# Contents

Preface, xiii  
Acknowledgements, xv  
List of Abbreviations, xvii  
About the Companion Website, xxi  

1 Introduction to Blood Science, 1  
   1.1 What is blood science?, 1  
   1.2 Biochemistry, 6  
   1.3 Blood transfusion, 8  
   1.4 Genetics, 10  
   1.5 Haematology, 14  
   1.6 Immunology, 17  
   1.7 The role of blood science in modern healthcare, 19  
   1.8 What this book will achieve, 22  
Summary, 23  
References, 23  
Further reading, 23  
Web sites, 23  

2 Analytical Techniques in Blood Science, 25  
   2.1 Venepuncture, 25  
   2.2 Anticoagulants, 26  
   2.3 Sample identification and tracking, 27  
   2.4 Technical and analytical confidence, 27  
   2.5 Major techniques, 32  
   2.6 Molecular genetics, 43  
   2.7 Point of care testing, 47  
   2.8 Health and safety in the laboratory, 48  
Summary, 49  
Further reading, 50  
Web sites, 50  

3 The Physiology of the Red Blood Cell, 51  
   3.1 Introduction, 51  
   3.2 The development of blood cells, 52  
   3.3 Erythropoiesis, 56  
   3.4 The red cell membrane, 58  
   3.5 The cytoplasm of the red cell, 60  
   3.6 Oxygen transport, 66  
   3.7 Recycling the red cell, 68  
   3.8 Red cell indices in the full blood count, 69  
   3.9 Morphology of the red cell, 72  
Summary, 74  
Further reading, 74
4 The Pathology of the Red Blood Cell, 75
   4.1 Introduction: diseases of red cells, 75
   4.2 Anaemia resulting from attack on, or stress to, the bone marrow, 78
   4.3 Anaemia due to deficiency, 80
   4.4 Intrinsic defects in the red cell, 85
   4.5 External factors acting on healthy cells, 100
   4.6 Erythrocytosis and polycythaemia, 103
   4.7 Molecular genetics and red cell disease, 105
   4.8 Inclusion bodies, 105
   4.9 Case studies, 105
   Summary, 107
   References, 107
   Further reading, 107

5 White Blood Cells in Health and Disease, 109
   5.1 Introduction, 109
   5.2 Leukopoiesis, 111
   5.3 Neutrophils, 115
   5.4 Lymphocytes, 116
   5.5 Monocytes, 117
   5.6 Eosinophils, 118
   5.7 Basophils, 119
   5.8 Leukocytes in action, 120
   5.9 White cells in clinical medicine, 127
   5.10 Case studies, 132
   Summary, 132
   Further reading, 133

6 White Blood Cell Malignancy, 135
   6.1 The genetic basis of leukocyte malignancy, 135
   6.2 Tissue techniques in haemato-oncology, 139
   6.3 Leukaemia, 141
   6.4 Lymphoma, 149
   6.5 Myeloma and related conditions, 152
   6.6 Myelofibrosis and myelodysplasia, 157
   6.7 Case studies, 157
   Summary, 158
   Further reading, 159
   Guidelines, 159

7 The Physiology and Pathology of Haemostasis, 161
   7.1 The blood vessel wall, 162
   7.2 Platelets, 163
   7.3 The coagulation pathway, 165
   7.4 Haemostasis as the balance between thrombus formation and removal, 168
   7.5 The haemostasis laboratory, 171
   7.6 The pathology of thrombosis, 173
   Summary, 175
   Further reading, 175
8 The Diagnosis and Management of Disorders of Haemostasis, 177
   8.1 Thrombosis 1: overactive platelets and thrombocytosis, 177
   8.2 Thrombosis 2: overactive coagulation, 181
   8.3 Haemorrhage 1: platelet underactivity and thrombocytopenia, 193
   8.4 Haemorrhage 2: coagulation underactivity, 199
   8.5 Disseminated intravascular coagulation, 203
   8.6 Molecular genetics in haemostasis, 204
   8.7 Case studies, 205

Summary, 206
References, 206
Further reading, 207
Guidelines, 207
Web sites, 207

9 Immunopathology, 209
   9.1 Introduction, 209
   9.2 Basics of the immune system, 210
   9.3 Humoral immunity, 212
   9.4 Immunopathology 1: immunodeficiency, 215
   9.5 Immunopathology 2: hypersensitivity, 221
   9.6 Immunopathology 3: autoimmune disease, 226
   9.7 Immunotherapy, 232
   9.8 The immunology laboratory, 234
   9.9 Case studies, 238

Summary, 239
References, 240
Further reading, 240
Guidelines, 240
Web sites, 240

10 Immunogenetics and Histocompatibility, 241
   10.1 The genetics of antigen recognition, 241
   10.2 Human leukocyte antigens, 245
   10.3 Transplantation, 251
   10.4 Autoimmunity and human leukocyte antigens, 257

Summary, 260
Further reading, 260
Guidelines, 260
Web sites, 260

11 Blood Transfusion, 261
   11.1 Blood collection and processing, 262
   11.2 Blood groups, 265
   11.3 Laboratory practice of blood transfusion, 273
   11.4 Clinical practice of blood transfusion, 279
   11.5 Hazards of blood transfusion, 281

Summary, 284
References, 284
Further reading, 284
Guidelines, 284
Web sites, 285
12 Waste Products, Electrolytes and Renal Disease, 287
   12.1 Renal anatomy and physiology, 287
   12.2 Homeostasis, 288
   12.3 Excretion, 295
   12.4 Renal endocrinology, 297
   12.5 Renal disease, 298
   12.6 Case studies, 301
Summary, 303
Further reading, 303
Guidelines, 303
Web sites, 303

13 Hydrogen Ions, pH, and Acid–Base Disorders, 305
   13.1 Ions and molecules, 305
   13.2 Blood gases, 308
   13.3 Acidosis (pH < 7.3), 312
   13.4 Alkalosis (pH > 7.5), 313
   13.5 Mixed acid–base conditions, 314
   13.6 Clinical interpretation, 314
   13.7 Case studies, 315
Summary, 316
Further reading, 317
Web site, 317

14 Glucose, Lipids and Atherosclerosis, 319
   14.1 Glucose, 319
   14.2 Dyslipidaemia, 333
   14.3 Atherosclerosis, 343
   14.4 Case studies, 347
Summary, 348
Further reading, 348
Guidelines, 349
Web sites, 349

15 Calcium, Phosphate, Magnesium and Bone Disease, 351
   15.1 Calcium, 352
   15.2 Phosphates, 355
   15.3 Magnesium, 355
   15.4 The laboratory, 355
   15.5 Disorders of calcium homeostasis, 357
   15.6 Disorders of phosphate homeostasis, 360
   15.7 Disorders of magnesium homeostasis, 362
   15.8 Bone physiology, 363
   15.9 Bone disease, 364
   15.10 Case studies, 368
Summary, 369
Further reading, 370
Guidelines, 370
Web sites, 370
16 Nutrients and Gastrointestinal Disorders, 371
   16.1 Nutrients, 371
   16.2 The intestines, 375
   16.3 Case studies, 381
Summary, 382
Further reading, 382
Guidelines, 382

17 Liver Function Tests and Plasma Proteins, 383
   17.1 Anatomy and physiology of the liver, 384
   17.2 Liver function tests, 389
   17.3 Diseases of the liver, 390
   17.4 Plasma proteins, 396
   17.5 Case studies, 405
Summary, 406
Further reading, 406
Web sites, 406

18 Hormones and Endocrine Disorders, 407
   18.1 Endocrine physiology, 407
   18.2 The pathology of the endocrine system, 417
   18.3 Case studies, 434
Summary, 435
Further reading, 435
Web sites, 436

19 Cancer and Tumour Markers, 437
   19.1 General concepts in cancer biology, 437
   19.2 Blood science and cancer, 440
   19.3 Molecular genetics, 444
   19.4 Case studies, 445
Summary, 446
Further reading, 446
Guidelines, 447
Web sites, 447

20 Inherited Metabolic Disorders, 449
   20.1 The genetics of inheritance, 449
   20.2 Molecular inherited metabolic disorders, 451
   20.3 Organelle inherited metabolic disorders, 455
   20.4 Antenatal diagnosis and neonatal screening, 455
   20.5 Case studies, 456
Summary, 457
Further reading, 457

21 Drugs and Poisons, 459
   21.1 Toxicology, 459
   21.2 Toxicology of specific compounds, 461
   21.3 Therapeutic drug monitoring, 465
   21.4 Case studies, 468
Summary, 469
References, 469
Further reading, 469
<table>
<thead>
<tr>
<th>Case Report</th>
<th>Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anaemia, hypercalcaemia, proteinuria, myeloma</td>
</tr>
<tr>
<td>2</td>
<td>Diabetes, glycated haemoglobin, chronic renal failure</td>
</tr>
<tr>
<td>3</td>
<td>Acute kidney injury, leucocytosis, neutrophilia, viruses</td>
</tr>
<tr>
<td>4</td>
<td>Part 1: Obesity, colorectal cancer, CEA, hypothyroidism. Part 2: Alcoholism, raised GGT and triacylglycerols</td>
</tr>
<tr>
<td>5</td>
<td>Part 1: No abnormalities. Part 2: Asthma, raised IgE. Part 3: Falling haemoglobin, rising ESR, lung cancer</td>
</tr>
<tr>
<td>6</td>
<td>Hypothyroidism, marginally reduced haemoglobin</td>
</tr>
<tr>
<td>7</td>
<td>Raised CRP, ESR, rheumatoid factor and anti-nuclear antibodies; borderline anti-dsDNA antibodies, low C3, low eGFR and so mild renal failure, systemic lupus erythematosus</td>
</tr>
<tr>
<td>8</td>
<td>Normal blood results in renal transplantation</td>
</tr>
<tr>
<td>9</td>
<td>Falling albumin, eGFR, haemoglobin, red cell count and platelets, rising ESR, white cell count and neutrophila, CRP, urea and creatinine, septicaemia</td>
</tr>
<tr>
<td>10</td>
<td>Microcytic anaemia, thrombocytopenia, lymphocytosis, abnormal LFTs, falling albumin, raised CRP, myositis with raised CK, viruses</td>
</tr>
<tr>
<td>11</td>
<td>Acidosis, hyperglycaemia, diabetic ketoacidosis, acute renal injury, raised urea and creatinine</td>
</tr>
<tr>
<td>12</td>
<td>Low haemoglobin, thrombocytopenia, raised CRP and d-dimers, abnormal LFTs, malaria, pregnancy</td>
</tr>
<tr>
<td>13</td>
<td>Raised aldosterone, hypernatraemia, hypokalaemia, Conn's syndrome</td>
</tr>
<tr>
<td>14</td>
<td>Paediatric diabetic ketoacidosis, hyperglycaemia, low bicarbonate, raised phosphates, ALP and proteins</td>
</tr>
</tbody>
</table>

References, 490
Appendix: Reference Ranges, 491
Further Reading, 493
Glossary, 495
Index, 519