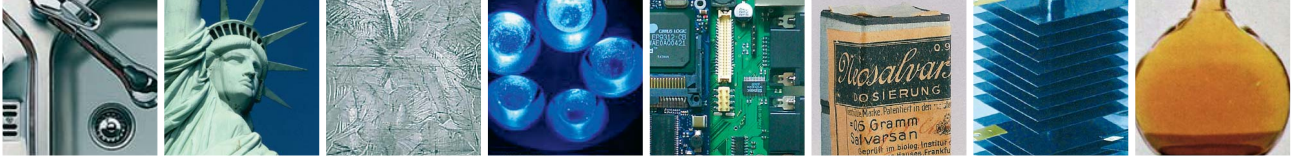

Hans-Jürgen Quadbeck-Seeger

World of the Elements
Elements of the World

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BICENTENNIAL 1807 WILEY 2007 BICENTENNIAL

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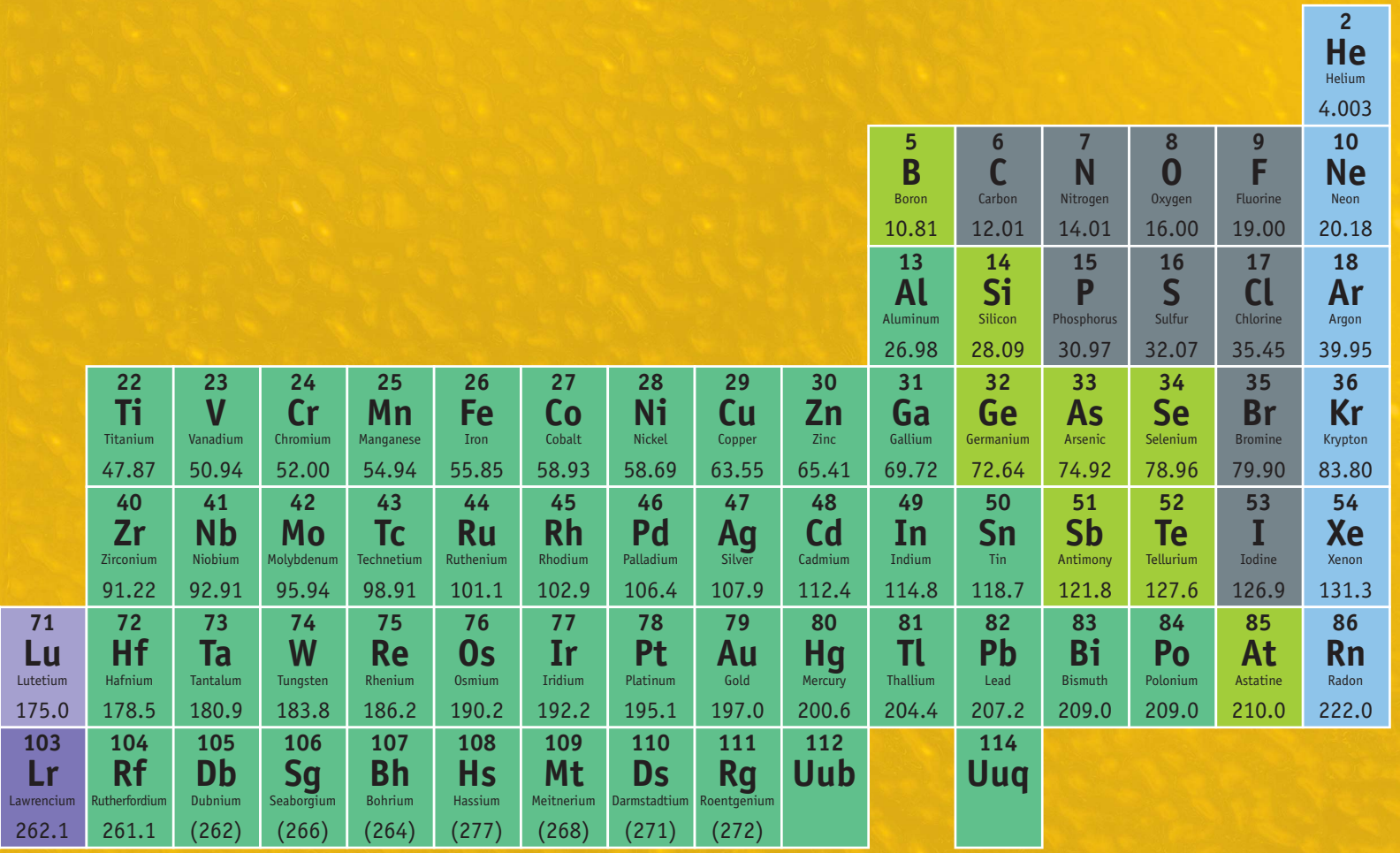
Periodic Table of the Elements

according to the International Union of Pure and Applied Chemistry (IUPAC)

- hydrogen
- noble gases
- alkali metals
- alkaline-earth metals
- semimetals
- nonmetals
- metals
- lanthanides
- actinides

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** Hydrogen 1.008																	
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012																
11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.30																
19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96															
37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91															
55 **Cs** Cesium 132.9	56 **Ba** Barium 137.3	57 **La** Lanthanum 138.9	58 **Ce** Cerium 140.1	59 **Pr** Praseodymium 140.9	60 **Nd** Neodymium 144.2	61 **Pm** Promethium 146.9	62 **Sm** Samarium 150.4	63 **Eu** Europium 152.0	64 **Gd** Gadolinium 157.2	65 **Tb** Terbium 158.9	66 **Dy** Dysprosium 162.5	67 **Ho** Holmium 164.9	68 **Er** Erbium 167.3	69 **Tm** Thulium 168.9	70 **Yb** Ytterbium 173.0		
87 **Fr** Francium 223.0	88 **Ra** Radium 226.0	89 **Ac** Actinium 227.0	90 **Th** Thorium 232.0	91 **Pa** Protactinium 231.0	92 **U** Uranium 238.0	93 **Np** Neptunium 237.0	94 **Pu** Plutonium 244.1	95 **Am** Americium 243,1	96 **Cm** Curium 247.1	97 **Bk** Berkelium 247.1	98 **Cf** Californium 251.1	99 **Es** Einsteinium 252.1	100 **Fm** Fermium 257.1	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.1		
1	2	3															

all lanthanides and actinides belong to group 3


2 He Helium 4.003
5 B Boron 10.81
6 C Carbon 12.01
7 N Nitrogen 14.01
8 O Oxygen 16.00
9 F Fluorine 19.00
10 Ne Neon 20.18
13 Al Aluminum 26.98
14 Si Silicon 28.09
15 P Phosphorus 30.97
16 S Sulfur 32.07
17 Cl Chlorine 35.45
18 Ar Argon 39.95
22 Ti Titanium 47.87
23 V Vanadium 50.94
24 Cr Chromium 52.00
25 Mn Manganese 54.94
26 Fe Iron 55.85
27 Co Cobalt 58.93
28 Ni Nickel 58.69
29 Cu Copper 63.55
30 Zn Zinc 65.41
31 Ga Gallium 69.72
32 Ge Germanium 72.64
33 As Arsenic 74.92
34 Se Selenium 78.96
35 Br Bromine 79.90
36 Kr Krypton 83.80
40 Zr Zirconium 91.22
41 Nb Niobium 92.91
42 Mo Molybdenum 95.94
43 Tc Technetium 98.91
44 Ru Ruthenium 101.1
45 Rh Rhodium 102.9
46 Pd Palladium 106.4
47 Ag Silver 107.9
48 Cd Cadmium 112.4
49 In Indium 114.8
50 Sn Tin 118.7
51 Sb Antimony 121.8
52 Te Tellurium 127.6
53 I Iodine 126.9
54 Xe Xenon 131.3
71 Lu Lutetium 175.0
72 Hf Hafnium 178.5
73 Ta Tantalum 180.9
74 W Tungsten 183.8
75 Re Rhenium 186.2
76 Os Osmium 190.2
77 Ir Iridium 192.2
78 Pt Platinum 195.1
79 Au Gold 197.0
80 Hg Mercury 200.6
81 Tl Thallium 204.4
82 Pb Lead 207.2
83 Bi Bismuth 209.0
84 Po Polonium 209.0
85 At Astatine 210.0
86 Rn Radon 222.0
103 Lr Lawrencium 262.1
104 Rf Rutherfordium 261.1
105 Db Dubnium (262)
106 Sg Seaborgium (266)
107 Bh Bohrium (264)
108 Hs Hassium (277)
109 Mt Meitnerium (268)
110 Ds Darmstadtium (271)
111 Rg Roentgenium (272)
112 Uub
114 Uuq
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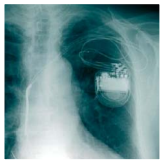
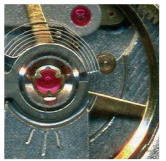





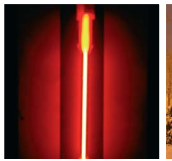
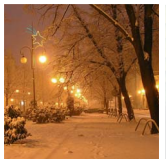

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World of the Elements
Elements of the World

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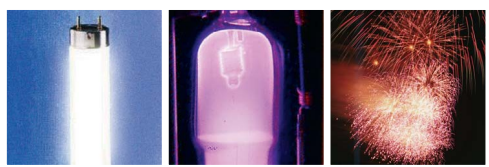

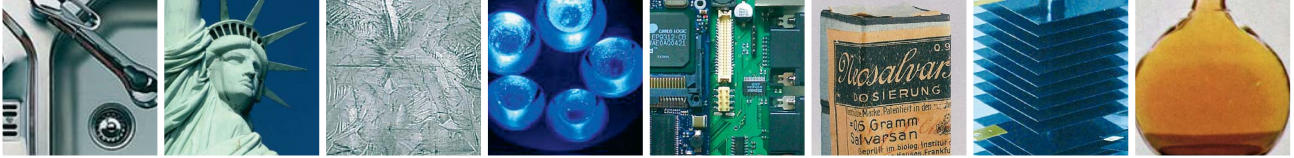

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Preface

Attention — this is not a textbook! It is also not meant to replace one. Nevertheless, there is a lot to be learnt, albeit in a different manner from that in which chemistry is normally presented. The initial question is old and simple: "What does the world consist of?" This leads to the next question: "Who were the researchers who discovered this?" They should not be forgotten by us, who take almost for granted all the advantages of progress. After all, the discovery of the 92 elements that occur in the universe and that can also be found on Earth is one of the greatest accomplishments of human intellectual curiosity. Through these discoveries we know what stars are made of, we know the composition of the Earth, and we know which elements are essential for life.

The transition of empirical alchemy in 18th century Europe to scientific chemistry allowed the discovery of more and more new elements through the thirst for knowledge, intuition, patience, and even luck. Known materials such as gold, silver, copper, iron, and lead were "suspected" to be elements relatively early. Despite all the best efforts, these materials could not be broken down into further components, and hence their being elements was consistent with the then generally recognized definition of John Dalton, which was also staunchly supported by Antoine de Lavoisier. New scientific methods (e.g. electrolysis) allowed the veteran elements to be joined stepwise by more and more unknown and unexpected substances that fulfilled the criteria for an element. In 1869, after many attempts to bring order into the growing chaos, Dimitri Mendeleev revealed a daring concept with his Periodic Table and its predictions. Each of the then known elements was assigned a place. The gaps represented elements that were not yet known. The discoveries of such elements proved that there was an order and system to the elements. This order explained much that was previously puzzling, for instance, the different atomic radii observed that same year by Julius Lothar Meyer, which seemed to follow a periodic trend.

The representation of the periodic system in this book shows yet another perspective. Each element has not only its own history but also its own identity. This is determined by the number of protons in the nucleus (the atomic number) and the corresponding number of electrons in the atomic shell. These electrons, in turn, give each element their properties, their "personalities", so to speak. There are relationships, but each element is unique in the sum of its properties. The text describes the particularities of each element, and the chosen picture indicates a scene from everyday life where we would encounter

the element. They are often hidden in functional systems such as electronics, or they impart particular properties to alloys, such as hardness and magnetism.

The tables and graphics at the end of the book provide an overview of how everything is connected. In general, it can be quite cumbersome for some to put together such a wealth of information. Hopefully, the selection presented will facilitate the search. Like all historical precedents, the discovery of the elements was complex and often multitracked. Some discoveries "were floating in the air" and were made independently by several researchers. Hence, even the authoritative literature leaves some questions unanswered, for example, regarding absolute priorities. These have been selected to the best of knowledge and belief, but unavoidable subjectivity should be borne in mind.

Chemistry would not be done justice if only the past and the status quo were discussed. Today, new heavy elements are discovered in nuclear accelerators as a result of their decomposition traces and are of interest in nuclear physics. The Periodic Table provides building blocks for new areas of chemistry. The possibilities for combining elements into defined compounds is far from exhausted, even though about 30 million have been described to date. Besides the question as to how molecules **react** with each other, a new phenomenon is becoming increasingly important: how molecules **interact** with each other. The principle of self-assembly was a condition for the origin of life. The targeted use of this fascinating property of materials to build functional systems is still in its infancy. An exciting phenomenon is the erratic change in properties as the particles of the material become very small. The door to the nanoworld (nano = 10^{-9}m) has only just been opened, but already fascinating perspectives with great potential can be seen in the transition from classical physics to quantum mechanics. Catalysis and materials science are undergoing dynamic developments. And finally, we are all aware of how molecular biology is rapidly developing at the interface of chemistry and biology. The Periodic Table is the foundation for the tower of knowledge and application of chemistry. The challenge for chemistry is and will remain the exploration of this knowledge for the good of mankind.

I am deeply grateful to many friends and colleagues, especially at BASF AG, for their help in collecting materials for this book. I am equally indebted to the imaginative graphic designer Gunther Schulz and the ever helpful colleagues at Wiley-VCH, without whose help this book would not have come together.

Hans-Jürgen Quadbeck-Seeger *June 2007*

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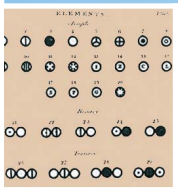
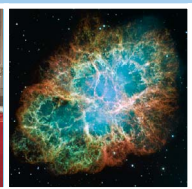
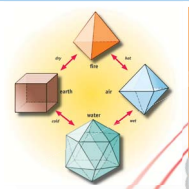
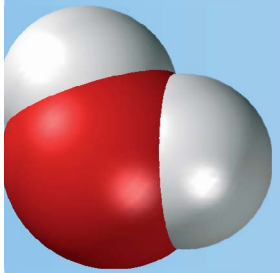
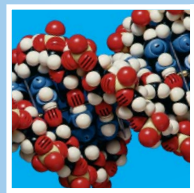
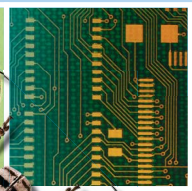
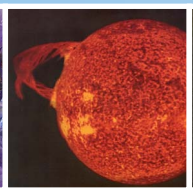


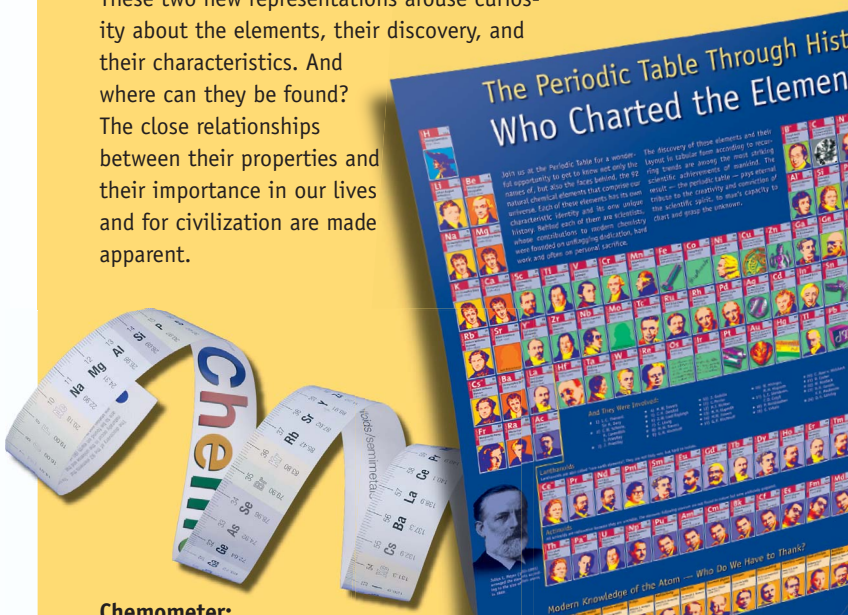





Appendix

About the **Historical Periodic Table** and the **Chemometer**

These two new representations arouse curiosity about the elements, their discovery, and their characteristics. And where can they be found? The close relationships between their properties and their importance in our lives and for civilization are made apparent.



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