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First published 1998 by
MACMILLAN PRESS LTD
Houndmills, Basingstoke, Hampshire RG21 6XS
and London
Companies and representatives
throughout the world

ISBN 978-1-4039-0562-8 ISBN 978-1-349-15201-8 (eBook)
DOI 10.1007/978-1-349-15201-8

A catalogue record for this book is available
from the British Library.

10 9 8 7 6 5 4 3 2
07 06 05 04 03 02 01 00 99 98

Typeset by Footnote Graphics, Warminster, Wilts

This edition is manufactured in India and is authorised for sale only in India, Bangladesh, Pakistan, Nepal and Sri Lanka.

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Preface

IN ORDER to use this book effectively, you ought to know why I have written it this way. My aim is to introduce the important ideas of Biology clearly, and in enough detail for you to be able to move straight on to more specialized literature written for undergraduates. The emphasis is on concepts rather than facts. There are plenty of facts here, but they are included to help explain the concepts, as needed. I have used scientific terms where they help, but never for their own sake. Mathematics is kept to a minimum. You will find little here about practical techniques, or the history of scientific ideas. All these things are important, but there are other ways to learn about them.

Arranging topics in sequence poses a difficult problem. We study Biology at many levels, from molecule to ecosystem. Should we start with small scale processes and then use them to explain things on a larger scale, or should we begin at the big end of the spectrum because these things are more familiar to us from our everyday experience? My compromise is to start big with an overview of the diversity of life, how we group organisms and give them names. Next comes natural selection, because we can explain very little in Biology without it. Then we go to the other end of the size scale with molecular and cell biology, and get bigger by way of genetics, reproduction, physiology, ecology and behaviour. The last two units are rather different. They deal with applications of biological principles in disease and biotechnology. Here, detailed examples are what matters. In order to pack enough detail into a reasonable space, these units consist of a series of information boxes, each dealing with an example or application.

Few people will sit down and read this book from beginning to end. Many readers will need to refer to a particular unit immediately. The 'Connections' boxes at the start of each unit help you to know which other units give useful background information. The index directs you to the key sections about each topic, not simply every page which mentions the word.

Biology is not only about special organisms in special places. The same principles apply to living things everywhere. The organisms which live around you are, if anything, more interesting than exotic ones, because they are there to be studied. The more you watch, think about and experiment with a plant or animal, the more interesting (and often more surprising) its life becomes. Throughout the book I relate biological ideas to the organisms which are familiar to me, around my home. I live on the edge of a country town in south west England. Agricultural grasslands are all around, grazed by sheep and cattle. The high moorland of Dartmoor is a few kilometres away on one side; the rocky shores of the English Channel are on the other. Do not be put off because my familiar organisms are not yours. The challenge is to get out and see the living things in your own backyard, and apply the same principles to them. I am passionate about my subject. I have written this book to encourage you to make it your own.

Julian Sutton

Acknowledgements

I am grateful to Sarah Sutton and Liz Mower for uninhibited comments on large parts of this book; to Richard Bennett-Lovesey, John Burston, Mark Edwards, Richard Graham, Chris Holt, Richard Jones and Tom Maclellan for comments on particular units from a range of viewpoints; and to five anonymous reviewers for a detailed appraisal of a draft version. Frances Arnold, Liz Jones and others at both Macmillan Press and Footnote Graphics have taken my stack of words and sketchy diagrams, and made them into a book.

It is traditional for authors to thank their partners and children for their support, tolerance, encouragement and so on. I used to think this was a polite convention. Now I know better, and gratefully follow tradition.

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Introduction

Science and the nature of explanation

We are an inquisitive species. We want to know what is around the next bend. We climb mountains because they are there. As children we are tempted to take clocks apart to find out how they work, or to flush playing cards down the lavatory to see what happens. Science is a natural extension of this curiosity. Our ambitious aim is to understand how the world works. Biology is a blanket term for all those areas of science which have to do with living things.

As we investigate the world, we do several things. We observe, compare, look for patterns and relationships, speculate and make hypotheses, formulate ideas about how things might be. We also experiment. Experiments are what makes science distinctive. An experiment involves changing the world and seeing what happens, setting up particular conditions and measuring the effect. Experiments allow us to test hypotheses. Simple observation may suggest several possible explanations. Carefully designed experiments help us to distinguish good explanations from bad. We might be interested in the distribution of *Hyacinthoides non-scriptus*, the plant known in England as the bluebell. It is a common woodland plant in many parts of England. Why does it grow there, but not in other habitats such as meadows or moorland? Perhaps it grows best in shade. This is a perfectly sensible hypothesis, but only experiments can show whether or not it is correct. If we grow bluebells in a garden, under controlled conditions so that light is the only factor which varies, they grow better in direct sunlight than in shade. The hypothesis was wrong. It turns out that competition from other plants, such as grasses, excludes bluebells from other habitats.

This is just one example of how science advances, which shows the importance of experiments, but there are other ways. This book is not about the process of scientific discovery. That is best learnt by direct experience, working with others in the trade. All scientific education, from primary school to postdoctoral research fellowship, involves an induction into the ways of science. This book is about what science tells us about the living world, the explanations that it has, and has not, provided.

We can look at nature on many different scales. I write this sitting on the ground, leaning against a birch tree on Dartmoor. The tree, a single organism, is made up of organs: stems, roots and leaves. Each is made up of several tissues, which in turn are made up of cells. Cells consist of many compartments, each with distinctive chemistry. All are made up of interacting molecules. Returning to a larger scale, my tree is not alone. I can see other birch trees in the area, some larger and older than others. They form a population. The birch population interacts with populations of gorse, heather and other plants, forming a community. All the living and non-living things around here constitute a still higher level of organization, the ecosystem. As I watch banks of cloud rolling in from the Atlantic, I am reminded that some processes can only be understood on a global scale.

Science tries to explain observations at one level in terms of processes going on at a lower level. This is called reductionism. It does not imply that the whole is just the sum of the parts. A body is not simply a collection of cells; it is a collection of inter-

acting cells. Many complex properties of the body as a whole can be explained in terms of the interactions between its cells.

We do not seek to account for every detail of a system in a reductionist explanation. Nature is vast, our minds are small. We aim to make models, pictures of nature which are simple enough to fit into our minds, yet retain important features of the real thing. We may never understand every factor which affects the distribution of bluebells; we may never want to. If we can draw out a few factors which have a big effect from the sea of factors which have some effect, and use them to explain important features of bluebell distribution, then we have made a useful model. Only then are we fulfilling our ambition as scientists. We are going beyond description, to explanation.