

CONTENTS

PREFACE	v
1. WHAT IS AN ELEMENTARY PARTICLE	1
Questions that may not have Answers	2
Something Unchanging	3
Is It Real?	5
2. QUARKS AND LEPTONS	9
The Quark — The Unconventional Elementary Particle that has not been Found	10
Heavy Particles, Light Particles, In-between Particles	11
What is the “Size” of a Particle?	15
Things to be Learned from Scattering Experiments	16
3. LOOKING FOR QUARKS	19
Structure of Protons and Neutrons	20
Looking for Fractionally Charged Particles	21
4. VARIOUS ACCELERATORS	27
Profundity of Nature — Stronger Blows Produce Deeper Resonances	28
The Principle of the Accelerator	29
Colliding Beams — The Power of the Counterpunch	32
5. THE BIRTH OF THE YUKAWA THEORY	37
From the Atom to the Nucleus	38
Yukawa’s Meson Theory	40
Relativistic Quantum Mechanics	42
The Ideas that Led to the Mesons	47
The 1930’s	48

6. THE APPEARANCE OF NEW PARTICLES	51
Coulomb Form and Yukawa Form	52
The π -Meson	55
From Two-Meson Theory to the Discovery of the Muon	57
The Dramatic Appearance of the V Particle	59
Trying Everything	62
7. ORDERLINESS OF ELEMENTARY PARTICLES AND CONSERVATION LAWS	65
The Gell-Mann-Nakano-Nishijima Law	66
The Key to an Idea	71
Strong Interactions and the Conservation of Isospin	72
The $3-3$ Resonance of the Pion and the Nucleon	74
8. PARITY AND CONSERVATION	79
What is Parity?	80
The Non-Conservation of Parity	82
CP Violation	86
Are Natural Laws Invariant under Time Reversal?	88
9. COMPOSITE MODELS OF HADRONS	91
What is Expected from Fundamental Particles	92
The Composite Model of Fermi and Yang	92
The "Elementary" and "Compound" in the World of Elementary Particle Physics	94
The Sakata Model	96
10. THE QUARK MODEL	103
How does the Quark Model Differ from the Sakata Model?	104
Baryons in the Quark Model	106
The Discovery of the Ω^- as Predicted	108
11. EVOLUTION OF THE QUARK MODEL	111
Making Quark Compounds	112
Analogy with Nuclei	114
Quarks Come in Colors and Flavors	116

The Nine Quark Model	117
Are there Colored Hadrons?	118
The Possibility of Integer Charged Quark	119
The Unexpected New Particle J/Ψ	121
12. CHARM AND ITS FOLLOWERS	123
The J/Ψ Indicates Profundity of Nature	124
The True Identity of the J/Ψ Particle	126
The Fourth Quark c That Completed the Quark Model	129
Outdone by Nature Again	131
At Least 6 Leptons and at Least 5 Quarks	133
13. QUARKS WITH STRINGS ATTACHED	135
A Paradox	136
String Model of Hadrons	139
What is a String?	144
14. WHAT IS A PARTON?	147
Hadrons are Soft	148
Infinitely Small Point Particle	150
Feynman's Parton Model	151
Comparison with the Quark Model	152
15. TOMONAGA'S RENORMALIZATION THEORY	155
Particle Physics is Busy Chasing New Phenomena	156
Quantum Electrodynamics	156
Infinite Self-energy	157
Renormalization Theory — An Act of Giving Up Something	159
16. QCD — THE QUANTUM MECHANICS OF COLOR	163
From Meson Theory to Color Dynamics	164
What is A Gauge Field?	164
The Dynamics of Color	165
The Gluon — The Glue to Hold the Quarks Together	166

Asymptotic Freedom	167
Wilson's Lattice Theory	171
17. SPONTANEOUS BREAKING OF SYMMETRY	173
What is Symmetry?	174
Spontaneously Broken Symmetry	175
The Relics of Spontaneous Symmetry Breaking	177
Superconductivity	178
The Origin of the Quark Mass	180
18. THE LEANING STRUCTURE OF THE WEAK INTERACTION	183
God's Mistake?	184
What is the Weak Interaction?	185
Orderliness in the Weak Interaction	186
There must be a Charmed Quark	187
19. THE WEINBERG-SALAM THEORY	193
Beyond the Yukawa Meson Theory	194
The W Boson	195
The Unification of Weak and Electromagnetic Forces	199
Comparison with the Superconductivity	200
20. THE UNIFIED FIELD THEORY	205
Unification of the Three Forces	206
Incredible Energy — But We Can't Say It's Nonsense	207
Einstein's Unfulfilled Dream	209
The Unification of Three Forces and the Unification of Particles	209
21. PROGRAM FOR GRAND UNIFICATION	211
The Last Question	212
The Unification Theory of Georgi and Glashow	213
Are There Particles at Lower Levels than Quarks and Leptons?	215
An Astonishing Conclusion — All Matter is Unstable	216

The Coming Together of Particle Theory and Cosmology	218
The Mystery of Man Who Divines Matter and Universe in an Instant	219
GLOSSARY	221
INDEX	225