a view is valid. The most famous heterochronic change is neoteny in which somatic maturation is slowed with respect to sexual. There are also many examples in postnatal growth of different organs – most new-born puppies look similar. But it is worth noting that the rate of growth of long bones is largely determined by the length of the proliferative zone of the growth plate and not by any timing mechanism.

Larval forms are very common in marine animals and their evolution is a fascinating problem. Raff implies that larval forms of sea urchin are the primitive condition and direct development a later modification. He shows that it is possible for early stages to be very significantly modified. However, I find it hard to imagine how adults could have originally developed from a larval stage – the case of the tadpole and insect larvae, which are clearly interposed stages, provide a much more plausible scenario. Indeed the evolution of novelty is a central problem.

Raff has summarised and brought together an enormous amount of information from relevant areas, particularly palaeontology, and has included historical as well as literary perspectives. There are references to Aldous Huxley's story about an ageing man reverting to ape-like form and Stefan Themerson's version of humans as seen by ants. In a way there is almost too much and the lack of extensive illustrations make many of the arguments – particularly in relation to development – difficult to follow. Nevertheless this is an invaluable resource for anyone at all interested in this rapidly advancing subject. There are, however, a few lacunae; the most striking is that there is nothing on the evolution of development itself – how, for example, did gastrulation evolve and why did the evolution of multicellular organisms occur at all? There is also very little on the cellular and molecular basis of development of form – what is sometimes referred to as morphogenesis. It is only by understanding the cellular basis of these processes that we can understand how they evolved. Development is essentially about how differential gene activity controls cellular behaviours.

LEWIS WOLPERT
Professor of Biology as Applied to Medicine, University College, London

Gregor Mendel: The First Geneticist. By V. OREL. Oxford University Press, 1996. pp. x + 363. Price £29.50, Hardback. ISBN 0 19 8547 74 9

Gregor Mendel's case is a curious one. His work was barely noticed in his lifetime, and his influence on genetics as it developed from 1900 onwards was more that of a catalyst than a pioneer because his now famous paper, published in the Moravian town of Brno in 1866, only came to light at the moment its main results were being independently discovered. Yet it, and its self-effacing author, exert a continuing fascination, partly because the work reported was so far ahead of its time – thirty-five years in a rapidly-developing science – partly because it was written up in such a meticulous and modern manner, and perhaps not a little because of the collective guilt felt by succeeding generations for the paper's neglect despite its wide distribution. And then there is the question of the good fit of the data to the Mendelian expectations.

R. A. Fisher pointed out in *The Genetical Theory of Natural Selection* (1930) that 'had any thinker in the middle of the nineteenth century undertaken, as a piece of abstract and theoretical analysis, the task of constructing a particulate theory of inheritance, he would have been led, on the basis of a few very simple assumptions, to produce a system identical with the modern scheme of Mendelian or factorial inheritance', and in 1936 when he wrote *Has Mendel's work been rediscovered?* he speculated that this is just what had happened, and that Mendel's 'experimental programme becomes intelligible as a carefully planned demonstration of his conclusions'. John Arbuthnot – the creator of John Bull and in 1710 the inventor of the significance test – had wondered

> *What am I? how produced? and for what end?*
> *Whence drew I being? to what period tend?*
> *Am I the abandoned orphan of blind chance,*
> *Dropt by wild atoms in disordered dance?*
> *Or from an endless chain of causes wrought?*
> *And of unthinking substance, born with thought?*

and anyone familiar with the elements of combinatorial theory, as Mendel was, might well see the link between the 'blind chance' which governed the 'wild atoms in disordered dance' and the binomial coefficients 1:2:1. Even Francis Galton, who knew rather little mathematics, was able to explain to his cousin Charles Darwin (who knew even less) in 1875 that 'If there were two gemmules only, each of which might be either white or black, then in a large number of cases one-quarter would always be quite white, one-quarter quite black, and one half would be grey'.

Thus Mendel's work raises many questions of interest to historians of science, regardless of its lack of impact when first published. What was the state of the relevant sciences in 1865 and how much might Mendel have known? What was his level of education, especially in mathematics? What textbooks had he used? Why was the work not seen as the striking advance it appears to us? How were the experiments organised, and at what stage are the integer ratios confirmed? To what extent had botanists arrived at Mendel's ratios independently by 1900? How have subsequent generations viewed the paper? How should we?

Dr Orel is the Emeritus Head of the Mendelianum at the Moravian Museum in Brno, and this biography is the result of a lifetime's study of Mendel and his intellectual and physical environment. No stone has been left unturned, no source untapped, no paper unread (there are 641 references, of which more than

50 are to works by Orel himself either alone or in collaboration). The reference to my own paper 'Are Mendel's results really too close?' is not, I hope and believe, typical of the accuracy of the references in general: my name, the title of the paper, the name of the journal, and the volume of the journal all possess errors of varying degrees. The very density of information which the biography contains does not make for easy reading, so that its value will be more that of an encyclopedia than a life (fortunately there is Orel's own *Mendel* in the Oxford University Press 'Past Masters' to fill the gap).

The question 'Are Mendel's results really too close (and, if so, why)?' is of enduring interest. In 1902 Karl Pearson's friend W. F. R. Weldon had been the first person to apply statistical tests to Mendel's data, at one point applying Pearson's new χ^2-test, but although in correspondence with Pearson he expressed surprise at the good fit of the data to the Mendelian ratios, he added 'I do not see that the results are so good as to be suspicious'. It was Fisher's 1936 analysis that suggested such a possibility. Orel oddly remarks 'No one has been able to explain why the criticism made by Fisher (1936) remained unnoticed for so long, until Zirkle (1964)...'. Fisher's paper was referenced at the end of the chapter 'Mendel's principle of segregation' in the standard textbook *Principles of Genetics* by Sinnott, Dunn and Dobzhansky (1950 edition) from which many of my generation learnt our genetics, and which contained an English translation of Mendel's paper. Although from 1936 until the Mendel centenary in 1965 rather little was published about Mendel, knowledge of the strange results was commonplace in genetical circles.

Orel reviews the many discussions of the problem in the post-1965 literature, but without any definite conclusion of his own: 'One can suppose that in future there will be further differences of opinion'. Referring to a recent paper of his with D. L. Hartl he says 'Thus the uncertainties in the experiments and ambiguities in this analysis discredit any inference of deliberate manipulation or falsification of data'. No serious student has ever suggested that Mendel deliberately manipulated or falsified his data (one should discount the colourful language in private letters by Weldon and Fisher), but the segregations do exhibit strange features which in my view have defied all attempts to explain them. It is unlikely that any further evidence will come to light, and the discussion now tends to revolve around the minute examination of Mendel's German, to which not everyone can contribute.

On this and other questions Orel painstakingly reports on the secondary literature. To use a modern metaphor, his book enables one to surf the whole subject of Mendel, his antecedants, his contemporaries and his successors. It will be an invaluable reference for all historians of science, probably never to be bettered. Only in one respect is it deficient – it fails to reprint one of the English translations of the great paper. To do so would have added only 10 percent to the book's length but 50 percent to its value.

A. W. F. EDWARDS
Gonville and Caius College, Cambridge, CB2 1TA

Genetics and Cancer: A Second Look. Edited by B. A. J. PONDER, W. K. CAVENEE and E. SOLOMON. Cancer Surveys Vol. 25. Cold Spring Harbor Laboratory Press 1995. 250 pages. Cloth cover. Price $75. ISBN 0 87969 469 6.

The current pace of gene identification and characterisation in the field of cancer genetics has ensured that much has changed since 'Genetics and Cancer' appeared in the Cancer Surveys series in 1990. The subject certainly needed reappraisal and this volume does indeed deserve a second look.

An introductory chapter by Robert Weinberg gives a good overview of the history of cancer gene identification, putting into perspective the past and present research. It compares the discovery of oncogenes with the current flurry of tumour suppressor gene (TSG) identification, and examines how the methods used for discovering these genes have influenced the types of genes recovered. The emphasis on genes involved in control of cell growth and differentiation is apparent, and Weinberg speculates as to how this imbalance may be redressed by the cloning of genes involved in other aspects of cancer development such as tumour immunology and angiogenesis.

The increasingly important role for transgenic mice in providing new models for the study of cancer genes is presented in a chapter from Sharan and Bradley. These models provide an opportunity to study the effect of defective genes in the context of specific tissue types as well as that of different genetic backgrounds.

The contribution of cancer epidemiology to the identification of causes of cancer is covered in a chapter by Elizabeth Claus. She outlines the types of statistics-based studies which use the occurrence of cancer in populations to determine the contribution of genetic or environmental factors. She also describes how patterns of cancer risks observed amongst the relatives of cancer patients have been used to derive genetic models.

One of the results of studying the patterns of cancer development in large populations has been the identification of the association of polymorphisms in enzymes involved in the metabolism of xenobiotic toxins with susceptibility to cancer. A chapter by Gillian Smith and others gives details of how specific alleles of these enzymes are thought to predispose to the development of tumours. Other mechanisms of cancer development are covered in chapters on nucleotide excision-repair, imprinting and a very