

Contents

Preface — vii

Acknowledgments — ix

Part A: Physical and physiological aspects of the body

1 Brief overview of body parts and functions — 3

- 1.1 Introduction — 3
- 1.2 Overview — 3
 - 1.2.1 Cells — 3
 - 1.2.2 Circulation — 5
 - 1.2.3 Heart — 6
 - 1.2.4 Kidneys — 6
 - 1.2.5 Respiratory system — 7
 - 1.2.6 Digestive system — 8
 - 1.2.7 Sensory organs — 9
 - 1.2.8 Nervous system — 10
 - 1.2.9 Locomotor system — 11
 - 1.2.10 Skin — 12
 - 1.2.11 Reproductive system — 13
- 1.3 Summary — 14

2 Body mechanics and muscles — 16

- 2.1 Introduction — 16
- 2.2 Static mechanical properties — 16
 - 2.2.1 Density — 16
 - 2.2.2 Center of mass — 17
- 2.3 Body mechanics — 19
 - 2.3.1 Mechanical models — 19
 - 2.3.2 Levers — 20
 - 2.3.3 Femur — 22
 - 2.3.4 Degrees of freedom — 23
 - 2.3.5 Biomechanics of walking — 25
- 2.4 Skeletal muscles — 27
 - 2.4.1 Structure of skeletal muscles — 27
 - 2.4.2 Muscle contraction — 30
 - 2.4.3 Muscle activation — 33
- 2.5 Summary — 35

3	Elastomechanics: bones and fractures — 37
3.1	Introduction — 37
3.2	Elastic deformation — 38
3.3	Plastic deformation — 39
3.4	Elastic properties of beams — 41
3.5	Structure of bones — 42
3.6	Elastic and plastic properties of bones — 46
3.6.1	Macroscopic level — 47
3.6.2	Microscopic level — 49
3.7	Summary — 51
4	Energy household of the body — 53
4.1	Thermodynamics — 53
4.2	Caloric oxygen equivalent (COE) — 53
4.3	Metabolic rate — 54
4.4	Metabolic heat production of the body — 57
4.5	Heat losses of the body — 58
4.5.1	Heat conduction — 59
4.5.2	Heat radiation — 60
4.5.3	Convection or wind chill — 61
4.5.4	Sweating and shivering — 61
4.6	Temperature regulation — 62
4.7	Summary — 63
5	Resting potential and action potential — 65
5.1	Introduction — 65
5.2	Resting potential — 67
5.3	Action potential — 69
5.4	Channel conductivity — 71
5.5	ATP pump — 72
5.6	Summary — 74
6	Signal transmission in neurons — 76
6.1	Introduction — 76
6.2	Overview on signal transmission — 76
6.3	Sensory receptor potential — 79
6.4	Analog-digital conversion — 81
6.5	Saltatory polarization current — 82
6.6	Communication across axons — 84
6.7	Neuromuscular junction – triggering muscle contraction — 86
6.8	Spinal reflexes — 88
6.9	Electromyography (EMG) — 89

- 6.10 Electroencephalography (EEG) — 90
- 6.11 Summary — 93

- 7 Electrophysical aspects of the heart — 95**
 - 7.1 Introduction — 95
 - 7.2 Cardiac action potential — 96
 - 7.3 Electric polarization of the heart — 99
 - 7.4 Electrocardiography (ECG) — 102
 - 7.5 Leads according to Goldberger and Wilson — 105
 - 7.6 Methods, procedures, and new developments — 109
 - 7.6.1 Electrocardiography — 109
 - 7.6.2 Magnetocardiography — 111
 - 7.6.3 Artificial pacemaker — 112
 - 7.7 Summary — 113

- 8 The circulatory system — 115**
 - 8.1 Introduction and overview — 115
 - 8.2 The heart as a pump — 117
 - 8.3 Energy, power, and efficiency of the heart — 120
 - 8.4 Fluid statics of the circulatory system — 123
 - 8.5 Hemodynamics of the circulatory system — 126
 - 8.5.1 Basic equations and assumptions — 126
 - 8.5.2 Flow resistance — 129
 - 8.5.3 Turbulent flow and windkessel — 130
 - 8.5.4 Flow velocity and pulse wave velocity — 132
 - 8.5.5 Viscosity of blood — 135
 - 8.5.6 Osmotic pressure — 139
 - 8.6 Binding of oxygen to heme — 140
 - 8.6.1 Structure of hemoglobin — 140
 - 8.6.2 High spin-low spin transition — 141
 - 8.6.3 Saturation curve — 143
 - 8.6.4 Ferritin — 146
 - 8.6.5 Absorbance — 147
 - 8.7 Summary — 148

- 9 The respiratory system — 150**
 - 9.1 Introduction — 150
 - 9.2 Respiratory organs — 151
 - 9.3 Gas exchange — 153
 - 9.4 Tidal volume and vital capacity — 158
 - 9.5 Pulmonary volume and pressure changes — 160
 - 9.6 Compliance — 163

- 9.7 Surface tension — 166
- 9.8 Airway resistance — 167
- 9.9 Cardiopulmonary bypass — 170
- 9.10 Summary — 174

- 10 Kidneys — 175**
 - 10.1 Introduction — 175
 - 10.2 Global characteristics of kidneys — 175
 - 10.3 Structure of kidneys — 177
 - 10.4 Filtration — 178
 - 10.5 Reabsorption — 181
 - 10.6 Renal clearance — 184
 - 10.7 Artificial filtering: dialysis — 190
 - 10.8 Summary — 193

- 11 Basic mechanism of vision — 194**
 - 11.1 Introduction — 194
 - 11.2 Optics of the eye — 196
 - 11.2.1 Refraction power of the eye — 196
 - 11.2.2 Accommodation — 198
 - 11.2.3 Resolving power — 200
 - 11.2.4 Visual acuity — 201
 - 11.2.5 Lens aberrations — 202
 - 11.2.6 Cataract — 204
 - 11.2.7 Intraocular pressure (IOP) — 206
 - 11.3 Photoreception and transduction — 209
 - 11.3.1 Structure of the retina — 209
 - 11.3.2 Sensitivity and adaptation — 211
 - 11.3.3 Phototransduction — 214
 - 11.3.4 Retinal signal processing — 219
 - 11.3.5 Receptive fields — 223
 - 11.4 Summary — 227

- 12 Sound and sound perception — 229**
 - 12.1 Introduction — 229
 - 12.2 Soundwaves — 230
 - 12.3 Crossing borders — 232
 - 12.4 Sound intensity — 234
 - 12.5 Outer and middle ear — 236
 - 12.6 Inner ear — 240
 - 12.6.1 Structure of the cochlea — 240
 - 12.6.2 Organ of Corti — 243

- 12.6.3 Inner and outer hair cells — **244**
- 12.6.4 From mechanical stimulus to receptor potential — **246**
- 12.6.5 Frequency coding — **248**
- 12.6.6 Pathway to the auditory cortex — **250**
- 12.6.7 Sound localization — **250**
- 12.7 Tone, sound, and noise — **253**
- 12.8 Hearing aids — **254**
- 12.9 The making of sound — **257**
- 12.10 Summary — **258**

Part B: Imaging modalities without ionizing radiation

- 13 Sonography — 263**
 - 13.1 Introduction — **263**
 - 13.2 Basic physical conditions for ultrasound imaging — **265**
 - 13.3 Sound propagation and attenuation — **266**
 - 13.4 Ultrasound transducer — **269**
 - 13.4.1 Piezoelectric effect — **269**
 - 13.4.2 US head — **270**
 - 13.4.3 Time gain compensation — **272**
 - 13.4.4 Near field and far field — **273**
 - 13.5 Medical imaging — **275**
 - 13.5.1 A-scan — **275**
 - 13.5.2 B-scan — **276**
 - 13.5.3 C-mode — **280**
 - 13.5.4 M-mode — **281**
 - 13.6 Scan characteristics — **282**
 - 13.6.1 Focusing — **282**
 - 13.6.2 Line density — **283**
 - 13.6.3 Scan frequency — **283**
 - 13.6.4 Depth of view — **283**
 - 13.6.5 Penetration depth — **283**
 - 13.6.6 Spatial resolution — **284**
 - 13.6.7 Artefacts — **285**
 - 13.7 Doppler Method — **285**
 - 13.7.1 CW Doppler method — **285**
 - 13.7.2 Pulsed Doppler method — **290**
 - 13.8 Summary — **293**

14	Endoscopy — 295
14.1	Introduction — 295
14.2	Standard uses of medical endoscopes — 295
14.3	Fiber optics — 296
14.4	Endoscope optics — 300
14.5	Resolution and magnification — 302
14.6	Specialized endoscopes — 303
14.6.1	Narrow band imaging — 303
14.6.2	Chromoendoscopy — 304
14.6.3	Endomicroscopy — 305
14.6.4	Confocal laser endoscopy — 305
14.6.5	Optical coherence tomography endoscopes — 306
14.6.6	Capsule endoscopy — 309
14.7	Future directions — 310
14.8	Summary — 311
15	Magnetic resonance imaging — 313
15.1	Introduction — 313
15.2	NMR basics — 314
15.2.1	Zeeman splitting — 314
15.2.2	Equation of motion — 316
15.2.3	Resonance absorption — 320
15.2.4	Spin-echo techniques — 323
15.2.5	Autocorrelation and spectral density — 326
15.2.6	Final notes — 329
15.3	Acquisition parameters and contrast — 330
15.3.1	Standard terms — 331
15.3.2	Contrast generation — 332
15.4	MR signal localization — 337
15.4.1	Slice encoding gradient — 337
15.4.2	Frequency encoding gradient — 338
15.4.3	Phase encoding gradient — 340
15.4.4	K-map — 340
15.4.5	Fourier transform — 342
15.4.6	Data acquisition — 342
15.5	Magnets and coils — 343
15.5.1	Main coil — 344
15.5.2	Gradient coils — 345
15.5.3	RF coils — 346
15.5.4	MRI machine specifications — 346
15.6	Applications of MRI — 348
15.6.1	Joints — 348

- 15.6.2 Dynamical contrast enhancement — 349
- 15.6.3 Angio-MRI — 351
- 15.6.4 Hyperpolarization MRI — 352
- 15.6.5 Diffusion-weighted imaging MRI (DWI) — 355
- 15.6.6 Multiple parameter MRI (mpMRI) — 358
- 15.6.7 Functional MRI (fMRI) — 358
- 15.6.8 Real time MRI — 360
- 15.7 New trends — 362
- 15.8 Advantages, hazards, and disadvantages — 363
- 15.9 Summary — 364

16 Questions & answers — 367

List of acronyms used in this book — 393

Index — 399