in two parallel tracks, but in tangled routes that continuously cross themselves, mixing and influencing each other. The difficult academic journey was tolerable because of satisfactions at home. The moments of setbacks in the family were overcome because of my scientific interest and passion. Near the end of the trip, it is clear to me that both my family life and academic career would not have been possible without the impulse of the other.

Acknowledgments

Thanks are due to Dr. Marinda Wu, 2013 President of the American Chemical Society, for her kind invitation to the Symposium on “Women Leaders of the Global Chemistry Enterprise” held during the 248th ACS National Meeting, San Francisco, August 2014. Special thanks are due to my family, particularly my husband Eduardo, for his continuous and unwavering support that has made this story possible. I want also to thank the students that joined my group at different stages of my career for their resilience and creativity to overcome the problems and find answers to our inquiries. Finally, many thanks are due to my senior collaborators, Ana María Leiva (RIP), Irma Crivelli and Mauricio Barrera, for their professionalism and deep thoughts, and for taking the group leadership while I was absent pursuing different duties, and to the colleagues of the Catholic University of Temuco, Angélica Francois and Ramiro Díaz, for long lasting research collaborations.

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Chapter 26

Peace and Satisfaction at the End of a Lot of Work, Obstacles, Efforts, and Challenges

Noemí Elisabeth Walsöe de Reca*

Vice President of the Argentine Chemical Society
CINSO (Centre of Materials Science) CITEDEF (Centre of Scientific and Technologic Research for Defence) UNIDEF (Unidad de Investigación y Desarrollo Estratégicos para la Defensa) MINDEF (Defence Ministry) - CONICET (National Council for Scientific and Technologic Research)
San Juan Bautista de La Salle 4397. Villa Martelli (B1603ALO) Buenos Aires, Argentina
***E-mail: walsoe@citedef.gob.ar.**

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From my early childhood I wanted to imitate my parents: my mother for her femininity and aptness to teach and my father for his will power and ability as a chemist. My goal was to be as accomplished as my parents. At the state secondary school, I received the diploma to be a teacher for primary education; afterwards, I studied Chemistry at the Faculty of Exact and Natural Sciences, University of Buenos Aires, specializing in physical chemistry and nuclear chemistry. I married a medical doctor at a young age and my husband and I continued our studies in Europe. We obtained postdoctoral certificates at universities in Munich, Germany and Orsay, France while raising three young boys. After several years, we returned to Argentina to continue our careers. Even though we experienced challenges, we were able to achieve our goals through hard work and study. I am currently actively involved in research, teaching (having directed 33 PhD's) and publishing (about 300 papers). I am a member of the National Academy of Science and have received several foreign and national awards. I have obtained fulfilment in my scientific career and personal life by engaging in enthusiastic research, helping my grandchildren, and contributing to young students' education. I am pleased, peaceful and grateful because my dreams have been attained.

When I was invited to write my biography, I understood that the scientific group CINSO (Centre of Materials Science) which I directed from 1980 must be the most important actor of this story. Now, this group was transformed into a very large new group UNIDEF-Institute, to which I belong but it is not the group which grew with me. Thus, as soon as I began to write about our physical-chemistry, materials science or nanotechnology contributions, I decided to drop the formalities and not to list our scientific publications, communications to congresses and meetings and invention patents, nor to take an accounting of fellowship holders, master and doctoral (PhD) students who studied at CINSO. That type of information would be similar to an annual report that we submit at the end of each year. It would include long lists of achievements but produce, at the same time, a tedious text. I prefer to relate a women chemist's emotions, challenges, fights, and memories, paying particular homage to people who helped grow CINSO and adding anecdotes that enrich the story of the group.

Early Life and Education

My name is Noemi Elisabeth Walsöe de Reca (Betty). I have a Norwegian chemist father, an Italian mother (who has been librarian at the Argentine Atomic Energy Commission-CNEA), and a brother who is an architect. Both my brother and I received strong moral principles, love, understanding, and a solid culture from our parents. I grew up in Argentina and received an early education (both primary and secondary) in the Public School for Teachers, Ner. 9,"D. F. Sarmiento", at Buenos Aires City, taking a teaching degree for the primary school. I then undertook university studies at the Faculty of Exact and Natural Sciences-FCEN, Buenos Aires University-UBA, receiving the Chemistry Master's Degree (Licenciatura) in 1960. In the same year, at the age of twenty two, I married Raúl Martín Reca, a twenty-five-year-old medical doctor.

First Research Job

By that time, I joined the Materials Department, Technology Administration, directed by Physics professor Jorge Sabato with a CONICET (National Council of Scientific and Technologic Research) fellowship that began my scientific work applying radioisotopes to metallurgy. Prof. Sabato, surrounded by an excellent staff mainly formed by engineers coming from the traditional University of Santa Fe, was engaged in the study of metallurgy "at the highest level in the world" to solve urgent problems of our country. After the end of the Second World War, the peaceful use of nuclear energy held the promise of solving new problems for Argentina in the fifties and the sixties. A few years later, the first Argentine nuclear reactor for medical applications was inaugurated and now, it is possible to declare that this goal has been completely accomplished.

Scientific publications on metallurgy in our country which were non-existent at that time were produced by Prof. Sabato and his collaborators and accepted in US and European publications. He invited the best known metallurgy

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experts in solidification, diffusion in solids, mechanical properties of materials, theory of defects, segregation, electron microscopy and electron microprobe or recrystallisation, among others, to teach us. He wanted us to join young CONICET fellowship holders and an intensive effort was devoted to provide professional resources in materials science through the lectures of National and Latin-American Metallurgy Programs.

A good education for young scientific people constituted an essential objective for Prof. Sabato and his collaborators. Moreover, to complete young scientists´ education, he sent them to important US or European laboratories to work on different metallurgy topics under well known professors. Young scientists could then learn not only metallurgy but also how to realize their dreams of being a useful professional for our country. Prof. Sabato´s vision and efforts have been the origin of the prestigious Materials Science Institute which carries his name today and, in small scale, the origin of my scientific dreams. His rich experience has influenced me soon after I joined his group as a young scientist.

Scientific Education in Europe

At the beginning of the sixties, my husband and I, with our eldest son Gustavo (only months old), lived in Germany. Raúl had received a Deutscher Akademischer Austausch Dienst (DAAD) Fellowship to perform research in ophthalmology at the Augenklinik der Universität München, and I received a fellowship of the International Atomic Energy Agency (IAEA) from Vienna to study "Segregations in nuclear purity zirconium" in the Institut für Metallurgie und Metallkunde, Technische Hoschschüle (TH) in Munich. My husband and I both worked very hard indeed. To rent a house was not easy in the sixties and few house-owners wanted to rent an apartment to a family with a baby and another to be born soon. At last, we found an attic in a modern house in Fürstenfelbrück, 20 kilometers from Munich and each day, at six in the morning, we drove our VW mostly through a frozen or snowy road…. However, we were glad of having learnt a lot about our fields of study and having done well in qualifying examinations.

After two years working in Germany and with simultaneous training in the French language, we moved to France, our second son Guillermo having been born already. My husband and I worked under French Government Technical Cooperation Fellowships to perform post-degree studies. I studied Materials Science (beryllium diffusion in pure and alloyed zirconium) in the Centre d' Etudes Nucleaires - Service de Recherche en Métallurgie Physique et Chimique, Saclay. At the same time, I began my Physics Master's curriculum at the Faculté d' Orsay, while Raúl performed research on glaucoma in the Cauchin Hospital, Paris. Two years later, we were happy and proud of our intensive work, of our efforts to take care of our little family, and to successfully complete our respective studies. Besides, the student life at the residence de la Croix de Berny (a residence for foreign residents, at only 20 minutes from Paris city) was bohemian, and the weekends were really magic for children and for us too. We carried Gustavo and Guillermo on the shoulders and went to see Paris and the surroundings: museums,

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parks, churches, and monuments; everything was wonderful for us. After nearly two years, we were reluctant to leave the nice student life forever, and we came back to Buenos Aires.

Coming Back to Buenos Aires

Upon coming home in 1966, my husband and I started our careers in Argentina. Raúl joined the University of Buenos Aires as professor and the University Medical Centre as physician; in addition, he installed his own medical practice. I joined CITEFA (Centre of Scientific and Technologic Research of the Army Forces, today CITEDEF-Centre of Scientific and Technologic Research of the Defense Ministry) and, at the same time, I won by contest the position of assistant member in the CONICET research group. I defended the Chemistry Doctoral Degree (PhD) at FCEN-UBA in 1966 with a thesis on "Self-diffusion in β-phase of Titanium and Hafnium", and soon our third son Federico was born.

That time was difficult. Indeed, the country's economy was in crisis and it was a hard time to find a stable position to perform research. Nonetheless, Admiral Fernando Millia (CITEFA President) and Prof. Jorge Sabato were planning to create a Materials Science Research Group and they were looking for young people able to study, to work hard and to fight against bureaucratic difficulties. Both directors shared dreams of a vigorous Argentina, with young research groups able to develop products and to transfer their technology to a local strong, useful and innovative industry. That was the origin of CINSO. Sabato often reminded us that "the development of scientific products cannot be achieved but through previous and responsible applied research…"

The History of CINSO

It is appropriate here to delineate the different work stages of the CINSO research group. From 1960 to 1980, metallurgy research was performed, and many metallurgic problems, mainly in magnetic materials (Ni-Fe alloys), were solved. Research continued and several papers were published in scientific, peered reviewed journals. Patents were filed, and education of students began through the direction of their research and monitoring of their investigations. A solid education in materials science constitutes a real tradition in the group.

The next period spanned 1980 through 1992. CINSO-CONICET-CITEFA was created in 1980 under my direction with two research projects: *"Functional Materials for Solid State Batteries"* (covering studies on solid state electrochemistry, solid electrolyte and electrode materials, organic-iodide charge transfer complexes and intercalation compounds) and *"IV-VI Semiconductors for the Infrared Radiation Detection."* The studies of batteries enabled us to perform applied research and to build novel solid-state cells and to file patents such as "*Solid state cells for cardiac pacemakers.*" A patent on "*Thin film cells*" can be used for photo-cameras, calculators and memories. Another patent on *"Batteries for surveillance systems"* can be used for commercial windows under extreme temperatures (from -40°C to +60°C) or for "*Antihail missiles*".

Research on *IV-VI semiconductors* was performed covering their synthesis, characterization and studies of structural, electrical and optical properties to be applied to *photoconductive infrared (IR) detectors,* operating at room temperature. Although IR detectors built with polycrystalline PbS or PbSe were well known after the Second World War, they were not produced in Argentina. Besides, the surface activation of detectors was accomplished by a novel oxidation method patented at CINSO. IR detectors built with IV-VI semiconductors were used in devices to measure the humidity of cereals, textiles and papers, to detect short circuits in complex circuitry, to measure CO_2 (g) emission in devices, and to detect fire in woods and silos.

Furthermore, *"infrared photovoltaic detectors",* operating at 77K, were built with the *II-VI semiconductors:* $Hg_{1-x}Cd_xTe$ (MCT) with x= 0.2, useful for IR detection in ranges of 3-5 μm for communications and of 8-14 μm to detect the IR radiation in the second transmission atmospheric window. The MCT compound exhibits the interesting property of showing a different λc (cut-off-wavelength) at each concentration (x). MCT exhibits a high strategic value (due to their numerous, dual and valuable applications) and a high commercial value (due to the know-how associated to its production). However, the time devoted to these studies was characterised by small research budgets due to the general economic crisis in our country. Thus, it was necessary to build by ourselves a considerable part of the infrastructure (furnaces to grow single crystalline ingots, furnaces to grow single crystalline epitaxies, temperature regulators, accurate systems to move the specimens, among others). Yet, our results were excellent because our MCT detectors, with one or two sensitive areas, exhibited properties similar to those of commercial devices. It will be possible for us to build arrays with multiple sensitive areas with a precision cutting equipment, including single microcrystalline areas for use as detectors in devices for air and satellite surveillance of natural resources, industrial and medical applications, air or satellite detection of minerals, separation of arid, cultivated and fertilized fields, detection of submarine currents, shoals of fish and shrimps, among others.

Actually, some researchers in this group have considerably extended this field by growing another II-VI ternary semiconductor, which is used to detect IR radiation (~10 μm) or to build the single crystalline substratum for MCT growth. Other single crystalline II-VI semiconductor compounds were also grown, characterized and used for devices for detection of X-ray, gamma and UV radiations.

The direction of the *first doctoral thesis on ceramic nanomaterials* in our country was the beginning of an intensive work on these materials and research is still going on. Ceramic nanosemiconductors were synthesized and characterized. Several of their surprising properties enabled us to build *gas sensors* to detect ppm of CO (g), H_2, NH_3 or volatile organic compounds (VOCs). Sensors built with nanoceramics exhibit a higher (30-37%) sensitivity and lower operational temperature (180-220 ºC) in comparison with those devices built with the same but microstructured materials (350-400 ºC). Several patents were filed on these subjects, and the developed technology is now going to be transferred to the local industry.

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In this period while the nanomaterials project was active, *nanostructured ceramics* were successfully synthesized, characterized, and used for SOFC (Solid Oxide Fuel Cells). In this research, new fuel cells (IT-SOFCs) work at intermediate operation temperature (550-650°C) in comparison with the working temperature of usual SOFC fuel cells (800-1200°), using hydrocarbons, natural gas or biogas (from garbage) or even hydrogen as fuels. Research on new nanomaterials for solid electrolytes and electrodes was performed (synthesis, characterization and studies of properties) and new design of cells was proposed. Nanomaterials enable us to retain usually unstable phases (good electrical conductors) of ceramic systems at the operating temperature of cells, being used for electrolytes. In conventional fuel cells, the fuel and the oxidant are located in two chambers separated by the electrolyte. Nevertheless, the feasibility of a "single-chamber" SOFC operating under a mixture of hydrocarbons and air was achieved at CINSO. These cells rely on the use of highly selective anode and cathode catalysts. In the anode, instead of internal reforming, the ambient oxygen is used to produce the partial oxidation of the hydrocarbon. Single-chamber SOFCs are relevant since they can symplify the cell design (with the subsequent reduction in weight and cost of the device). Besides, the partial oxidation of hydrocarbons can be catalyzed at intermediate temperature, enabling, as mentioned above, a considerable decrease of the operating temperature. These cells can also directly work with H_2 without production of CO_2 but, if hydrocarbons are used as fuel, their CO_2 emission, results in low generation of electricity per unit. It is also important to point out that the use of these cells is relevant in several Latin American countries which have considerably large hydrocarbon reserves such as natural gas or biogas. In the future when hydrogen production and storage become easier and cheaper, they can also be operated with H_2. This project deserved, during its early development, the Repsol-YPF Award (2003) given to the most innovative scientific and technological project. Later when valuable results were published, the Mercosur "Integration" Awards (2004, 2010) were given by UNESCO to recognize the Innovative Projects in Science and Technology and the Nanotechnology Applications to Gas Sensors and Fuel Cells, as developed by two combined Argentine and Brazilian research groups.

In the past few years several groups were incorporated into CINSO (at DEINSO Department in CITEDEF). Research and services were performed with *electronic noses* to control food quality (for olive oils and orange juices, to separate garlic and carrots cultivars, to determine effects of packing on food, etc.), to study medicinal plants, to monitor the environmental contamination, to monitor the residual effect of insecticides or to study the evolution of biosolids. Now, this section of the group is also devoted to fabricate lyophilised and freeze-dried nutritive portions of food (meat, vegetables or fruits) packed for long duration (minimal 3 years) to be used for emergencies or for soldiers during military maneuvers.

Another group was incorporated into CINSO in recent years performing research and development (with filed patents) in form-memory alloys. This is an active group developing an intensive research in Ni-Cu-Al alloys and their applications and putting considerable efforts to train students and technicians and to build the necessary infrastructure. A small group was also incorporated into

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CINSO and is now performing research and service in corrosion problems of aeronautic alloys (Figure 1).

The last project incorporated into CINSO considers the use of methane and methanol as alternative fuel sources for transport media. Methane is transported as liquefied, compressed or adsorbed natural gas. This last storage technique enables us to absorb the natural gas in an absorbent carbonaceous material at room temperature and under low pressures. The absorbent materials are synthesized and characterized at CINSO.

Figure 1. Group picture of selected members of CINSO. [Reproduced with permission. CINSO-CITEDEF-CONICET (DEINSO).]

When I tell you about the CINSO story at the end of a lot of work, obstacles, efforts and challenges, I feel "peace and satisfaction" as I expressed in this article title. Work and study were intense and education was very active but, there were also problems. Those problems and obstacles were related to the country's economy and politics affecting periodically the grants and the organization of institutions. Challenges included lack of money due to economical crisis, instability of governments, changes in the scientific planning, and the changes in the conditions required for the students' training. Many scientists left the country and a lot of them have got positions in well recognized US or European laboratories. However, work performed with love and dedication enabled Argentina to produce a lot of results: five Nobel Prizes provide real merit for a developing country. Three of them are in the scientific area (Dr. Bernardo Houssay, Dr. Luis Federico Leloir and Dr. César Milstein) and the other two dedicated their lives to defend peace between Latin American countries (Dr. Carlos Saavedra Lamas) or to fight for human rights (Adolfo Pérez Esquivel).

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Numerous scientists, writers, artists, physicians, sportsmen/women, architects, professors, among others, are well known abroad.

In the modest frame of the CINSO work, we can list publications in scientific reviews or books, development of devices, patents, technology transfer, education of students (more than fifty PhD theses), cooperative research with valuable institutes and universities in France, Japan, Germany, Italy, Spain, Slovenia and, above all, with Brazil, sharing research, grants, prizes and awards. I am grateful to CINSO (today UNIDEF) and its members. Without their assistance, this history could not have been possible!

I take only very few minutes to tell about my own biography. I have published more than three hundred papers in peer-reviewed national and international journals. I have written reviews, books and book chapters (published in Brazil, Argentina, Spain, UK, France, India, Germany). I am the author or co-author of sixteen patents. I have participated in a thousand meetings where I presented at least one paper. I have organized meetings and lectures. I have supervised more than thirty PhD theses, and several more students' investigative works were directed by me. Several of my students have received awards or prizes due to their doctoral theses. For twenty years I was a Materials Science professor at the National Technologic University-UTN and at the Engineering Faculty-University of Buenos Aires. I was chosen as a member of the ANCEFyN (National Academy of Exact, Physics and Natural Sciences) since 2007. I have been honoured with awards and prizes for my work on materials chemistry and physics:

- *Condecoration des Palmes Academiques of French Government- Ordre de Chevalier des Palmes Academiques* as proposed by the French Education Ministry (1987);
- *Research Award:* "ISOVPE Growth of $Hg_{1-x}Cd_xTe$ (x=0.2) on pure and alloyed CdTe with different crystalline orientations", Ukranian State Academy of Sciences, 2nd International School-Conference on Physical Problems in Materials Science of Semiconductors, Chernivtsii, Ukraine (1997);
- *"Simón Delpech Award in Materials Science"* given by the National Academy of Exact, Physical and Natural Sciences, Buenos Aires, 2001;
- *"Bernardo Houssay 2003 Award in Scientific and Technological Research"* given by SECyT, Buenos Aires, 2003;
- *"Repsol-YPF 2003 Award "* to the Best Innovative Project in Science and Technology, shared with Dr. D, Lamas, 2003,
- *"Integration"- Mercosur - UNESCO 2004* to the Project: "Solid oxide fuel cells to generate electrical energy operated at intermediate temperatures with methane-air mixtures as fuel", shared with D. Lamas and CINSO staff, Brazil;
- *"Mercosur-UNESCO 2010-Integration Award*" given by UNESCO-MINCyT to the Project: "Nanostructured Materials: Synthesis Studies with Synchrotron Radiation, Properties and Applications", shared with Dr. A. Craievich and Dr. M. Fantini (Brazil) and with Dr. D. Lamas (Argentina), 2010, among others.

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I have been a member of the Argentine Chemical Society (AQA) for more than 50 years. Formerly, I collaborated with the Directive Council in the Nanotechnology Commission. At the present, I am the vice-president of AQA. The photograph of AQA Directive Council (Figure 2) was taken at the 100th Anniversary of AQA in 2012. Dr. Lydia Galagovsky is the second from the left of the middle row. She shared with me the honour of participating in the symposium on "Women Leaders of the Global Chemistry Enterprise" and in the AQA she is in charge of the Chemistry Education Commission. Dr. Eduardo Castro, AQA President, and Dr. Carlos Azize, AQA Past President, are located on the second and the third positions in the first row. I am proud to be the first woman vice-president of AQA.

Figure 2. Members of AQA Directive Council. The author is the woman in the first row. [Reproduced with permission. Asociación Química Argentina (AQA).]

To Be a Woman…

I was a very young woman in 1960 when I received the Chemistry "Licenciatura" in the Faculty of Sciences of the University of Buenos Aires. When I graduated, there were five women together with sixty men. At the beginning of our studies, nearly half of the boys came from secondary technical schools (boys only) and perhaps for that reason this group was always joking with girls. As soon as they understood that we did not go to the university to look for a fiancé, we became good friends and a sort of agreement was reached among us: we helped them to solve chemistry problems and they helped us to manufacture glass pieces and to build (or to improve) glass equipments since ours usually resulted in dreadful species of dinosaurs.

When I obtained my Chemistry PhD, I won a CONICET fellowship to work in the Department of the Argentine Atomic Energy Commission-CNEA (today Institute "Jorge Sabato"). There were few women but they were well accepted at CNEA. In Germany, it was not easy indeed. I was the only professional woman in the Metallkunde Lehrsthul -Technische Hochschule-München, I knew some colleagues trying to protect me and make my stay more pleasant. They taught me and corrected my German language. Other researchers made me feel as “a rare insect coming from the Pampas.” Sometimes, it was a little depressing because nobody knew more than they did. Luckily, my husband was always very supportive. Yet, study, work and a lot of good will is a good formula to get over difficulties and our time in Germany was both productive and pleasant. Afterwards, life in France was easier. There were two women in the SRMPC-Saclay, but I have to confess that one of our challenges was not scientific at all. We fought for some months to have a “toilette only for women”; it was, at last, a successful fight.

Upon returning to Buenos Aires, I joined a new research group at CITEFA-the Argentine Armed Forces Research and Technology Centre (today CITEDEF). My work contract demanded me to contribute more to scientific research in this well-known institute and less to military technology. It was not an easy time indeed, not only because I was a woman. It was necessary to build everything from the start, not only with regards to the organization of laboratories but to the philosophy of work.

Five professional women constituted the group. We worked as men and we were proud of not asking for help but we returned tired and a little depressed to our homes. With hard work and advice and instructions of our professors and colleagues, everything became easier. On the other hand, I have often been the only woman in physics or chemistry meetings, but not now.

The situation of women in Argentina has soon changed and we are glad to verify that the number of female students in our country increases every year. Moreover, today in Argentina in several careers, the number of women students, professors or university administrators is higher than that for men. Women fought to defend their salaries (mostly in the industry), so now it is only in few places that women still receive lower salaries than men. When I received the French Medal of the Palmes Academiques dans l´Ordre de Chevalier, friends and relatives were always joking: at last you have been promoted to a knight!

Women’s situation today is much better in Argentina but misogynous groups still remain not only in our country but everywhere, and violence and discrimination against women tend to increase in non-educated media. Only education and time will solve this problem, and we must contribute to education as much as we can. However, I often remember my mother’s saying: “A women needs double curriculum vitae to get a working position: one to gain the position and the other because she is a woman.”

Acknowledgments

Nobody can do anything alone. Thanks are always given to God (it doesn´t matter which Name has He). Thanks are also given to those who helped me, to the CONICET and CITEFA, to CINSO colleagues, visiting professors, laboratory mates and students for their understanding and friendship….

I am grateful to my family, mainly to my husband who passed away in 2000 leaving us his love, patience and spiritual strength, to my three sons, my daughters-in-law and my grandchildren for their patience towards their hyperkinetic grandmother and to my friends.

Thanks are also given to those unknown people who can communicate confidence and strength with a word or a smile.

Final thanks are due to Dr. Marinda Li Wu, 2013 President of the American Chemical Society, who organized the symposium "Women Leaders of the Global Chemistry Enterprise" that enabled us to acquaint with other successful women whose rich experiences have mutually encouraged ourselves.

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Chapter 27

Chance and Destiny on the Road To Becoming the First Woman Professor of Chemical Engineering in Romania

Gheorghiţa Jinescu*

Vice President of the Romanian Chemical Society, Department of Chemical and Biochemical Engineering, University Politehnica of Bucharest, 313 Splaiul Independentei, Bucharest, Romania, RO-060042
***E-mail: jinescu_gheorghita@yahoo.com.**

In this paper is presented a brief story of my professional life, portraying chance and destiny on the road to becoming the first woman-professor of chemical engineering in Romania. A great influence upon my professional career during the situation after Second World War can be attributed to my professors who initiated me to the optimistic world of knowledge with professional devotion and pedagogical skills. For more than half a century I have been working in the field of chemical engineering, a field that provided a tremendous boost to the development of modern society, both economically and socially. Also highlighted and discussed in this article are research topics that have stimulated new areas in fundamental and applied chemical engineering science in the past 50 years. In recognition of my achievements in scientific research, development and education, I was variously appointed PhD advisor, reviewer, and member of editorial boards of scientific journals. The work done in the service of engineering science or in collaboration with research and industrial institutes was rewarded with many diplomas and medals as a sign of appreciation. More than 20 years of my life were dedicated to activities in professional societies such as the Romanian Chemical Society and the Romanian Chapter of Balkan Environmental Association. As vice-president of National Confederation of Women from

Romania, I worked hard to create career opportunities for young women and to establish professional qualifications of women specialists who lost their jobs due to the collapse of large chemical plants after 1989. A permanent mission throughout my life was to pass on knowledge and experience to the next generations of engineers and researchers so that they are better prepared for the major challenges with which they will be confronted in the future.

Introduction

At the ceremony when I was awarded the title of Doctor Honoris Causa in 2013 by the University Politehnica of Timisoara, I chose my lecture topic to be "*The Road of Chemical Engineering from Empiricism to Process Engineering – a Multi-disciplinary Science as Tool and Hope in the Postmodern World*" (*1*). The topic chosen for that moment of time was of particular significance for me because I had been working in the field of chemical engineering for more than half a century as an academic "who keeps learning so that others might learn." That is how I became an active participant and witness to the rapid transformations of the science of chemical engineering in content and role as well as the involvement of its practitioners, the chemical engineers, in the economic and social development of human society.

Similar to the structure of the atom that has simultaneously positive and negative features, so chemical engineering has a beneficial role as a catalyst to stimulate economic development as well as its accompanying negative impact against the environment and socio-human-menthal cast.

Furthermore, chemistry and chemical engineering have been involved in the development of technologies and processes dealing with environmental stewardship and renewal of material and energy resources, in changing human attitudes about the "*what, why and how*" of consumption, and in raising human awareness as to how to use the power of chemistry and chemical engineering to promote sustainable living on planet Earth for its inhabitants.

Chemical engineering, a multi-disciplinary science springing from the exact sciences and still evolving, has undergone the following stages of development:

- the stage of *unit operations*, where the concept of unit operation underlay the foundation of the design and the rational and economic exploitation of countless chemicals and their technological options;
- the stage of *property transfer phenomena*, where in the sistematization of processing chemicals, revealed that in over 90 unit opperations three fundamental processes of chemical engineering are involved, namely, the *transfer of momentum, energy transfer and mass transfer.* These phenomena can be found in homogeneous and heterogeneous systems, with monodisperse or polydisperse phases, in Newtonian and non-Newtonian fluids;

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.;
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- the stage of *modeling-simulation-optimization,* in conjunction with *system engineering,* through the actual use of modern computing techniques in modern chemical industry;
- the stage of *process engineering*, representing chemical engineering in its maturity, its capabilities having been multiplied by the needs determined by social development in the modern era such as food, energy, raw-materials, green environment, water, air, soil, health, and sustainable development (*2–4*).

These are the stages that I experienced and was trained for in my professional work and development.

Let me first take the story from the beginning steps that turned me into the first woman professor of chemical engineering in Romania. I have been its dedicated and active worker throughout a time span of more than five decades. Was it chance or fate?

The Beginning

Who am I? I was born on July 4, 1938 in Bucharest, Romania, as the third child of the Nastase family. My family originated from Muscel, Arges County, a sub-Carpathian region whose inhabitants are well known for their good husbandry, respect for work and tradition, astuteness, inquisitive spirit and love of their homeland.

Two members of my family fought during World War I: my father (only 18 at the time) and my mother's father who died as a hero, leaving his wife, aged 28, to raise their 6 children all by herself; I remember her - with the fondness one looks at an icon- wearing her self-made folk costume of matchless beauty in the Muscel style.

In 1945, immediately after the end of the Second World War, I started elementary school and then the "Gheorghe Lazăr" high school in Bucharest (1952-1955). In both schools I was lucky to have very good teachers. So, I was always a top student and graduated with honours.

After the war, with its great destruction and a three-year severe drought, life was very tough, with many shortages in food, books, housing, and clothing. The children of my generation matured suddenly and lived their childhood in the brief holiday spans spent in the countryside at their grandparents' places.

Slowly, the country was restructured along the pattern of a new economic and social system. The beginning of the country's industrialization, the construction of large chemical and metallurgical plants, machine and tool building factories and the education reform (1948) that provided free education became the incentives that attracted many young people to take up engineering for their higher education studies. The optimism in the years of reconstruction and the awareness of the needs of that age, an awareness that was brought about by a precocious maturity induced by the war hardships, made me take up the engineering profession. My choice puzzled my former high school teachers who knew me to be the constant winner of all school competitions in literature and mathematics.

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In 1955 I was admitted to the Faculty of Industrial Chemistry in the wake of a procedure based on a "*scientific interview*" (the admission filter for faculties where the number of students enrolling with a diploma with honors was greater than the number of places available, a situation to be found only with two of the Romanian faculties that year: Faculty of Chemical Engineering and Faculty of Electronics from the Polytechnic Institute of Bucharest). I graduated from this Faculty with flying colors, being awarded a so-called "republican grant", a special merit scholarship.

Although the '50s were difficult years, we managed to get through with the help of our teachers, who steered us into the happy world of knowledge with utter professional devotion and pedagogical skill. Chemistry – a realm of science and dreams - attracted in those years many young studious and intelligent people whom I had the honor to meet as my colleagues. The classroom atmosphere was very special; today we might call it mystical, and the teachers were for us priests on the altar of science.

Some of the figures who made themselves conspicuous as beacons for our young generation were the professors and academicians Costin D. Nenitzescu, (who had taken his PhD degree with Hans Fischer - Nobel Prize for chemistry in 1930 in Germany) and Emilian A. Bratu (PhD degree with Prof. Emil Otto and lecturer Redlich Abel at the Polytechnic School of Vienna, Austria).

From my student days, my fascination with the miracle of chemistry led me to join the student scientific circles. I started with research in organic synthesis and polymer chemistry. The paper "Contributions to the isotactic polymerization of styrene", received an award at the National Students' Session, Iasi, Romania, in 1960.

The courses on "*Methods and equipments in chemical industry*" and "*Chemical reactors*" extraordinarily delivered by Professors Emilian A. Bratu and Raul Mihail, respectively, which I attended, were based on knowledge in such areas as chemistry, physical chemistry, mathematics, physics and mechanics. From my academic training I realized that a major contribution and imperative, after the destructions of war, can only be brought about by the industrial-scale production of substances and materials used as such for consumption or as catalysts for the development of other economic sectors. This knowledge was the trigger for my decision to become a specialist who could be immediately useful at the construction sites of new chemical plants.

Overview of My Career

But fate had other plans in store for me.

After graduation, until 1989, the year that radically and brutally changed the socio-economic system, all higher education students had the certainty of being assigned a job upon graduation, beginning their work as trainee engineers.

In 1960 I finished my academic training. I earned a B.Sc. in chemical engineering, with specialization in Organic Chemical Technology. After graduation I asked the Human Resource Committee in charge of job assignment to allow me to work at the site of the Săvineşti Chemical Plant. Nevertheless,

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Emilian Bratu, my professor, at that time Head of the Chemical Engineering Department, offered me to work in his department. I accepted for a year, still dreaming about the Savineşti site, but then one year turned into a lifetime commitment. The time flew between my first year at university and the present time (Fig. 1).

Figure 1. Left: Photo on my first employee card at Politechnic Institute of Bucharest, 1960. Right: Photo during the Doctor Honoris Causa ceremony, University Politehnica Timisoara, 2013. (Courtesy of the author.)

With an inquisitive mind and a penchant for work, I had the chance to develop professionally alongside Professor Emilian Bratu, who founded, with love and care, the School of Chemical Engineering in Romania (*5*). When celebrating Professor Bratu's 80th birthday, the President of the Romanian Academy, Acad. Radu Voinea said: "*Academician Emilian A. Bratu embodies chemical engineering, and the terms"*Emilian Bratu*"and "*Chemical Engineering*"have become synonymous."* I was the first woman to work in an all-male team, but Professor Bratu's personality as a scientist and person made the work environment supportive and friendly (Figs. 2 and 3).

This environment and atmosphere of broad international openness and national involvement had a huge influence on my education as a professional and as a socially committed citizen. From 1970, Professor Eli Ruckenstein is "full professor" at the State University of New York at Buffalo. For his outstanding contribution to the development of the science of chemical engineering he was awarded in 1998 the *National Medal of Science*, the highest scientific award in the U.S.A., which was given to him by U.S. President Bill Clinton at the White House (*6*).

It was not easy for me. During this period, I acquired all the specific knowledge about chemical engineering science. As a constant participant in our chair's weekly scientific seminar, a combination of fundamental and applied scientific forum held by Professors Emilian A. Bratu and Eli Ruckenstein, I came to realize that chemical engineering is fundamentally different from chemical technology. I came to understand that chemical engineering is a science with specific methods in studying unit operations, chemical reactions, chemical manufacturing plants and systems, integrating the results of different

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fundamental sciences, engineering disciplines and management approaches from an interdisciplinary perspective, such as to create an engineering profession whose mission is to support the development of chemical industry in research, design, operation and education. I started to systematically study the field literature (in English and Russian). I found it highly insightful to assist Professor Eli Ruckenstein with the seminar series, as the seminars dealt with the treatment of unit operations based on property transfer phenomena - momentum, energy, mass- and elements of mathematical modeling.

Figure 2. In the Chemical Engineering department lab., 1961. (Courtesy of University Politehnica of Bucharest.)

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This approach allowed me later to design new higher education courses in chemical engineering involving the use of modeling, simulation and optimization with high performance computers. In answer to industrial needs, the *Faculty of Plant and Chemical Process Engineering* was created in 1977 at the Polytechnic Institute of Bucharest.

But let's go back in time.

Having the privilege of being a student and close collaborator of Professor Emilian A. Bratu, I needed all my energy, rigor and self-critical spirit to consolidate my knowledge and develop my scientific maturity. I worked in Professor Bratu's research group, under whose supervision I obtained in 1970 my doctoral degree in Chemical Engineering with the thesis "*The properties and structure of vibrated fluidized layer*", a vanguard subject in enhancing transfer phenomena.

Between 1960 and 1982, I rose steadily in the university professional hierarchy through increasing scientific and educational credentials and human qualities such as perseverance and fidelity to my profession, to become Professor in 1982, *the first woman-professor of chemical engineering in a Romanian university.* Since 2009, I hold the title of *Professor Emeritus* at the same University.

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Figure 3. With some of my department colleagues, May 1st 1963: left to right - Gheorghe Iordache, Gheorghiţa Jinescu, Professor Emilian A. Bratu, Octavian Floarea, Octavian Smigelschi, Professor Eli Ruckenstein. (Courtesy of University Politehnica of Bucharest.)

In my educational work, I attempted to continue the work of my mentor, Professor Emilian A. Bratu. I expanded and strengthened the Romanian School of Chemical Engineering. In this respect it is worth mentioning the seven chemical engineering courses introduced for the first time in a Romanian university. The courses were mainly based on my own experience and the results of my original scientific research, i.e.

- *Hydrodynamic processes and specific equipment for chemical industry;*
- *Intensification procedures in chemical engineering;*
- *Heat transfer intensification;*
- *Unconventional material drying processes;*
- *Real flow in chemical equipments;*
- *Transfer phenomena in biochemical industry;*
- *Intensive procedures in depollution technologies.*

In collaboration with my team colleagues I created and equipped new laboratories for teaching and research (hydrodynamic processes, intensification procedures, and hydrodynamics of multiphase fluids) and I contributed to the development of new forms of education (Faculty of Plant and Chemical Process Engineering and - later - postgraduate and master's studies).

I am the author or co-author of 14 books, numerous laboratory and design guidebooks, compendia for problem solving, and works of encyclopedic nature in the field of chemical technology, to be used by students, doctoral candidates, research and design specialists in the field of process engineering. Mention should be made of three books (*7–10*):

- “*Intensive procedures in transfer unit operations*” where I provided an original synthesis of the mechanisms underlying the intensification of transfer phenomena and the performance of intensive processes and equipment;
- “*Mass transfer and kinetics of acid extraction process of uranium”,* in which is presented original research using ultrasound for process intensification in chemical decontamination of radioactive wastewater;
- *“The process of lactic fermentation”: kinetic modifiers and intensifying procedures”, which includes* experimental research concerning the use of micro- and nano–porous materials based on clays as kinetic modifiers for fermentation processes and kinetic intensification using ultrasound.

In any form of didactic and scientific activity with undergraduates and doctoral students, I tried, by actively participating in scientific events, congresses and national and international conferences, to impart my passion for science and the joy involved in building the future through research.

I became a PhD supervisor in 1985 in the specialties “*Processes and Equipments in Chemical Industry”* and “*Chemical Engineering.*” I supervised the completion of 26 theses on topical issues featuring both theory and applications in chemical engineering and environmental engineering. The PhD curriculum was one way to train high-caliber specialists who are now leaders at R&D institutes or higher education institutions, at home or abroad.

For 8 years I served as Dean of the “*Faculty of Plant and Chemical Process Engineering*” (6 years) and “*Chemical Technology*” (2 years) that encompassed the schools of chemistry and chemical engineering from the Bucharest Polytechnic Institute and the Bucharest University school of chemistry. I used my organizational skills and tact to attempt to develop a spirit of collaboration among the members of the teaching staff and between teachers and students.

Scientific and Applied Activities

In my theoretical and experimental work, I sought original research topics that mapped out new areas covering both fundamental and applied research domains. In this activity I carried out fruitful cooperation with research institutes, with production units in the field, with universities in the country and abroad, and with outstanding personalities of Romanian science. I worked with over a hundred specialists with whom I have published and /or delivered papers at national and international congresses and conferences. Scientific work was focused mainly on:

- fundamentals of chemical engineering science: property transfer phenomena (momentum, energy, mass) in homogeneous and heterogeneous systems, Newtonian or non-Newtonian fluids, modeling, simulation and process optimization;

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- intensification of property transfer phenomena by developing intensive processes in heterogeneous two-phase and three-phase systems, based on the use of mechanical oscillations (pulsations, vibrations), ultrasound and static turbulence promoters;
- unit operations in chemical engineering of advanced separation of heterogeneous solid-fluid systems, fluid–fluid systems, solid-liquid extraction, reactive extraction and recovery of uranium from ores, filtering (with ultrasound for filtering hard-to-filter suspensions), ultra-filtration, adsorption on nano-materials, exchange resin and biomass;
- energy intensive procedures of enhancing energy cost-effectiveness in coal with high content of tailings;
- development of the intensive procedure of contacting solid particles and fluids (gas, liquid), *fluidization,* with major contributions in:

    - fluidization of poly-disperse solid layers
    - modified fluidized layer by using pulsation, vibration and mechanical stirring with quasi-homogeneous structures leading to increased intensification of over 150% of the speed of property transfer processes;
    - circulating fluidized bed for intensifying the combustion of coal rich in tailings content;
    - three phase fluidized layer in mono- and multi-layered columns, in intensive de-pollution technologies of gaseous effluents and wastewater;

- intensification of simultaneous heat and mass transfer in drying thermo-labile materials (polymers) and thermal and xero-labile biomaterials by using intensive methods such as pneumatic transport, modified fluidized layer (vibrated and in a centrifugal force field), spouted layer for granular or powder materials and the atomization process for the polymer solutions (*11*);
- intensive processes in the remediation of gaseous and liquid effluents and of soil;
- separation of uranium from radioactive wastewaters by adsorption on ion exchange resins;
- combustion of highly calorific wastes in a circulating fluidized bed (patented procedure);
- reduction of obnoxious emissions by burning coal in a circulating fluidized bed;
- decontamination of radioactively polluted soils by using ultrasounds (patented procedure).

For the help I received in the publication of my work in reputed journals, I owe my gratitude to teachers Ion Teoreanu and Eli Ruckenstein with whom I published my first article in the *Canadian Journal of Chemical Engineering* in 1965 (*12*). Since then, my original scientific results have been published in

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over 240 papers in prestigious international journals such as *British Chemical Engineering*, *Canadian Journal of Chemical Engineering*, *Chemical Engineering Science*, *Journal of Drying Technology*, *Hungarian Journal of Industrial Chemistry*, *Filtrieren und Separieren*, *Chemical Engineering Technology* and also in national journals *(Revista de Chimie – Bucharest*, *Revue Roumaine de Chemie*, *Romanian Cell Biotechnology*, *Modeling and Optimization in the Machines Building Journal*, *Romanian Reports in Physics*) and in the proceedings of national and international conferences and congresses. I participated in over 340 conferences and submitted papers at national and international scientific meetings in many countries (Romania, Czech Republic, Italy, Poland, Greece, England, U.S.A., Australia, Bulgaria, Macedonia, Montenegro, Serbia, Hungary, France, Germany, Portugal, China, Netherlands, Canada, Sweden, and Brazil).

My creative work in applied engineering research has been embodied in 128 contracts involving scientific and technical research – as director in 99 of them - and 8 patents. This activity involved fundamental and applied science research in the field of industrial chemistry, with themes such as:

- *designing new and improved equipment* (e.g. vibrated-fluidized layer dryers, continuous extractor for sugar beet, evaporators for thermo-labile solutions);
- *optimization of the operating parameters of chemical plant and equipment in order to improve yields, decrease energy and materials consumption* (e.g., the use of H_2S and NH_3 adsorption columns from coke gas, SO_2 adsorption from waste gases on volcanic tuff, capitalizing on by-products in dimethyl-terephtalate technology, compact heat exchangers, quadruple effect evaporation plants, polymerization reactors, pneumatic dryers, spouted layer dryers, improvement of acetylene manufacturing technology, modeling and simulation of the caprolactam polymerization process);
- *development* of depollution technologies and procedures, environmental protection and waste recovery (e.g., waste recovery of metal slag and ash pyrite with trace nutrients and microelements for soil improvement, technologies for the decontamination of transformers impregnated with synthetic oils, industrial effluents treatment through the three-phase fluidization technique, the use of nano-materials in unconventional technologies for the decontamination of polluted waters, soil rehabilitation intensive procedures in areas of radioactive ores mining and processing.);
- *development* of mathematical models and algorithms for the design and simulation of unit operations in process industries.

The interest in these works is reflected in citations and comments made by specialists in reviews and in important publications in this field (e.g., *Chemical Abstracts*, high impact journals, and Google Scholar searches).

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Appreciation and Recognition

The above mentioned research has been recognized by national and international scientific community who invited me to take part in many scientific committees associated with international conferences (50), e.g., International Drying Symposium - IDS (1982 to present), International Conference of the Chemical Societies of the South East European Countries (ICOSECS), Symposium of Chemistry and Environment and Colloque Franco-Roumaine de Chemie Appliqué, and national (over 25), IDS Awards Committee. I was key speaker in conferences held in France, Canada, Switzerland, Greece, Brazil, or moderator or presider of scientific sessions in national and international symposia or events.

With sponsorship from U.S.National Academy of Science, I was visiting professor in 1978 at Chemical Engineering departments at six universities in the U.S.A. (Texas State University at Houston, University of Texas at Austin, Oregon State University, Carnegie-Mellon University, Rensselaer Polytechnic Institute, and The City College of New York - CUNY) where I presented seminars on my research in process intensification of transport phenomena in vibrated fluidized layer.

Also in 2000 I was invited for two weeks at Centre Natural Resources Canada – NRCAN, Ottawa to share my scientific results in burning coal in circulating fluidized bed and in intensive procedure applied to wastewater biological treatment through multilayer three-phase fluidization.

In recognition of my contributions in fundamental and applied research in chemical engineering I have been appointed as:

- Ph D supervisor since 1985;
- Scientific reviewer for the journals: *Revue Roumaine de Chimie*, *Revista de Chimie* Bucharest, *Plastic materials*, *Drying Technology, Scientific Bulletin of the Politehnica University of Bucharest, Chemical Engineering Science*;
- Member of the editorial board of scientific journals: *Revista de Chimie* Bucharest, *Plastic materials, Bulletin of Petroleum-Gas University of Ploiesti (Technical Series), Studies & Research Chemistry Series, Chemical Engineering, Biotechnology, Food Industry of the University of Bacau, Journal of Environmental Protection and Ecology (Official Journal of the Balkan Environmental Association*);
- Deputy editor of the *Revista de Chimie Bucharest*, (1999-present).

In view of my numerous activities in scientific research, development and education, I have received a number of awards and titles, the most important being:

- the title of "Outstanding Professor " granted by the Ministry of Education, Romania, 1984;
- member of the Academy of Technical Sciences in Romania (2002);

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- academic title of *Doctor Honoris Causa* granted by the University of Bacau (2008);
- academic title *Doctor Honoris Causa* granted by the Technical University of Timişoara (2013);
- "Nicolae Teclu" Award granted by the Romanian Academy (1998), for the original contribution regarding the application of artificial neural networks (ANN) to modeling chemical engineering processes (granular and powder material drying, fermentation processes in bioreactors), which opened a new avenue in the research, design and operation of chemical processes by using process computers, by appropriate optimization and quick decision making;
- "Opera Omnia" Award granted by Ministry of Education and Research, (2008);
- Revista de Chimie Busharest Award, (2000);
- "Eng. Elisa Leonida Zamfirescu" Award for outstanding achievements in promoting Romanian science and technology, granted by the Technical Museum "Dimitrie Leonida" and National Women Confederation Roumania (1995).

I was listed in:

- "*Mondofemina – Femei române, Dictionary*", (1995);
- "*Who's Who in the Romanian Science and Technology*" (1996);
- "*Who's Who în Romania*" (2002);
- "*Remarkable Romanian Woman Especially in Research and in Profesional Teaching*", (2012).

My theoretical and experimental work in the field of modified fluidization initiated a new approach to apply oscillations for the intensification of mass and heat transfer phenomena. As recognition of my contribution to the developments in this area, I was invited to become a member of the Advisory Panel of the International Drying Symposium's biennial conference, a position that I have held since 1982 until now. This started a long collaboration with Professor Aaron Mujumdar at McGill University, Montreal, Canada. Because of travel restrictions prior to 1990, I was unable to deliver my oral contributions before 1990.

The work done in the service of engineering sciences and continued collaborations with research and industrial institutes were rewarded with diplomas and medals as a sign of appreciation, viz., the Jubilee Diploma and Medal awarded by Oltchim SA (2006), Diploma and Medal of Honor awarded by the Romania Chemistry Society in (2004), Certificate of Merit awarded on the occasion of the semi-centennial jubilee of the Revista de Chimie Bucharest (1999), Diploma awarded by IITPIC Iaşi (1988), Jubilee Medal (1998) and Diploma of Excellence awarded by the Politehnica University of Bucharest as a token of recognition of professional-scientific merit upon being awarded the title of *Consulting Professor*, Bucharest (2009), and the Professor Emeritus Diploma awarded by the Politehnica University of Bucharest (2013).

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Public Service in Professional Societies

All these manifestations of recognition have strongly motivated me to commit myself to public service involving the management and development of policies for science, education and economics in my capacity as head of a range of scientific bodies throughout my career. Among these one could mention the following: member of the Senate of the Polytechnic Institute of Bucharest (1981 -1989), later the Politehnica University of Bucharest (1996-2004); member of the Board of the Ministry of Chemical and Petrochemical Industry (1981-1989); member of the National Council for Science and Education (1985-1989); member of the Councils of State Representatives of such companies as RAFIROM S.A., CHIMOPAR S.A., CONVEST S.A., during 1990-1998; and reviewer for the evaluation of research and projects in various national bodies.

After 1990, the Romanian community of chemists and chemical engineers founded a series of professional societies. I contributed to the reactivation and development of national professional chemical societies as Secretary General and then as Vice President of the Romania Chemical Society (1994 - present), and founding member of the Chemical Engineering Society in Romania. The Romanian Chemical Society is currently a member of the European Association of the Chemical and Molecular Science, EUCHEMS.

I contributed to the cooperation among chemistry societies from South East Europe by organizing the biennial international conference ICOSECS. In collaboration with the American Chemical Society I supported the establishment of the "Romanian International Chapter" in 2013. In cooperation with the Balkan Environmental Association B.En.A, I was involved with organizing the Romanian- B.En.A chapter in 1999. This association organized scientific events, developed programs, and funded research grants in the field of environmental engineering. These programs were targeted for young researchers and PhD students and were sponsored by manufacturing companies.

An outcome of my involvement in international cooperation for tuning up faster the level and the content of teaching activities up to European standards was the initiation of mastership studies in Chemical Engineering with the aid of colleagues from the Chemical and Biochemical Department from *L'Ecole Nationale Superieure de Chemie*, Universite Blaise Pascal, France. The graduation diploma was mutually recognized in Romania and France, a highly appreciated asset by students.

A special and permanent social concern for me has been the creation of career opportunities for young women and the professional qualification for women specialists who lost their jobs after the collapse of large chemical industrial plants after 1989. I attempted to fulfill these goals in my activities over a span of 20 years as vice-president of the National Confederation of Women in Romania (1992-present).

There have been quite a few moments in my work when the novelty of some situations took me - as well as the international scientific community – by surprise. Two examples come to mind:

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- At the 1972 CHISA Congress in Prague, where my speech was scheduled, there were only men in the conference room; the chairman invited Mr. Jinescu to present the paper on the agenda and to the astonishment of all, the only Miss present in the room took the floor;
- In 1978 in an exchange of experts between the Romanian Academy and the U.S.A. Academy of Sciences, I received an invitation to present my research in the field of property transfer in an intensified fluidized bed at several U.S. universities for two months. I could read on those occasions the surprise and disbelief on the faces of my all-male audience when I entered the conference room. This disbelief changed into keen interest after the end of the lecture when I had to answer a lot of questions. One such question was whether I did everything single-handedly, the experimental research, the physical and mathematical modeling, and the correlation and generalization rendered by the original equations of the results. When I said *Yes,* they further probed me with the question, "*But does that leave you time to do anything else*?" They were surprised to hear that I have two children, that I do housework, and take care of my children's education.

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My Family

I have the great and unconditional support of my husband Valeriu. He always encouraged me in difficult moments of life. I had many interesting discussions with him in connection with our respective fields, he being a mechanical enginer and a Professor in the Process Equipment Department from University Politehnica Bucharest.

Also, I see myself fortunate that both my sons pursued university and research careers. My elder son, Cosmin, graduated as a chemical engineer from the Politehnic Institute Bucharest, took a master degree at Clemson University, South Carolina, U.S.A., a PhD degree in Chemical Engineering, and now he is a reader at the University Politehnica Bucharest. He has a boy, Matei, five years old. My younger son, George, with MD and PhD degrees from the Carol Davila University of Medicine, Bucharest, is a physician specializing in trauma surgery; now he is working as an assistant professor at the same university. His wife, Gabriela Beatrice, has a PhD degree in Economics. They have two very nice children (Ioana – 14 and Tudor – 11).

In over 50 years of university life and collaboration with research and technical institutes, and industrial firms, I might claim that I have a much larger family. I have mentored many students at undergraduate, Master's, PhD (26 Doctoral Theses), and postdoctoral levels as well as young collaborators from my faculty and from other faculties throughout my country.

Conclusion

Certainly, I have not been spared some failures, mainly due to obstacles inherent in the external circumstances (three dramatic changes of socio-economic-political regimes in a life time!). As the saying goes, "*times are not under the control of people; people are under the control of times.*" Other failures pertain to the fact that I published my work in the Romanian language (which is a Romance language related to other languages such as French, Spanish, Italian, and Portuguese) because in Romania in the 70's and 80's publishing papers in foreign journals was extremely difficult.

Nonetheless, I have always been optimistic and kept working with my PhD students. Recently I started teaching a new course about *intensifing procedures in depollution technologies*.

I believe that the objectives of the process engineering profession can be implemented as long as we keep alive the ties and the knowledge between generations. Moreover, the key positions in these inter-generation ties should be filled by people whose intellect and achievements rise to the height of our former professors.

I want to thank all my collaborators for their ideas and their energy in conducting the research. I hope that our scientific work will contribute to the advancement of their careers and give them the opportunities to achieve their dreams.

I was impressed by the homage paid by my department colleagues to my 70th anniversary, published in Romanian Chemical Journal Revista de Chimie, Bucharest, 59, nr. 10, 2008, from which I quote (*13*):

> "*Professor Gheorghiţa Jinescu's strong personality as both teacher and scientific researcher has a deep and equally important human edge if we consider her affectionate relations with and care for the young, her relationships with all her colleagues regardless of age and professional concerns, her broad humanistic inclination, her open and optimistic nature, and her love of all that is Romanian. Her devotion to school and her keen sense of responsibility sharpend by her high standards and self-criticism have brought Professor Gheorghiţa Jinescu the respect and recognition of teacher colleagues in the Department of Chemical Engineering, being regarded as a source of equilibrium but also as a dynamic factor, full of energy, always young and resourceful in initiating a range of collaborative projects among departments, faculties and universities at home and abroad.*"

Their high opinion has convinced me that the choice of the career which I have served dutifully for over half a century has been both my chance and my destiny.

Let me end with a quote that has constantly been my guide: "The world cannot give you what it does not receive from you" (Friedrich Schiller).

Acknowledgments

Thanks are due to Dr. Marinda Li Wu, 2013 President of the American Chemical Society for inviting me to contribute a chapter to the book partly based on the ACS Symposium "Women Leaders of the Global Chemistry Enterprise."I am pleased to have the opportunity to share my professional story with interested readers.

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Chapter 28

My Experience Being a Woman and a Professor of Chemistry in Morocco

Mama El Rhazi*

Department of Chemistry, Faculty of Sciences and Technologies, Universty of Hassan II - Casablanca, Morocco, BP 146, 20650, Mohammedia, Morocco
***E-mail: elrhazim@hotmail.com.**

I obtained my bachelor degree in chemistry at the Faculty of Sciences in Oujda, Morocco. At that time, I was 21 years old and I wanted to continue my studies, so I applied for a master's degree program in Paris. It was not easy for me since I had to find financial support. I was accepted at the University Pierre & Marie Curie in Paris. Accordingly, I moved to Paris and achieved my Master's degree in electrochemistry with honors and completed my PhD thesis in 1992. Later on, I started my professional career by teaching chemistry at the University of Versailles Saint-Quentin France and Cergy-Pontoise as an associate professor. I decided to return to Morocco with the ambition to contribute to the scientific development of my home country at University of Hassan II- Mohammedia. In 2006, My university sponsored for the first time my oral presentation in Cairo University where I met a wonderful woman who encouraged me to create a society of analytical chemistry in Morocco. This experience in Cairo was a turning point in my professional involvement. Currently I am a full-time professor in the Department of Chemistry at the University of Sciences & Technologies in Mohammedia as well as occupying different positions as President of Moroccan Society of Analytical Chemistry for Sustainable Development and Vice President of Federation of African Societies of Chemistry. My research interest is electroanalysis, particularly modified electrodes using conducting polymers or bismuth film for the detection of heavy metals or organic compounds.

In Jobs, Collaborations, and Women Leaders in the Global Chemistry Enterprise; Miller, et al.;
ACS Symposium Series; American Chemical Society: Washington, DC, 2015.

Introduction

I was on the point of finishing my PhD in the summer of 1992 when my supervisor Claude Deslouis (a brilliant man who I admire and respect) asked me "Mamia, what do you want to do after getting your PhD?" My answer was,"Return back to my country to contribute to its development. I want to go far enough in my profession to make an achievement that my country can benefit from." At this time, many Moroccan students chose to stay in France after getting their PhD.

Did I regret my decision? I think that as a scientist, we have some duties towards our younger students and our society. We have to play a major role in education, and I believe sincerely that it is important to transmit clear messages to our young students the values of contributing to a better world. My Number 1 message to young scientists is "*Read, read and read in order to learn more.*"

I have always felt that disappointments will come when my efforts do not give me the expected return. If things do not go as I have planned or if I face failure, what do I do? Failure is extremely difficult to handle, but it makes us stronger. When faced with adversity, I have always the same opinion: Make an attempt, continually seek advice, embrace failure and learn through our mistakes. That is what failure teaches me despite unhappiness due to failure. Sometimes I wanted to quit and stay at home, but in our daily struggle through life, the road is not always smooth, nor has it ever been promised to be so. There will always be challenges and always hurdles to be overcome. In our area, chemistry, there are always demands for additional funding and always a lot of competition among scientists. Thus, my message Numbers 2 and 3 are:

- *Never give up.*
- *Learn from your mistakes and failures and also from your success.*

My Current Positions

I am currently a full-time professor in the Department of Chemistry at the University of Hassan II Mohammedia Faculty of Sciences & Technologies in Mohammedia as well as occupying different positions as President of Moroccan Society of Analytical Chemistry for Sustainable Development, Vice President of Federation of African Societies of Chemistry, and member of Pan African Chemistry Network and Arab Union of Chemists. My research interests include the development of electrochemical sensors using conducting polymers or bismuth film. These sensors can then be used for the detection of heavy metals or organic compounds.

My Early Life

I was born in 1967 and grew up in a small town called Oujda. It is the main city of eastern Morocco, close to the Algerian border. The past few years saw rapid economic, demographic and social change in Oujda. Only the position of women was kept largely unchanged, even more so than in most Moroccan cities.

In Oujda, Moroccan girls have had access to schooling since immediately after Morocco's independence in 1956, and significant progress has been made to narrow the gender gap in education. However, the formal/informal structure of Moroccan education has maintained an elitist delivery system of learning and scientific practice in terms of class and gender. As a result, women have suffered from cultural bias and inferior class positions in education and scientific practice. Even now, Oujda is much more conservative socially than other Moroccan cities .

I was raised in a typical middle-class family with a large number of children (Figure 1) . Both my parents were illiterate. They were orphans raised by their uncles. Thus, their illiteracy had many causes, such as poverty, socio-cultural beliefs and traditions. My mother, Saliha Fridi, was born in 1938 and she lost her parents while she was very young. She married my father at age fifteen. She was a housewife all her life, a hardworking and fastidious person, she sewed, knitted, cooked, and never felt alone or desperate. When my father was alive, she was very supportive. She acquired even more responsibilities after my father passed away. My father was a storekeeper, a self-made man who built his own life with his own hands. He did not want his children to face the same problems he went through because he had no other choice at the time.

In a town in which most of the girls did not go to school, my father insisted that my sisters and I went to school. The most challenging thing in my parents' life was to give the best education possible to their children and it was a success. We are a very strong family in which every family member has a good job and a good position in the society by God's grace. I think it is very important to highlight that our religion Islam encourages learning through observations and sciences. The first revelation that Prophet Muhammad received was given in the first verses in Sura al-'alaq: "Read, read in the name of your Lord, who created, created man from a clot. Read! And your Lord is most bountiful. The use of the pen taught man what he knew not."

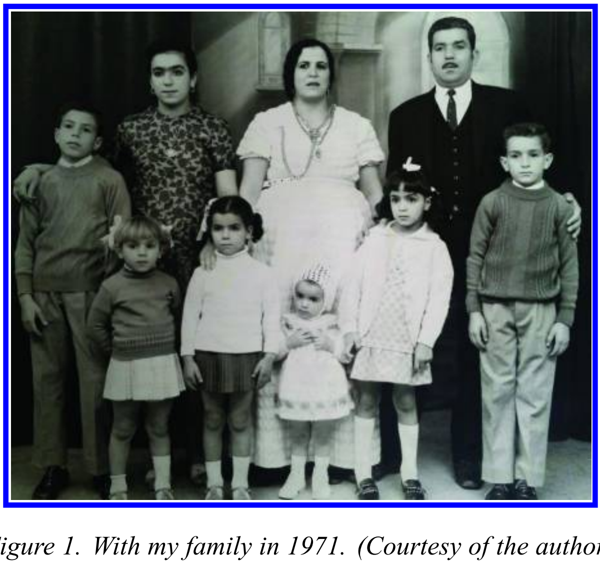

Figure 1. With my family in 1971. (Courtesy of the author.)

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Starting my Career

In 1988, I obtained my bachelor's degree in chemistry at the Faculty of Sciences in Oujda, Morocco. At that time, I was 21 years old and going through a difficult phase of my life. In fact, my father passed away in the same year, and together with my brothers and sisters, we had to face the harsh reality of life. With this in mind, I wanted to continue my studies and applied for a master's degree in Paris. It was not easy for me since I had to find financial aid and moral support. Nevertheless, I was accepted at the Pierre & Marie Curie University in Paris. Accordingly, I moved to Paris and achieved my DEA of electrochemistry with honors and completed my PhD thesis in 1992 with the support of my family, specially my big brother (God bless him). Later on, I got my first job. I started my professional career by teaching chemistry at the University of Versailles Saint-Quentin – Paris 7 as "temporary teaching assistant" and met my husband in the same year. He was working in computer science in the "Institute of Transportation Research and Safety". He and I liked our work in Paris; however, we had to make a big decision. Should we stay in France where the working conditions were appealing or go back to Morocco where the lack of chemistry equipments and funds would discourage most of the researchers. At this point of time, most of the Moroccan scientists preferred to teach, and the few left in Morocco had to fight to do research with limited means. We obviously decided to come back to our country to share the knowledge we acquired and to be closer to our respective families. So, educated and trained in France, we gave up a comfortable life abroad in order to return to our homeland in 1994. I got my first job in Morocco in the Faculty of Sciences and Technologies in the Department of Chemistry at Mohammedia in 1994 and my husband got his in the Computer Department .

Since the French PhD thesis was not recognized by the Moroccan government, I had to prepare a second PhD thesis in Morocco in collaboration with Cergy Pontoise University where I was invited to serve as an associate professor during 1994 and 1996. Thus, I completed my second PhD thesis in 1996. The title was "Electrochemical Properties of Modified Electrode by a Fibrinogen or Polymer". This work was a collaboration between our university and University of Cergy Pontoise and led to a cooperative agreement between both universities. To get my second PhD, I carried out my administrative registration in Morocco but all my research in the University of Cergy Pontoise with Professor Maxime Nigretto. In 1995, I was pregnant with my first child and had to travel a lot between Casablanca and Paris. I tried to find a balance between my work, life and family. I wanted this event to be a source of motivation for me rather than a source of pressure, and I saw it in that positive light. Six months after my child was born, I had to return to France to complete my second PhD thesis. I made arrangements for my son to stay with my family. It was very hard to leave my baby in Morocco. I was assisted by my mother, my mother-in-law, and other female members of the family. Here, I give special thanks to my family, who has always supported me: my husband Azedine, my mom, my sisters, and my brothers. It is important to emphasize that, as a woman, working is never very easy. Moreover, sometimes women have to face some difficult situations that most men do not have to in Morocco. Not that men don't want to help, but they don't feel it as we women do .

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Challenges and Opportunities in 2000

After getting my second PhD thesis in 1996, I was forced to stop my career as a researcher for four years to raise my children Badredine and Asmae. However, I continued to give lectures to my students in Faculty of Science and Technologies at Mohammedia. I was also head of an European project during 1997/1998 on *"Assistance technique à la FSTM - Assistance à l'enseignement technique et Appui à l'orientation relative aux relations universités- Entreprise*".

In 2000, I decided to get back to my research. It was not easy dealing with the local situations. In France we used to have all the equipment that we needed to do good work. It was more difficult in Morocco to acquire equipment. At that time, the challenge was to look for the funds to start my research. Government funding for academic research remained limited, and competition for grants remained high. Researchers across the country encountered increasingly fierce competition for money. The funding rates in some program areas were substantially worse. Even the most prominent scientists found it difficult to maintain funding for their laboratories. The situation was even worse for younger scientists, and the allocation of funds per project was minimal given the small amounts allocated to a very large number of projects. The second problem was the lack of cooperation between the universities and the industry. The Moroccan government was aware of the seriousness of the situation and took several initiatives. Thus, the support for science and technology in Morocco has been significantly improved in recent years. The Moroccan government has been implementing reforms to encourage scientific research in the Kingdom (*1*, *2*). While research has yet to acquire the status of a national priority in Morocco, the country does have major assets that can transform the R&D sector into a key vehicle for development. The industry remains dominated by the public sector, with the universities employing most of researchers. Morocco's own evaluation of national research system revealed that the country has a good supply of well trained high quality human resources and that some laboratories are of very high quality (*3*, *4*). However, the greatest gap at that point of time was in the link between research and innovation (*5*).

The first grant I obtained was from International Foundation for Science (IFS) in 2000, which helped me to start my research in Morocco. The topic was the "Development of Electrochemical Sensors for Detection of Mercury in Wastewater and Sea Water in Mohammedia City" in the Laboratory of Chemical Analysis and Biosensors. IFS provides opportunities for young scientists to propose research relating to biological and water resources in low income countries. This grant allowed me to supervise my first PhD thesis in our laboratory between 2000 and 2003. I used to collaborate with Professor Aziz Amine who is the leading chemist in the field of biosensors. I have to say that we were able to do good work with very limited resources.

In 2006, my university sponsored for the first time my oral presentation on "Screening and Determination of Cadmium and Lead in Food Samples by an Electrochemical Batch Injection Sensor" at Cairo University. It was a good opportunity for me. Professional meetings are often organized around research problems or methodologies. As such, they provide us the opportunity to learn more and grow as researchers and presenters and to gain visibility in our discipline. I met in this symposium a wonderful woman (Chairman of the Symposium of Analytical Chemistry for a Better Life and President of Egyptian Society of Analytical Chemistry – Figure 2) who encouraged me to create the Moroccan Society of Analytical Chemistry. I have to say that this experience in Cairo was a turning point in my professional involvement. The participation in this important scientific event allowed me to meet highly qualified people with international skills. So, the benefits of attending an international conference are many. The experience can be rich, educational, and very valuable in terms of networking.

Figure 2. Picture with professor Motaza Khater and Yousry Issa in Cairo University in 2006. (Courtesy of the author.)

The discussion with eminent scientists such as Motaza Khater and Professor Yousry Issa encouraged me to create with my colleagues the Moroccan Society of Analytical Chemistry for Sustainable Development in 2008. Our association then joined the Federation of African Chemical Societies (FASC) in 2009 and Union of Arab chemists in 2011. We organized the first symposium on Analytical Chemistry for Sustainable Development in Mohammedia - Morocco in 2010 with the cooperation of Egyptian Society of Analytical Chemistry. Three years later, the association also organized its second symposium and the fourth Congress

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of FASC with the support of the Royal Society of Chemistry and American Chemical Society. So, my message Number 4 for young scientists and students is : "*Attendance in seminars and workshops provide real learning experience for scientists and students. Do your best to attend national or international conferences.*"

Statement of My Research Interest

In the past few years, my research has been devoted to electrochemical sensors based on electrodes modified with conducting polymers or bismuth film electrodes. The introduction of a chemical modifier, which is able to preconcentrate metallic ions on the electrode surface by either complexation or electrostatic attraction, can lead to more sensitive electroanalytical procedures with lower detection limits. The combination of carbon electrode and conducting polymers provide extrordinary properties in term of conductivity and electrochemical sensing. Organic conducting polymers, reported in 1977 with the pioneering work of MacDiarmid (Nobel prize in 2000), have received great attention due to their potential applications (*6*). For many reasons, I chose to work with carbon paste electrode (probably because it was one of the cheapest electrode). We focus our work first on synthesis and characterization of poly(phenylenediamine) and poly(diaminonaphthalene) and their substituted composites prepared on different electrodes with particular attention to carbon paste electrodes (*7*). Motivated by the striking properties of poly(1,8-diaminonaphthalene) and the wide uses of monomers in the fundamental and practical electrochemical studies obtained, we are extending our work on different type of polymers (*8*). As effective support, carbon structure, such as carbon paste, carbon nanotube, carbon nanofibers and graphene have been considered suitable materials for polymerizations of a number of monomers. The combination of carbon nanomaterials with polymers is expected to improve the properties of these materials (*9–13*). A recent project currently underway, which is funded by the Ministry of Higher Education, will allow us to work on polymers prepared on carbon paste electrode (CPE), carbon nanotube (CN) and graphene and their applications as electrochemical sensors or as nanofiltration membranes (Figure 3). This work is a collaboration between two laboratories of the Faculty of Sciences Mohammedia – University of Hassan II and Professor Khalid Lafdi from University of Dayton - USA. Our work as any other scientific project, requires close collaboration between material scientists and polymer scientists to better understand the fundamentals associated with the electrochemistry of this kind of modified electrodes (e.g., conduction mechanism).

Another aspect developed by our team is the application of bismuth film electrode called "environmentally friendly electrode" developed by Professor Wang in 2000. The increased risks associated with the use of metallic mercury or mercury salts have led some countries to completely ban mercury. New materials with properties comparable to those of mercury have been developed such as bismuth film. We applied this electrode to the detection of lead and cadmium in different kind of canned foods such as tuna and sausage (*14*).

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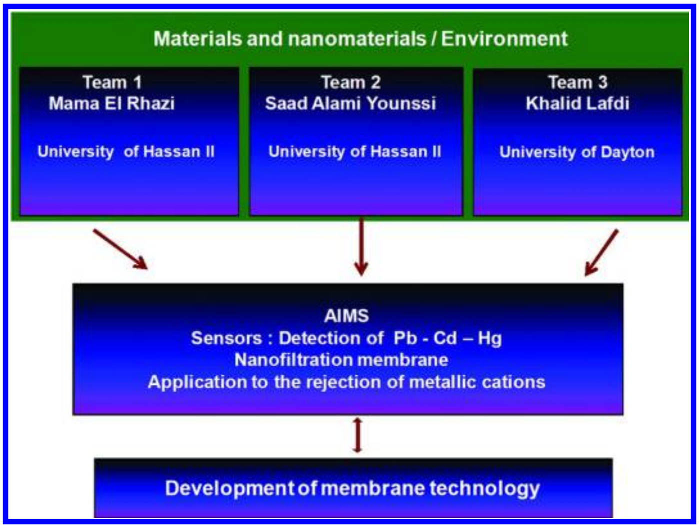

Figure 3. The main research topics developped in the author's lab

In light of recent advances, With my colleagues and students (Figure 4), our challenge for the coming years will be to continue making progress and to find new approaches to synthesize composite materials based on carbon paste electrode, carbon nanotube or graphene with conducting polymers or bismuth. The idea is to improve the simplicity and efficiency of the new composite and to extend the application of the composite materials with low costs.

Figure 4. In my lab with my PhD students and my colleagues. (Courtesy of the author.)

Conclusion

Improving my work has always been my obsession. Yet my satisfaction and enjoyment come from doing what I do as a woman and a human being. I am proud of my achievements. It was definitely difficult being a woman and growing up a girl in my country. As a woman, you really need to develop a very strong sense of self-confidence and the earlier you can do that, the better it is. I think the background you come from has a strong effect on your personality and the decisions you take in your journey in life. I am fortunate enough to enjoy my job and to interact with many leading scientists, young scientists and students in my profession.

I became what I am now by working hard. My biggest support came from my family. I was very lucky to have parents who wanted for me what they did not have: schooling. Even though they were illiterate, they were aware of the importance of education. They gave me love and confidence and above all, they taught me that nothing would mean anything if I did not live a life of use to others.

In conclusion, my message Number 5 to students and younger scientists is: *"Be curious, and develop a critical mind."*

Acknowledgments

Many thanks to Dr Marinda Li Wu, 2013 President of the American Chemical Society for inviting me to the Symposium on "Women Leaders of the Global Chemistry Enterprise " in San Francisco, and all the people who gave me this opportunity to share my experience. Many thanks are also due to Motaza Kather from Egyptian Society of Analytical Chemistry, Alejandra Palermo from RSC, and all my family particularly Meriame.

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Chapter 29

Experiences of a Female Chemist in South Africa

Bice S. Martincigh*

School of Chemistry and Physics, University of KwaZulu-Natal, Westville Campus, Private Bag X54001, Durban, 4000, South Africa
***E-mail: martinci@ukzn.ac.za. Telephone: +27-31-2601394.**

The current author is now Associate Professor in the School of Chemistry and Physics at the University of KwaZulu-Natal in Durban, where she teaches and does research in Physical Chemistry. In 2011 she was awarded the University's Distinguished Teacher Award in recognition of "her exceptional ability to tailor and differentiate her teaching to meet the different levels of study of her undergraduate and postgraduate students, in what is, moreover, regarded as a 'difficult' subject – chemistry." Her main research interests are in sunscreen photochemistry and environmental chemistry. She has successfully supervised more than 20 postgraduate students and mentored many new members of staff. Her advice to female aspirant chemists is: Find an area that you really like and can be passionate about, be open-minded and explore the field as widely as possible, rely on your own efforts and determination, and stand up for your beliefs, especially when you believe things can be done better!

Although I was born and grew up in South Africa, my background is not typical of a native South African. The story begins in north-east Italy, in the province of Friuli, where my family originates from. My parents were from a small village called Castello di Porpetto. When my father returned home from serving in World War II, he found employment with SNIA (Societa Nazionale Industria Applicazioni) in the nearby town of Torviscosa. This company manufactured rayon pulp from a locally grown reed. In the early 1950s SNIA, together with the

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British company Courtaulds, invested in South Africa to build a plant to produce dissolving pulp. The site chosen for this new factory was Umkomaas, on the South Coast of what was then the province of Natal. This location was particularly well suited for the factory because the Umkomaas River, the second largest river in the province, would provide a constant supply of water. Consequently approximately 350 families, mostly from Friuli, emigrated to South Africa to settle in Umkomaas. My father was in the second contingent to arrive in South Africa to man the new factory. He arrived in Umkomaas in July 1954 and was followed a year later by my mother, Norma, and my sister Germana, then six. I was born two years later in the nearby town of Scottburgh, where the nearest hospital was located.

The new cellulose plant was named SAICCOR (South African Industrial Cellulose Corporation). It was a tripartite co-operation between the South African Industrial Development Corporation (IDC), Courtaulds and SNIA, and this was reflected in its first logo of three shaking hands (not unlike Marinda Wu's Presidential Logo "Partners for Progress and Prosperity": see Figure 1). The company has gone from strength to strength, with expansions each decade, and is now one of the biggest dissolving pulp manufacturers in the world.

Figure 1. The first logo of SAICCOR (1) (used with permission) shows a remarkable resemblance to the ACS "Partners for Prosperity" emblem.

Prior to the arrival of the Italians and the construction of the cellulose plant, Umkomaas was a typical seaside resort with a number of hotels, a few shops and a government primary school. When the news broke that a large contingent of Italians would arrive to build and man SAICCOR, some of the local inhabitants were in trepidation of this avalanche of Italians, as can be seen from the cartoons that appeared in the local newspapers at the time (Figure 2). The construction of SAICCOR brought many changes to the village. Hotels were upgraded, new housing developments sprung up and the town now had cultural activities as well as its own soccer team! The Italians brought their own distinctive flair to the town by building a Catholic Church as well as an Italian Club.

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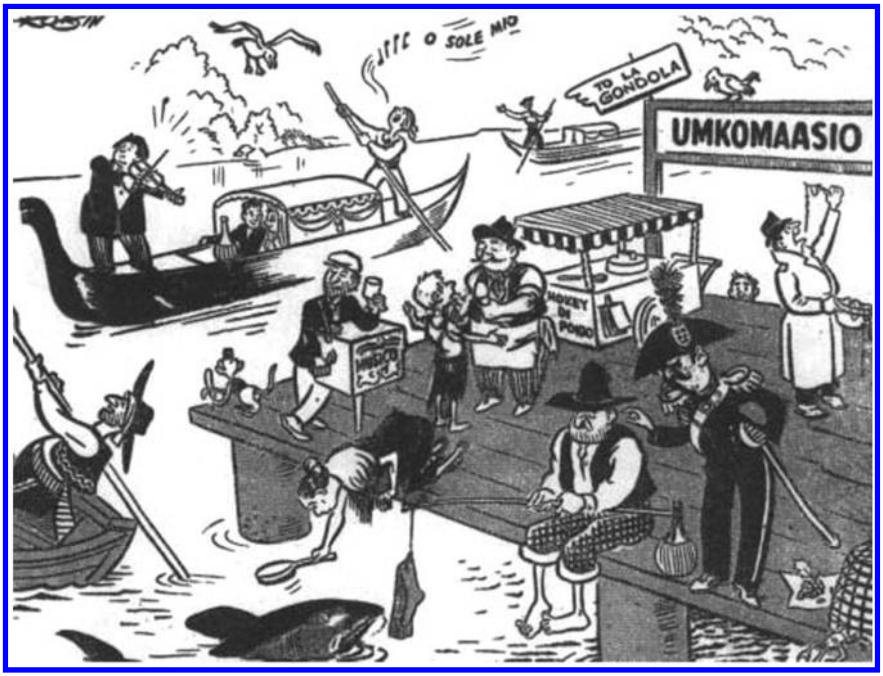

Figure 2. A cartoon that appeared in a local newspaper in 1952 reflecting the misgivings of the Umkomaas inhabitants about the imminent arrival of the Italian settlers (1). (Used with permission.)

My parents had no higher education but they instilled the importance of education into us from a young age. Since there were no kindergartens in Umkomaas, I spent the first six years of my life at home with my mother. She was a dressmaker and so I would imitate her by making dresses for my dolls. My father taught me the alphabet and how to count. I could not wait for the day that I would start school. That day came in 1963 when I joined the Umkomaas Government School but I could not speak a word of English!! I was fluent in my home language of Fûrlan and could also speak some Italian. My first three months at school saw many tears as I grappled with this new language. However, this disadvantage did not hold me up and I was soon well on my way. What I did learn from this experience is that you need to have determination and you need to do things for yourself!!

After completing primary school (seven years) I attended Kingsway High School some 17 miles north of Umkomaas in the town of Amanzimtoti. This meant that, instead of walking to school and going home for lunch, I needed to catch a bus early every morning. After two years at high school the school had become so large that the Natal Education Department decided to split the school into a Junior and a Senior High School. In 1972 I therefore moved to new premises and I was in the lowest grade of the new Kingsway Senior High School. As you will see, this would become the story of my life: wherever I worked I would have to move premises. I graduated from high school in 1974 as Dux of the School.

I enrolled at the University of Natal in Durban for a BSc degree, majoring in Mathematics and Chemistry. Since Durban was some 30 miles north of Umkomaas this was also when I moved out of home and lived in a university residence. After three years I graduated with a BSc and decided to continue with a BSc(Hons) degree. This is when I decided to become a chemist. I had always had an interest in the sciences, but at first I thought of becoming a mathematician. However, I decided that perhaps the job opportunities in South Africa were better for a chemist. At the time South Africa had a number of large chemical companies, namely, AECI, Sasol, Sentrachem, Unilever, as well as a number of research facilities such as the CSIR, Mintek, and the Atomic Energy Corporation (AEC). It therefore seemed to me that my employment opportunities would be better if I pursued a career in chemistry.

After completing my Honours degree with a first class pass, the natural progression was to specialize in Physical Chemistry, which combines Mathematics and Chemistry. I therefore stayed on at the University of Natal to pursue my PhD. For my PhD I performed research in the area of solution thermodynamics of coordination complexes. In particular, I investigated the influence of primary and secondary nitrogen donor atoms on the thermodynamics of complex formation in aqueous solution. This involved a lot of meticulous experimental work, from which I learnt much and which has stood me in good stead for the rest of my research career.

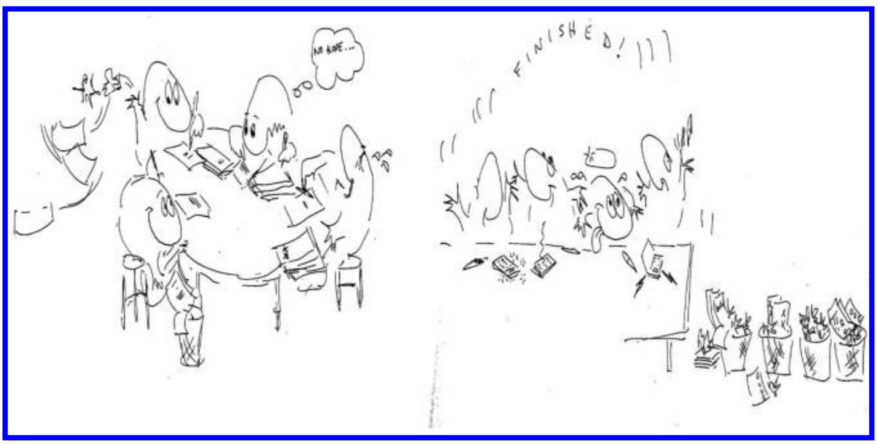

Figure 3. A portrayal by the author's friend, Dr Igle Gledhill, of the amount of marking she did while employed at Natal Technikon. (Illustration by Irvy Gledhill. Used with permission.)

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Having from a young age wanted to be a teacher, I found an academic career a natural choice. I had spent my university vacations working in the chemical laboratory of SAICCOR and later I had been offered sponsorship by chemical companies, but I realized that my preference lay in academia. My first job was at Natal Technikon (now the Durban University of Technology) in Durban. At that time the Technikons in South Africa were similar to the Polytechs of the United Kingdom. I was employed in the School of Chemical Sciences that offered diplomas in Analytical Chemistry to both full-time and part-time students. At the time (early 1980s) these were essentially teaching institutions and the workload was very onerous. I taught 25 contact hours per week and I would set up to 16 tests per semester as well as mark 90 practical reports per week (see Figure 3). There was, therefore, no time even to think of research! However, when I look back at this period of my life I realize that it taught me to survive under stress and not to have any fears when facing a class. The good parts of this job were that the classes were small (approximately 25 students) and you got to know the students on an individual basis. During my time at this institution we moved to new premises on the Berea Road Campus as our building in the city centre was due for demolition so that a new highway could be built. Moving offices, and in particular laboratories, is not an easy task and this was to recur some years later in my next job.

After six years at Natal Technikon, I joined the University of Natal as a Lecturer in Physical Chemistry in January 1990. The teaching load was less than that at the Technikon and I was able to start my research career and supervision of postgraduate students. Nevertheless, teaching did take priority and on my second day in my new job I was presented with a pile of examination scripts to mark, even though it was only the 3rd of January and the students were on vacation. At the time the University of Natal was an institution mainly for "White" students but it had the unusual feature of a Medical School for "Black" students only. This changed after the new democratic government took over in 1994 and gradually the student population changed from largely white to largely Black. Durban was served by a second university, the University of Durban-Westville, which was founded in the early 1960s, during the years of apartheid, to train students of Indian descent. With the new government came changes in the tertiary education landscape and in 2004 the two universities were merged to become the University of KwaZulu-Natal. This new university was at the time the largest residential university in the country with five campuses and over 40 000 students. In Durban the faculties were moved so that all the staff and facilities for a particular subject were based at one campus. Hence, came my next office move, from the Howard College Campus to the Westville Campus in December 2006 (see Figure 4). The building housing Chemistry at Westville was a dismal building with laboratories that were more like rabbit warrens, with narrow passages and every entrance barred by a security gate. Fortunately, the government granted the University funds to upgrade the buildings and facilities, and Chemistry was privileged in receiving a significant grant to do so. The architect appointed to design and oversee the refurbishment of the building was Gerald Seitter, and he did a wonderful job of transforming a dark cluttered building into spacious modern laboratory and office facilities. We were also fortunate in being able to purchase some very good instrumental equipment which allowed us to start off in the new institution on a sound footing. With the merger, however, came significantly larger class sizes, the likes of which we had not seen before. Our first-year Chemistry class for science majors jumped from 300 to 1200 students, with not much change in staff numbers. My third-year Physical Chemistry class in 1990 was 35 students and now I teach 110. This has had major implications for how we teach and examine the students, but the sheer volume has brought with it a lot of administration which was absent before. At the Howard College Campus we had one first-year laboratory that housed 102 students in one sitting. We now have four first-year laboratories that house 48 students each and we typically run 24 laboratory sessions a week and 28 "small"-group (anywhere between 35 to 72 students) tutorials per week. The organization of this is a huge task.

I have many people to thank for the advancement of my research career. I would like, in particular, to mention two of them. Firstly, Professor Reuben Simoyi, who welcomed me into his laboratories at West Virginia University and Portland State University on a number of occasions during periods of sabbatical leave. There I investigated convective instabilities that arise from highly exothermic oxidation reactions and the kinetics and mechanisms of a number of antioxidant systems (*2*, *3*). This research has proved highly fruitful and I thoroughly enjoyed going back to the bench and interacting with his postgraduate students. Our collaboration continues and has now reached its twentieth year. Secondly, Professor Leo Salter, who was my immediate colleague in Physical Chemistry at the time I joined the University of Natal in 1990. He introduced me to the fascinating world of photochemistry and in particular, the photochemistry of sunscreen absorbers: their photostability, possible production of reactive oxygen species and their interactions with DNA (*4*, *5*). He left the University in 1992 to return to the United Kingdom, but this research thread continues and has fascinated a number of my postgraduate students. My emerging research interest is in nanomaterials for the remediation of contaminated water by either adsorption or photocatalytic degradation (*6*). This work is starting to bear fruit and hopefully will continue especially now that the University has established a Nanotechnology Platform. My research would not have progressed without the input of the postgraduate students I have supervised. To date I have graduated 18 MSc and 5 PhD students, and I need to thank them all. They have enriched my life in so many ways and kept my curiosity of the scientific world alive (Figure 5).

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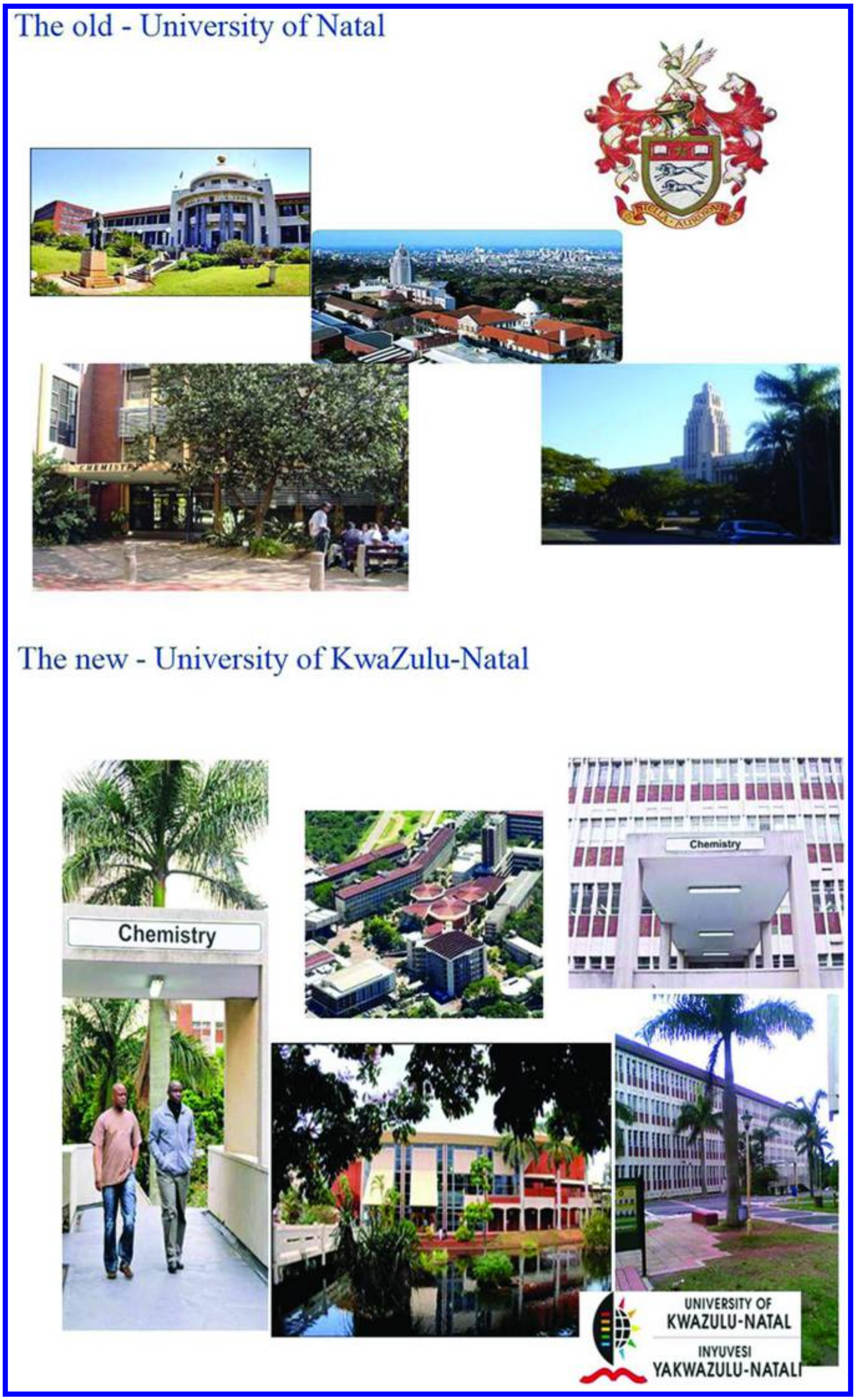
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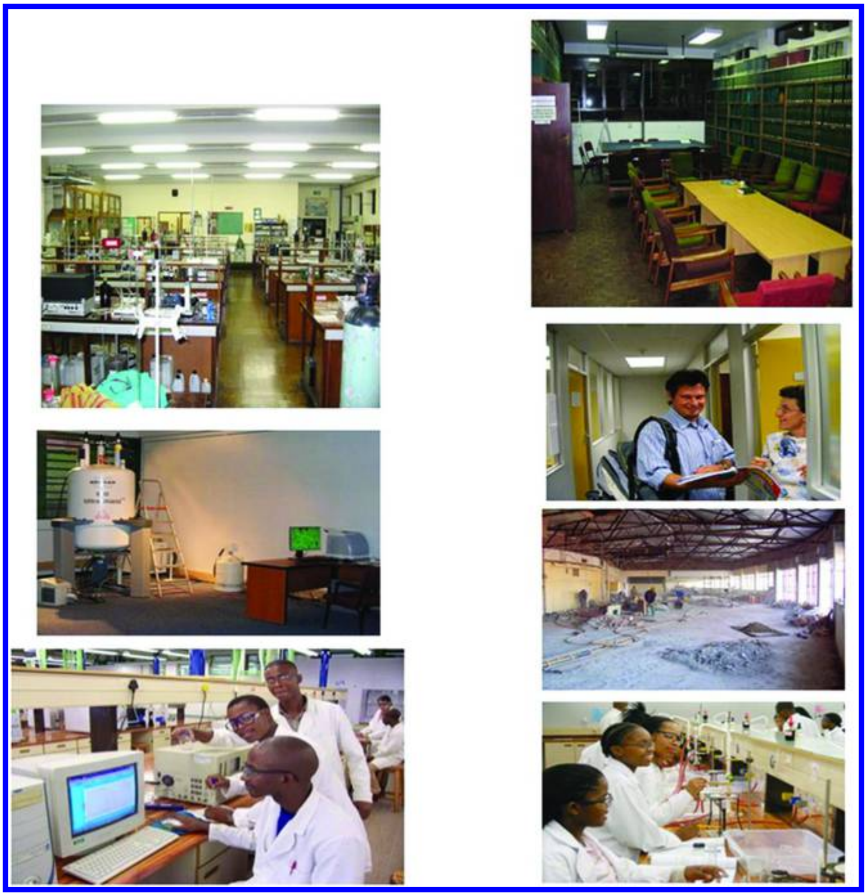

Figure 4. Images of the author's workplace. (Courtesy of the University of KwaZulu-Natal. Used with permission.)

Within the first year of my appointment at the University of Natal I was made the first-year course co-ordinator, and this task has remained with me for most of my career. As the background of our student population has changed over the years, this has led me to introduce a number of changes to our first-year curriculum and our teaching methods. In 2011, the University of KwaZulu-Natal honoured me with a Distinguished Teachers Award in recognition of "her exceptional ability to tailor and differentiate her teaching to meet the different levels of study of her undergraduate and postgraduate students, in what is, moreover, regarded as a "difficult" subject – chemistry" (see Figure 6). I was particularly pleased that, after so many years of teaching, my efforts were recognised.

Figure 5. The author with her current research group. (Photograph by Enock Chekure. Used with permission.)

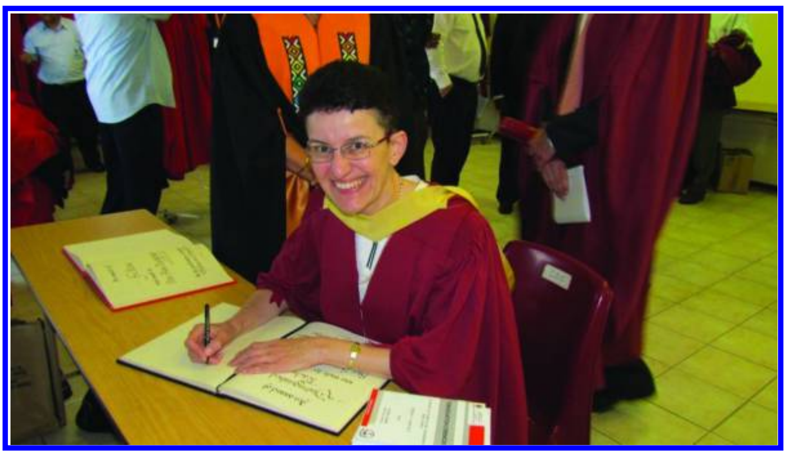

Figure 6. The author signing the Distinguished Teachers Book at the award ceremony. (Courtesy of the author.)

Besides my teaching and research, I partake in a number of other activities that ensure I have very little free time! For a number of years now I have been involved in the organisation of the annual FFS Expo for Young Scientists. This is an event for high school students to display for adjudication a scientific project that they have undertaken. The winners of the competition are awarded prizes and taken on a tour of scientific interest to various sites in South Africa. Together

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with the late Professor Mike Laing, I have also taken part in numerous Chemistry Magic Shows as "Miss Rabbit" (see Figure 7). My present colleagues, Vincent Nyamori and Bernard Owaga, and I now perform a Magic Show where we are the "Three Magicians" (after the Three Tenors). I believe it is important to excite young children about the marvels of science, so that they are not blinded by the bad publicity that is sometimes given to Chemistry, but also to ensure more generally that science gets the attention it deserves.

Figure 7. The author having fun at various Magic Shows! (Courtesy of the author.)

I am a member of a number of professional bodies such as the South African Chemical Institute (SACI), the American Chemical Society, IUPAC, the American Society for Photobiology and the European Society for Photobiology. Within SACI, I am currently serving as Vice-President and in July 2015 will take office as President. I hope that I will be able to build on what others have achieved for the chemical community in South Africa and keep the Institute going from strength to strength. I am also currently the Physical Chemistry subject editor for the South African Journal of Chemistry published by the Institute. Earlier this year I was part of the organising committee for the 5th International IUPAC Conference on Green Chemistry. This was the first meeting of its kind in South Africa and I am pleased that the meeting was well attended and brought to the forefront the importance of Green Chemistry to our society.

When I joined the University of Natal in 1990 I was the second woman to be employed in the department as an academic. In fact, as a student at the same institution, I was never taught by a female lecturer in any subject! The situation is now very different. Of the 25 academic staff employed in Chemistry at the Westville Campus, 11 are women. There are now many more opportunities for female scientists in the country. The government has initiated a policy of equity and redress. For any academic post where a number of candidates are found appointable, the female candidates are given preference. There are also more job opportunities for women and associations aimed at female scientists, such as the South African Association for Women in Science and Engineering (SAWISE). Certain classes of research funding administered by the National Research Foundation (NRF) and the Department of Science and Technology (DST) are earmarked for women. Various institutions have implemented mentoring schemes for women. For example, the University of KwaZulu-Natal has devised the

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Women in Learning and Leadership (WILL) programme, where women can meet in a supportive atmosphere and discuss aspects of their academic careers with other women academics. The DST, in particular, recognises the achievements of women scientists in the country through the award of prizes such as the DST South African Women in Science awards. And I am pleased to report that the current Minister of Science and Technology of South Africa is a woman, the Honourable Minister Naledi Pandor.

In my own institution, the number of female students in our undergraduate and postgraduate Chemistry programmes is increasing (see Figure 8). This year, for the first time, the number of female students in our Chemistry Honours class (fourth year) is more than twice the number of male students. We hope that this trend will carry over to our postgraduate MSc and PhD programmes.

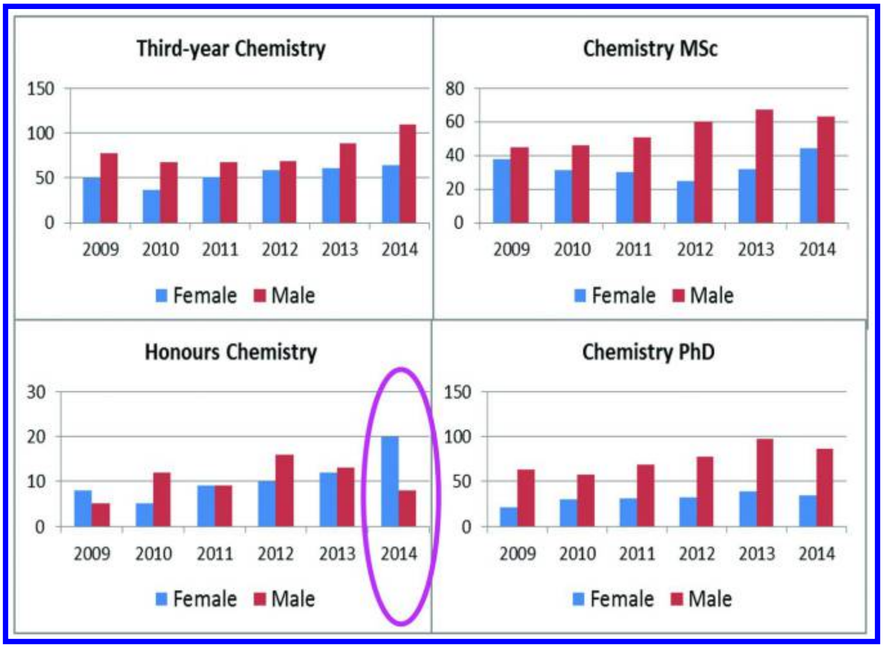

Figure 8. Trends in Chemistry enrolments at the University of KwaZulu-Natal.

A recent gender benchmarking study "found that the levels of female representation in the science, technology and innovation (STI) fields in the world's leading economies were not only "alarmingly low", but also on the decline" (*7*). Results from South Africa demonstrated that, although women had more opportunities available to them than ever before, their participation in the STI workforce remained low. Women remained severely under-represented in degree programmes for engineering, physics and computer science. However, the country demonstrated comparatively high rates of women on corporate boards and as science academy members. There is a need to encourage young women to enter the field of science and to pursue rich and rewarding careers in their chosen area.

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My advice to female aspirant chemists is: Find an area that you really like and can be passionate about, be open-minded and explore the field as widely as possible, rely on your own efforts and determination, and stand up for your beliefs, especially when you believe things can be done better!

Acknowledgments

I am deeply indebted to Dr Marinda Wu for inviting me and giving me this wonderful opportunity to share my personal and professional journey at the Presidential Symposium on "Women Leaders of the Global Chemistry Enterprise" held at the ACS 248th National Meeting in San Francisco on 12 August 2014. I am also grateful for the partial sponsorship provided. I also wish to thank the National Research Foundation of South Africa (NRF) for the award of a Knowledge Interchange and Collaboration grant to enable me to attend the Symposium.

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Chapter 30

Glimpse of My Scientific Path: The Quest Continues

Samira Ibrahim Islam*

Head- Drug Monitoring Unit,
King Fahd Medical Research Centre, King Abdulaziz University,
P.O. Box 488, Jeddah 21411 Kingdom of Saudi Arabia
***E-mail: dmukauh@yahoo.com.**

My scientific path is a result of inspiration and perseverance. I was blessed with parents who believed in the importance of education at a time when formal education for women was practically non-existent in my country, Saudi Arabia. I was sent abroad for my education, and became the fist Saudi woman ever amongst all fields of specialties to obtain a Bachelor's, then Ph.D. degree and became the first Professor of Pharmacology, amongst all Saudi men and women. I returned to my country determined to serve my society the best I can and to make my parents proud. However, establishing myself in a male-dominated society, that had lacked the infrastructure for university education for women or for scientific research was not easy. Supported by those who believed in me, I was able to slowly influence changes in our educational system that finally allowed Saudi women to be accepted into formal university education. I established scientific colleges for women as well as shared in the establishment of a medical school and its associated colleges. During my professional career, I became the first woman vice-dean in a university and the first Full Professor of Pharmacology in Saudi Arabia as well as the first Saudi woman to be given a post at the World Health Organization (WHO). With initial international collaboration with universities abroad, I was able to begin research projects that continued after the transfer of technology and know how. I founded the first Drug Monitoring Unit in my country which helped clinicians in safe drug dose adjustments as well as

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serving as a research facility from where 120 research articles were published. One of my main research achievements was to define the Saudi population's polymorphism in metabolic pathways of drug; the publications that resulted from that research have become well cited literature reference. I am continually involved with public health services, strong advocacy of women's empowerment in my society and the fight against drug of abuse and addiction. I was the first person to receive the Makkah Award for Excellence for my contribution to science and research, which is the highest distinction bestowed on Saudi citizens.

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Introduction

My country, the Kingdom of Saudi Arabia (KSA), was founded by King Abdulaziz Al Saud in 1932. As in many cultures throughout history, education was the responsibility of the religious establishment. In 1957 schooling and education for boys became the responsibility of the Ministry of Education (MOE).

In the face of fierce resistance by the conservatives, schools for girls were only allowed to open their doors after it was agreed that education for women would be controlled by a separate new entity The General Presidency of Women' Education (GPGE) was established in 1960, to cater to the educational needs of girls. It worked independently, yet somewhat in tandem with the MOE.

This late start of formal school education for girls in KSA was only made possible due to the tireless perseverance of the late Queen Effat Al-Thunayyan with the support of her husband Prince Faisal bin Abdulaziz who in 1964 became the King of Saudi Arabia. They also were surrounded by other royals and Saudi citizens who were determined to make a difference to the cause of girls' education. The King and the Queen were great patrons of education for both boys and girls. They financed the construction of high-standard school campuses and recruited the best teachers from all over the Arab World to work in their schools.

The Ministry of Higher Education (MOHE) was later established in 1975 to implement the Kingdom's higher education policy in the rapidly expanding sphere of post-secondary education, in colleges and universities (*1*). However, girls' education throughout all grades, remained completely under the control and responsibility of the GPGE until its dissolution in 2003, when MOE and MOHE took over these responsibilities, finally unifying the country's educational system.

The establishment of King Saud University (KSU) in Riyadh in 1957 marked the starting point of a higher education system in Saudi Arabia. It was also the first university to open its doors in the Arab Gulf States. KSU remained exclusively a men only educational establishment until 1979, when it opened its first women's campus dedicated to fine arts, literature, languages and history colleges.

Beyond kindergarten, education in KSA remains segregated by gender. Boys and girls are taught in different schools, colleges and universities by men or women respectively. The only exception is in King Abdullah University for

Science and Technology (KAUST). This University opened its doors in 2009 after its impressive campus was built in record time. KAUST focuses exclusively on post-graduate co-education and research in science and technology using English as the official language of instruction.

Start of my Journey

In the 1950's Saudi Arabia was still a young country barely a few decades old. The fledgling government offices, ministries and various authorities were still in their establishment phase. Boys' education was given special attention but was still understandably not nearly up to the standard of even contemporary educational systems in some other Middle Eastern countries. The establishment of schools and colleges had to follow the slow spread of suitable infrastructures over the vastness of the recently-founded KSA. Social, cultural and conservative beliefs also served as a hindrance to the rapid spread of modern education. These factors also meant that there was an unofficial, but complete ban on girls' education at any level. Attempts by some individuals to open private schools for girls were met by fierce resistance. The permitted "schoolings" for girls, were the privately owned "Kuttabs", in which they were taught how to read and recite the Holy Quran. Through that, girls learned how to read and write.

Like most of the girls of my childhood years, I started my schooling in those Kuttabs. Using chalk on slate we were taught how to read and write.

In view of the importance of education, the "Kuttabs" did not meet my father´s expectation. He then took the opportunity of allowing us to be taught at home by employing teachers, whom the Saudi government had recruited for the only school in the Kingdom in Makkah (Madrasat Tahdheer Albethat) which was dedicated for preparing Saudi boys to be enrolled in universities abroad. Those same high caliber teachers, who were mainly from Egypt and Syria, were also employed by then Prince Faisal to teach his own daughters at home.

In the mornings, we attended the Indonesian School of Al-Shamiyya in Makkah. Our home teaching sessions took place in the evenings and on the weekends. Being part of a large family, my sibling, cousins and me gave our house a school feel, especially when the numbers of our little private tutorials swelled with children of our neighbors whom my father had invited to attend.

Keen on giving us the best education possible, my father with the encouragement of our mother, had to make the hard decision of sending us all abroad for better schooling. Most of my cousins and I were sent to Egypt. Others went to Lebanon and some to Turkey. At the time travel was hard and communication was difficult, so I can only imagine how painful it must have been for my parents to send us so far away from them, but it was necessary. A fortune was invested by my father to make all this possible for us.

Settling in Alexandria in Egypt, I was extremely fortunate to be accepted to the EGC, the English Girl's College, back then a world renowned and internationally famous school. I was 8 years old and I spent the remainder of my school years in its boarding house. At the end and to the pride of my parents, I graduated with

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honors, which meant that I was completely free to choose the path that I wished to pursue in my university education. My first thought was that I wanted to become an engineer or an architect, because I was very talented in arts and mathematics.

Alexandria University

Throughout my school years my parents were more than supportive in any choice that I made. I received nothing but encouragement and compassion from them and I was left to select the subjects without any objections. My interests were clearly scientific physics, chemistry, biology and mathematics which were subjects regarded as unladylike by most people of the time and especially by people from my country. People around me in Alexandria made that obvious to me and dissuaded me from engineering as it would have been a useless qualification in Saudi Arabia for a woman. My father's wishes had always been that I would become a doctor, but it was only after I had already decided to study medicine, that he made this known to me. Medical school was the best choice for me to be able to pursue a career in Saudi Arabia, I was convinced.

My time spent in medical school in the Alexandria University was limited. Unfortunately, despite my promising performance and attaining top marks throughout the first year, my intolerance to dissecting cadavers and the prospect of dealing with suffering and sick people got the better of me. In the middle of my second year of studying medicine, I was unable to continue.

My decision to leave medicine was not met with fierce objections by my family, but it certainly was a shock to my professors. They could not believe that anyone who was doing so well in her studies would just leave by her own choice. They really though that I was cut out for medicine. They tried their best to convince me to stay, but I was adamant to leave. Realizing that, they were quick to make alternative suggestions for me. My transfer to the School of Pharmacy in the same university was made easier by the high recommendations attached to my application and I was immediately accepted. This was to the delight of my father who had a thriving pharmaceutical business at the time and thought of my own decision as even more promising.

In the summer of 1964, I graduated with a bachelor's degree (BSc) in Pharmacy and Pharmaceutical Chemistry. Two years later and in 1966, I completed a master's degree (MSc) in Pharmacy by obtaining a diploma in Drug Analysis and a diploma in Biochemical Assays. My desire to further my studies drove me to immediately join a doctorate degree program which concluded in 1970 with me obtaining a Ph.D. in Pharmaceutical Sciences (Pharmacology).

Completing these objectives meant that by 1970 I was the first Saudi Arabian woman to obtain a bachelor degree (BSc), a master's degree (MSc) and a Ph.D.

Return to KSA

In 1970, Egypt was in a stagnant shock from the losses of the 1967 war. Some of my university classmates never made it back alive and others were

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maimed for life. It was a miracle that I managed to complete my Ph.D. project in such a defeatist atmosphere. Meanwhile, King Faisal had set the wheel of rapid modernization of Saudi Arabia in motion. He encouraged all educated Saudis living abroad to return. It was time for me to return to my beloved country. Of course it was also my parents' wish that I come back home to Jeddah.

Surprisingly, my return to Saudi Arabia made headline news in many newspapers, magazines and radio interviews. Until then I really had not thought much of what I had achieved. To me it was simply getting on with my life and working hard on what I loved doing most. When asked how he felt about my Ph.D. success, my father declared in an interview with a newspaper "Now I can accept death with pleasure" I was told that tears welled up in his eyes when he said this. Sadly, his words could not have come any sooner for he passed away from a heart attack only a few weeks later. Understandably, the media frenzy subsided with the news of my father's death. I was given time to grieve privately.

Overcoming Major Hurdles

My father was gone and so was his driving force that had brought me to this point of my life. My period of mourning was also the perfect time to reflect and to think of my future. Admittedly, I felt lost and that my career had ended before it had even begun. What woke me up from this daze that I was in were the words of Princess Al-Jawhara bint Saud Al-Kabeer, who on the last day of my father's funeral whispered in my ear "Become what your father wanted you to be", her condoling words gave me a new sense of hope and purpose.

Saudi Arabia was a very conservative country, which was dominated by men. Job opportunities for women were mainly limited to school teachers, doctors and nurses. However, very few Saudi women had actually taken up what little was offered. It was just unacceptable to many Saudi families to allow their women to work. It was a cultural attitude. Foreigners made up the bulk of the women's workforce. In such an environment, what was the only Saudi woman with a Ph.D. in Pharmacology to do? At that time my country even lacked the foundations of an infrastructure that would support scientific research, laboratory experiments or even teaching women at university level.

My Academic Achievements

Without any suitable employment for my qualifications most authorities hesitated in offering me a job. It is an odd situation to be in; when one's high achievements become the hindrance to one's career prospects. I knocked on every door possible but got nowhere. However, I decided not to give up that easily. I was determined to work by any means. It was then that I requested an appointment with the Rector of King Abdulaziz University (KAAU) at the time, H.E. Dr. Ahmad Mohammad Ali. By the end of our meeting I volunteered to serve the university without pay. My offer was accepted and I was given the job title of Volunteer-Lecturer.

At that time women's education was officially under the responsibility of General Presidency for Girls' Education (GPGE). Therefore KAAU could not enroll women students in their formal education program. However, due to popular demand, KAAU had already begun registering women as external students in a distant learning program. During the academic year women would collect their educational materials and study guides together with their assignments and would only enter into the university campus to sit for their final exams.

In addition KAAU initiated non-obligatory evening classes and support lectures. It soon became apparent that this initiative was extremely popular, especially with the women in Makkah. Every woman who could attend was present and the classes were always full throughout the academic year.

After working as a volunteer without pay for more than a year, I was appointed by the university rector as an official member of the teaching staff (lecturer post) in the College of Education at KAAU, Makkah Branch. This job also meant commuting daily the 80km distance between Jeddah and Makkah on a narrow and primitively paved road. For my convenience, a chauffeur-driven University-car was allocated shuttle to chauffeur me between the two cities. Unfortunately, most University cars at the time were not even air-conditioned. This relentless commute continued even while I was pregnant in 1974 with my youngest child. I also had two little children to take care of at home. Luckily, I had a very supportive mother who took care of them while I was at work.

Things had began to change starting back in 1972 when a new Rector was appointed to KAAU. H.E Dr. Mohmed Abdu Yamani who was extremely enthusiastic about main streaming women's education. He appointed me to be the Academic Advisor for Women's Education as well as the Head of the Science Departments, which were to be simultaneously established for women in both, the Jeddah and the Makkah branches of the University. This was the first time that a head of a department post was ever given to a woman in a Saudi niversity. Using my authority as an academic advisor, I proposed the idea of commencing formal daytime University study enrollment for women, to which Dr. Abdu Yamani was supportive but yet hesitant due to the uncertain acceptance that this project would receive.

To ensure the society's acceptance to this major change of the educational system of my country, I conducted an official survey that included questionnaires, interviews and discussions with the students and members of their families as well as the university's Vice Rector and all the deans of the various colleges of KAAU. Backed by an overwhelmingly positive feedback from my survey, we were able to quell the objections put forward by the conservative leaders of our community and we quickly filed for permission to allow the classes to commence.

The official acceptance of this endeavour did not come easily. Convincing the GPGE needed dedicated and tireless lobbying that seemed to go on forever. Eventually, in 1973 and for the first time in Saudi Arabia, women were admitted as formal university students. Understandably, a major concern was gender segregation of the university students. This was guarenteed by creating a completely independent and self containing campus that has since been

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periodically expanded over the years to accommodate the increasing numbers of women students. Today it occupies a significant area of KAAU and it even includes sport facilities.

Before 1973 women enrolled in the KAAU colleges were only allowed to attend non-obligatory evening classes as part of the distant learning program. It was an arrangement best described as part-time education. My first achievement as the Academic Advisor for Women Education, was to change all that by main-streaming their lecture times. They became full-time students whose classes ran throughout the day. What might be seen as an ordinary transformation in anywhere else in the world had an immense impact on all the women in KSA. Becoming full-time university students was their first step to gender equality.

In my role as the Head of Science Department, I established many new educational programs for women. Using my influencial position, I founded the Departments of Chemistry, Physics, Biology and Mathematics. In addition I also founded the library in the women's section of KAAU-Makkah Branch.

Naturally, I also had to establish well-equipped scientific laboratories for each department for practical learning. The idea of women performing laboratory experiments created unfounded apprehension and anxiety from fear of accidents and injuries. The laboratory session were only allowed after I had signed a legally-binding document taking full-responsibility for any injuries or harm that may occur during laboratory experiments.

In 1974 a Royal Decree was issued calling for the establishment of the second Medical College in Saudi Arabia to be placed in KAAU, Jeddah. The founding Dean of the College Dr. Abdullah Basalamah requested my help to take the responsibilities of establishing the women's section of the Medical College at KAAU women campus. At first I expressed my reservations to his request, because I would have preferred to work in my own area of expertise which is Pharmacology. Moreover, because of my academic qualification, I disagreed with being simply assigned as one of the supervisors of this project a job which does not require academic rank. My conditions were met when I was appointed Founding Vice Dean in what became known as the Faculty of Medicine and Allied Sciences (FMAS), which includes all the health specialities programs and colleges. This trend was a new approach in which all the health professions study together in the first year core curriculum then gradually separate in the following years.

Appointing a woman to such a position in Saudi universities had never been done before, but luckily an approval from the Ministry of Higher Education (MOHE) was quickly granted to confirm my position and official job title.

Being in the women campus separate from the FMAS men section, the work affiliated with my post was almost an Acting Dean. Being in such position, I had to select the best 20 students to be enrolled in the medical program and had to refused many qualified students. Thereupon, I went on to establish a BA degree program in Natural Sciences for women, within the FMAS facilities. The first group of students was enrolled in 1975. I remained in charge of this college and involved with its development until it became a completely independent Natural Science College of KAAU three years later.

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My most significant achievement at the foundation phase was made when I made sure that the commencement of studies of the Medical and Natural Science for women to start on the same day as their male counterparts started their classes. This was unusual in Saudi universities where women were usually enrolled many years after men were enrolled in the same colleges.

In 1976 I managed to gain an approval to establish a Nursing Program at FMAS-KAAU for women only. I was given the full responsibilities for preparing the program's curriculum. The curricula of many accredited nursing schools in developed and developing countries were reviewed, followed by visits and discussions with the concerned authorities in those countries. Together with my enthusiastic team, we set up the full curriculum to be proposed for ratification by the MOHE.

The first year core curriculum courses (which medical and nursing women students study together), the corresponding laboratory classes and clinical hours were presented to the International Advisory Board. These enjoyed tremendous support and encouragement from the concerned authorities: the Minister of Higher Education himself, the University Rector and the Deans of various colleges especially the College of Medicine. The Ministry of Health (MOH) and the World Health Organization Eastern Mediterranean Regional Office (WHO-EMRO) were also very enthusiastic about our planned project mainly due to the need of university graduate nurses, which did not exist in the Kingdom while the medical colleges produce many doctors.

Following the successful launch of the nursing program I was able to gain approval to hold and chair the first international women's conference in the Kingdom of Saudi Arabia. Its title was "The Philosophy of Nursing". In attendance were 18 international nursing authorities from outstanding institutions from around the world as well as academics and health service authorities from many countries. The conference was a huge success and initiated the interests in establishing similar programs in other universities and colleges in KSA. The extensive media coverage of the conference and of our nursing program was also a catalyst to encourage more women to join the nursing profession.

The nationwide interest in nursing was further invigorated by the fact that nursing was regarded as a pious profession in Islam. The wives and daughters of Prophet Mohamed (PBUH) all played their part in the early days of Islam by helping the sick and the wounded. The late Queen Effat was very supportive of home-grown nursing programs and even encouraged her own daughters and the daughters of other members of the Saudi Royal Family to join the nursing program in King Saud University in Riyadh. Despite all the above mentioned encouragements, the society still regards nursing as a lower career achievement than becoming a doctor.

In 1978 Crown Prince Fahd Bin Abdulaziz, inaugurated the first custom-built University Hospital at KAAU. In his speech at the opening ceremony he announced appreciation of my contribution and his pride in seeing one of his country's daughters becoming part of the driving force in our nation's transformation.

My Scientific Highlights

Research Activities

The Saudi Arabian pharmaceutical market remains completely dependent on imported medications. Dosages of these preparations are calibrated based on clinical trials documenting the response of the population where those medications were manufactured, tried and tested. Efficacy, toxicity and side effects to the drugs are also documented based on the same trials without enough attention given to ethnic diversity.

Ethnic and genetic factors play an important role in drug metabolism and there was a complete lack of information specific to the way that the Saudi populations respond to prescription medications. As a result, physicians were only being able to calculate dosages of their prescribed medication based on the empirical data that are based on foreign trials. In the majority of cases this is a safe and acceptable practice. However, in medications that have a narrow therapeutic index and are highly influenced by the rate of their metabolism, this practice can at best render the treatment ineffective and at times be as harmful as causing the death of the patient.

The aim of my research studies (Table 1) was to define the genetic influences of the Saudi population on drug metabolism and thereby documenting the effective as well the toxic doses specific to its ethnic group. My findings provided the basis for individualized medication and the smart prescription which are now trending in modern-day medical practice. This practice also has its economical benefits, by avoiding unnecessarily high dosages and the over-prescribing of sometimes extremely expensive medications.

Two papers from my researches (*2*, *3*), were the first of their kind to be published in international medical literature. These publications which define the genetic characteristics of drug metabolism of the Saudi population have been used as references in Pharmacogenetics ever since.

These two research projects were only made possible with the collaboration of Prof. Robert "Bob" Smith and Jeffrey Idle at St. Mary's Hospital and Medical School. During the academic year, I would conduct surveys and collect data as well as samples from volunteers within various population clusters in Saudi Arabia. I would then spend all my holidays running analytical tests on the samples collected, using the biochemical pharmacology department at St. Mary's Hospital, Medical School. Once completed and published this work was submitted with my application for Full Professorship in Pharmacology.

The work was difficult and time-consuming as expected, but it was made much harder, because of the lack of laboratory facilities in my country and the need to travel to accomplish the task. This served as an inspiration for me to establish high-standard laboratory facilities at KAAU for me to continue with my work as well as to allow aspiring scientists and physicians to locally conduct their research projects with ease. To achieve this, I submitted an application for funding to King Adulaziz City for Science and Technology (KACST), a government authority responsible for funding research projects in the KSA.

The grant was approved and the Drug Monitoring Unit (DMU) came into existence in 1982. Located at the King Fahd Medical Research Center (KFMRC)

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of KAAU in Jeddah, the DMU was the first facility of its kind in the Kingdom and probably one of the first in the whole Arab region. Being a research facility it also provided the previously unavailable public health service of blood drug level monitoring making it possible to calibrate dosages of medications highly specific to the individual patient's therapeutic needs. This facility insures the effective treatments while providing pharmacovigilance in preventing any harmful side effects or toxicity.

Table 1. Research Grants That I Obtained

(1) As Principal Investigator	
1982- 1985	Grant No. AR-4-021 sponsored by King Abdulazziz City for Science and Technology (KACST) "Design and Monitoring of Drug Plasma Levels for Optimal Therapeutic Response"
1988 – 1991	Grant No. 130/408, sponsored by KAU "A Study of Cyclosporine A as an immunosuppressant used by renal transplant patients in the western region of KSA"
1992 – 1993	Grant No. 026/411, sponsored by KAAU "Cyclosporine A efficacy as an immunosuppressive agent in kidney transplants"
2003 – 2004	Grant No. AR-21-81 KACST "Population Pharmacokinetics of Carbamazepine and Optimizing its use in Saudi Epileptic Children"
(2) As Co- Investigator	
1982	Grant AR-4 -004, sponsored by KACST "Survey for normal values among Saudi nationals living in the Jeddah area"
1996- 1997	Grant 101/ 416, sponsored by KAAU "Studies of the efficacy and consequences of chronic cyclosporine administration in kidney transplant patients"
(3) Collaborative Research	
1974	Chemical Pathology Department, Kings College, London University, UK.
1979 – 1981	Biochemistry and Experimental Pathogenetics Dept. at St Mary's Hospital Medical School, London University, UK.

In 1983 I was granted full professorship in Pharmacology thereby becoming the first Professor of Pharmacology amongst all Saudi men and women. This also meant that I was the first Saudi woman to become a full professor amongst all subjects.

Since the time DMU was founded till date, over 40 senior scientists and physicians (mainly men) from various medical specialties and institutions joint in high standard multidisciplinary healthcare research projects. The patients' data compiled in DMU were the main research material which also served clinicians

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in other medical publications and was a training ground for them to be involved in study design, laboratory and statistical data analysis. Post-graduate research students from local and neighboring countries were involved in the projects and and were given the chance of running their analytical studies using DMU facilities. As a result of this teamwork, spread of awareness of the importance of individualized medications and use of drug level monitoring was initiated for the first time in the region. More than 38 peer reviewed research articles were published in high impact scientific and medical journals and more than 60 presentations in specialized international conferences and meetings about rational use of drugs and pharmacovigilance awareness. These facilitated promotions to higher academic ranks of all involved investigators (*4–9*).

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Other Positions

While working at KAAU, I also had the opportunity to serve as a delegate to other projects and was assigned to other jobs in other institutions.

Serving the Health Sector of the Armed Forces and Aviation

In response to their General Director's request, I accepted the post as Establishing Dean of the School of Health Sciences for Women at King Fahd Military Hospital in Jeddah. The objective of this school was to train and qualify paramedics to work within different medical specialties in the military hospitals. I designed an specialized secondary school program by which student study during the three years official secondary school qualifying courses plus one health science paramedic subject.

Serving in the World Health Organization (WHO)

In 1996-1998, I was appointed Regional Advisor of Essential Drug Program in the Eastern Mediterranean Regional Office (EMRO) thereby becoming the first Saudi Arabian woman to hold an official staff position at the WHO. My responsibility at EMRO was to ensure drug safety, effectiveness and availability of drugs in each of the 23 countries of the region that is under its supervision. My work with the WHO was a delightful and invigorating experience where I had the opportunity to meet, collaborate and advise highly qualified professionals and government officials who shared with me the same scientific interests. I also had the opportunity to represent the WHO in many conferences and workshops throughout the region. In my home town, Jeddah for example, I was the WHO representative in the International Conference on Herbal Medicine, which was sponsored by HRH Prince Majid Bin Abdulaziz, Governor of Makkah Region of KSA (Figure 1).

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Figure 1. HRH Prince Majid Bin Abulaziz, awards the Trophy of the International Herbal Medicine Conference to WHO Representative Prof. Samira Islam. (Courtesy of the author.) (see color insert)

Establishing Dean – Effat College

At a time when I was excelling at my prestigious job as Regional Adviser for the WHO Drug Program in charge of 23 countries in the Eastern Mediterranean Region, I received the personal request of Queen Effat saying that she always wished to have me working for her but did not have the academic rank suitable for my qualification. Fortunately, permission to open private university colleges was made possible. I still remember Queen Effat words, "I need you to establish for me the first private university college in the Kingdom".

My love and admiration for this visionary and courageous woman made me accept the challenge without hesitation. I resigned from my WHO position to take on this mammoth task.

There were countless obstacles to overcome. Being the first college of its kind, I had to tackle a lot of issues with MOHE. This was especially so, because they wanted my work to be set as a standard for similar projects that had applied to them for private colleges licences. Some of the most difficult tasks in this endeavour, was to convert a pre-university old school buildings with its bureaucratic key staff into state of the art university premises and to equip them with modern classrooms and scientific facilities that had to be acquired. Concomitantly, I was in charge of setting up the six various BSc academic curricula for the subjects to be taught at Effat College by collaborating with many colleges and experts from all over the world.

Effat College is now Effat University. It was the first private College for women in Saudi Arabia. I am full of pride to have been given the chance to help Queen Effat realise one of her most important achievements in advancing women's education and for her to see the first batch of of students enrolled in her college before her death.

Returning to Jeddah, I was able to dedicate some of my time to my scientific interests at the Pharmacology Department, FMAS as well as DMU, KFMRC of KAAU

Social Services

For almost 50 years I have been an active member of different welfare and professional societies and contributed to several media productions both as broadcasts and in print. My objectives are to increase awareness of:

(a) Drug abuse, misuse, toxicity among people from all walks of life, by conducting courses and training workshops for school educators, sports trainers and social workers. Recognition of drugs abuse and abusers as well as pathways taken to prevent and treat such problems. I also published Arabic language public awareness brochures on drug abuse.
(b) General health as well as hereditary disease e.g. Thalassemia.
(c) Women's welfare and their empowerment through national and international conferences and meetings.
(d) Women's education and support of their research projects in science and technology.
(e) Women's valuable contribution to their society by joining the nursing profession. This was achieved by promoting its professional and social image through establishing the high standard educational program which start with the core curricula with the medical students as well as conducting the first international women's conference on "The Philosophy of Nursing".

As part of my philanthropic work, I established Dr. Darhouse Medical Centre in 2004 and I have acted as its CEO ever since. This non-profit clinic is located in Gholeil, a highly populated low income District of Jeddah (Figure 2). The aim of this clinic is to care for the medical needs of the poor, regardless of their nationality or social status**.**

Figure 2. Entrance of Dr. Darhouse Medical Centre. (Courtesy of the author.)

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National and International Recognition

UNESCO–L'Oreal "For Women in Science Awards"

This award, which was first instituted in 1998, selects women scientists from all over the world's six continents who have made a major contribution to their areas of expertise. Saudi Arabia, China, Japan, Taiwan, Korea and India were the six countries with their respective women scientists, chosen from Asia that year.

In late 1999 the UNESCO awards committee in Paris nominated me as one of 32 finalists out of 100 scientists initially shortlisted for the award. I was invited to participate in the L'Oreal-sponsored scientific meetings, symposia and award ceremonies which were held in Paris on 6-12 January 2000. A ceremony was held especially for me in Dubai, U.A.E. on May 2000 (Figure 3) attended by many key personalities in the Arab Region.

Figure 3. The author receiving the UNESCO/L'Oreal "For Women in Science Award" in Dubai, U.A.E. May 2000. (Courtesy of the author.) (see color insert)

During the meetings I shared my views that scientists' achievements are not limited by what country they come from or by gender. I was able to share my own experiences that despite working within a man-dominated conservative society with strict customs and regulations, I was able to successfully gain the biggest national grant provided by KACST and the position of Principal Investigator of a three-year research project working with a team of four senior Ph.D. and medical fellows co-investigators who were all men (Table 1).

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Makkah Award for Cultural and Scientific Excellence

Established in 2009 awarded to Saudi citizens and institutes, for different exemplary contributions to Saudi Society. I was one of the first ever individuals to be selected for this award together with nine other male laureates representing large companies and institutes. I received the award for my contribution to "Science and Research" in Saudi Arabia (Figure 4).

Figure 4. The author receiving 'Makkah Award" for Cultural and Scientific Excellence', in May 2009 from HRH Prince Khaled al Faisal (L), Prof. Abdulaziz Al Kodairy (far L) and Sheikh Saleh Kamel (R) witnessing. (Courtesy of the author.) (see color insert)

Looking to the Future

Because of the government's commitment to women's education, the number of girls' schools increased faster than boys' schools. According to the World Bank, in the year 2008, the literacy rate for females ages 15-24 in KSA was 97 % (*10*)

In 2009, an expert in administration became the first woman minister in Saudi Arabia. Nora Bint Abdullah Al-Fayez, was appointed deputy Education Minister in charge of a new section of the Ministry of Education responsible for women' and women's education. In addition, the Saudi government now offers one of the world's largest scholarship programs for women. This resulted in thousands of women earning advanced degrees, including doctorate degrees from Western universities (*11*).

Women educational reforms begun by starting the government official primary school in 1960 and accelerated in recent years under the leadership of King Abdullah, who has given Saudi women equal access and support for education with dramatic results. More than ever, women are taking the lead in education (Figure 5). Please note that the apparent decrease between the year 2006 and 2011 is due to newly started King Abdullah scholarship-program for studying abroad (*12*).

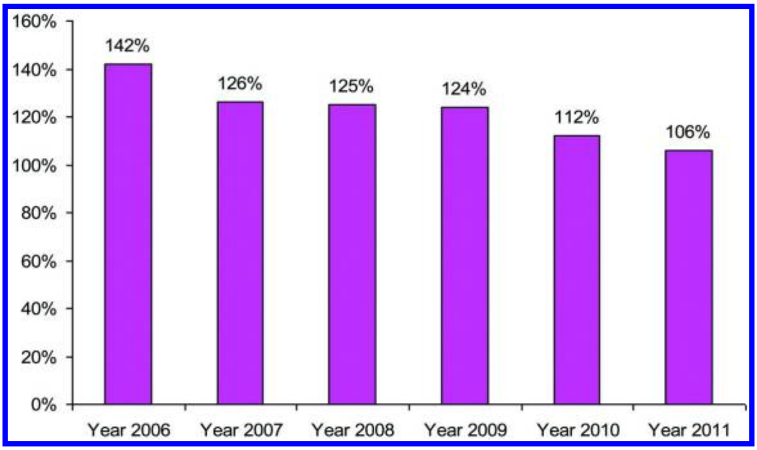

Figure 5. Ratio of women to men tertiary level enrolment in Saudi Arabia by year.

World Bank and Saudi government figures show that the ratio of women to men in tertiary level enrolment is consistently high. In 2012, more than half of all university students (58%) were women (*12*).

In 2010, the ratio of women to men in higher education was 1.5 % higher than in the USA, Japan, and several European countries. Saudi women are also pursuing the sciences in ever increasing numbers at universities both in the Kingdom and abroad.

The Kingdom has seen an influx of women students taking an interest in science nationally (Figure 6) and internationally.

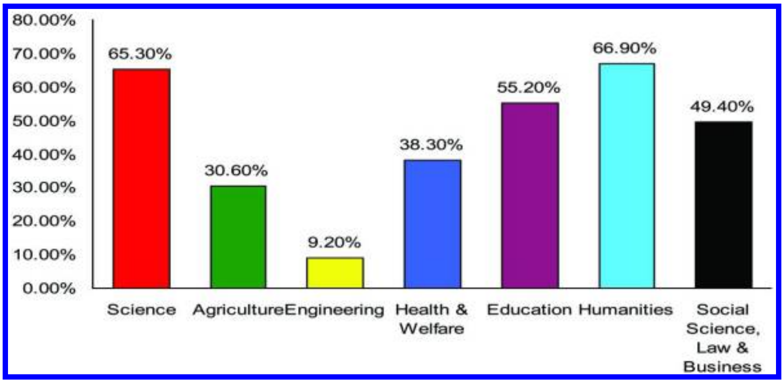

Figure 6. Women's share of enrollees in tertiary level in Saudi Arabia during the year 2011 by field of study.

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In 1989 the number of graduates from all of the Kingdom's colleges and universities was almost the same for men and women: about 7,000 each. During the years 2008 – 2011, the percentage of women graduates out-numbered men in all major fields of study except agriculture and engineering (Figure 7) (*13–16*)

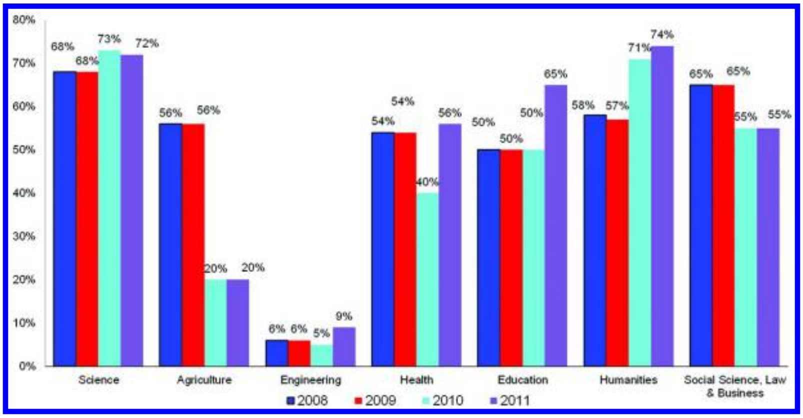

Figure 7. Women's share of graduates in tertiary level in Saudi Arabia in the years 2008- 2011 by fields of study

Scientific fields in Saudi Arabia continue to be dominated by men, but that also remains the reality in the USA and European nations.

Although there remains strong resistance to women's social freedoms, rights, and job opportunities in Saudi Arabia, there is a good reason for optimism about the future of Saudi women. In 2004, HRH King Abdullah bin Abdul Aziz al-Saud, The Custodian of the two Holy Mosques issued a decree encouraging women to seek jobs in fields that had previously been reserved for men, such as law and business. That was one of many signals he has sent suggesting that Saudi Arabia cannot progress economically or socially without giving more power to women (*11*).

More than 22,000 commercial licenses have been issued to women, many of whom run their own beauty, furniture and fashion business. Women are also beginning to realize the importance of investments, and so it happens that women now own nearly 20 percent of mutual funds. It is believed that about SR15 billion in cash assets are owned by women and stored in current accounts (*13*). Women also have a strong presence in medical fields; about 40% of practicing Saudi doctors is women (*17*).

Probably the biggest change for Saudi women in recent years occurred in September 2011, when King Abdullah granted them the right to vote in beginning of the year 2015 and in 2013 appointed 30 women (20%) as members of the consultative Shura council. "We refuse to marginalize the role of women in Saudi society," the King declared in his speech when announcing his planned reforms. Women certainly remain marginalized in Saudi Arabia, but given the combination of King Abdullah's futuristic thinking and boldness, Saudi women have demonstrated determination and vigorous pursuit of education. With the winds of change sweeping across the Middle East, it is easy to imagine many more Saudi women serving as successful doctors, teachers, and administrators, but also as physicists, engineers, lawyers and entrepreneurs. Maybe one day in the near future, they will be even driving their own cars to their place of work.

My journey through science has been most rewarding. It began at a place and time where, I was a girl with big dreams was only lucky to even learn how to read and write. Good fortune blessed me with a family that understood the importance of education. They gave me a rare opportunity and I did my best to make them proud.

I have learnt a lot and have taught a lot. My research work has been a wonderful experience that has hopefully been of great use to other scientists and of benefit to their patients and society.

Through this journey I have witnessed dramatic changes to the education system for women in my country. Returning to Saudi Arabia at a time when cultural acceptance to women's education was slowly gaining momentum, with the enthusiasm and support of friends and family, visionary members of the royal family and government officials, against all odds as a woman, I was able to initiate for the fist time the enrolment of women into Saudi universities as official student and establish several scientific higher educational programs for women in Saudi universities. Such programs have now flourished all over the country and had become an essential part of our education system.

With all that in mind, I am even more inspired and invigorated to continue my quest on behalf of women and science in my beloved country, Saudi Arabia.

Acknowledgments

Acknowledgments are due to my beloved parents (May they rest in peace), Sheikh Ibrahim Mustafa Islam and Mrs. Saadia Mustafa Fathalla Alsayed (Figure 8) and my three beloved children (Figure 9)

Figure 8. My parents, Sheikh Ibrahim Musta Islam (L) and Mrs. Saadiya Mustafa Fathulla Alsayed (R). (Courtesy of the author.) (see color insert)

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Figure 9. (From L) Kholoud Darhouse, Business Administrator and mother of Marya Bougary; the author; Dr. Khaled Darhouse, MRCOG Consultant Obstetrician and Gynecologist in Reproductive Medicine and Assisted Conception and father of Zoeyla Darhouse; and Dr. Nagham Darhouse, MRCS, Surgeon in Reconstructive Surgery. (Courtesy of the author.) (see color insert)

Special thanks are due to Dr. Marinda Li Wu, 2013 President of the American Chemical Society for inviting me to the International symposium on “Women Leaders from the Global Chemistry Enterprise” on August 10–14, 2014 in San Francisco, CA U. S.A and giving me the opportunity to share my "long and winding but very fulfilling" scientific career path.

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Chapter 31

Challenges and Opportunities in Indian Science: My Experiences

M. Lakshmi Kantam*

(Former Director, CSIR-IICT, Hyderabad)
Professor, Department of Chemical Sciences,
Tezpur University(A Central University)
Tezpur-784028, Assam, India
***E-mail: mlk@tezu.ernet.in; mlakshmi@iict.res.in.**

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My journey towards the design and development of catalysts started with an aim to develop innovative, green, and economical processes for chemical industry and to fulfill my life's ambition of serving the society through meaningful research contributions. Our research group developed cutting edge technologies for fine chemicals, employing catalysts that meet stringent environmental specifications in pollution abatement. We made significant contributions in developing various novel solid acids / bases, homogeneous and heterogeneous catalysts and processes for alkylation, nitration, oxidation, C-C and C-N coupling, asymmetric catalysis and other reactions. I have 301 research publications and 42 international patents to my credit. I serve as an editorial board member for The Chemical Record and Journal of Chemical Sciences. I am a Fellow of Indian National Science Academy, India and Royal Society of Chemistry (London, U.K.). I am a member of scientific committees in India and am the Chairperson for Chemical Sciences of Women Scientists Scheme, Department of Science and Technology, India. I am an Adjunct Professor at RMIT University, Melbourne, Australia. My father was a medical doctor and he had a great influence on me. In the early sixties, I was the first girl to go to school and college on a bicycle in my native place and this became a trend setter for many girls later. This kind of upbringing helped me to be bold in all walks of my life. Despite having

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an opportunity to go for medical education, I opted for a Ph. D. in Chemistry. In accordance with my professional ambition, I joined CSIR-IICT, Hyderabad, a premier research laboratory in Chemical Sciences and Technology, as a Scientist in 1984. I served as Head, Inorganic & Physical Chemistry Division for 9 years and rose to the position of Director, CSIR-IICT in 2013. I attribute my success to my willingness to do hard work and strong will to make appropriate decisions.

Introduction

India is a unique example of unity in diversity and is known as a land of opportunities. This great nation offers abundant opportunities for women, not only in science, but also in many other walks of life. There is a progressive increase in the participation of women in science, and many of them are at leadership positions of different organizations. I, for example, served as the Director of CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad, from April 2013 to March 2015. Around six decades of my personal life and over three decades of professional journey in science have been very enterprising.

Childhood, Family, and Early Education

I was born in 1955 in Tenali, a town in Guntur District of Andhra Pradesh, India. Tenali, also known as Andhra Paris, is famous for its rich historical, agricultural, cultural and literary background. Tenali Ramakrishna, a scholarly poet, well known for his wit and impressive Telugu poetry, who was in the court of Emperor Krishnadeva Raya of Vijayanagara Empire of 16th century, hailed from here.

My father, Dr. Mannepalli Seshagiri Rao, who is my role model, was a medical doctor and a man of few words with a clear vision about the future and progressive thinking, while my mother, Mrs. Rama Saraswathi, is a house wife. I was fortunate enough to be born in a well-educated family. As is the norm in India, ours was a joint family, where my grandparents, uncles and aunts shared the same house. Both my grandfathers (paternal and maternal) were very famous advocates of an independent India during the British Period. My brother Mr. Shankar and I were nurtured in this great atmosphere and were cared for by our uncles and aunts. My family still continues to be a joint one with my brother, sister-in- law, my nephew and my parents staying together for the past 34 years (Figure 1).

I completed my school education in the late sixties at Netaji Upper Primary School, Municipal School and Iowa Girls High School in Repalle, a coastal town of Guntur District, located on the banks of holy River Krishna. Repalle is well known for its agriculture, scenic beauty and educational institutions. I started my schooling along with my brother, who later moved to Sainik School for his higher education. In those days in a small town, I became a trend setter for many girls by my going to school on bicycle.

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Figure 1. My family. (Courtesy of the author.)

Traditionally, in Indian culture, a woman holds a very respectable position at home and society, but it is not the same in education and particularly in science. Although very few women chose science and education, the role of women was mostly limited to mentoring the family and taking care of home. In independent India there has been a radical shift in the thinking of society and women are taking up science on par with men. It is highly appropriate to quote the father of Indian Nation, Mahatma Gandhi, who said, "When a man is educated, an individual is educated. When a woman is educated, a family and a country are educated." India has implemented this principle and I feel lucky that I am one of the beneficiaries due to the strong support and progressive thinking of my family. This upbringing has helped me enormously in all walks of my life to face any problems boldly.

Opting Science as Career and Higher Education

Generally most of the Indian parents want their children, be it a son or a daughter, to either become an engineer or a doctor. If not that, then the girls in particular are asked to prefer one of the Arts subjects, rather than science. My father also wanted me to opt for medical education. When I took a decision to pursue my career in science, he concurred with me and supported my endeavours in science. He used to tell me that "you should be the decision maker for your own career and I will not force you to fulfil my wish". After this decision I completed my graduation at JMJ College for Women and VSR College, Tenali, opting to study Chemistry, Botany and Zoology. I was more fascinated by Chemistry from the beginning. This fascination was due to inventions in Chemistry and the industrial applications of it. During my college days, the major learning for me was to listen to everyone's suggestions but do whatever your conscience tells you to do if you want to lead a successful life.

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Another major decision, rather the turning point of my life, was to pursue my post-graduate degree in Chemistry at Kurukshetra University, Kurukshetra, in northern India. It takes almost 36 hours to travel by train to Kurukshetra from my native place. It was a difficult decision in those days for a woman to go away from home for education. My father's friends and well-wishers advised him against this but my father stood behind me like a solid rock. After completing my post-graduation in chemistry, I had options like taking on private or government jobs, but I pursued my passion and continued further in scientific research. I worked for my Ph. D. in Chemistry at Kurukshetra University, under the supervision of Prof. Yatirajam. I owe a lot to the professor, my guide and mentor, for training me on research in applied industrial chemistry and encouraging me to become a strong and independent researcher. He always told me that research should be carried out for the betterment of society and the ultimate aim of research should be for the application to the end user. Kurukshetra is far from my native place. I found my second home in the house of my professor, Prof. Yatirajam away from my own in Repalle, where I stayed with his family, his wife, two daughters and a son, for more than seven and half years. He and his wife took care of me as their fourth child and as an elder daughter. Everyone in Kurukshetra University thought that I was the eldest daughter of Prof. Yatirajam and were wondering on how I could work with my father for the Ph. D.

Professional Career

After completion of my Ph. D. at Kurukshetra, I came back to Tenali and joined as a Lecturer, for a brief period of time, in the same college where I did my graduation. Then came the turning point of my life, i.e., joining the Regional Research Laboratory, Hyderabad, now CSIR-IICT, first as a Post-doctoral fellow and later as a Scientist B. Interestingly, at RRL, I found the potential of fulfilling my dream of finding applications of research in the process chemistry and technology development. This great institute is well known for its contributions in the pharma, agrochemical and other industries. I joined the electrifying atmosphere of the institute and worked with Dr. B. M. Choudary for 21years, where a lot of research was going on in the area of process chemistry in these sectors to fulfil the growing needs of the country towards self-reliance. Thus, I decided to pursue my career in technology and process development. I was well aware that good basic science only can lead to good technology and one has to strike a balance between them to provide a good technology 'on time'. Keeping this vision in mind, we had initiated research in our group covering both aspects in the area of catalysis science and technology. My prime objective was to serve the chemical, pharmaceutical and strategic sectors through continuous efforts in this area. During the course of my scientific career, I have completed several industrial projects in applied research in I & PC division, while continuing my basic research in the areas of catalysis for sustainable product/process development. Several of my basic research results are being utilized for the industrial process development today.

Forging International Collaborations

By choosing to pursue science as a career, I felt that it should be truly international in character with no boundaries. I am an avid supporter of this and started forging international collaborations from the very early part of my professional career. Soon after joining RRL, Hyderabad, I visited the laboratory of Prof. Likholobov in Russia, during 1987, as a visiting scientist. I moved to the laboratory of Prof. I. E. Marko at University of Sheffield, U.K., during 1990-91 (Figure 2) to advance my knowledge in the area of organometallic chemistry as a research associate and I spent more than a year and half there, which perhaps is my longest stay abroad. I was offered the prestigious JSPS fellowship as a visiting scientist during September 1995 to July 1996 by Prof. Takaya and Prof. Nozaki at Kyoto University, Kyoto, Japan, where I worked in the area of frontiers of catalysis. I visited the laboratory of Prof. Figueras at IRC, Lyon (Figure 3), France, and also Prof. Iwasawa at Tokyo University, Tokyo (Figure 4) to work in the area of industrial catalysis. I would also like to mention the names of Prof. A. Vinu, NIMS, Tsukuba, Japan; Prof. Bhargava, RMIT University (Figure 5), Melbourne, Australia; Prof. K. Ramanuja Chary, Rowan University, U.S.A. (Figure 6) and Prof. K. Klabunde, U.S.A. who invited me as visiting scientist and provided warm hospitability with fruitful scientific collaborations. To add further, I acknowledge the support of professors and industries across the globe who have offered positions to my research students in their organizations, as I always count it is one of the parameters of acceptance of our research on a wider platform. I would like to mention another important point here that I have visited and worked in several laboratories across the globe and got lucrative job opportunities in U.K., Japan and France, but I was firm in continuing my job in India and serve my people, besides serving all human beings through appropriate technology development.

Figure 2. Prof. I. E. Marko. (Courtesy of the author.)

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Figure 3. Prof. Figueras, IRC, France. (Courtesy of the author.)

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Figure 4. Prof. Iwasawa, Tokyo University, Japan. (Courtesy of the author.)

Elevation as Head, I&PC, CSIR-IICT

I was elevated to the position of Head of the Inorganic and Physical Chemistry (I&PC) Division of CSIR-Indian Institute of Chemical Technology (IICT), Hyderabad, in 2005, where I led a team of 35 highly qualified scientists, 20 supporting technical staff and 140 young research scholars. Under my leadership, I&PC division provided excellent research outputs covering Heterogeneous Catalysis, Homogeneous Catalysis, Organometallic Chemistry, Material Science, and Nanotechnology, catering to the needs of health, energy and environmental sectors. My emphasis has all along been on the promotion of both basic and industrial research.

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Figure 5. Prof. Bhargava, RMIT, Australia. (Courtesy of the author.)

Figure 6. Prof. K. Ramanuja Chary, Rowan University, U.S.A. and Dr.B.M. Reddy , IICT, Hyderabad. (Courtesy of the author.)

Appointment as Director CSIR-IICT

I was appointed as the Director of CSIR-IICT in April 2013, to lead this great institution with its main focus on chemical sciences and technologies. This was widely covered by media, since I am the first women director of CSIR laboratories (chain of 37 laboratories across India) in its existence of more than seven decades (Figure 7 and 8). However, I am a firm believer and advocate of gender equality; hence, I would like to be better termed as one of the directors of CSIR laboratories, rather than the first women director in the CSIR system. The moment I took over the reins, I refocused our orientation on technology and process development through involvement of industries, in parallel with continuing basic research in the chemical & allied sciences and engineering. Besides this, my focus is also on nurturing young talent and creating skilled and professional scientific human resource.

Figure 7. CSIR-IICT, Hyderabad, India. (Courtesy of the author.)

Figure 8. Director's Office, CSIR-IICT, Hyderabad, India. (Courtesy of the author.)

Scientific Contributions and Professional Accomplishments

My main research area has been Catalysis, Materials and Process Chemistry. During more than three decades of my research in this area, our team has been able to develop several novel homogeneous and heterogeneous catalysts for innovative, green, energy efficient and economical processes and technologies for industries. The development of specially designed homogeneous/heterogeneous catalysts for chemical reactions with innovative scientific inputs to achieve highest possible atom economy has been one of my prime objectives. In particular, our contributions are on the utilization of nanomaterials, hydrotalcites

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and hydroxyapatites as supports and catalysts for asymmetric catalysis for C-C and C-N coupling reactions. Development of ligand-free heterogeneous layered double hydroxide supported nano-palladium catalyst using basic LDH in place of basic ligands exhibiting higher activity and selectivity in the Heck olefination of chloroarenes is a success story. Asymmetric hydrosilylation of ketones to chiral secondary alcohols with good yields and excellent enantioselectivities using Cu-Al hydrotalcite and BINAP has opened up a new perspective.

Designed and developed recyclable heterogeneous catalysts, copper-exchanged fluorapatite and *tert.*-butoxyapatite by incorporating basic species F^-/$tBuO^-$ in apatite for N-arylation of imidazoles with chloroarenes and fluoroarenes for the first time. I have also carried out development of phosphine free homogeneous catalysts, palladium(II) complexes of tetradentate dicarboxyamide/dipyridyl ligands for Heck reaction of aryl halides - the first report on the use of purely N-donor ligands. Nanomaterials as catalysts and supports is another area which has systematically been exploited by my group for the advancement of science. In the area of technology development & demonstration, we have developed various new catalysts for the synthesis of organic intermediates and fine and bulk chemicals. Some of the process technologies demonstrated are: synthesis of triphenylphosphine, TBBA, *L*-phenylalanine, benzaldehyde from toluene, nitration of toluene, *tert*.-butyltoluene, *tert*.-butylbenzoic acid, and conversion of waste plastic to oils.

I have published around 301 research papers so far in reputed international and national journals with a '*h* index' around 42. I have 42 international and 42 national patents to my credit and 30 research students have obtained their Ph.D. degrees under my guidance.

In a career spanning over three decades, I have been recognized and rewarded by organizations, scientific bodies, universities and academies. Some of honours I received are: Honorary Doctorate (Honoris Causa) in Science by Sri Padmavathi Womens University, Tirupati (2014); Fellow of Indian National Science Academy (2014); NEERI CHEMCON Distinguished Speaker Award by Chemcon (2013); Fellow of Royal Society of Chemistry, London (2013); Vasvik Award (2011); Lifetime Achievement Award, Indian Chemical Society (2011); Platinum Jubilee Lecture Award (ISC-2010); Visiting Scientist, RMIT University, Melbourne, Australia (2009); Fellow of National Academy of Sciences, India (2008); Adjunct Professor, RMIT University, Melbourne, Australia (2008); B. D. Tilak Visiting Fellow, UICT, Mumbai (2008); Visiting Scientist, NIMS, Tsukuba, Japan (2008); RMIT Foundation Fellowship Award, RMIT University, Australia (2007); Fellow of Andhra Pradesh Akademy of Sciences, Hyderabad (2006) etc. I am the Chairperson, Subject Expert Committee, Women Scientist Scheme, Department of Science and Technology, Government of India.

My parents are the biggest influence in shaping my career and personal life. I regard my father as my role model and whatever I am today is due to his encouragement, forward thinking, vision, fast decision-making, and example of of intellectual freedom. I still remember his golden words: "Nobody can stop you from what you want to do". In this context, I take this opportunity to acknowledge Dr. B. M. Choudary, MD, Ogene Systems India Ltd., Hyderabad, all my former directors, Dr. G. Thyagarajan, Dr. A. V. Rama Rao, Dr. K. V. Raghavan and Dr. J.

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S. Yadav, Prof. M.K. Chaudhuri, Vice-Chancellor, Tezpur University, Prof. G. D. Yadav, Director, ICT, Mumbai, all my colleagues and students at CSIR-IICT for their contributions in my professional growth and all my collaborators from India and abroad. I would like to pay my profound gratitude to Prof. C. L. Khetrapal (Figure 9), who is my mentor and godfather in professional life .

Figure 9. Prof. Khetrapal, India. (Courtesy of the author.)

Opportunities and Challenges for Women in Indian Science: My Perspectives

It is my strong belief that, there are unlimited opportunities for women in Indian Science. One has to pursue dreams with passion, hard work, dedication and perseverance.

I would refrain from citing statistics of women in Indian Science, their roles in science and education, and the awards they have received. However, I would like to tell with certainty that the growth trend of women in Indian Science is in the positive direction. Women make several sacrifices, both professionally and personally, face daunting challenges related to culture and societal expectations, and have to strike a fine balance on two fronts - priority between the family and professional demands. The social norms/demands, societal structure, relationship between family and work, and the organizational processes of scientific institutions have been the root of the problems and challenges for women in Indian science (*1*, *2*). However, the people-centric sustainable development initiatives such as education, training, economic resources, information, communication and marketing are being implemented to ensure and enhance the participation of women in science and technology. The perseverance, intelligence, talent and overall qualities of women are being exploited to create rich S&T enterprises and capacity building (*3*). I strongly believe that knowledge does not differentiate

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between genders. Hence, we only have to change our perspective in our understanding, without having a pre-conceived notion on gender as a criterion. "Empowering women through science and technology, is about giving them the opportunity to advance themselves and become successful (*3*, *4*)." I would like to quote Maharishi Karve's vision of '*Sanskrita Stree Parashakti*' (an enlightened woman is a source of infinite strength). Hence, the world has to realize this strength and more participation of women in science is a must for the good of humanity and welfare of the world.

Conclusions

Looking back at my life so far, I feel a deep sense of gratitude for having been able to serve the scientific community through sheer determination and commitment within my limited capacity and resources. It has been a rich rewarding life, both intellectually and personally, and I am very proud of my association with a great organization like CSIR for more than three decades.

I urge all the youngsters to opt for a career in the fascinating world of science and I feel that the innovative and enterprising youngsters have the potential to make it. Can you imagine the happiness one gets when the products/processes/materials developed by you are in the market? Or a reaction, an instrument, or a diagnostic tool that bears of your name? Listen to the suggestions and opinions of all around you, analyze yourself and the situation, but be firm in pursuing your dream, by being responsive to the situation, rather than being reactive. Finally, I would like to end with the saying "Nothing is impossible, provided you have a strong will to succeed."

Acknowledgments

Thanks are due to Dr Marinda Li Wu, 2013 President of the American Chemical Society for inviting me to the Symposium on "ACS Women Leaders of the Global Chemical Enterprise" in San Francisco and giving me the opportunity to share my thoughts.

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Chapter 32

Participation of Women Scientists and Engineers in Japan

Kazue Kurihara*

Tohoku University,
Sendai, Miyagi Prefecture 980-8577, Japan
***E-mail: kurihara@tagen.tohoku.ac.jp.**

Japan is making efforts to promote more women scientists and engineers because the Japanese society needs to utilize all available resources and possibilities for its vital growth when it faces the so-called "Shoshi-ka" (low birth-rate). Another reason for the promotion is that as more women study science and engineering now, hopefully they will work throughout their entire careers, unlike the previous generations. Therefore, it is important that the political, societal and academic systems support them. This change is not so easy because the Japanese society has had a long tradition that men and women serve different roles in the society. In this article, I will describe our efforts, and how I myself have worked through the systems.

Introduction

Japan is currently making serious efforts to increase the number of female scientists, engineers and professionals in its workforce. However, despite its efforts, Japan still falls behind in promoting women to research positions (Figure 1). This is largely because the Japanese traditionally expect men and women to play different roles in the society and the family; women attending to family matters at home, while men work outside the home. Changing this belief is not an easy task. Although the change is slow, Japan is making progress.

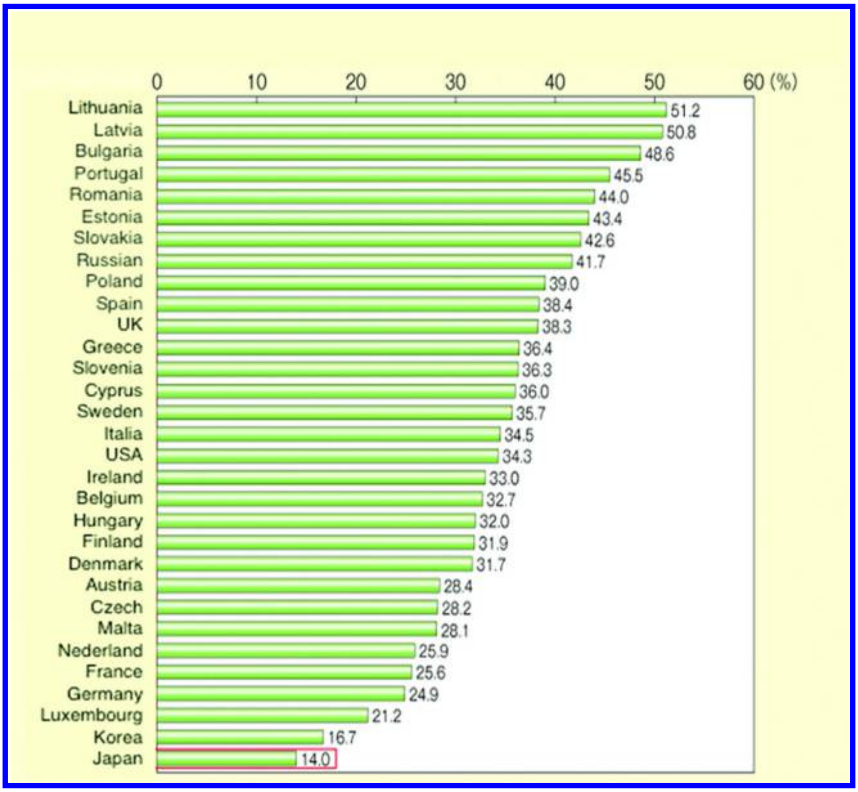

Figure 1. The percentage of female researchers in OECD countries. Japan and Korea, which share similar cultures, are at the bottom. (2013 White Paper from Gender Equality Bureau Cabinet Office, Japan; used with permission) (1).

A number of circumstances are leading to the promotion of women. Now, more than ever before, women are pursuing science and engineering at universities and choosing to work throughout their careers, unlike previous generations, who usually ended their careers upon marriage. There is also a growing acceptance that Japanese society needs a wider variety of talent for flexible and sustainable development. Perhaps the most practical circumstance is the declining birth-rate in Japan. In 2014, the Japanese birthrate was 1.43. As a result, Japan needs everyone, regardless of gender, to work together for the future. Because of these circumstances, a general consensus has emerged that Japanese women need to be encouraged to work.

National Survey of Women's Status Conducted by EPMEWSE

The promotion of women is not a new challenge for Japan. Academic associations, such as the Japan Association of National Universities, have been leading the effort to promote women scientists in the workforce for quite some time. They have tried using top-down promotion and setting female enrollment targets at universities. But this approach was not very successful, and it took some time before real promotion, starting at the bottom level, began to occur. The turning point for promotion came when a liaison of academic societies, known as the Japan Inter-Society Liaison Association Committee for Promoting Equal Participation of Men and Women in Science and Engineering (EPMEWSE) – which included the Chemical Society of Japan -- conducted a large national survey on the status of women scientists (*2*). The survey received more 20,000 responses, and revealed a number of problems:

(1) Three quarters of the women and half of the men surveyed thought there was unequal treatment in the workplace in science and engineering fields.

(2) Among scientists above the age of 40, only 60-70% of women are married while more than 90% of men are married. On the average, these women have one child, while the men have two.
About 40% of women in their 30's in academia have taken child-care leave, while ca. 80% of women in their 30's in industry professions have taken child-care leave.

This survey transformed the problems which were considered "personal (individual)" to "social" problems. This survey report motivated many groups and associations to make promotional proposals to the government. These efforts resulted in somewhat increased social promotion. The Third Science and Technology Basic Plan (FY2006-FY2010) created the goal of increasing female scientists by 25% (Science 20 %, Engineering 15 %, Agriculture 30 %, Health Science 30 %) among new appointments. This goal was raised in the fourth plan (FY2011- 2015) to 30%. Affirmative actions were taken to meet these goals.

Recent Affirmative Actions at Universities in Japan

In 2006, MEXT (Ministry of Education, Culture, Sports, Science and Technology) launched two major programs to support women scientists and engineers. The first was the Restart Post-doctoral (RPD) Fellowships for Ph.D.s who have stopped working for child-care in the last five years. Fifty fellowships are granted each year, which provide a 362,000 yen monthly allowance for three years, as well as a 1.5 million yen yearly research grant. Researchers of all fields of science including humanities can apply for this fellowship.

The second program was the "Model Project for Promotion of Women Scientists," where universities propose a unique model plan for increasing the employment of women faculty members in science and engineering, and receive a yearly 30 million yen grant to carry out their plan for three years. As of 2014, 76 universities have been accepted in this program. Tohoku University, to which I belong, was one of the ten universities selected in 2006 to conduct this project.

Tohoku University's model plan aimed to help scientists with small children by checking work regulations, introducing a shorter working hour system, employing post-docs and providing financial support to baby sitters. The program also supported an "on campus day care center for recovering children," initially to support university hospital staff, but later, with the program's support, it expanded to include faculty and students as well. Female graduate students also worked to promote science to high school girls as part of the program. The model plan has led to successive programs, which have more effect on the acceleration of the female faculty employment.

How have we progressed? From 2004 to 2012, there has been a significant increase in female faculty at Japanese universities across all levels of disciplines (Figure 2). In addition, the number of women who choose to end their careers in their 30's and 40's has decreased substantially over a similar timeframe (Figure 3).

For the fiscal year 2015, MEXT will enhance the promotion based on the current government policy to achieve 'A Society where Women Shine'. It will increase the number of RPD fellowships to 75 and the support to universities for improving the working conditions of women from 984 million yen in 2014 to 1088 million yen in 2015.

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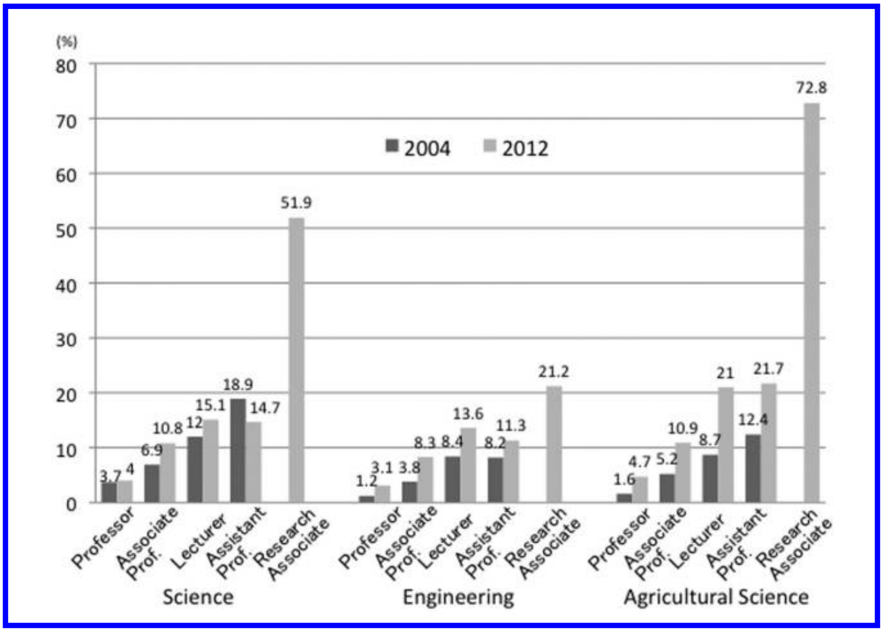

Figure 2. The percentage of women employed in various faculty positions at Japanese universities from 2004 to 2012. The research associate position was recently introduced and did not exist in 2004. (2005 & 2013 White Paper from Gender Equality Bureau Cabinet Office, Japan; used with permission) (3, 4)

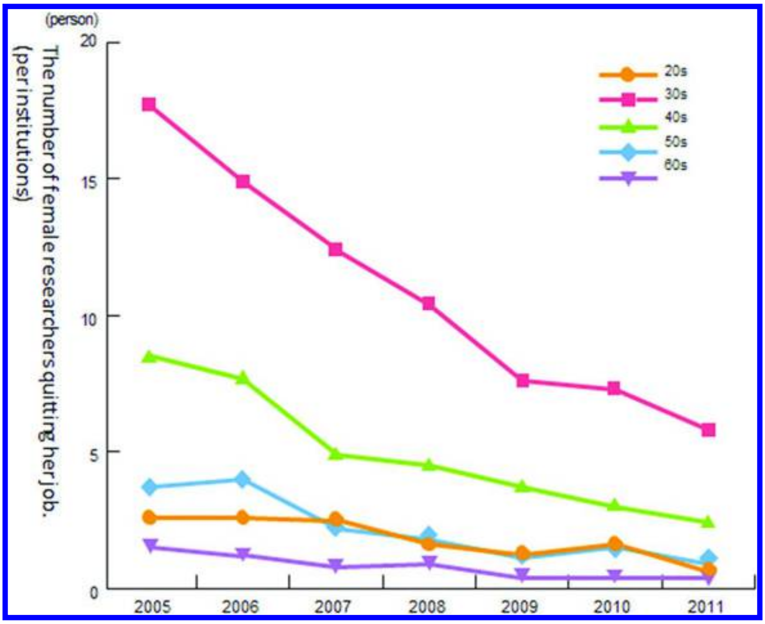

Figure 3. The average number of female researchers quitting their jobs at institutions supported by the model plan from 2005 to 2011. (Report from MEXT, 2012; used with permission) (5)

My Professional Journey as Scientist

For the last section of this chapter, I will tell a little bit about myself. I did my undergraduate education at Ochanomizu University and did my Ph.D. at the University of Tokyo. I appreciated the education I received in these very different environments. Ochanomizu University was the first women's college in Japan, so its alumnae include the first female imperial university students at Tohoku University in 1913 and the first female graduate student at the University of Tokyo. I found many role models there. At the University of Tokyo, I met many colleagues, whom I still work with in academia. After receiving my Ph.D., I worked for a while at the group where I did my Ph.D. and then moved around the world as a post-doc, a research associate and a visiting scientist, before being offered a group leadership position in a large, five-year project in 1987. When the project ended, I was promoted to associate professor at Nagoya University in 1992, and then to professor at Tohoku University in 1997. These promotions marked the first time a female had ever filled those roles. I was the first female group leader of ERATO, the first female faculty member above the lecturer level at the engineering school of Nagoya University, and the first female professor at the school of natural sciences at Tohoku University. One may notice that these promotions coincided with the establishment of the essential laws for affirmative action in Japan: The Equal Employment Opportunity Law (1986) and The Basic

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Law for a Gender-equal Society (1999). I am part of the first generation of female scientists researching at the top universities in Japan. In order to achieve this, I had to work hard, but the changes in the Japanese society were also critical. Because of this, I try to volunteer for professional societies when possible. I am currently a member of the Science Council of Japan and the president of the International Association of Colloid and Interface Scientists (IACIS).

What is the key element in promoting women in science? I think the bottom line is the contributions to science. In my field of research, which is colloid and interface science, there were two famous, pioneering women: Agnes Pockels, who studied surface monolayers in her kitchen and published an article in Nature, which contributed to the establishment of surface science; and Katherine Burr Blodgett, who developed the method for transferring monolayers at the air-water interface on solid substrates. The Langmuir-Blodgett films, which are named after Katherine and her mentor and colleague, Irving Langmuir, provide a glimpse into her life. This history is perhaps why we have such active participation of women at IACIS, which elected its first female president in 1994. I became the second female president in 2012, and 16% of the current Council members of IACIS are women. This indicates that scientific achievements can overcome gender bias and encourage more women in science. Thus, as women scientists, we should work together and encourage one another to be successful.

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Chapter 33

Achieving Work-Family Harmony: My Experiences as a Chemist and a Housewife

Supawan Tantayanon*

Professor of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand
***E-mail: supawan.t@chula.ac.th.**

Growing up in a large, middle-class family shaped me to be strong and responsible. As a child, my mother trained me to do house work and taught me how to do it efficiently. Fortunately, my parents gave me the opportunity to obtain a good basic education and supported my decision to pursue higher education. During my studies, I learned how to adapt to my environment, which built my confidence. After earning a Ph.D. in chemistry, I taught and performed chemistry research. I was assigned to set up a new graduate program and then tasked with establishing the first college in Chulalongkorn University, focusing on petrochemical industry which was new to Thailand at the time. I later was a consultant of some petrochemical companies. This experience made me realize the importance of chemical safety for human health and the environment and the integration of chemistry, business and society. It influenced my teaching and research interest so much that my focus shifted to "greener" and application-driven chemistry. I then initiated and constructed two more new academic programs aimed at applied chemistry and the transformation of science and technology to innovation. Since the beginning of my teaching career, I served in several science and science-related foundations and societies, mainly involving science education and communication. My interests led me to focus on small-scale chemistry and green chemistry which I have tried to introduce to schools and universities in Thailand even now. This led me to invent the portable organic lab kit, which has the benefit of saving chemicals and energy, as well as reducing experiment

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time and waste. I was the first female President of two national societies and two international federations till now. Through the Chemical Society of Thailand and the Federation of Asian Chemical Societies, I contributed significantly to the scientific community and general public, both nationally and internationally. I did all this work while assuming the responsibilities of being a housewife and mother of two sons. However, my first priority has always been my family.

Learning Through Practice in My Childhood

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I was born in the small, old city of Ratchaburi, a glorious town during the Dvaravati period of Thai history. It is located on the bank of the Mae Klong River, 80 kilometers west of Bangkok and borders Myanmar on the west. It is a quiet city with a population of about 0.8 million people as of 2014. It is abundant in natural resources and historical sites, and its economy relies on all kinds of crops, vegetables and plant cultivation, as well as tourism.

I am the third child of 6 sons and 4 daughters in a middle-class family (Figure 1). However, I was the eldest daughter, as my elder sister died when she was six. My father was a Chinese medicine merchant and my mother was a housewife. My father worked very hard to earn enough money to raise us. He invested in many businesses with his friends in addition to Chinese medicine, but he often lost them, which created financial problems for our family. My mother helped earn some money from homemade fruit snacks and drinks she sold at home, while taking care of us and doing all the house work by herself. She was an excellent manager of our family. Each of us was assigned to do some house work and look after the younger ones since we were around 9-10 years old. I was often called on to help my mother cook, wash dishes, clean the house, prepare beds and more. My mother trained me to work efficiently and taught me several tricks and techniques. For example, she taught me to cook several dishes in one pan from a mild dish to the more spicy ones without washing the pan in between, which I still do today. My mother did everything well, quickly and inexpensively. She saved as much as possible and whenever practicable. She collected the discarded items that could be turned into cash, like the empty glass bottles of the energy drinks sold in our shop, and sell them back to the manufacturer. She also taught me how to listen and observe what other people needed so that we would better satisfy them.

Increasingly I developed her attitude and strong work ethic. When I turned 10, I began to earn some money myself every summer, selling paper bags made from our used workbooks or exercise books at higher prices than what they would fetch as used writing papers. I tutored my younger brothers and sisters, at first just for fun, but later for pocket money from my father. My neighbors learned of my teaching, and they paid me to tutor their children. My family was slightly wealthier than our neighbors. My father was very sociable and built connections for his career. He was always the first to have the best-brand radio, a black-and-white television, and later a color one, and kept upgrading to the brand new ones, so his friends and children in the area would often come to watch TV at my house. One

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day, I set a rule that everyone had to buy something from our shop to be able to watch a TV, so we could sell more products. When I was in 11th and 12th grade, I would cook breakfast for everyone in my family and clean everything up before I bicycled to school. As a result, I never arrived at school in time to get in line with other students to sing the national anthem, so I volunteered to work in the library while they were singing.

Figure 1. My parents, brothers and sisters. (Courtesy of the author.)

Both of my parents had only attended primary school. My mother had actually finished only the 1st grade because of the Chinese tradition that a girl should get married at a young age and be a housewife. Fortunately, they understood that education was important and paid for my siblings and I to go to private missionary schools, which taught grades 1-10 in our home town. These schools were strong in English and Mathematics, and so the tuition fee was more expensive than the state schools. At the time, only two state schools offered studies up to grade 12: one for males in science majors and the other for females in non-science majors. However, both accepted male and female students for 11th and 12th grade studies. My conservative grandparents, who moved from China to settle in Ratchaburi, were not supportive of my higher studies. Luckily, my parents were more progressive and allowed me to study as much as I wished.

I passed the entrance exams of both state schools, but chose to study science because I thought that it would give me better job opportunities. This decision influenced me enormously. As one of the 9 girls in the class and only one of the

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20 girls in a school of 900, I was a minority. Typically, the female students were always teased by male students, so I avoided being their target. In my English class, the teacher would ask every student questions, keeping everyone standing until someone answered correctly. More often than not, I was the last person to be called on and the only one to be able to answer correctly. Similarly, in my mathematics class, I was named the most meticulous, as I never made any mistakes in my calculations. All these experiences changed me so that I paid more attention on my studies. In grades 1-10, I actually never studied hard and was normally an average student in my class. As I studied harder, it was not surprising that I ranked second in the class after the final exam in grade 12.

After my father passed away at the age of 75, my mother became the central figure of my family. My mother was, of course, instrumental in all our successes. She was nominated by Ratchaburi provincial governor to receive the National Outstanding Mother of the Year in 2013, at the age of 91. She is now 93, healthy and still happy with the little work she can do to help my brother at the Chinese medicine shop. She currently has 18 sons, daughters and their spouses, 19 grandchildren and 5 grand grandchildren.

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My Interest in Chemistry

At the time, I did not have a plan for my life but knew that I must pursue science. I took the national entrance exam and was able to study in the Faculty of Science, Chulalongkorn University, which every student in Thailand dreams of entering. During my freshmen year, there were many social activities that all the freshmen had to attend in addition to taking classes. I stayed with my aunt, who lived far from the university. It took me more than an hour to ride two bus lines and a ship which crossed the Chao Phraya River to get to the university. I normally left early in the morning and didn't get back to my aunt's house until after dark. I had to manage time very well for my classes, university activities and my house-work at home in order to avoid probation or suspension from the university. I survived my first year of university, while about one-third of 280 students received probation or suspension. Because of the social activities, most of my friends and I still get together once a year as well as helping and supporting one another in many different ways.

In the second year, we had to decide the major for our study and I chose to study chemistry because I understood the subject better than the other sciences. I met my husband, Mr. Rewat Tantatyanon, who was my classmate in the Department of Chemistry (Figure 2 left). He has some skills that I do not have, and these profoundly influenced my success in several tasks later. After graduating with distinction as a chemist, I saw working as a lab technican as my only career option. At the time, there were limited jobs in the chemical industry and business, which were mostly given to men. I decided to pursue a career in teaching, simply because of no other choice, so I continued my studies at Mahidol University, one of the famous scientific universities and worked towards a Master's degree in organic chemistry. I went on to join the Department of Chemistry, Faculty of Science, at Chulalongkorn University as an instructor in 1975.

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Figure 2. My husband and I on convocation day at Chulalongkorn University (picture on the left) and with my advisor at Worcester Polytechnic Institute (picture on the right). (Courtesy of the author.)

About a year later, I obtained a Fulbright scholarship to further my studies in the U.S. Fulbright applied to five universities for me, but I did not wait for a reply from them all, and immediately decided to study in Worcester Polytechnic Institute (WPI), essentially because it accepted me first. Even today, I do not regret my decision to study there. WPI provided me with many benefits, including the opportunity for my husband to study in the same class as me, because we were newly-weds at the time. I realized my husband was doing me a huge favor, because he sacrificed his own career so as not to separate from me after our marriage. At first, our lives in Worcester were quite tough. We did not know Worcester or anyone there before our arrival. We had to find the place to live on the first day and take the preliminary exams during our first two days there. In fact our first snow experience was in the year of the blizzard'78, which was called for the disaster with more than 1 meter high of snow. We adapted to the different culture and our new lifestyle, and overcame all the struggles of living there. I can hardly imagine how much I would have accomplished if I had studied alone. We both studied hard and performed our research so well that all the professors in the department were satisfied and appreciative of our efforts. I worked with Professor James W. Pavlik, my thesis advisor (Figure 2, right). He was one of the most disciplined and meticulous people I have ever met. Of course, I followed his steps but was only half as competent as he was.

The circumstances at WPI allowed me to grow in many other ways aside from academics and research, which built my confidence even more. I planned and managed my time very well in order to accomplish my research work and teaching responsibly, while doing all the house-work, including cooking, cleaning and other house-related chores. Thai food was not popular at the time, and so it was difficult for me to find the ingredients to cook Thai food. But these problems did not stop me. I adapted my cooking to use the vegetables and ingredients available. For certain Thai ingredients, I grew plants inside the apartment during winter and placed them in the ground outside during the summer. After harvesting them, I kept them frozen as fresh crops or boiled them before freezing, so they could be used for several months or even thoughout the year. For five years, I cooked Thai food every night for lunch and dinner the next day. I learned how to cook and plan more effectively every day. Looking back on my five years of study, I am so happy with what I accomplished in Worcester.

Constructing Three New Academic Programs at Chulalongkorn University

After obtaining a PhD in 1982, I returned to Chulalongkorn University. That year, the government began developing the first petrochemical complex in Thailand. I was lucky to be one of the four faculty members assigned to the project. We were to design and teach a multidisciplinary master's program on petrochemistry and polymer science. This program began accepting students in 1985. I became one of the few Thai people who understood the petrochemical industry. I was later appointed to be the Founding Director of the Petroleum and Petrochemical College, the first of its kind in Thailand. Establishing a new organization at a university is quite challenging, because it must receive government approval. My colleagues and I organized a series of colloquial seminars, inviting senior people from government and private sectors to be the speakers. These seminars were open to students and academics as well as the public and media in order to publicize our work around the country. It provided me with a great opportunity to get to know and interact with many executives from different industries and businesses. It took about two years, but our first submission to establish the college was approved by the Thai cabinet.

When the college was finally established in 1989, I was approached by some petrochemical companies to work for them. My husband did not approve of me leaving the university, so I decided to stay with the university and work as a consultant for a group of petrochemical companies for 11 years. This opportunity taught me about the relationship between chemistry, education, industry and business. I initiated to open a weekend Master's degree program on petrochemistry and polymer science in 1995, which is still popular to this day.

I also initiated an international undergraduate program in applied chemistry, which began accepting students in 2005. It was the Faculty of Science's first international undergraduate program. It became popular in the country because it offered a unique integration of chemistry and its applications to industry, business and society. In creating the program, I adapted the Worcester Polytechnic

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Institute (WPI) course, 'Interactive Qualifying Project (IQP),' into a new course called 'Interactive Science and Social Project (ISSP)'. As the co-ordinator of the WPI Bangkok Project Center, I managed 24 WPI IQP students in Thailand for more than 20 years, and observed the students' professional development upon completing their projects. The course gives students the opportunity to solve real-world problems, learn how to work as part of a team, and develop many skills, including research, problem solving, critical thinking, effective writing, oral presentation, and other professional skills. Aside from those skills, students also learn how to make connections between science, technology and society, apply their classroom learning to the real world, and develop their communication skills and understanding of other cultures. I negotiated with WPI to have a joint IQP-ISSP study, which began in 2009. This opportuity allowed WPI students to work with our Thai students on joint projects, and learn about each other's culture.

While serving as the Deputy Dean of Faculty of Science from 2005-2009, my colleagues and I became worried about the decreasing number of students in our faculty. I proposed offering a short course, "Entrepreneurship based on Scientific Research", to faculty and staff in science and science-related fields in the universities across Thailand, which was funded by the Ministry of Education. The main objective was to allow the faculty members to explore the possibility of transforming their research findings to new businesses and to teach the importance of their research's market potential. My husband helped me design the course, finalize its topics, and recruit business-related lecturers. The course was so successful that a second one was organized by request.

These courses enabled my colleagues and I to design a multidisciplinary Master's and PhD program, called 'Technopreneurship and Innovation Management,' which aimed to bring lab-bench work and patents to the market. The program, which I led, began accepting students in 2007. It is not solely focused on business, as many other business programs are offered elsewhere. Students first take six core courses: Creative Morphology, Innovation Syntheses I & II, Product Planning and Development, Technology Commercialization, and Entrepreneurship and Capital Venture Creation. Each student must identify the unmet need or the gap with the potential market. Then the student will search for the available research results relevant to the expectations. Each student had a team of advisors, up to three people from different discipline, during conducting research. After doing a technology and market assessment, they planned and prototyped their products, developed the potential manufacturing process and verified its market value. It is now the most competitive PhD program at Chulalongkorn University. Every year, there are more than 100 applicants and only 30 PhD students are selected. It is required that the applicants must have at least two years of work experience, but most selected students have more than 10 years. I am surprised to find that the more diverse the students' fields of study are in the class, the better and more fruitful their discussion. The success of this program is due not only to the multidisciplinary courses and lecturers, but also the students' backgrounds and experiences. The program has led us to license more intellectual property and patents than ever before, and some startup companies have emerged from the program.

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Enjoyment in My Teaching Career

In the beginning of my teaching career, I only taught basic chemistry, but my experiences have given me the opportunity to learn more about chemistry's real world applications. As a result, over the last two decades of teaching chemistry, I have expanded my teaching to applied chemistry subjects, like green chemistry, industrial chemistry, petrochemistry, chemical safety in petrochemical industry, chemical hazard management, and chemical safety, as well as other courses, such as petrochemical project investment, technopreneurship, business concept for chemists, innovation and chemistry, and innovation syntheses.

I enjoy teaching the most when I can give examples and explain why chemical industries and businesses have done something a certain way. This often influenced by factors beyond the theoretical viewpoints of chemistry. I always take the students out to visit chemical companies and industrial plants in order to experience the real world. A few weeks before each visit, I give assignments to the students, asking them for the information about the plant or company relevant to the aspects I taught for a certain course. While traveling on the bus, they take turns doing group presentations so that every student has enough background knowledge of each location. They then have discussions after the visits. I can see how much they appreciate my classes, as everyone is almost always in attendance.

A Challenge in Doing Research for Commercialization

My doctorate work dealt with the synthesis and photochemistry study of the heterocyclic compounds using titanium dioxide as a catalyst. My first research project in Thailand was to investigate the photodegradation of PVC. In 1987, I was appointed as the Founding Director of the Petroleum and Petrochemical College of Chulalongkorn University, my research is thus expanded to cover the petrochemical reactions and polymer science, which involved both synthesis and industrial application. Furthermore, being a consultant to the petrochemical companies for 11 years gave me the opportunity to better understand the industry and the importance and the influence of chemical accidents on human beings and businesses. I increasingly included chemical safety in my research projects, whenever practical. I then came across small-scale chemistry and green chemistry, and these expanded my research futher to include energy, renewable resources and waste recycling.

Recently my interest has gone beyond research for publications and patents. I now look at my research's potential for commercialization. This potential was realized for a few of my projects. One example is a new material I developed from used car tire rubber, which I started to work since 2000. My students and I have prepared and measured the mechanical properties of several blends of reclaimed car tire rubber powder and various types of virgin or waste plastics powder with and without other waste materials, using different crosslinking agents. Although we believe in the potential uses of these blends and composites at this stage, they have not yet been commercialized. I have a PhD student in the Technopreneurship and Innovation Management program researching the potential market of my

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composites, conducting the technology and venture assessment, planning and developing the products, following the manufacturing process, and proving their market value.

Today, through regional and international business plan competitions, our composites have become known to the investors around the world. My student, along with five students from Sasin Business School of Chulalongkorn University, have teamed up and named "Redigen" to compete against 20-50 teams at these competitions (Figure 3). At the first two competitions organized in Thailand, Redigen was selected to be the first runner-up of "The MAI Bangkok Business Challenge® @Sasin2014" and the winner of "Asia Venture Challenge 2014". The other two competitions, held in the U.S., were much larger. Redigen became the winner of "The 2014 Oregon New Venture Championship", and received the first runner-up prize of "Biz Plan World Championships," and won the "Wells Fargo Clean Energy Award : Green & Clean Innovation 2014" in the Global Venture Labs Investment Competition (GVLIC). I have now licensed my intellectual property to the students of the Redigen, and they have set up a company.

Figure 3. Redigen team with the awards from four regional and international competitions. (Courtesy of the author.)

Chemical Safety, Small-Scale Chemistry, and Green Chemistry

I believe everyone in my department understands the dangers of chemicals, but we seem to ignore the importance of chemical safety -- probably because of budgetary constraints and lack of enforcement. A few colleagues and I attempted to promote and set up a chemical safety program in 1990, beginning with the formation of the Chemical Safety Steering Committee of Department of Chemistry. Through this committee, we established rules and regulations regarding chemical safety. Each research lab must be audited and the graduate

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chemistry students must pass a chemical safety test before gaining permission to conduct research in the lab. Now, universities require all science and science-related undergraduates to learn chemical safety and pass a test before they are allowed to take lab courses. For the graduate students, they must attend a safety training with staff and pass a chemical safety test before beginning their research. I am responsible for the program's development and am still conducting training courses several times a year.

In 2000, I initiated a project, supported by the Thailand Research Fund, entitled "Chemistry laboratory based on chemical safety and pollution minimization", collaborating with 14 different faculties from seven Thai universities. This arose from my concern for the safety of students while performing chemistry lab experiments. We selected and tested experiments from both general chemistry and organic chemistry labs. During our investigation, we all agreed to go for small-scale chemistry or microscale chemistry, which is defined by IUPAC as the reduction of chemical use to the minimum level at which the experiments can be effectively performed. For general chemistry, it can be done using apparati and techniques developed in microbiology and molecular biology research. For example, using plastic pipettes and well plates that scale down the chemicals' volume and mass to one-thousandth the size of those used in traditional chemistry labs.

However, we were faced with a lack of small-scale glassware in our country. To solve this, I designed a few pieces of special glassware. For example, a recovery distilling head and suction filter with ground glass joint. I thought about what we would need to carry out safe and convenient organic experiments, and so other equipment, like hot plates, lab stands, clamps, water hoses as well as water suppliers and suction pumps were put together. I made a prototype of a portable, complete set of small-scale organic equipment, called Small-Lab Kit (Figure 4 upper left and right). I patented several pieces of the kit as an inventor and the university has licensed the kit to the company. Today, the Small-Lab Kit is commercially available. I have promoted the Small-Lab Kit through workshops, lectures, exhibition displays and presentations at several conferences. Fortunately UNESCO requested me to share online the experiments the Small-Lab Kit can perform (*1*, *2*), which can now be accessed and downloaded from the UNESCO website since 2009 (Figure 4, lower left). This has made me very proud of the invention.

In 2001, I was selected to join the green chemistry workshop prior to the CHEMRAWN XIV in Boulder, Colorado, U.S. I learned the concepts, principles, and methodologies of green chemistry. I could see that green chemistry is well complementary to small scale chemistry (*3*). I then invite the representatives of Green Chemistry Institute to conduct the green chemistry workshop in Bangkok, Thailand for the participants from South East Asian countries in 2002. I have also translated a book, "Green Chemistry: Theory and Practices", by Paul Anastas and John Warner, into Thai. The translated book was printed by the CST and disseminated to schools, universities, research institutes and the CST members during the International Year of Chemistry in 2011 (Figure 4, lower right). In addition, I am currently a member of the National Executive Board of Hazardous Materials and the National Council of Science and Technology Professionals.

Figure 4. A box of Small-lab kit (upper left) and its components (upper right), Small-lab kit on UNESCO website (lower left; used with permission) and Green Chemistry book in Thai (lower right; used with permission).

Service in the Chemical Society of Thailand

The first organization that I have serviced volunteerly is Professor Dr. Tab Nilanidhi Foundation since 1975 till today. Its objective is to promote and award the top first-year undergraduate in science and the top fourth-year students in chemistry every year, then expanded to all areas of science in the universities in Thailand. I was the only young person among the committee members over 50 years old. It made me accustomed to and dare to approach the senior and well

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known people in Thailand later. The other major organizations in Thailand I have volunteerly serviced includes the Dr. Preecha-Prapai Amartayakul Science Foundation, Foundation for the Promotion of Science and Technology Under the Patronage of His Majesty the King, Science Society of Thailand under the Patronage of His Majesty the King, and Chemical Society of Thailand (CST). However, I have devoted much more time to the CST than to the others.

The CST, established in 1979, is a non-profit and rather academic organization like the other science societies in Thailand. Before my presidency, its activities rely on volunteers and are usually coordinated with universities, such as seminars, meetings, workshops and some conferences.

I was approached by a senior faculty member of the Department of Chemistry at Chulalongkorn University to work for the Chemical Society of Thailand (CST). I was nominated to be a candidate for the election of its board members in 2007. I became one of the ten board members and was voted unanimously to be the 10th President of the CST, a position I held from 2007 to 2012.

It took me about one and a half years to do the documental work of society internally, including officially changing the name of “The Chemical Society” to “The Chemical Society of Thailand”. I proposed that the CST executive board create several regular activities, including an annual conference named ‘Pure and Applied Chemistry International Conference’ (PACCON) together with the General Assembly of CST; the national meeting of Chemistry Department Heads held three times a year; the Chemistry standard test for undergraduates and interested people twice a year; and several CST awards for outstanding research and achievement in various areas. In addition, I have organized the teachers’ training about small scale chemistry whenever possible. At the present, DOW Chemicals (Thailand) has financially supported such trainings for three years. These activities gradually gained recognition from chemists in Thailand and are now recognized and financially supported by many companies. Another high recognition is that Her Royal Highness Princess Chulabhorn Mahidol has generously adopted the CST under her patronage. The CST is currently performing very well, both academically and financially, with more than 3,000 members.

Opportunity for International Exposure

In 1986, I was introduced to a small Thai polymer group established by Professor Hayashi of Osaka University. He coordinated with polymer scientists in South East Asia to form an association financially supported by UNESCO. It gave me the opportunity to meet polymer scientists from around the globe at several conferences. I became well-known internationally, and was invited to attend the 1991 council meeting of the Pacific Polymer Federation (PPF) as a representative of Thailand. They encouraged me to set up the Polymer Society of Thailand (PST), so that it could become a member of PPF. In 1997, the PST was established and I became its first President. I was then elected to be the Vice President from 1999-2001, and went on to become the eighth President of the

Pacific Polymer Federation from 2001-2003 – I was the first woman to hold this position till today. Through PPF, I was able to connect with the most reputable polymer scientists around the world.

In 2002, I was also appointed to be the Director of the Green Chemistry Institute (Thailand Chapter) of American Chemical Society, a position which I still hold today (Figure 5, left). As the President of the Chemical Society of Thailand (CST) from 2007-2012, I sought the organization's recognition worldwide for the benefit of the CST members and Thailand. I looked at CST's international roles and connections with Asia and the world in general. With my expertise and performance on small-scale chemistry, I was appointed to be the Co-Director (2007-2008) and Director (2008-2009) of the Low-cost Instrumentation and Microscale Chemistry of the Federation of Asian Chemical Societies (FACS). I was then elected to be the President-Elect (2009-2011) and the seventeenth President (2011-2013) of FACS, once again as the first woman in that position. I am now the Immediate Past President of FACS (2013-2015).

Prior to my presidency, the CST was the Affiliated National Adhering Organization (ANAO) of the International Union of Pure and Applied Chemistry (IUPAC). It requires the annual membership fee of 500 USD, but with this status CST cannot vote and have no right to ask for any project, except receiving the International Chemistry magazine. Because of its weak financial status, CST could not afford to be a NAO of IUPAC, which required an annual membership fee of around $7,000-$8000, depending on the amount of chemicals Thailand produced each year. During my presidency, I raised funds from the private sectors for previous few years in order for CST to become a NAO of IUPAC, and managed in such a way that its membership fee is currently paid by a governmental organization.

I have had great opportunities to meet reputable people worldwide, including Nobel Laureates, the Presidents of IUPAC, the Presidents of the American Chemical Society as well as the Presidents of other national chemical societies. These people are kind, willing to help young chemists, and eager to contribute to the global chemistry community.

Besides my roles as President of different national and international organizations, I have also had other international roles. Recently I was invited to give plenary lectures at three events, 'Small Scale Organic Chemistry in Education' at the 25th Philippine Chemistry Congress in 2010, 'Small Scale Chemistry: Experiences for Developing Countries' at Simposio Miicroquim in 2010 and 'Small Scale Chemistry in Asia: Opportunities and Challenges' at the International Symposium for the 70th Anniversary of the Tohoku Branch of the Chemical Society of Japan in 2013 (Figure 5, right).

I have also served as chair for many national and international conferences, such as the 26th and 27th Congresses on Science and Technology of Thailand in 2000 and 2001, the 8th Pacific Polymer Conference in 2003, the First International Conference on Science Education in the Asia-Pacific in 2007, the 14th Asian Chemical Congress in 2011, and the IUPAC World Polymer Congress in 2014. In addition, I co-chaired two sessions in Pacifichem 2010: 'Small Scale and Green Chemistry in the Curriculum' and 'Chemical Security and Safety in the University and the Laboratory.'

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ACS NEWS

GCI Spreads Green Message, Opens New Chapter In Thailand

In late May, chemistry faculty members from across Southeast Asia gathered at Chulalongkorn University, Bangkok, for an international training workshop on gree chemistry. The nearly 100 attendees hailed from Thailand, the Philippines, Vietnam alaysia, Australia, Indonesia, and India. The workshop was sponsored by the Intern ional Union of Pure & Applied Chemistry CHEMRAWN XIV Committee; the American hemical Society's Green Chemistry Institute (GCI); and the United Nations Educatio l, Scientific & Cultural Organization.

The workshop was led by Paul T. Anastas, director of environmental programs at he White House Office of Science & Technology Policy; Dennis L. Hjeresen, director f GCI; Mary M. Kirchhoff, ssistant director of GCI nd international work- hop coordinator; and ohn Warner, chairman of he chemistry department t the University of Massa- husetts, Boston. These our presented topics that ncluded an introduction to he principles and practice f green chemistry; re- earch and educational rograms; water and agri- ultural applications; ethods for establishing ational programs in reen chemistry; and ways o design safer chemicals, harmaceuticals, and

GREEN WORLD Supawan Tantayanon (second from right), associate professor of chemistry at Chulalongkorn University, presents a token of appreciation to workshop participants (from left)

Figure 5. The news, concerning my Green Chemistry Workshop held in Thailand in 2002, in the Chemical & Engineering News magazine (left; Courtesy of the American Chemical Society) and the poster for the international symposium in honor of the 70th anniversary of the Tohoku Branch of the Chemical Society of Japan in 2013 (used with permission).

Figure 6. Receiving the Honorary Fellow of Singapore National Institute of Chemistry award together with 2010 Nobel Laureates, Professor Akira Suzuki (third from the left) and Professor Ei-ichi Negishi (second from the right). (Courtesy of the author.)

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I have conducted several workshops, supported by FACS, on small scale chemistry and green chemistry at conferences and events in various countries, such as Indonesia, Malaysia, Republic of China, Kuwait, Philippines, Mexico, Sri Lanka and Thailand. Some of these workshops in Thailand were broadcasted to 14,000 schools through the Distance Learning Foundation. With all these chemistry contributions around the world, I was approached by Wiley to give an interview as one of the selected women in Chemistry on the occasion of the International Year of Chemistry in 2011 (*4*). Moreover, I had received an Honorary Fellow of Singapore National Institute of Chemistry in 2013, together with two 2010 Nobel Laureates, Professor Akira Suzuki and Professor Ei-ichi Negishi (Figure 6).

My Beloved Family

I am fortunate that my husband is also a chemist. He earned his PhD in chemistry from Worcester Polytechnic Institute with me, and also holds a Master's degree in Business Management. He first worked in a few chemical companies before holding his last position as a Senior Vice President of Bangkok Bank. He is currently a consultant for Bangkok Bank. He understands my roles and responsibilities very well and always supports and assists me in any way he can. We share and discuss our work experiences when we have time. I actually get many new ideas on how to proceed with my work from him, as he offers perspectives different from my own.

I have two sons, who are now 30 and 23 (Figure 7). When they were children, I hired a maid, who usually worked for less than a year, to clean the house and look after them while my husband and I were at work, in light of my mother-in-law staying with us. However, I cooked and took care of all the house work. After my sons went to school, I stopped hiring the maid because I was often frustrated with the messy work done by the maids. I am more than happy to do everything myself, utilizing good management and using all available appliances. In fact, my husband sometimes helps me do the house work. He is afraid that I am going to exhaust myself, but he cannot stop me.

Today, I plan and prepare all the daily house work very well, including meals and household chores. I normally think of the meals and do the preparation one day in advance, so I can quickly finish the meal when I return home. I also buy some delicious and well-known dishes whenever I have a chance. We also will occasionally eat out. Normally, I spend time at home with the family and finish cleaning up after meals around 10pm, then I take time to do my personal business, including work with the university, foundations and professional socities I am apart of. When I know I will be away for some time, I prepare as many things for my family as possible, so they do not feel neglected.

When my sons were children, I brought them along for plant visits and events, as well as oversea business trips, whenever practicable. Both of my sons have been traveling abroad since they were four years old with my husband and sometimes my mother. They have understood how much I work since they were children, and still understand. I arrange one weeklong overseas trip each year for my family, sometimes in coordination with my business trips. Of course, every one in the family can choose where to visit. I have done this for about 20 years, and it is the only time that we spend time together without any distractions. Once my elder son asked whether he could skip the overseas trip for a few years. I told him that he should not, and he should bring along his wife and his kids after his marriage. I would like to keep our family tradition of spending time together, but that may soon change to visiting places in Thailand rather than overseas, as my husband and I are getting older. I always ensure that my family is happy, that is my top priority (*5*).

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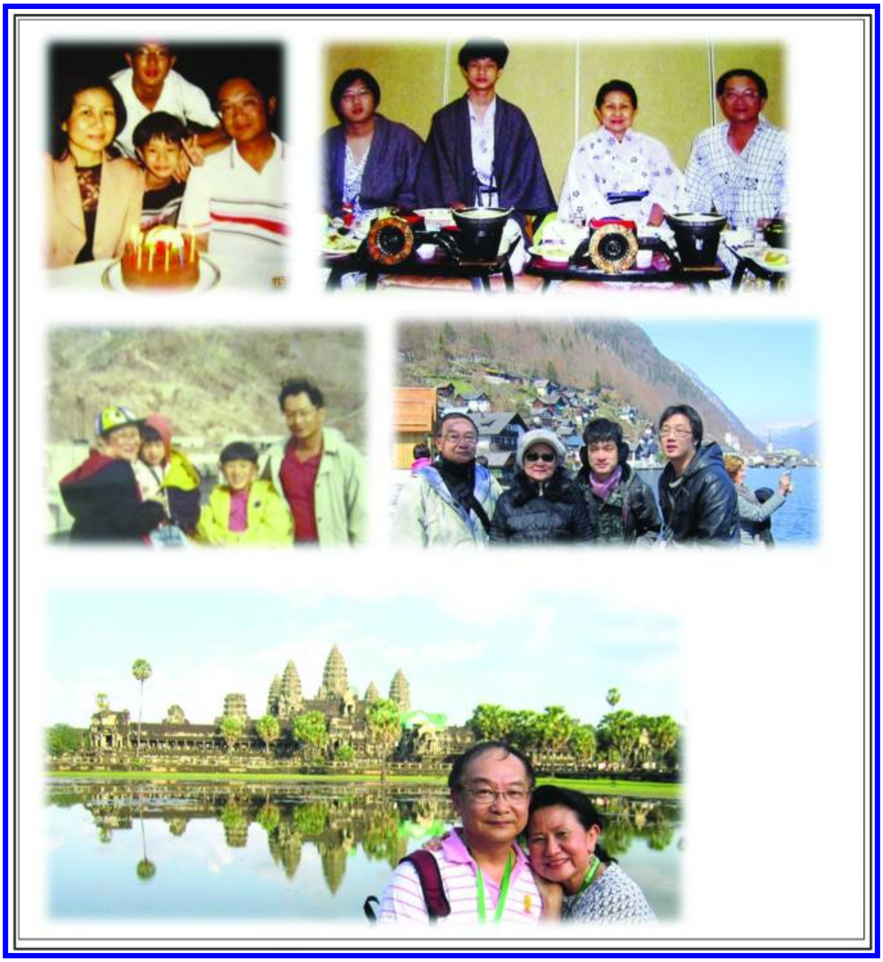

Figure 7. My family of four. (Courtesy of the author.)

Conclusions – My Life's Journey

I have been working since I was a child, so I do not feel that I have to work, but rather always do something I enjoy. My experience has taught me to simply open up, look for opportunities, and never say no. My colleagues often wonder how I accomplish all of my work so successfully. Of course, I was never alone. I always did most of it with dedication and a well-thought out plan. Sometimes when obstacles arose, I altered my path to reach my goal, but I never changed my decision to achieve my goal – again, always making my family's happiness my top priority. I believe that my success is not just about what I have accomplished, but what I can inspire others to do.

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I am grateful to Dr. Marinda Wu, 2013 President of American Chemical Society, for her effort to organize and invite me as one of the speakers for the special symposium entitled "Women Leaders of the Global Chemistry Enterprise" in the 248th ACS National Meeting, San Francisco, U.S.A. I also appreciate her thoughtfulness which gives me the opportunity to share my life's journey as a chapter in this book. In addition I would like to thank Dr. H.N. Cheng for his review and useful comments which make my article more enjoyable to read.

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