



---

# Contents

---

<i>Preface</i>	vii
<b>Part A: At the root of the endeavor</b>	1
1 Human limitations	3
a. <i>Limits by principle</i>	3
b. <i>Bounds of human nature</i>	5
c. <i>Restrictions by complexity</i>	6
2 Theory and the role of mathematics	9
a. <i>What is a scientific theory?</i>	9
b. <i>What does mathematics have to do with nature?</i>	11
3 Scientific objectivity	15
a. <i>The evolution of a scientific theory</i>	15
b. <i>Acceptability criteria</i>	17
c. <i>Invariance: the irrelevance of the specific observer</i>	19
4 The aim of scientific theory	23
a. <i>Explanation and prediction</i>	23
b. <i>Unification</i>	27
<b>Part B: The world of relativity</b>	33
5 Space and time: from absolute to relative	35
a. <i>Galileo, the pioneer</i>	35
b. <i>Newton, the first great architect of mathematical theory</i>	37
c. <i>The relativity of Newtonian mechanics</i>	42
6 Imposed consistency: special relativity	49
a. <i>Maxwell and the ether hypothesis</i>	49
b. <i>The paradox of the speed of light</i>	52
c. <i>Einstein's fiat</i>	55
d. <i>Simultaneity</i>	62
e. <i>Fast moving clocks and meter sticks</i>	65
f. <i>The conversion of matter into energy</i>	72
g. <i>Space-time geometry</i>	75
h. <i>Poincaré invariance</i>	86

7	Gravitation as geometry: general relativity	89
a.	<i>Newton's universal gravitation</i>	89
b.	<i>Why Einstein searched for a new gravitation theory</i>	91
c.	<i>The equivalence principle</i>	93
d.	<i>Curved space-time</i>	97
e.	<i>General relativity</i>	102
f.	<i>Gravitational radiation and black holes</i>	106
8	Revolutions without revolutions	111
a.	<i>Established theories</i>	111
b.	<i>Scientific revolutions</i>	114
<b>Part C: The quantum world</b>		119
9	The limits of the classical world	121
a.	<i>The classical world begins to fail</i>	121
b.	<i>The discovery of quantization</i>	125
10	Concepts of the quantum world	134
a.	<i>Waves and particles</i>	135
b.	<i>Quantum particles</i>	141
c.	<i>Indeterminacy</i>	144
d.	<i>Uncertainty</i>	147
e..	<i>Complementarity</i>	151
f.	<i>The essential link</i>	153
11	From apparent paradox to a new reality	158
a.	<i>Quantum systems</i>	159
b.	<i>Observables and measurements</i>	161
c.	<i>Schroedinger's cat</i>	166
d.	<i>Einstein's reality</i>	169
e.	<i>Quantum reality</i>	175
f.	<i>Quantum logic</i>	180
g.	<i>Macroscopic quantum phenomena</i>	184
12	The present state of the art	189
a.	<i>The marriage between quantum mechanics and special relativity</i>	189
b.	<i>The onion of matter</i>	194
c.	<i>Elementary particles</i>	196
	Epilogue	202
	Notes	205
	Glossary of technical terms	219
	Name index	223
	Subject index	225

