

# Contents

I. INTRODUCTION	<i>page</i>
1. Origin, Scope, and Plan of this Book	1
II. THE BEGINNINGS	
2. X-rays	
2.1. Physics at the Time of Röntgen's Discovery of X-rays	6
2.2. Röntgen's Discovery	9
2.3. Progress in the Knowledge of X-rays up to 1912	11
3. Crystallography	
3.1. Descriptive Crystallography	17
3.2. Symmetry	19
3.3. Theories of Crystal Structure	22
4. Laue's Discovery of X-ray Diffraction by Crystals	
4.1. Physics and Crystallography at the University of Munich in 1912	31
4.2. Ewald's Thesis	37
4.3. Laue's Intuition	40
4.4. The Experimental Verification	42
4.5. The Publication of the Work	47
5. The Immediate Sequels to Laue's Discovery	
5.1. W. H. Bragg and his Studies of Ionization by Gamma and X-rays	57
5.2. W. L. Bragg and the Origin of Crystal Structure Analysis; X-ray Spectroscopy	59
5.3. C. G. Darwin's Work	74
5.4. Early Work in Other Countries	75
III. THE TOOLS	
6. The Principles of X-ray Diffraction	
6.1. X-ray Reflection according to W. L. Bragg	82
6.2. X-ray Diffraction according to Laue	85
6.3. Fourier Space	97
7. Methods and Problems of Crystal Structure Analysis	
7.1. Various Forms of the Problem	102
7.2. The Algebraic Structure Determination	106
7.3. The Analytical Structure Determination	108
7.4. Methods of Phase Determination	110
7.5. The Patterson Method	112
7.6. The Mathematical and Instrumental Approach to Structure Determination	113

## IV. THE GROWING FIELD

8.	The Growing Power of X-ray Analysis, <i>by W. L. Bragg</i>	120
9.	Problems of Inorganic Structures, <i>by Linus Pauling</i>	
9.1.	Simple Inorganic Structures	136
9.2.	Inorganic Complexes	140
9.3.	Inorganic Molecular Crystals	143
9.4.	Metals and Other Crystals involving Metal-metal Bonds	143
9.5.	Other Problems	145
10.	Problems of Organic Structures, <i>by J. Monteath Robertson</i>	147
11.	The Growing Field of Mineral Structures, <i>by F. Laves</i>	
11.1.	General Remarks	174
11.2.	Highlights of Structure Determination	176
11.3.	Point Defect	178
11.4.	Feldspars	179
11.5.	One-dimensional Disorder (Stacking Faults) and Polytypism	183
11.6.	What is a Mineral? What is a Crystal?	184
11.7.	Concluding Remarks	187
12.	Applications of X-ray Diffraction to Metallurgical Science, <i>by W. Hume-Rothery</i>	190
13.	Problems of Biochemical Structures, <i>by Ralph W. G. Wyckoff</i>	212
14.	X-ray Diffraction and its Impact on Physics, <i>by Dame Kathleen Lonsdale</i>	
14.1.	Introduction	221
14.2.	Early Ideas	222
14.3.	Importance of the Ionization Spectrometer	223
14.4.	Structure of the Atom	224
14.5.	Structure of the Nucleus	225
14.6.	The Nature of Radiation	226
14.7.	X-ray Absorption and Related Phenomena	227
14.8.	Crystal Dynamics	229
14.9.	Crystal Texture	231
14.10.	Ferroelectricity	234
14.11.	Fluorescence; Electrical and Thermal Conductivity	235
14.12.	Atomic and Ionic Radii	237
14.13.	Magnetic Properties of Crystals	239
14.14.	Electrical Properties of Crystals	241
14.15.	Optical Properties of Crystals; Absolute Configuration	244
14.16.	Thermo-optical Properties	245
15.	Dynamical X-ray Optics; Electron and Neutron Diffraction, <i>by P. P. Ewald</i>	
15.1.	Inadequacy of the Kinematical Theory	248
15.2.	Darwin's Theory	249
15.3.	Ewald's Dynamical Theory (1917)	250
15.4.	Laue's Form of the Dynamical Theory	253
15.5.	One and Two Rays in the Dynamical Theory	254
15.6.	Some Applications of the Dynamical Theory	257
15.7.	Electron and Neutron Diffraction	262

16. X-ray Spectroscopy, <i>by Manne Siegbahn</i>	
16.1. Early History	265
16.2. The Advent of the Diffraction X-ray Spectroscopy	266
16.3. X-ray Spectra and Atomic Structure	267
16.4. Development of X-ray Spectroscopy	268
16.5. Emission and Absorption Processes	271
16.6. The Electronic Shells of the Atom	273
16.7. X-ray Spectroscopy as an Analytical Tool	274
16.8. General Conclusions	275

## V. IN MEMORIAM

Max von Laue, <i>Autobiography</i>	278
William Henry Bragg, <i>by E. N. da C. Andrade</i>	308
Shoji Nishikawa, <i>by I. Nitta</i>	328
Charles Mauguin, <i>by J. Wyart</i>	335
E. S. Fedorov, <i>by I. I. Shafranovskii and N. V. Belov</i>	341
Artur Schoenflies, <i>by P. P. Ewald</i>	351
William Thomas Astbury, <i>by P. P. Ewald</i>	354
Carl H. Hermann, <i>by P. P. Ewald</i>	357
Gösta Phragmén, <i>by A. Hultgren, B. Kalling and A. Westgren</i>	360
Victor Moritz Goldschmidt, <i>by O. C. A. Bastiansen</i>	364
Christen Johannes Finbak, <i>by O. C. A. Bastiansen</i>	366
Paul Knipping, <i>by P. P. Ewald</i>	367
Memorial Tablets	368

## VI. SCHOOLS AND REGIONAL DEVELOPMENT

17. British and Commonwealth Schools of Crystallography	
17.1. General Survey, <i>by J. D. Bernal</i>	374
17.2. Crystallography in Britain during and after World War II, <i>by J. D. Bernal</i>	384
17.3. Post-war Commonwealth Development, <i>by J. D. Bernal</i>	397
17.4. Research in Non-industrial Laboratories outside the Uni- versities and the Royal Institution, <i>by J. D. Bernal</i>	400
17.5. Crystallography in British Industrial Laboratories, <i>by C. W. Bunn</i>	404
17.6. Early Work at University College, London, 1915–1923, <i>by Dame Kathleen Lonsdale</i>	408
17.7. Crystallography at the Royal Institution, <i>by Dame Kathleen Lonsdale</i>	410
17.8. Early Work on Crystal Structure at Manchester, <i>by R. W. James</i>	420
18. The Development of X-ray Diffraction in U.S.A.	
18.1. The Years before 1940, <i>by Ralph W. G. Wyckoff</i>	430
18.2. From the Beginning of World War II to 1961, <i>by Elizabeth A. Wood</i>	434
19. The New Crystallography in France, <i>by J. Wyart</i>	
19.1. The Period before August 1914	446
19.2. The Period 1918–1950	448

20. Germany, by <i>E. E. Hellner and P. P. Ewald</i>	456
21. The Netherlands, by <i>J. M. Bijvoet</i>	469
22. Scandinavia, by <i>G. Hägg</i>	477
23. Japan, by <i>I. Nitta</i>	484
24. Schools of X-ray Structural Analysis in the Soviet Union, by <i>A. V. Shubnikov</i>	493
25. The World-wide Spread of X-ray Diffraction Methods, by <i>P. P. Ewald</i>	498
VII. PERSONAL REMINISCENCES	
E. N. da C. Andrade: <i>Some Personal Reminiscences</i>	508
K. Banerjee: <i>Development of X-ray Crystallography Research in India</i>	514
N. V. Belov: <i>Personal Reminiscences</i>	520
J. D. Bernal: <i>My Time at the Royal Institution 1923-27</i>	522
J. M. Bijvoet: <i>Reminiscences</i>	526
W. L. Bragg: <i>Personal Reminiscences</i>	531
J. C. M. Brentano: <i>Personal Reminiscences</i>	540
M. J. Buerger: <i>Personal Reminiscences</i>	550
C. L. Burdick: <i>The Genesis and Beginnings of X-ray Crystallo- graphy at Caltech</i>	556
C. G. Darwin: <i>Moseley's Determination of Atomic Numbers</i>	559
J. D. H. Donnay: <i>For auld lang syne</i>	564
R. Glocker: <i>Personal Reminiscences</i>	570
A. Guinier: <i>Personal Reminiscences</i>	574
G. Hägg: <i>Personal Reminiscences</i>	579
Albert W. Hull: <i>Autobiography</i>	582
R. W. James: <i>Personal Reminiscences</i>	588
H. Lipson: <i>Personal Reminiscences</i>	592
K. Lonsdale: <i>Reminiscences</i>	595
H. Mark: <i>Recollections of Dahlem and Ludwigshafen</i>	603
Isamu Nitta: <i>Personal Reminiscences</i>	608
A. L. Patterson: <i>Experiences in Crystallography-1924 to Date</i>	612
Linus Pauling: <i>Early Work on X-ray Diffraction in the California Institute of Technology</i>	623
Michael Polanyi: <i>My Time with X-rays and Crystals</i>	629
J. Monteath Robertson: <i>Personal Reminiscences</i>	637
Paul Scherrer: <i>Personal Reminiscences</i>	642
A. V. Shubnikov: <i>Autobiographical Data and Personal Reminiscences</i>	647

## CONTENTS

IX

M. E. Straumanis: <i>Personal Reminiscences</i>	654
Jean Jacques Trillat: <i>Some Personal Reminiscences</i>	662
B. E. Warren: <i>Personal Reminiscences</i>	667
A. Westgren: <i>Personal Recollections</i>	672
A. J. C. Wilson: <i>My Part in X-ray Statistics</i>	677
W. A. Wooster: <i>Personal Experiences of a Crystallographer</i>	680
Jean Wyart: <i>Personal Reminiscences</i>	685
Ralph W. G. Wyckoff: <i>Reminiscences</i>	691
VIII. THE CONSOLIDATION OF THE NEW CRYSTALLO- GRAPHY	695
APPENDIX: Biographical Notes on Authors	707
SUBJECT INDEX	715
LIST OF REPEATEDLY OCCURRING SUBSTANCES	718
INDEX OF LOCALITIES AND SCHOOLS	719
INDEX OF NAMES	721