## Contents

	List of illustrations	<i>page</i> xi
	Preface	xix
1	Introduction	1
1.1	About this book	1
1.2	The stellar life-cycle	2
1.3	The space between the stars	3
1.4	The distribution of the stars	6
1.5	The magnetic field	8
1.6	Star formation in a galactic context	10
1.7	Known sites of contemporary star formation	12
1.8	The initial mass function	15
1.9	Objectives of star-formation theory	16
2	Probing star formation	21
2.1	Introduction	21
2.2	Properties of photons	21
2.3	Intensity	22
2.4	Flux	24
2.5	Radiant energy density	24
2.6	Continuum radiation – studying the dust	25
2.7	Radiative transfer	27
2.8	Calculating the dust mass	29
2.9	Line radiation – studying the gas	32
3	The ISM – the beginnings of star formation	39
3.1	Introduction	39
3.2	The 21-cm line of atomic hydrogen	39
3.3	Molecular gas	48
3.4	Line shapes and the motion of the gas	52
3.5	Absorption lines – searchlights through the ISM	56
3.6	The curve of growth	61
3.7	The use of absorption lines	63

4	Molecular clouds – the sites of star formation	65
4.1	The equation of state	65
4.2	Fluid mechanics of molecular clouds	66
4.3	Gravitational instability	69
4.4	The virial theorem	72
4.5	Observations of molecular clouds	75
4.6	Turbulence in molecular clouds	78
4.7	Magnetic fields in molecular clouds	83
4.8	Chemistry in molecular clouds	87
5	Fragmentation and collapse – the road to star	
	formation	95
5.1	The road to star formation	95
5.2	Theoretical collapse solutions	96
5.3	The minimum mass of a star	98
5.4	Effects of the magnetic field	102
5.5	Observations of the initial conditions of collapse	108
5.6	Pre-stellar cores and the IMF	111
5.7	Binary and multiple star formation	113
6	Young stars, protostars and accretion – building a	
	typical star	117
6.1	Pre-main-sequence evolution	117
6.2	Hayashi tracks	119
6.3	Henyey tracks	125
6.4	Accretion onto protostars	128
6.5	Observations of protostars – the birth line	135
6.6	Millimetre-wave continuum observations	136
6.7	Millimetre-wave spectroscopy	138
6.8	Infrared and optical observations	139
7	The formation of high-mass stars, and their	
	surroundings	143
7.1	Introduction	143
7.2	The main stages of high-mass star formation	144
7.3	Building a high-mass star	149
7.4	Line radiation from HII regions	153
7.5	Recombination rate and emission measure	156
7.6	Free-free radio continuum emission	158
7.7	Size of an HII region – Strømgren radius	161
7.8	lonisation fronts	162
79	Expansion of an HII region	166

8	By-products and consequences of star formation	173
8.1	Introduction	173
8.2	Circumstellar discs	173
8.3	Bipolar outflows	175
8.4	Disc fragmentation	179
8.5	Planet formation	180
8.6	Brown dwarf stars	184
8.7	Galaxy formation	187
8.8	Starburst galaxies	190
8.9	The epoch of star formation	191
	List of mathematical symbols	195
	List of figure credits	201
	Index	205