

Contents

Preface to the Fourth Edition
Preface to the First Edition

vii
ix

Section 1: General Physiology

1. The Cell

2

Introduction 2
The cell structure 2
The cell membrane 2
The cytoplasm 4
The cytoplasmic organelles 4
The nucleus 6
Linkage between cells 6

2. Homeostasis

8

Internal environment (milieu interieur) 8
Homeostatic mechanisms 9
Blood pressure homeostasis 10
Blood glucose homeostasis 10
Properties of homeostatic control systems 10
Physiological control systems 11

3. Transport through the Cell Membranes

14

Body fluids 14
Composition of extracellular and intracellular fluids 15
Transport mechanisms 15
Diffusion 15
Active transport 22
Hydrogen ion concentration of blood 25
Acid-base buffers 25
Other buffer systems in the body 26
Henderson-Hasselbalch equation 26
Isohydric principle 27

Section 2: The Blood

4. Red Blood Cells

30

Functions of blood 31
Red blood cells (erythrocytes) 31
Hemoglobin 32
Fetal hemoglobin 33
Genetic (inherited) defects of hemoglobin synthesis 34
Hemopoiesis 34
Erythropoiesis 36
Regulation of erythropoiesis 36
Nutrients required for normal erythropoiesis 38
Red cell metabolism 39
Red cell indices 40

Pathophysiology of anemia 41
Etiological classification of anemias 41
Polycythemia (erythrocytosis) 42
Polycythemia vera (primary polycythemia) 43
Osmotic fragility of red cells 43
Erythrocyte sedimentation rate 43
Lifespan of red blood cells 44
Destruction of red blood cells 44
Pathophysiology of jaundice 45
Blood groups 47
A-B-O system of blood groups 47
Role of blood groups in blood transfusion 48
Inheritance of A and B antigens 49
Hemolytic disease of the newborn 50
Blood transfusion 51
Blood donation 52

5. White Blood Cells

53

Function of polymorphonuclear neutrophils 53
Granules of a neutrophil 55
Pools of neutrophils 55
Eosinophils 56
Basophils 56
Monocyte-macrophages 56
Tissue macrophage system 57
The spleen 57
Lymph nodes 59
Leukopoiesis 59
Pathophysiology 61
Immunity 61
Memory cells 62
Immunoglobulins 64
Mechanism of action of antibodies 65
Vaccination 67
Pathophysiology 67

6. Plasma Proteins and Haemostasis

70

Functions 70
Some important plasma proteins 71
Origin of plasma proteins 72
The platelets (thrombocytes) 72
Functions 73
Thrombopoiesis 74
Haemostasis and blood coagulation 74
Mechanism of coagulation 75
Clot retraction (contraction) 77
Fibrinolytic system 78
Pathophysiology of haemostasis 78
Laboratory investigations in bleeding disorders 79
Thrombosis 80

Anticoagulants 80
 Heparin 81
 Dicumarol 81

Section 3: The Heart

7. Physiology of Cardiac Muscle 84

Introduction 84
 Functional anatomy of the heart 84
 The cardiac muscle 86
 Electrophysiology of myocardium 87
 Mechanical properties of myocardium 89
 Specialized excitatory and conductive tissues of the heart 92
 The origin and spread of cardiac impulse 94
 Spread of cardiac impulse 96

8. The Heart as a Pump 97

The cardiac cycle 97
 Murmur 105
 Cardiac output 106
 Echocardiography 108
 Regulation of cardiac output 108

9. Electrocardiography 112

The heart as a dipole 112
 Electrocardiographic leads 112
 Vector analysis 116
 Clinical applications of ECG 118

Section 4: The Circulation

10. Basic Principles of Pressure, Flow and Resistance 126

Basic principles of pressure, flow and resistance 126
 Blood pressure 130
 Methods for measurement of blood pressure 131

11. Pressure and Flow in Different Segments of Circulatory System 136

The arterial system 136
 The arterioles 137
 The capillary circulation 138
 The lymphatic circulation 141
 The venous circulation 142

12. Regulation of Systemic Arterial Blood Pressure 146

Neural cardiovascular regulatory mechanisms 146
 Medullary cardiovascular center (vasomotor center) 146
 Regulation of heart rate 151
 Non-neural regulatory mechanisms 151

13. Regulation of Blood Flow in the Tissues 154

Neural mechanisms 154
 Humoral mechanisms 155
 Reactive hyperemia 157

14. Regional Circulations 158

Coronary circulation 158
 Cerebral circulation 160

Cutaneous circulation 161
 The splanchnic circulation 164
 Pulmonary circulation 164

15. Cardiovascular Homeostasis in Health and Disease 167

Effect of posture on cardio vascular hemodynamics 167
 Effects of severe gravitational forces 168
 Circulatory shock 168
 Hypertension 170
 Heart failure 171

Section 5: Respiration

16. Pulmonary Ventilation 174

Functional anatomy 174
 Pulmonary ventilation 178
 Mechanism of ventilation 179
 Lung volumes and capacities 180
 Expansibility of lungs and thoracic cage 184
 Work of breathing 186

17. Pulmonary Diffusion 188

Physical laws governing rate of diffusion of a gas across a membrane 189
 Pulmonary diffusion of gases 189

18. Transport of Gases 192

Composition of atmospheric air and alveolar air 192
 Oxygen transport in blood 192
 Oxygen-hemoglobin dissociation curve 193
 Carbon dioxide transport in blood 196
 Rate of total CO₂ transport 197

19. Regulation of Respiration 198

Neural control of respiration 198
 Chemical control of respiration 201
 Central chemoreceptors 202
 Breath holding 205
 Effects of hyperventilation 206

20. Respiratory Adjustments in Health and Disease 208

Hypoxia 208
 Cyanosis 210
 High altitude physiology 211
 Abnormal patterns of breathing 213
 Emphysema 215
 Bronchial asthma 216
 Oxygen therapy 216
 Effects of high barometric pressure 217
 Artificial respiration 218
 Pulmonary function tests 219

Section 6: Nerve and Muscle

21. The Nerve 224

The neuron (the nerve cell) 224
 Electrical properties of a neuron 226
 Neuroglial cells 234

Neurotrophins 235
Effects of neuronal injury 235

22. The Muscle

238

The skeletal muscle 238
Mechanical properties of skeletal muscle 239
The smooth muscle 248
Excitation-contraction coupling 249
Neuromuscular transmission 251

Section 7: Central Nervous System

23. Synaptic Transmission

256

Structure of a synapse 256
Chemical transmission of nerve impulse 257
Neurotransmitters 257
Electrical events during synaptic transmission 260

24. Somesthetic Sensory System

267

Sensory receptors 267
Transmission of sensations 271
Some special aspects of sensory function 276
Pain 278
Gate control hypothesis 281
Synthetic sensations 283

25. Somatic Motor Activity: Regulation of Posture

284

Somatic motor activity 284
Reflexes 285
The stretch reflex 285
Flexor (withdrawal) reflex 289
Some properties of polysynaptic reflexes 290
Regulation of posture 291
Mechanism of standing in man 293
Mechanisms of decerebrate rigidity (spasticity) 294
Classification of reflexes 295
Deep reflexes (tendon jerks) 295
The vestibular apparatus 296
Motion sickness 300

26. Cerebellum and Basal Ganglia

301

Functions 303
Basal ganglia 304

27. The Motor Cortex

308

Motor cortex 309
Paralysis 314
Hemiplegia 314
Spinal cord lesions 315

28. The Thalamus, Reticular Activating System, EEG and Sleep

318

The electroencephalogram (EEG) 320
Reticular activating system 322
Sleep 323

29. Higher Functions of the Cerebral Cortex

326

Language and speech 327
Learning and memory 329

30. Limbic System and Hypothalamus

331

Functional anatomy of limbic system 331
Functions of limbic system 332
Hypothalamus 334
Regulation of body temperature 338

31. The Cerebrospinal Fluid

346

Blood-brain barrier (BBB) 348
Blood-CSF barrier 349
Parts of brain outside the blood-brain barrier 350

32. Autonomic Nervous System

351

Biosynthesis and fate of the autonomic neurotransmitters 357
Autonomic function tests 360

Section 8: The Special Senses

33. Vision

364

Functional anatomy 364
Refractive mechanisms of the eye 367
Acuity of vision 369
The retina 371
The photoreceptors 372
Rhodopsin (visual purple) 373
Color vision 375
Visual pathways 377
The pupillary reflexes 378
Binocular vision 379
Movements of the eye 380
Electroretinography 381

34. Hearing

382

The external and middle ear 382
The cochlea 383
Qualities of sound: loudness and pitch 386
Auditory pathways 388
Deafness 389
Tests of hearing 389

35. Taste and Smell

392

Taste 392
Smell 394

Section 9: The Gastrointestinal Tract

36. Functional Organization of GI Tract

398

Physiological anatomy of GI tract 398
Innervation of the gut 399
Regulation of gastrointestinal motility and secretion 400
Gastrointestinal hormones 401

37. Mouth and Oesophagus

404

Salivary secretion 404
Esophagus 406

38. Stomach

409

Functional anatomy 409
Gastric juice 411
Functions of the stomach 414

39. Pancreas, Liver and Gallbladder

- Pancreas 420
Liver and the gallbladder 423
Functions of the liver 427

40. The Intestines

- The small intestine 430
The colon (large intestine) 433

41. Digestion and Absorption

- Carbohydrates 436
Dietary fiber 439
Proteins 439
Fats 440

Section 10: Metabolism and Nutrition**42. Carbohydrate Metabolism**

- Metabolism 446
Glucose metabolism 447
Metabolism of hexoses other than glucose 451

43. Lipid Metabolism

- Lipids 453
Plasma lipids 453
Prostaglandins 456

44. Protein Metabolism

- Proteins 458
Amino acids 458

45. Nutrition

- Basal metabolic rate 463
Total caloric requirements 465
Balanced diet 465
Carbohydrates 465
Fats 467
Proteins 467
Minerals 468
Vitamins 472

Section 11: Endocrines**46. Mode of Action of Hormones**

- Endocrine, paracrine and autocrine hormones 476
Some physical characteristics of hormones 476
Mechanism of action of hormone-receptor complex 478

47. Pituitary Gland

- The adenohypophysis 481
Physiology of anterior pituitary hormones 483
The neurohypophysis 486

48. Thyroid Gland

- Biosynthesis of thyroid hormones 489
Hormone secretion 490
Actions of thyroid hormones 492
Pathophysiology 494

49. Adrenal Gland

- The adrenal cortex 496

420

430

436

446

453

458

463

476

481

489

496

- Glucocorticoids 497
Mineralocorticoids 502
Adrenal androgens 504
Pathophysiology 504
Adrenal medulla 505
Neuroendocrine response to surgical stress 510

50. Endocrine Pancreas

- Insulin 513
Glucagon 516
Hormonal regulation of blood glucose level 517
Diabetes mellitus 518

51. Hormonal Control of Calcium Metabolism

- Calcium metabolism 521
Functional anatomy of bone 522
Vitamin D 524
The parathyroid glands 526
Calcitonin 527
Pathophysiology 527

52. Endocrine Function of the Heart, Kidneys and Pineal Gland

- Endocrine function of the heart 530
Endocrine function of the kidneys 531
Pineal gland 532

Section 12: Reproduction**53. Male Reproductive System**

- Functional anatomy 534
Spermatogenesis 535
Endocrine function of the testes 539
Testosterone 539
Regulation of testicular function 541

54. Female Reproductive System

- Functional anatomy 544
The ovarian cycle 545
The ovarian hormones 547
The menstrual cycle 550

55. Physiology of Human Pregnancy and Lactation

- Transport of sperms 557
Transport of ovum 557
Fertilization 557
Functions of the placenta 558
Physiological changes during pregnancy 561
Parturition 564
Lactation 567
Milk 568

Section 13: Pediatric Physiology**56. Growth and Development**

- General growth 572
Growth curves 572

512

521

530

534

544

557

572

Regulation of growth 573
Growth factors 574

57. Systemic Physiology of Fetus, Neonate and Childhood

576

Nervous system 576
Respiratory system 577
Cardiovascular system 579
ECG 581
Blood 581
Gastrointestinal system 582
Kidney 583
Temperature regulation 584
Sexual growth and development 585

Section 14: The Kidney and the Body Fluids

58. The Kidney

590

The functional anatomy 590
Functions of kidney 594
Glomerular filtration 594
Tubular mechanisms 598
Renal transport of some specific substances 599
Hydrogen ion secretion: Acidification of urine 606
Chloride transport 609
Urea transport 609
Urine 609
Pathophysiology of renal disorders 611
Kidney function tests 612

59. Physiology of Micturition

615

Structure of urinary bladder 615
Pathophysiology of micturition 617

60. Regulation of Extracellular Fluid Composition and Blood Volume

618

Effective circulating volume (ECV) 618
ECV sensors 618
Response to varying salt intakes 619
Regulation of water balance 620
Regulation of hydrogen ion balance 621

Section 15: Physiology of Exercise and Sports

61. Physiology of Exercise and Sports

626

Muscular performance 626
Fast and slow muscle fibers 626
Sources of energy for muscular work 628
Cardiovascular adjustments in exercise 629

Section 16: Senescence Physiology

62. Physiology of Aging

640

Cardiovascular system 641
Respiratory system 641
Central nervous system 642
Autonomic nervous system 643
Special senses 643
Gastrointestinal tract 644
Endocrines 644
Blood 645
Musculoskeletal system 646
Skin and hair 646
Kidneys 646
Theories of aging 647

Index

649