How ionizing radiation affects cells

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The Molecular Theory of Radiation Biology. By K.H. Chadwick and H.P. Leenhouts. Pp.377. ISBN 3-540-10297-3/0-387-10297-3. (Springer-Verlag: 1981.) DM 128, $67.20.

SOME of the best epidemiological data relating carcinogenic risks to environmental hazards comes from research into the consequences of exposure to ionizing radiation. The recent recalculation of dosimetry at Hiroshima and Nagasaki has just about eliminated any effects in these populations ascribable to neutrons, and, because gamma ray data are not robust below 30 rads, there are, for practical purposes, no human data at low doses or for particles of higher linear energy transfer. Thus, even in this best case, one needs models and theories for extrapolating from acute high dose effects to chronic low dose ones. If such a problem cannot be solved for ionizing radiation with its relatively good dosimetry, the chances are negligible that it will be solved for populations exposed to chemical agents.

In this book, Chadwick and Leenhouts describe the development of a theory that can be used to extrapolate the biological effects of ionizing radiation to low doses, many different LET particles, and to interactions between radiation and chemical agents for end points such as cytotoxicity, mutation, chromosome aberrations and carcinogenesis. Their theory is based on the premise that DNA is the target and that double-strand breaks in it are the molecular lesions reponsible for the biological effects of radiation. The authors are led to this assumption for a number of reasons, the principal one of which is that the dependence of many biological effects on dose contains both a linear and a square term. The linear term is thought of as representing double-strand breaks arising from the passage of a single ionizing particle close to DNA, and the square term represents double-strand breaks arising from two nearby single-strand breaks made by two ionizing particles.

The text is a careful and complete exposition of the implications of these assumptions. Of necessity, other concepts and hence additional parameters and suppositions must be introduced, such as allowance for the repair of double-strand breaks and the assumption that *all* radiation mutations arise from double-strand breaks. Thus, the analysis rapidly accumulates other variables that are often difficult to evaluate independently and that must be adjusted to fit the experimental results. The general problem faced by the authors is equivalent to that of determining enzyme mechanisms at the molecular level from enzyme kinetics: it cannot be done. Certainly, there is no unique solution to the problem especially because there have been relatively few good determinations of double-strand breaks as a function of dose and, because of a lack of basic knowledge of events at the molecular level, of how ionizing radiation affects even simple end points — such as the inhibition of the initiation of clusters of eukaryotic replicons — and inhibits the progression of cells through the cell cycle.

The authors do themselves an injustice by overstating their case. The assumption made early in the book that double-strand breaks are important becomes a fact later on. Such confidence is misplaced because it ignores data on the effects of radiation on the replicative form of ΦX174, in either protective or dilute solution, in which inactivation is not correlated with double-strand breaks but with some type of base damage. Moreover, although fibroblasts from individuals with the disease ataxia telangiectasia are more sensitive to the cytotoxic effects of ionizing radiation than are normal cells, and show more chromosomal aberrations as a result of radiation, they are hypomutable. Hence, not all of the biological end points are comparable and the simple theory expounded in the text seems to need major revision based on solid biology.

These are obviously serious criticisms. Nevertheless *The Theory of Radiation Biology* is an important book for radiation and environmental biologists for, if nothing else, it is sure to stimulate new experiments and ideas. □

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Counting calories

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Physiological Ecology: An Evolutionary Approach to Resource Use. Edited by Colin R. Townsend and Peter Calow. Pp.393. Hbk ISBN 0-632-00555-6; pbk ISBN 0-632-00617-X. (Blackwell Scientific/Sinauer: 1981.) Hbk £21, $38; pbk £11.80, $23.60.

I WAS once told by a fellow graduate student, trained in herpetology, that physiological ecology was the science of shoving thermometers up lizards'cloacas. A quick check in the subject index of this volume revealed that, given the veracity of my colleague's assertion, things have come a long way in the past 15 years.

The book, comprising a collection of original articles and intended as a text for undergraduate courses, is mainly about how plants and animals get their daily calories and what they then do with them. The unifying theme linking such diverse topics as photosynthesis, digestion, cellular repair and social behaviour is that all aspects of earning and spending calories can be treated from a functional viewpoint as optimization problems. Different chapters illustrate different degrees of progress in applying this approach. In some areas, for example leaf design and foraging behaviour, the first generation of explicit models has been formulated and tested fairly thoroughly, while in others such as defence mechanisms and social behaviour the questions have, in the main, been formulated only qualitatively.

The articles also vary in the extent to which they present totally new ideas. R.M. Sibly, in one of the more original chapters, provides a fresh and stimulating approach to digestive strategies. He starts with a version of the marginal value theorem to predict optimal retention times for food in the gut, and leads via a discussion of gut morphology to consider why food empties from the stomach at an exponentially decreasing rate from the time of the last meal (no simple answer to this question emerges, but the relevant data and hypotheses are neatly brought together). The highlight of the book in terms of entertainment value is D.H. Janzen's fireside chat about defences against predators and parasites. Among the aphorisms that abound in this chapter is the answer to "Why should some species of seed be so well defended when the plant makes so many?" — ". . . for the same reason that a young man protested at being sent to Vietnam". At the same time, I should add that Janzen does not, to my mind, succeed in pushing the study of plant and animal defences from a series of intriguing evolutionary stories to forming a coherent theory. He appeals for a change in attitude from "descriptions of yet another alkaloid [to measuring] fitness gains and costs that the organism accrues with and without its defences" without stating explicitly how these hard-won measurements will be used to make a general theory of defences.

Some contributors — for example Pianka on resource acquisition and allocation among animals, and Gosling and Petrie on the economics of social organization — try to cover too wide a field, and in so doing do not analyse any single problem beyond introductory textbook level, while others — Kirkwood on repair and its evolution, for example — deal in detail with a more restricted range of topics. Overall, however, the book is a worthy collection of reviews which covers a range of subjects that are not normally assembled in one volume. □

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