Plasticity, Robustness, Development and Evolution

How do we understand and explain the apparent dichotomy between plasticity and robustness in the context of development? Can we identify these complex processes without resorting to 'either/or' solutions?

Written by two leaders in the field, this is the first book to fully unravel the complexity of the subject, explaining that the epigenetic processes generating plasticity and robustness are, in fact, deeply intertwined. It identifies the different mechanisms that generate robustness and the various forms of plasticity, before considering the functional significance of the integrated mechanisms and how the component processes might have evolved. Finally, it highlights the ways in which epigenetic mechanisms could be instrumental in driving evolutionary change.

Essential reading for biologists and psychologists interested in epigenetics and evolution, this book is also a valuable resource for biological anthropologists, sociobiologists, child psychologists and paediatricians.

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Preface

'Nobody reads books these days.' Such was the unhelpful advice of one of our colleagues. So why have we written one? Our answer is that, in many areas of biology and psychology, advances in what is known have not been matched by advances in what is understood. This is particularly true when questions about developmental origins are raised in biology and psychology. All too often such debates are reduced to whether a particular feature of an individual is due to nature or nurture. Many scientists in the fields of both biology and psychology have an interest in either development or evolution, or both. Similarly, many practitioners of human and veterinary medicine also wish to have a much clearer understanding of the debate about developmental origins, as do many biological anthropologists and philosophers of biology. This book was written for those who have become dissatisfied with the way in which these debates are conducted.

Biology can show us many wonders, but one of the most remarkable is how a complex organism grows from almost nothing – a tiny seed or a microscopic embryo. Until recently, the processes that are involved seemed beyond understanding and, even now, much remains to be discovered. Nevertheless, the factual certainties have been known for a long time. An egg taken from a hen's nest and incubated artificially does not hatch out as a different species from its mother. Its characteristics were latent from the moment its mother's egg was fertilised by its father's sperm. These *robust* constancies of development are profound and real. At the same time, the hatched chick is capable of adapting to many challenges posed by its environment. It can cope with disabilities generated by accidents or disease. It can learn to recognise particular members of its species and acquire preferences for particular foods that are available to it. The *plasticity* of the bird is as remarkable as its robustness. These twin characteristics, broadly defined, are found

throughout the animal and plant kingdoms. They have given rise to a widely held view that the characteristics of any one organism, including the characteristics of a human being, may be grouped into those that are due to the inner workings of its body and those that are due to the external environment.

Along with many others, we feel that it is possible to do a great deal better than that. The treatment needs to be extended to the length of a book because it takes extended argument to change long-established patterns of thought. Words and ideas have to be clarified. In the case of development, the reader needs to have a straightforward view on what is meant by robustness and plasticity – terms that have considerable complexities embedded within them – and then be given an insight into how these seemingly opposed characteristics are integrated in the growing organism. How do the products of such an integration serve the needs of the individual, and how might they have evolved? Finally, have these characteristics of organisms fed back to shape the course of evolution itself?

Our intention in writing this book was to bring clarity to some of the debates that have muddied the waters in biology and psychology for far too long. We have markedly different backgrounds. One of us is a behavioural biologist interested in the development and evolution of whole organisms. The other was trained in paediatrics and has a deep interest in the molecular and evolutionary biology of development. Frankly, we admit that we each sometimes had difficulty with the drafts that the other had written. The molecular stuff was too technical and riddled with jargon, and the behavioural stuff assumed knowledge that is not widely shared by other biologists. We have had to accommodate to each other and recognise that the resulting text might sometimes seem uneven, and maybe irritating, to specialists who have an intimate knowledge of some of the material we present and will judge us to have presented it too simply. However, the issues are so important to biologists and psychologists that the presentation should be cross-disciplinary, and we trust that the overarching picture will make sense. Our hope is that the quality of understanding will start to match the quality of the evidence.

Acknowledgements

A book of this nature very much depends on the many informal interactions we have had over many years with many of our colleagues. More than simply reading the literature, the warm and stimulating interactions with colleagues and students allowed our ideas to develop. We are sure that many of these will see echoes of past conversations, and often intense debate, in what we have written.

Working with some colleagues has been particularly instructive. Mark Hanson of Southampton has worked with both of us for many years and, with P. G., has led a major programme of empirical and conceptual work in developmental epigenetics and its role in human health, and across many of the issues we discuss in this book. Hamish Spencer of Otago has been involved in many discussions with us, and his deep knowledge of the comparative and modelling literature has been invaluable. Kevin Laland who was a colleague of P. B.'s at Cambridge for many years before moving to St Andrews made many helpful comments on the draft manuscript. Eva Jablonka (Tel Aviv), whose work has been seminal in the field covered by this book, also made valuable comments. Mark Blumberg (Iowa), who kindly wrote a pre-publication comment for the book, also went through the entire manuscript and made many helpful suggestions for improvement. We thank these friends and the following from around the world who kindly read parts of the draft manuscript: Alan Beedle (Auckland), Gillian Brown (St Andrews), Tatjana Buklijas (Auckland), Frances Champagne (Columbia), James Curley (Columbia), Partha Dasgupta (Cambridge), Peter Dearden (Otago), John Funder (Melbourne), Lupus von Malzen (London) and Daniel Nettle (Newcastle).

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