

Essentials of Water

Water shapes the planet and all life upon it. Breaking down traditional disciplinary barriers, this accessible, holistic introduction to the role and importance of water in Earth's physical and biological environments assumes no prior knowledge. It provides the reader with a clear and coherent explanation of the unique properties of water and how these allow it to affect landscapes and underpin all life on Earth. Contemporary issues surrounding water quality – such as the rise of microplastics and climate change – are highlighted, ensuring readers understand current debates. Giving all of the necessary background and up-to-date references, and including numerous examples and illustrations to explain concepts, worked mathematical calculations, and extensive end-of-chapter questions, this is the ideal introductory textbook for students seeking to understand the inextricable links between water and the environment.

Peter D. Blanken is a professor and former chair of the Department of Geography at the University of Colorado, Boulder, where he has taught courses in climatology and biometeorology for over 25 years. His research appears in almost 150 peer-reviewed journal articles and several book chapters. He is co-author of *Microclimate and Local Climate* (2016, Cambridge University Press), and has served on the Editorial Board of the *Bulletin of the American Meteorology Society* for over 20 years.

“This book is beautifully written, meticulously researched, and a pleasure to read. It is a remarkably complete source of knowledge of water in the environment, including soils, plants, animals, water bodies, and the atmosphere. The book would be an excellent text for an undergraduate course.”

Thomas A. Black, University of British Columbia

“Thales of Miletus, the ancient Greek philosopher, famously asserted that ‘All is water.’ This is a comprehensive, accessible, and must-have book for anyone interested in the origin and vital role of water within the intricate water cycle system, our daily life, and the broader scope of our planet.”

Fei Chen, The Hong Kong University of Science and Technology

“This book is a good alternative to traditional introductory physical geography textbooks. Using water as a subject, the content is ideal for an introductory class that wants to expose a mix of students from diverse majors to learning the basics of environmental and physical principles and processes controlling the weather, climate change, landscape formation, as well as chemical and biological processes in life forms. The book will be a good resource also for high school students taking precollege courses.”

Mario A. Giraldo, California State University

“Professor Blanken has compiled an excellent text spanning multiple water-related topics. While the book assumes no prior knowledge of the role of water in Earth’s physical and biological environments, the technical content is in fact suitable for a wide audience. Professor Blanken’s approach to interweaving water’s origins, its history in sanitation and public health, and its role in global climate, hydrology, and biodiversity (among other topics) is truly unique.”

Andrew Gronewold, University of Michigan

“Blanken’s very informative and well-researched textbook on water uses unique presentation principles: atomic physics, chemistry, and the resistance model of electricity, Ohm’s Law – cleverly applied in a variety of settings. He uses these organizing ideas in a far-ranging discussion of water, from the effects of its molecular make-up to its impact on landscape vegetation, agriculture, animals and humans, insects, amphibians, ecosystems, and society. The final chapter is devoted to climate change. The problem sets require some research and creative solutions that should help students in the real world. I enjoyed reading this book and, as an active researcher, will find it useful as a reference.”

Robert L. Grossman, University of Colorado

“*Essentials of Water* is a comprehensive and systematic overview of the myriad roles of water in the environment, especially from a physical and biological perspective. This is a transdisciplinary text that will become an instant classic. Its accessible writing style, informed by decades of scholarly engagement with the topic, ensures that it can be utilized by different fields within the natural and environmental sciences. Each chapter begins with succinct learning objectives, and ends with a list of questions that serve as a review. The text is supported by ample figures, photos, and equations, with the latter being thoroughly explained in a manner that reflects an extensive teaching career. Physical and chemical concepts are clearly explained, and include linkages to broader topics, such as Earth’s origins, microplastics, water pollution, and climate change. *Essentials of Water* is an appropriate text for undergraduate and graduate courses, and will be a staple reference for scholars and practitioners in fields across the natural and environmental sciences.”

Paul Hudson, Leiden University

“*Essentials of Water* is just that: essential knowledge about water as a substance, its origins on Earth, and its critical functions in all life forms, especially plants – but also contains fascinating chapters on thermoregulation in animal and human physiology. This is a fine treatise on water in its many forms, fluxes, scales, and challenges. It also connects key scientific advances with water myths, history, and human concerns. It thus offers a creative, well-structured approach to the water sciences that will inspire seasoned scholars as well as university students entering the field.”

James L. Wescoat Jr., Massachusetts Institute of Technology

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Water in the Earth's Physical and Biological Environments

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Cambridge University Press is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

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www.cambridge.org

Information on this title: www.cambridge.org/highereducation/isbn/9781108833981

DOI: 10.1017/9781108988896

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First published 2024

A catalogue record for this publication is available from the British Library

A Cataloging-in-Publication data record for this book is available from the Library of Congress

ISBN 978-1-108-83398-1 Hardback

ISBN 978-1-108-98437-9 Paperback

Additional resources for this publication at www.cambridge.org/blanken

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Contents

Preface	<i>page xi</i>
Acknowledgments	xiii
1 The Historical Significance of Water	1
1.1 Introduction	1
1.2 Water in the Stars, Myths, and Spirits	2
1.3 The Two Faces of Water in Health and Hygiene	4
1.4 Altering Water's Path	7
1.5 The Water Balance and Cycle	10
1.6 Summary	13
1.7 Questions	14
References	15
2 The Composition of Water	17
2.1 Introduction	17
2.2 The Discovery of Oxygen and Hydrogen	17
2.3 The Atomic Structure of Oxygen and Hydrogen	20
2.4 Valence Electrons	22
2.5 Types of Chemical Bonds	24
2.5.1 Metallic Bonding	24
2.5.2 Ionic Bonding	25
2.5.3 Covalent Bonding	26
2.5.4 Polarity and Covalent Bonds	26
2.6 Bonding between Oxygen and Hydrogen: Water	28
2.7 Summary	29
2.8 Questions	30
References	30
3 The Properties of Water	31
3.1 Introduction	31
3.2 Hydrogen Attraction between Water Molecules	32
3.3 Cohesion and Adhesion	33
3.4 The Universal Solvent	35

vi Contents

3.5	Density	37
3.6	Specific and Volumetric Heat Capacity	41
3.7	The Three States of Water	41
3.8	State Diagram	43
3.9	A Northwest Passage Example	45
3.10	Summary	46
3.11	Questions	47
	References	48
4	The Origin of Water	49
4.1	Introduction	49
4.2	The New Earth	49
4.3	The Origin of Hydrogen Gas on Earth	50
4.4	The Origin of Oxygen Gas on Earth	51
4.5	Hydrogen and Oxygen Bonding to Form Water	53
4.6	Endothermic and Exothermic Reactions	54
4.7	Chemical Reaction Rates	56
4.8	Earliest Evidence of Liquid Water	59
4.9	Summary	62
4.10	Questions	63
	References	63
5	The Distribution of Liquid Water	65
5.1	Introduction	65
5.2	Oceans	66
5.3	Lakes	69
	5.3.1 Lake Formation	70
	5.3.2 Lake Classification	73
5.4	Wetlands	75
5.5	Streams and Rivers	76
5.6	Near-Surface Liquid Water	77
	5.6.1 Soil Moisture	77
	5.6.2 Groundwater	81
5.7	Summary	82
5.8	Questions	84
	References	85
6	The Distribution of Ice	88
6.1	Introduction	88
6.2	Ice Sheets and Shelves	88
6.3	Sea Ice	90
6.4	Glaciers	94

	Contents	vii
6.5 Snow		96
6.6 Frozen Ground and Permafrost		98
6.7 Summary		99
6.8 Questions		100
References		100
7 Evaporation, Condensation, and Precipitation		103
7.1 Introduction		103
7.2 Evaporation		104
7.2.1 Controls on the Evaporation Rate		106
7.2.2 Global Evaporation Patterns		108
7.3 Condensation		112
7.3.1 Dew		113
7.3.2 Clouds		113
7.3.3 Atmospheric Cooling Mechanisms		116
7.4 Precipitation Formation		120
7.4.1 Cloud Condensation Nuclei		120
7.4.2 The Bergeron Process		121
7.4.3 The Curvature or Kelvin Effect		123
7.4.4 The Solute or Raoult Effect		124
7.4.5 Combined Curvature and Solute Effects: Köhler Theory		125
7.5 Summary		126
7.6 Questions		127
References		129
8 Melting and Freezing, Sublimation and Deposition		130
8.1 Introduction		130
8.2 Melting		131
8.3 Sources of Energy to Warm and Melt Ice		134
8.4 Freezing		136
8.5 Sublimation		138
8.6 Deposition		140
8.7 Summary		141
8.8 Questions		142
References		143
9 Warm-Region Abiotic Processes and Landforms		145
9.1 Introduction		145
9.2 Generating Surface Runoff		146
9.3 Stream or River Classification		148
9.4 River Discharge		150
9.5 Shear Stress		151

viii Contents

9.6	Sediment Transport	152
9.7	Estimates of Historic River Flows	154
9.8	Fluvial Landforms	155
9.9	Intermittent-Flow Fluvial Landscapes	158
9.10	Denudation Rates	160
9.11	Chemical Weathering	162
	9.11.1 Hydration	162
	9.11.2 Hydrolysis	163
	9.11.3 Dissolution	164
9.12	Summary	164
9.13	Questions	166
	References	167
10	Cold-Region Abiotic Processes and Landforms	169
10.1	Introduction	169
10.2	Small-Scale Processes	170
10.3	Medium-Scale Processes and Landforms	172
10.4	Large-Scale Processes and Landforms	177
10.5	Summary	180
10.6	Questions	181
	References	182
11	Water within Vegetation	184
11.1	Introduction	184
11.2	The Roles of Water in Terrestrial Vegetation	185
11.3	The Ascent of Water within Vegetation	186
11.4	Xylem Tissue	187
11.5	The Cohesion–Tension Theory	189
11.6	Water Potential: ψ	192
	11.6.1 Solute or Osmotic Water Potential: ψ_s	193
	11.6.2 Pressure or Turgor Water Potential: ψ_p	195
	11.6.3 Matric or Soil Water Potential: ψ_m	196
	11.6.4 Gravitational Water Potential: ψ_g	198
	11.6.5 Liquid–Air Water Potential: ψ_a	199
11.7	Summary	202
11.8	Questions	203
	References	204
12	Transpiration	206
12.1	Introduction	206
12.2	The Process of Transpiration	207

12.3	Partitioning Transpiration from Evaporation	209
12.3.1	Leaf Measurements	209
12.3.2	Tree Measurements	210
12.3.3	Forest Measurements: Eddy Covariance	212
12.3.4	Forest Measurements: Stable Isotopes	217
12.4	Modeling Approaches	219
12.5	Transpiration Controls	222
12.5.1	Temperature	222
12.5.2	Soil Moisture	223
12.5.3	Carbon Dioxide Concentration	223
12.6	Summary	225
12.7	Questions	226
	References	227
13	Water and Thermoregulation: Ectotherms	231
13.1	Introduction	231
13.2	The Concept of Thermoregulation	232
13.3	Amphibian Species: Frogs	236
13.4	Desert Species: Lizards	241
13.5	Insects	243
13.5.1	Aquatic Insects	244
13.5.2	Terrestrial Insects	245
13.6	Insect Adaptations to Conserve Water	246
13.7	Flying Insects: Honeybees	247
13.8	Summary	248
13.9	Questions	249
	References	250
14	Water and Thermoregulation: Humans	254
14.1	Introduction	254
14.2	An Endotherm's Thermoregulation	255
14.3	Estimating the Energy Balance Components	256
14.3.1	Shortwave and Longwave Radiation	256
14.3.2	Metabolism	259
14.3.3	Conduction	261
14.3.4	Convection (Sensible) Heat Flux	264
14.3.5	Evaporative Cooling: Sweating	265
14.4	Requirement for Evaporative Cooling during Activities	270
14.5	Summary	273
14.6	Questions	274
	References	275

15	Water Quality	278
15.1	Introduction	278
15.2	Vegetation and Salinity	279
15.3	Agriculture and Urban Fertilizer Runoff	282
15.4	Harmful Algal Blooms	283
15.5	Microplastics	287
	15.5.1 Microplastics in Soils and Vegetation	287
	15.5.2 Microplastics in Rivers and Lakes	288
	15.5.3 Microplastics in Oceans	290
	15.5.4 Microplastics and Human Health	291
15.6	Summary	292
15.7	Questions	293
	References	295
16	Changes in Evaporation and Humidity	299
16.1	Introduction	299
16.2	Changes in Evaporation	300
16.3	Trends in Potential Evaporation	304
16.4	Trends in Actual Evaporation	307
16.5	Trends in Vapor Pressure Deficit	309
16.6	Trends in Transpiration	311
16.7	The Effects of Changes in Humidity on Ectotherms: Amphibians	312
16.8	The Effects of Changes in Humidity on Ectotherms: Insects	313
16.9	The Effects of Changes in Humidity on Endotherms: Humans	314
16.10	Summary	317
16.11	Questions	319
	References	320
	Index	324

Preface

Water is an element that shapes our lives and the world around us. *Essentials of Water* explores how the properties of this unique molecule have resulted in our inextricable connection to water. I am not the first to realize how important water is to life on Earth, and many books have been written on water resources, management, policy, politics, hydrology, ecology, and engineering. So why write another book about water? After 25 years of university teaching and research, I became motivated to write *Essentials of Water* for two main reasons.

First, this book fills a gap in the existing literature by examining the role and importance of water spanning both the Earth's physical and biological environments in a unique, holistic framework. Books that target one aspect of water, such as engineering hydrology or water policy and management, do so for a good reason. However, often prior coursework is required before such topics can be fully understood and appreciated. As a result, students who have an interest in water but do not have the background knowledge are excluded. This book provides the foundational requisite knowledge so these focused subtopics can be fully understood. Alternatively, this book can be viewed as a stand-alone text providing a well-rounded examination of the connection between water and life.

My second reason for writing *Essentials* is for those students for whom this book might be their first exposure to the subject. Everyone should be offered the opportunity to discover how the one molecule that we cannot live without affects nearly everything around us. This is a comprehensive book that aims to fulfill this need for an undergraduate student or anyone with an interest in the topic.

The only prerequisite to enjoy this book is an interest in water and the desire to learn how one molecule changed a planet. There is some basic chemistry and mathematics involved to help illustrate important concepts. I have included many examples, illustrations, and questions at the end of each chapter to ease any chemistry or math worries. Where possible, I have added a historical social perspective by including some relevant details behind the individuals who made key discoveries. I have also tried to include information and examples illustrating the dramatic changes to the water cycle in the changing climate.

As I assume no prior knowledge, the first section of *Essentials of Water* has chapters on topics including water's impact on life and society, the discovery of oxygen and hydrogen, and the properties of the water molecule that result in the many unique and peculiar properties it displays. Next, the role water plays in the abiotic environment is covered. Water's origin on Earth, its past and present distribution, and the water cycle are described. How water in its liquid and solid forms eroded and shaped the Earth into the many landforms we see is also illustrated. In the biotic environment, how vegetation has developed the means to lift water to tall heights and transfer liquid water from the soil to water vapor in the atmosphere is

xii Preface

explained. The vital importance of water for thermal regulation for organisms such as insects, frogs, lizards, and humans is covered next. After a chapter on water quality, including questions of salinity, fertilizer runoff, algal blooms, and microplastics, we conclude by looking at how a changing water cycle may affect the abiotic and biotic environments in the near future. My intent in writing this book is that you can pick and choose chapters to read depending on your background and interest, and arrange chapters accordingly to supplement the typical 15- or 16-week-long semester.

I hope that you learn something about water in *Essentials of Water* that you did not know before, and that this book is the beginning of your quest to learn more and help protect this vital resource.

Acknowledgments

This book would not have been possible without the support and efforts of many. Countless individuals, inspired by their inquisitive nature, conducted experiments and communicated to us what they discovered regarding the essential aspects of water that shapes life and the landscape. Their knowledge provided the foundations of this book. The students that I have had the pleasure of teaching provided the energy and enthusiasm that keeps research alive. I will not forget a student who came to lecture dressed as a water molecule on Halloween, stating that water was her favorite molecule. My professors also transferred this enthusiasm to me, and I thank them for that and the opportunities they provided. The professional staff at Cambridge University Press provided tireless support throughout this project. In particular, the efforts of Matt Lloyd, Helen Shannon, Olivia Marsh, and Lindsay Nightingale elevated the quality of this book. Only I am at fault for remaining mistakes. Lastly, I express my thanks to my family. This book has almost become part of the family over the past few years. Their enthusiasm for learning about the natural world is truly contagious.