

Table of Contents

The Character of Particle Physics	1
Executive Summary	5
1 Introduction	5
2 Precision Tests of Electroweak Theory	6
3 Quantum Chromodynamics	7
4 Heavy Flavor Physics and CP Violation	8
5 Neutrino Mass and Mixing	10
6 Electroweak Symmetry Breaking and New Physics at the TeV Scale	11
7 Astrophysics, Cosmology, and Unification of Forces	12
8 Exploratory Theory	14
9 Accelerator Physics, Technology, and Facilities	14
10 Detectors	15
11 Computing	16
12 Structural Issues in High-Energy Physics	16
13 Conclusions	17
Precision Tests of Electroweak Physics	19
1 Introduction	19
2 Standard Electroweak Model.	19
3 Expected Schedule of Future Measurements	24
4 Measurements of Electroweak Couplings Near the Z Pole	25
5 Measurements of Electroweak Couplings at low Q^2	27
6 Measurements of the W -boson Mass	29
7 The Top Quark	31
8 Global Analysis of Electroweak Data	36
9 Direct Searches for the Higgs Boson	45
10 Couplings of the Gauge Bosons	48
11 Conclusions	48
Acknowledgements	49
References	49
Quantum Chromodynamics	55
1 Preface	56
2 Introduction and Executive Summary	56
3 Experimental Studies of QCD	58
4 Theoretical Studies of QCD	66
5 QCD and Dense Matter	70
6 Lattice QCD	75
References	84

Heavy Flavor Physics and CP Violation	91
1 Overview	91
2 Standard Model Parameters and Tests	92
3 CP Violation and T Violation	97
4 Rare and Forbidden Decays	103
5 Strong Interaction Effects in Heavy Flavor Physics	106
6 Facilities	111
7 Conclusions	115
Acknowledgements	115
References	115
Neutrino Mass and Mixing	119
1 Introduction	119
2 Basic Properties of Neutrinos	120
3 Neutrino Counting	123
4 Cosmology and Astrophysics	124
5 Supernova Constraints on Neutrino Masses	124
6 Direct Mass Measurements	126
7 Double Beta Decay	129
8 Neutrino Oscillations	130
9 Masses Below 10^{-2} eV (Solar Neutrinos)	131
10 Atmospheric Neutrinos	136
11 Reactor Neutrinos	140
12 Accelerator Neutrinos	142
13 Summary	147
References	148
Electroweak Symmetry Breaking and New Physics at the TeV Scale	153
1 Introduction	153
2 Weakly-Coupled Higgs Bosons	156
3 Low Energy Supersymmetry: Implications of Models	163
4 Low Energy Supersymmetry: Phenomenology	166
5 Strongly Coupled ESB Sector: Model- Independent Approaches	170
6 Strongly Coupled ESB Sector: Implications of Models	172
7 New Gauge Bosons	173
8 New particles and Interactions	176
9 Anomalous Gauge Boson Couplings	179
10 Top Quarks as a Window to Electroweak Symmetry Breaking	182
11 Virtual Effects of New Physics	184
12 Experimental Issues at Hadron Colliders	186
13 Experimental Issues at e^+e^- Linear Colliders	187
14 Conclusions	189
References	190

Astrophysics, Cosmology, and Unification of Forces	195
1 Executive Summary	195
2 Cosmology	195
3 Unification	200
4 Gravity	203
5 Interface with Cosmic Rays, Nuclear Physics, and Astrophysics	204
6 Experiment	205
7 Structural Issues	208
Selected Bibliography	209
The State of Exploratory Theory Beyond the Standard Model	211
1 Introduction	211
2 Experimental Opportunities to Detect Supersymmetric Physics	213
3 Recent Theoretical Progress	214
4 Theoretical Challenges	215
Accelerator Physics, Technologies, And Facilities	217
1 Introduction	217
2 Hadron Facilities	219
3 Electron Linear Collider Facilities	228
4 Electron-Positron Circular Collider Facilities	251
5 Advanced Accelerators	253
6 Conclusions	258
Acknowledgments	258
References	258
Detectors	261
1 Introduction	261
2 Tracking	262
3 Calorimetry	266
4 Muon Detectors	269
5 Particle Identification	271
6 Large-Area Detectors for Non-Accelerator Physics	275
7 Electronics	278
8 Conclusions and Recommendations	280
References	282
Computing	287
1 Introduction	287
2 Past Progress and Current Status	287
3 Mode of operation	289
4 Technology Needs	289
5 Recommendations	292

Structural Issues In High-Energy Physics	293
1 Introduction	293
2 Governance and Advising	293
3 Career Issues	295
4 Education and Outreach	296
Appendix A	300
Appendix B	300
References	301