

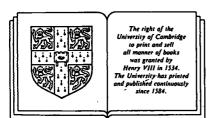
FOURTH EDITION

ANIMAL PHYSIOLOGY:

Adaptation and environment

KNUT SCHMIDT-NIELSEN

James B. Duke Professor of Physiology, Department of Zoology, Duke University



CAMBRIDGE UNIVERSITY PRESS

CAMBRIDGE NEW YORK PORT CHESTER MELBOURNE SYDNEY

About this book ix Preface to the fourth edition xi What is physiology? 1 PART ONE: OXYGEN **Respiration 5** The atmosphere 6 Solubility of gases 9 **Contents** Comparing water and air 14 Respiration in water 16 Respiratory organs 25 Mammalian lungs 29 Air-breathing fish 36 **Bird respiration 42** Respiration in eggs 47 Insect respiration 51 References and Additional reading 62 2 Blood 67 Oxygen transport in blood 68 Oxygen dissociation curves 71 Facilitated diffusion 81 Carbon dioxide transport in blood 84 References and Additional reading 90 3 Circulation 93 General principles 94 Vertebrate circulation 96 The physics of flow in tubes 108 Invertebrate circulation 117 Blood coagulation and hemostasis 122 References and Additional reading 124 PART TWO: FOOD AND ENERGY 4 Food and fuel 129 Feeding 130 Digestion 138 Nutrition 150

Specific nutritional needs 151 Chemical defense 159 References and Additional reading 164

5 Energy metabolism 169

Metabolic rate 170
Energy storage: fat and glycogen 172
Effect of oxygen concentration 173
Problems of diving 179
Metabolic rate and body size 192
Size and problems of scaling 199
Energy cost of locomotion 201
Physiological time 207
Effect of high altitude 209
References and Additional reading 212

PART THREE: TEMPERATURE

6 Temperature effects 217
Confusing terminology 218
Effects of temperature change 218
Extreme temperatures: limits to life 221
Tolerance to high temperature 222
Tolerance to cold and freezing 225
Temperature adaptation 231
References and Additional reading 238

7 Temperature regulation 240
Body temperature of birds and mammals 241
Temperature, heat, and heat transfer 246
Heat balance 252
Torpor and hibernation 276
Body temperature in "cold-blooded" animals 282
References and Additional reading 291

PART FOUR: WATER

8 Water and osmotic regulation 299
The aquatic environment 300
Aquatic invertebrates 303
Aquatic vertebrates 313
The terrestrial environment 322

Moist-skinned animals 324
Arthropods 327
Terrestrial vertebrates 336
Marine air-breathing vertebrates 341
References and Additional reading 348

9 Excretion 353
Organs of excretion 354
Contractile vacuoles 355
Invertebtate excretory organs 358
Vertebrate kidneys 364
Nitrogen excretion 377
References and Additional reading 387

PART FIVE: MOVEMENT, INFORMATION, INTEGRATION

10 Movement, muscle, biomechanics 393
Ameboid, ciliary, and flagellar locomotion 394
Muscle and movement 399
Skeletons 419
Locomotion: biomechanics 422
Buoyancy 433
References and Additional reading 449

Control and integration 454
 Control and control theory 455
 Nerves and nervous systems 460
 How nerve cells function 461
 Nerve impulses 468
 The synapse: excitation, inhibition, and computation 475
 References and Additional reading 484

12 Hormonal control 486 How is endocrine function studied? 487 Endocrine systems in vertebrates 489 Transmitter substances 501 Invertebrates: control and integration 507 References and Additional reading 517

13 Information and senses 520 Sensory qualities 521

CONTENTS

General principles 522

Chemical senses: taste and smell 523

Vibration and sound 527

Light and vision 535

Animal electricity 542

Transmission and sorting of sensory information 549

References and Additional reading 561

APPENDIXES

- A Measurements and units 567
- **B** Diffusion 571

- C Logarithmic and exponential equations 574
- D Thermodynamic expression of temperature effects 575
- E Solutions and osmosis 576
- F The animal kingdom 580

INDEX 583