

Contents

The Chemical Element: Chemistry's Contribution to Our Global Future	V
Introduction	XIII
List of Contributors	XVII

1	Chemistry for Development	1
	<i>Stephen A. Matlin and Berhanu M. Abegaz</i>	
1.1	Chemistry, Innovation and Impact	1
1.2	Poverty and Disparities in Life Expectancy	8
1.3	The Millennium Development Goals	9
1.3.1	Goal 1: Reducing Poverty and Hunger	10
1.3.2	Goal 2: Achieving Universal Primary Education	12
1.3.3	Goal 3: Promoting Gender Equality and Empowering Women	12
1.3.4	Goals 4 and 5: Reducing Maternal and Under-Five Child Mortality	13
1.3.5	Goal 6: Combating HIV/AIDS, Malaria and Other Diseases	13
1.3.6	Goal 7: Ensuring Environmental Sustainability	13
1.3.7	Goal 8: Developing a Global Partnership for Development	15
1.4	Science, Technology and Development	15
1.5	Chemistry and Development	19
1.5.1	Chemical Research Applied to World Needs	19
1.5.2	International Organization for Chemical Sciences in Development	20
1.6	Science and Technology for National Development	22
1.6.1	Investments in Research and Development	22
1.6.2	Outputs from Investments in Research and Development	25
1.6.3	Connecting Science, Technology and Innovation	30
1.7	Capacity Building: Some Key Requirements for Chemistry's Role in Development	32
1.7.1	Evolution of Capacity Building Approaches in LMICs	32
1.7.2	National Policies for S&T	33
1.7.3	Responsibilities	34
1.7.4	Professional Associations and Cooperative Networks for Chemistry and Development	36
1.7.5	National Funding for Research	42
1.7.6	Gender Issues	43

1.7.7	Open Access	44
1.7.8	Technology Transfer	44
1.8	Chemistry and Future Challenges to Health, Wealth and Wellbeing	46
1.8.1	“Glocal” – Thinking and Acting from Global to Local	46
1.8.2	Agriculture, Food and Nutrition	47
1.8.3	Climate Change	49
1.8.4	Energy	50
1.8.5	Environment and Sustainable Development	50
1.8.6	Health	51
1.8.7	Intellectual Property	53
1.8.8	Natural Resources Exploitation	54
1.8.9	Water	56
1.9	Conclusions	56
	Acknowledgments	58
	References	58
2	The Role of Chemistry in Addressing Hunger and Food Security	71
	<i>Jessica Fanzo, Roseline Remans, and Pedro Sanchez</i>	
2.1	Chemistry is the Backbone of Food and Nutrition	71
2.2	Global Hunger and Malnutrition in the World Today	73
2.2.1	Progress on the Proportion of Children Who are Underweight	73
2.2.2	Progress on the Proportion of the Population Who are Undernourished	74
2.3	Hunger, Nutrition, and the Food Security Mandate	74
2.4	Chemistry’s Influence on the Pillars of Food Security	76
2.4.1	Food Availability	76
2.4.2	Chemistry and the Green Revolution	76
2.4.3	Genetically Engineered Crops and Food Production	80
2.4.4	Food Access	82
2.4.4.1	Post-Harvest Treatment and Storage	82
2.4.5	Food Utilization	85
2.4.5.1	Balanced Diets and Utilization of Nutrients: The Chemical Components	85
2.4.5.2	Antinutrients	88
2.4.5.3	Fortification of Food Vehicles: One Chemical at a Time	89
2.4.5.4	Improving Utilization through Modern Medicine: The Contribution of Chemistry to Basic Medicines	90
2.5	Conclusion	92
	References	94
3	Poverty	99
	<i>Mari-Carmen Gomez-Cabrera, Cecilia Martínez-Costa, and Juan Sastre</i>	
3.1	Contribution of Chemistry to Social and Economic Development	99
3.2	Concept and Historical Evolution of Poverty	102
3.3	Asymmetry of Poverty in the World	104

3.4	Causes of Poverty	106
3.4.1	Geopolitics	107
3.4.2	Geography	107
3.4.3	Lack of Economic Growth	107
3.4.4	Deficient Governance	108
3.4.5	Deficient Health	108
3.4.6	Failures of Effective and Sufficient Development Aid	108
3.5	Poverty, Malnutrition, and Life Expectancy	109
3.6	Strategies against Poverty: A General Approach with Context-Specific Solutions	112
3.6.1	Renewable Energy Sources and Sustainable Development	112
3.6.2	Infrastructure, Science, and Technological Progress	114
3.6.3	Microcredits and Inclusive Business Models	116
3.6.4	Health Promotion and Malnutrition Prevention	117
3.6.5	Involvement of the Local Government: The Ijebu-Ode Experiment	119
3.6.6	UN, CSOs, and Governments from Developed Countries: a Joint Crucial Effort	120
3.6.7	Additional Efforts towards Eradication of Poverty	121
3.7	Chemistry is Essential for Poverty Alleviation	122
3.7.1	Nanotechnology and Nanochemistry	122
3.7.2	Industrial Biotechnology and Biofuels	126
3.7.3	Combinatorial Chemistry	127
	References	128
4	The Human Element: Chemistry Education's Contribution to Our Global Future	131
	<i>Peter Mahaffy</i>	
4.1	The International Year of Chemistry Educational Challenge	131
4.2	Scene 1 – Chemistry to the Rescue of Threatened Communities	132
4.3	Sequel to Scene 1–An Education in Chemistry	135
4.4	Equipping the Human Element with Relevant Education <i>in, about, and through</i> Chemistry	137
4.4.1	Identify the Learners, Understand Their Overall Learning Objectives and Career Goals, and Ensure Education in Chemistry Meets Their Needs	138
4.4.2	Build and Support Active Learning Communities	139
4.4.3	Engage Students with Curriculum and Pedagogy that Takes Account of Research about How They Best Learn and How They Best Learn Chemistry	140
4.4.4	Provide Education about Chemistry, and through Chemistry, as well as in Chemistry	142
4.4.5	Move beyond the Fractionation of Knowledge	144
4.4.6	Show the Integral Connection between Chemical Reactivity and Human Activity	145
4.4.7	Integrate Sustainability Themes into Chemistry Education	147

4.5	An Example of Integrating Sustainability and Chemistry Education Curriculum: Visualizing the Chemistry Underlying Climate Change	149
4.6	Scene 2—Chemistry Education and Our Global Future	152
	References	154
5	The Impacts of Synthetic Chemistry on Human Health	159
	<i>René Roy</i>	
5.1	The Molecules at the Origin of Drug Discoveries	159
5.2	From Bench to Market Place	162
5.3	General Concepts of Drug Design	169
5.3.1	Tasks and Bottlenecks in Medicinal Chemistry	170
5.3.2	Lead Validation	171
5.4	Patent Protection Issues	172
5.5	Drug Metabolism and Drug Resistance or Why Make Big Pills?	173
5.5.1	Drug Metabolism	174
5.5.1.1	Phase I Transformations	174
5.5.1.2	Phase II Transformations	174
5.5.2	Drug Resistance	174
5.6	Antibacterial Agents	176
5.7	Antiviral Agents: The Flu Virus Story: The Naissance of a Sugar-based Flu Drug	177
5.8	The Viagra Story—Serendipity Leading to a Blockbuster Drug	180
5.9	Human Vaccines as a Prophylactic Health Remedy	182
5.9.1	Carbohydrate-based Vaccines	182
5.9.2	The Role of Chemistry in Synthetic Vaccines	183
5.9.3	Bacterial Capsular Polysaccharide Vaccines	183
5.10	Conclusion	185
	References	186
6	The Greening of Chemistry	189
	<i>Pietro Tundo, Fabio Aricò, and Con Robert McElroy</i>	
6.1	Introduction	189
6.1.1	The History of Green Chemistry	189
6.1.2	Green Chemistry in the Economy: the Chinese Circular Economy (CE)	197
6.1.3	Award for Green Chemistry Research	199
6.1.3.1	The Presidential Green Chemistry Challenge	199
6.1.3.2	Award for Green Products and Processes	200
6.1.3.3	The European Sustainable Chemistry Award	200
6.1.3.4	The Institution of Chemical Engineers Award	200
6.1.3.5	Green and Sustainable Chemistry Network Award (Japan)	200
6.1.3.6	RACI Green Chemistry Challenge Award	200

6.2	Areas of Green Chemistry	202
6.2.1	Alternative Feedstocks	203
6.2.2	Use of Innocuous Reagents	206
6.2.2.1	Less Hazardous Reagent	206
6.2.2.2	Generate Less Waste	210
6.2.2.3	High Conversion and Selectivity	213
6.2.2.4	Catalyst	213
6.2.3	Employing Natural Processes	215
6.2.4	Use of Alternative Solvents	217
6.2.5	Design of Safer Chemicals	220
6.2.6	Developing Alternative Reaction Conditions	222
6.2.7	Minimizing Energy Consumption	222
6.3	Metrics in Green Chemistry	226
6.4	Conclusions and Future Perspectives	227
	References	229
7	Water: Foundation for a Sustainable Future	235
	<i>Maya A. Trotz, James R. Mihelcic, Omatoyo K. Dalrymple, Arlin Briley, Ken D. Thomas, and Joniqua A. Howard</i>	
7.1	Introduction	235
7.2	Water Pollution and Water Quality	239
7.2.1	Biochemical Oxygen Demand	239
7.2.2	Nutrients (Nitrogen and Phosphorus)	239
7.2.3	Global Cycling of Carbon in Water	245
7.2.4	Turbidity and Pathogens	246
7.2.5	Arsenic and Fluoride	247
7.2.6	Global Cycling of Mercury	249
7.2.7	Emerging Chemicals of Concern	251
7.3	Water Treatment Technologies	254
7.3.1	Point of Use Treatment and Advanced Oxidation Processes	254
7.3.2	Membranes	256
7.3.3	Arsenic	256
7.3.4	Water Reuse	259
7.3.5	Carbon Sequestration	261
7.4	Conclusions	262
	References	263
8	Facing the Energy Challenges through Chemistry in a Changing World	269
	<i>Gabriele Centi and Siglinda Perathoner</i>	
8.1	Introduction	269
8.2	Chemistry and the Role for Development of Society	272
8.3	Chemistry and Sustainable Energy	275
8.4	Sustainable Energy Scenarios and Climate Changes	282
8.5	Nanomaterials for Sustainable Energy	283

8.6	Biofuels	290
8.7	Towards Solar Fuels	296
8.8	Conclusions	304
	References	305
9	Ozone Depletion and Climate Change	311
	<i>Glenn Carver</i>	
9.1	Introduction	311
9.2	Ozone in the Atmosphere	312
9.2.1	Chapman Reactions	314
9.2.2	Catalytic Cycles	315
9.2.3	How Ozone is Measured	316
9.3	The Antarctic Ozone Hole	317
9.3.1	The Steps to the Ozone Hole	321
9.4	Arctic Ozone	324
9.5	Montreal Protocol and Beyond	327
9.6	Ozone and Climate Change	330
9.6.1	The World Avoided	332
9.7	Perspectives	333
9.8	Resources	334
	Acknowledgments	335
	References	335
	Epilogue	337
	<i>Jeffrey Sachs</i>	
	Color Plates	341
	Index	371