Evolving Animals

The Story of Our Kingdom

What do we know about animal evolution in the early twenty-first century? How much more do we know today than Darwin did? What are the most exciting discoveries that have been made in the last few decades?

Covering all the main animal groups, from jellyfish to vertebrates, this book considers all of these questions and more. Its 30 short chapters, each written in a conversational, non-technical style and accompanied by numerous original illustrations, deal equally with the pattern and the process of evolution – with both evolutionary trees and evolutionary mechanisms. They cover diverse evolutionary themes, including: the animal toolkit; natural selection; embryos and larvae; animal consciousness; fossils; human evolution; and even the possibility of animal life existing elsewhere than on Earth. This unique text will make an excellent introduction for undergraduates and others with an interest in the subject.

WALLACE ARTHUR is Emeritus Professor of Zoology at the National University of Ireland, Galway. He is one of the founders of the interdisciplinary field of evolutionary developmental biology (evo-devo), and has a special interest in explaining scientific concepts in plain, non-technical language. He is the author of nine previous books, including *Biased Embryos and Evolution* (Cambridge, 2004) and *The Origin of Animal Body Plans* (Cambridge, 1997).

Evolving Animals

The Story of Our Kingdom

WALLACE ARTHUR
Emeritus Professor of Zoology
National University of Ireland, Galway

Illustrations by
STEPHEN ARTHUR

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107049635

First published 2014

Printed in the United Kingdom by Clays, St Ives plc

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

Library of Congress Cataloguing in Publication data
Arthur, Wallace.
Evolving animals : the story of our kingdom / Wallace Arthur; illustrations by Stephen Arthur.
pages cm
Includes bibliographical references and index.
ISBN 978-1-107-62795-6 (Paperback) – ISBN 978-1-107-04963-5 (Hardback)
1. Evolution (Biology) I. Title.
QH366.2.A775 2014
591.3'8–dc23 2014007080

ISBN 978-1-107-04963-5 Hardback
ISBN 978-1-107-62795-6 Paperback

In memory of two inspirational mentors in the field of animal evolution

Alec Panchen (1930–2013)
vertebrate palaeontologist

Bryan Clarke (1932–2014)
population geneticist

Contents

Preface

When our planet was only half its current age it was already teeming with life, yet not a single animal swam in its oceans, walked on its land, or flew in its skies. Now, in contrast, there are well over a million known species of animals on Earth. Sometime in between, the very first animal arose from a unicellular ancestor. This animal was probably a tiny marine creature whose body consisted of just a handful of cells. One way of looking at the animal kingdom is as a vast number of lines of descent – or lineages – radiating out through time from that original animal, with each lineage either terminating in an extinction or continuing to evolve today.

Each line of descent has its own story to tell. So the story of the animal kingdom is a composite one, with many subplots being played out in individual lineages. In between a single lineage and our whole kingdom lie the stories of particular animal groups. In this book, I try to tell some of the individual stories, notably the human one, and some of the group stories, for example those of the three biggest groups of animals (the arthropods, the molluscs and the vertebrates). From these accounts, the composite story of the animal kingdom gradually emerges.

Often, biologists distinguish between the *pattern* and the *process* of evolution. The former concerns relationships – the issue of which types of animal are most closely related to which other ones. The latter concerns the mechanisms by which evolution comes about, including Darwinian natural selection. There have been major advances in both areas in the last two or three decades, with the result that our current view of evolution is considerably different from the view that prevailed in the middle of the twentieth century. In terms of patterns of animal relationships, a radical reappraisal of our perception of these began in the 1990s; and our views have been refined ever since through the use of DNA data to build more accurate evolutionary trees. In terms of process, the comparative study of embryonic development using modern techniques has yielded new insights into the way in which evolution works at the level of the individual animal. These insights

complement earlier ones concerning how evolution works at the level of population and species. Ultimately, our theory of evolution must incorporate insights into the key mechanisms operating at both of these levels.

Not only can a story have many facets, but it can be told in many ways, each appropriate for different kinds of reader. This book is intended for anyone with an interest in the animal kingdom, its history, and how it came to be as we find it and not otherwise. All the chapters are short and are written in a conversational, non-technical way. This means, I hope, that the book will appeal to the general reader, as well as to students of zoology and other biological sciences. Also, the structure of the book is designed to ensure variety in the sequence of topics encountered, with chapters about evolutionary pattern interspersed with chapters about process.

The pictures are very much part of the story. All of the illustrations and diagrams herein are original and were commissioned specifically for this book. They are varied in type, including many evolutionary trees and several pictures relating to animal development. However, there are quite a lot of illustrations that are simply pictures of animals. It's important for readers to be able to picture in their minds animals that are not familiar to them. These include animals that are very small (for example, millimetre-long water-bears), animals that are rare (for example, fish called coelacanths), animals that are found in places we are unlikely to visit (for example, the beard-worms that are found in association with thermal vents on the seabed), and animals that are extinct and are not as well known as the dinosaurs (for example, anomalocarids and plesiosaurs). I hope that the combination of original artwork and non-technical language makes for an enjoyable read.

Acknowledgements

There are many people I would like to thank for their help in getting the book from a first draft to its present form, but with the traditional caveat that I alone am responsible for any errors of fact or failures of clarity that remain. The following people kindly read and commented upon draft material: Louise Allcock, Chris Arthur, Helen Arthur, Andy Cherrill, Ariel Chipman, Michael Coates, Erica De Milio, Uri Frank, Brian Henderson, Rose Henderson, Ronald Jenner, Grace McCormack, Dave Newton and Gerhard Schlosser. Also, special thanks should go to Robert Asher and Mark Davies, both of whom read the complete draft manuscript and provided much constructive criticism. The staff at Cambridge University Press were a pleasure to work with. I would especially like to thank my editor, Dominic Lewis, for his support throughout the period from initial proposal to final manuscript. I would also like to thank Megan Waddington, Noel Robson and Christina Sarigiannidou. My copy-editor Hugh Brazier rendered my inconsistencies consistent with a light touch, and inspired the sort of confidence an author likes to feel, but rarely does, on handing over the manuscript to a third party. Sincere thanks to everyone named above, and indeed also to the many people who are not because their work on the production of the book is invisible to the author – out of sight is not necessarily out of mind.