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The Chemical Element

Chemistry's Contribution to Our Global Future



WILEY-VCH Verlag GmbH & Co. KGaA

The Chemical Element: Chemistry's Contribution to Our Global Future

Every year several books are published dealing with chemistry, but this book is different and takes the reader far from the expected esoteric and academic chemistry to a chemistry that embraces our continuing existence on planet Earth. By placing chemistry at the centre of challenges and solutions for our planet, it provides a much-needed perspective on the role and importance of science for development and demonstrates the critical linkage between research in chemistry, policy, industry, education and concrete actions for sustainable development. The book is inspired by the United Nations declaration of 2011 as the International Year of Chemistry (IYC), and clearly spells out the role and importance of chemistry for meeting the United Nations Millennium Development Goals.

The International Union of Pure and Applied Chemistry (IUPAC) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO) were designated by the United Nations General Assembly as lead agencies for promoting and coordinating the IYC. The objectives of the Year are to:

- increase the public appreciation and understanding of chemistry in meeting world needs,
- encourage the interest of young people in chemistry,
- generate enthusiasm for the creative future of chemistry,
- celebrate the role of women in chemistry or major historical events in chemistry, including the centenaries of Mme. Curie's Nobel Prize and the founding of the International Association of Chemical Societies.

Through the Year, the world is celebrating the art and science of chemistry, and its essential contributions to knowledge, environmental protection, improvement of health and economic development. The critical over-arching need in this context is for the responsible and ethical use of chemical research, and its applications and innovations, for equitable sustainable development.

In January 2011, the official launch of the IYC took place at UNESCO Headquarters in Paris. This meeting set the themes for the Year by associating "chemistry" with the words "progress of civilization, solutions for global challenges,

climate change, creating a sustainable future, nutrition, food production, water, health and disease, global health, energy solutions for the future, materials of tomorrow, economic and social aspects . . .". The chapters of this book mirror these themes and present the reader with a comprehensive view of what "chemistry" means for our lives and our futures.

This book is therefore to be highly recommended to a wide readership including individuals concerned for sustainable development, politicians, young people, scientists, teachers, and global strategists. It is a must for every chemist who can use it as a tool in teaching students or in informing non-scientists about the possibilities of this fundamental science. Most of all, we hope that this book will be used to show young people that "chemistry" is exciting and meaningful, and that many will be enticed and inspired to take up careers in this field of scientific endeavour.

We congratulate the editors and authors of this marvelous book, published specially as part of the celebration of the IYC.

Nicole Moreau
President, IUPAC

Julia Hasler
UNESCO Focal Point for IYC

Epilogue

To read these chapters is to share in humanity's greatest triumph: the mobilization of scientific knowledge for human betterment. Chemistry, in particular, has been foundational, providing the tools, models, insights, and techniques for every major area of endeavor: health, agriculture, energy, transport, water, and more. The stories in this marvelous book are exhilarating, powerful, and forward looking. They draw on chemistry's past challenges and triumphs to shine a light on the future needs and potential achievements.

The challenge of translating science into human advance is more urgent than ever before. In many ways, we are of course victims of our own success. Chemistry's past accomplishments—in creating nitrogen-based fertilizers, harnessing large-scale energy sources, controlling infectious diseases, cleaning the urban water supplies—have led to a burgeoning of the world's population as well as an unprecedented scale of production per person on the planet. We are now 7 billion human beings tightly packed into the Earth's fragile ecosystems. Average output per person per year has reached \$10,000 (in a common purchasing-power adjusted measurement). The consequence is a human impact on the environment of unprecedented scale and scope. The dangers for future wellbeing abound, whether in human-induced climate change, natural resource depletion, unchecked pollution, or other adverse consequences of the global economy.

Our tasks are highly complex. Not only is humanity imposing unprecedented burdens on the Earth's ecosystems, but is doing so in the context of unprecedented inequalities of conditions and risks on the planet. Around 1 billion people, one sixth of humanity, continue to live in extreme poverty, fighting daily for their survival, basic health, and dignity. Another billion at the top of the income distribution consume roughly half of the planet's annual economic output, and often elbow the poor aside to ensure their own continued disproportionate access to the world's goods and services.

Our challenges are therefore multiple and complex, and at all scales from the local to the global. The world, and notably the poor world, yearns for economic improvement, which in the short term often entails even greater demands on the Earth's ecosystem services and depleting resource base. Yet the planet as a whole needs to live within global ecological and biophysical boundary conditions to sustain life and wellbeing. And in the midst of these unprecedented challenges,

the specific, urgent, life-and-death problems of extreme poverty must be addressed and solved. Our first rendezvous with global solutions is 2015, the target date for fulfillment of the Millennium Development Goals.

Every scintillating chapter in this book makes clear that chemistry must play a central role if we are to succeed in facing these complexities. Sustainable development—combining poverty reduction, global economic improvement, and ecosystem health—will require new ways of accomplishing our most basic economic tasks: growing food, preserving public health, mobilizing safe and plentiful energy, and converting materials safely for human comfort and safety.

This volume is unique in offering a comprehensive and cutting-edge perspective on the future of sustainable development through the vision of some of the world's leading chemists. As a policy strategist, I was riveted page by page, as the technological possibilities for the future were authoritatively conveyed. Each chapter offers remarkable clarity, breadth, technical precision, and a deep sense of humanity. If there is a theme that runs in common, it is that the highest flights of science are bound up intimately with the highest human aspirations. Chemistry is not a dry subject of equations and reactions. It is a science of human purpose as well, with the drama and illustrious history of breakthroughs and contributions of monumental importance.

Professor Peter Mahaffy is compelling in advocating a new way to teach science, one that grips the students through the drama of the human condition. I was convinced and entranced. He recounts the dramatic “call to action” made by British chemist William Crookes in 1898 to find a new chemical pathway to mobilize nitrogen for food production, lest the world succumb to hunger in a global nitrogen shortfall. Crookes' call to action was answered a decade later by the world changing Haber–Bosch process for the industrial manufacture of nitrogen-based fertilizer. This book is our generation's call to action, to find new chemical pathways for supporting food production and nutrition, the mitigation of human-induced climate change, the supply of safe water, the development of new medicinal compounds, and the greening of chemical processes so that the vast benefits of industry are not undone by tragic and often unforeseen side effects.

During my quarter century of work on the challenges of sustainable development, I have seen repeatedly the essential, and indeed overpowering, role of technical knowledge in sound policy making. When science is brought to bear on our great challenges, solutions are found. When politics succumbs to special interest groups, public prejudices, and even outright ignorance, we are dangerously led astray. The remarkable chapter by Dr. Glen Carver on ozone depletion reminds us indeed that some of humanity's greatest challenges and risks will be uncovered first by cutting-edge science. Bringing top science to bear on public policy will be increasingly vital for our very survival.

Fittingly, the United Nations has designated 2011 as the International Year of Chemistry. If there is any question as to why this choice was made, this book answers it fully. Chemistry is key to human wellbeing. The appreciation of chemistry's contributions is vital to emerging the next generation of scientists, policy makers, and informed citizens. This book makes a unique and important contribu-

tion to that task. It will be widely read around the world, and provide a path and inspiration for sustainable development in the years ahead. I personally would like to express my profound appreciation to the editors and authors of this book for this important contribution.

Prof. Jeffrey Sachs

Director of The Earth Institute

Quetelet Professor of Sustainable Development, and Professor of Health
Policy and Management at Columbia University