

Contents

<i>Preface</i>	vii
1. Introduction	1
1.1 Our Perception	1
1.2 The Story of Star Formation	2
1.3 The Early History	5
1.4 Modern History	7
1.5 Summary	8
2. The Physics and Chemistry	9
2.1 Scales and Ranges	9
2.2 The Ingredients	13
2.2.1 Atoms, molecules and dust	13
2.2.2 Cosmic rays, ions and magnetic field	15
2.3 Observations	17
2.3.1 Radio	17
2.3.2 Millimetre, submillimetre and far-infrared	18
2.3.3 Infrared observations	20
2.3.4 Optical, ultraviolet and X-rays	21
2.4 Processes	22
2.4.1 Interstellar extinction and reddening	22
2.4.2 Photo-dissociation	24
2.4.3 Hydrogen chemistry	25
2.4.4 Chemistry	27
2.4.5 Cooling and heating	29
2.5 Summary	30

3.	The Clouds	31
3.1	Phases of the Interstellar Medium	32
3.2	Weighing up Molecular Clouds	33
3.3	Molecular Clouds	37
3.3.1	Breeding grounds for high-mass stars	37
3.3.2	Orion	37
3.3.3	The Eagle	40
3.3.4	Breeding grounds for low-mass stars	41
3.3.5	Isolated clouds	43
3.4	The Internal Dynamics and Structure of Clouds	44
3.5	Rotation Trends	48
3.6	Structural Analysis: Fractals and Filaments	51
3.7	Summary: Invisible Clouds	52
4.	Cloud Formation, Evolution and Destruction	53
4.1	The Ages of Clouds	53
4.2	The Origins of Clouds	57
4.2.1	Formation of the giant clouds	57
4.2.2	Formation of Bok globules and dark clouds	60
4.3	The Fate of a Cloud	61
4.3.1	Gradual evolution: cloud pressure	61
4.3.2	Long-lived isolated clouds	62
4.3.3	Bound globules	64
4.3.4	The Jeans mass	66
4.4	Summary	68
5.	Turbulence	69
5.1	Concepts of Turbulence	70
5.2	Origin of Turbulence	72
5.3	The Transfer to Turbulence	74
5.4	Dissipation of Turbulence	76
5.5	Computer Simulations	78
5.6	Collapse of Turbulent Clouds	81
5.7	Molecules in Turbulent Clouds	84
5.8	Summary: The New Paradigm	85
6.	The Collapse	87
6.1	Observing Starless Cores and Pre-stellar Cores	87

6.2	Properties of Starless Cores	91
6.2.1	Physical parameters	91
6.2.2	Dynamical parameters	92
6.2.3	Distributions	94
6.3	Classical Collapse Scenarios	95
6.4	Core Theory	97
6.5	Turbulent Evolution of Cores	99
6.6	The Approaching Birth	100
7.	The Magnetic Mediation	101
7.1	Magnetic Field Observations	102
7.2	Magnetohydrodynamics	103
7.3	Magnetic Field and Flux	105
7.4	Super-critical or Sub-critical Collapse?	109
7.5	Sub-critical Contraction: Ambipolar Diffusion	110
7.6	Spin	114
7.7	MHD Turbulence	117
7.8	Summary	118
8.	The Birth	119
8.1	Commencement of Life	120
8.2	Identifying and Classifying Protostars	121
8.3	Observations of Protostellar Cores	124
8.3.1	Class 0 protostars: the observations	125
8.3.2	Class I protostars: the observations	126
8.4	Theory of Accretion onto Core	127
8.5	Accretion Rates from Static Initial States	128
8.6	Protostellar Accretion from Turbulent Clouds	130
8.7	Number, Age and Statistics	132
8.8	Protostellar Evolution	133
8.9	Protostellar Envelopes	135
8.10	Summary: Observation versus Theory	136
9.	The Young Stars	139
9.1	T Tauri Stars	140
9.1.1	Classical T Tauri stars	140
9.1.2	Weak-line T Tauri stars	142
9.1.3	Outbursts: FU Ori objects	143

9.2	Class II and Class III Objects	144
9.3	Location and Number	144
9.4	Accretion	146
	9.4.1 General characteristics	146
	9.4.2 Accretion disk specifics	146
	9.4.3 The star-disk connection	151
9.5	Class and Disk Evolution	152
9.6	Interiors	155
9.7	Giant Flares, Starspots and Rotation	156
9.8	Summary	158
10.	Jets and Outflows	161
	10.1 Classical Bipolar Outflows	162
	10.2 High-collimation Bipolar Outflows	165
	10.3 Molecular Jets	166
	10.4 Atomic Jets	168
	10.5 Herbig-Haro Flows	170
	10.6 Launch Theory	172
	10.7 Jet Theory	176
	10.8 Outflow Evolution	179
	10.8.1 The jet flow	179
	10.8.2 The bipolar outflow	180
	10.9 Impact Theory	181
	10.10 Summary	182
11.	Massive Stars	185
	11.1 Basic Characteristics	186
	11.2 Compact H II Regions	187
	11.3 Models for Massive Star Environments	189
	11.4 Hot Cores and Masers	191
	11.5 Outflows from Massive Stars	192
	11.6 Accretion Theory	193
	11.7 Formation within Clusters	196
	11.8 Intermediate Mass Stars	198
	11.9 Summary	199
12.	The Distributions	201
	12.1 Types and Prototypes	202

12.2	Binarity and Multiplicity	203
12.2.1	The adult population	203
12.2.2	The pre-main sequence population	204
12.3	Binarity: Theory	205
12.3.1	Mechanisms	205
12.3.2	Fragmentation	206
12.4	Nearby Clusters: Observations	208
12.5	Cluster Formation: Theory	210
12.5.1	From gas to stars	210
12.5.2	Cluster relaxation	211
12.5.3	Cluster dissolution	212
12.6	Brown Dwarves and Planets	213
12.7	The Masses of Stars	215
12.8	Summary	219
13.	Cosmological Star Formation	221
13.1	The First Stars	222
13.1.1	The scene	222
13.1.2	The first stellar nurseries	224
13.1.3	The first generation	225
13.1.4	Early cosmological evolution	226
13.2	Cosmological Star Formation History	227
13.3	Starbursts	228
13.4	Star Formation on Galactic Scales	232
13.5	Globular Clusters	234
13.6	Summary	235
	Epilogue	237
	<i>Index</i>	239