

used terminology and a couple of schematic diagrams are highlights of this chapter.

In chapter 9, Arthur Georges *et al.* describe mathematical and other models for TSD under the title 'Thermal models of TSD under laboratory and field conditions'. This is the one of the important chapters of the book for field biologists. It contains information regarding the mode of action of temperature on development, and sex ratio under both laboratory and field conditions. Also, information for the prediction of embryonic development trajectories, thermo-sensitive periods and ultimately sexual outcome from nest temperature data are well presented. Details of the 'degree-hour approach' and 'constant temperature equivalent' (CTE) methods, which attempt to reconcile results from controlled laboratory experiments and variable temperature regimes by focusing on development rather than absolute time, are highlights of this chapter. However, the explicit mathematical models may distract or confuse some readers of this well-written chapter.

Chapter 10 'Phenotypic effects of incubation temperature in reptiles' by Turk Rhen and Jeffrey Lang provides a detailed review of the effect of incubation temperature on phenotypic traits other than sex in both TSD and GSD taxa, particularly in relation to fitness. This chapter addresses issues that are slightly deviated from the main theme of the book, but relevant to evolutionary interpretations for the adaptive significance of TSD. It provides a wealth of information for reptilian biologists.

In chapter 11 'The temperature-dependent sex determination drama: same cast, different stars' Allen Place and Valentine Lance review current knowledge about the molecular mechanisms associated with sex determination in vertebrates, starting with the best studied orders with GSD (i.e. mammals followed by birds) and then comparing this information with TSD reptiles. A detailed description of genes, their location on chromosomes, family, putative functions, etc. are well presented. However, this chapter (like many others) is already out-of-date following recent work by Ursula Mittwoch⁵ revealing some exceptional examples in mammals (for GSD) that prove the rule and link mammalian system with non-mammalian vertebrates.

Chapter 12 by Pamela Elf is again restricted to reptiles and explores the rela-

tionship between yolk steroid hormones and sex determination. Hypotheses about mode of action, published and unpublished observations of the dynamics of yolk hormones during development in TSD taxa are discussed. This field is likely to become a major research theme within the next few years, so a review is timely indeed.

Chapters 13–15 present a new phylogenetic analysis exploring the ancestry of sex-determining mechanisms in vertebrates (i.e. 'which was first, TSD or GSD?' by Fredric Janzen and James Krenz), and review hypotheses regarding TSD's past and present evolution (by Nicole Valenzuela), as well as interactions among TSD, offspring sex-ratio, population dynamics, and some conservation issues (by Mark Girondot *et al.*). In the last section, Nicole Valenzuela presents an overall view, conclusions, and attempts to identify missing links and future directions on TSD research. Her own focus on turtles and her opinions about the needs for careful definitions to distinguish between processes such as TSD vs thermally-induced sex reversal, come through very clearly. Time will tell whether this attempt to rigorously define different sex-determining systems is premature, given the strong conservatism in genetic mechanisms underlying both TSD and GSD⁵, and the apparently high frequency of evolutionary shifts between the two systems. I suspect that we may need to know more about the diversity of sex-determining systems before we can generate robust classification systems.

One of the best things about this book is that it brings together, for the first time, the diversity of information and issues related to TSD from various perspectives. The volume also has a few shortcomings. The title appears too broad; TSD is not known in one major class of vertebrates, i.e. mammals. Depending on definitions, one might also conclude that TSD does not occur in birds and amphibians either – so that we are left with the apparent restriction of TSD to one vertebrate class only – the reptiles. So why not call the book 'TSD in reptiles'?

The price US \$70 (Rs 3150) seems to me beyond the reach of many researchers and especially students. The book will be soon out-of-date simply because sex-determining systems are attracting such intense attention, and new results are appearing so rapidly. For example, we now have the first report of a thermal effect

on offspring sex ratios in a bird (a mound-building megapode)⁵.

Overall this volume will be useful for students, biology teachers, general biologists and anyone who is interested in sex determination mechanisms. Especially, it is a crucial reference source for budding researchers who want to undertake research in sex determination. I hope that all institutional libraries will have copies of this volume. Further, I hope the book stimulates young minds to undertake more detailed research using non-mammalian as well as mammalian systems to tackle the long-standing question 'what determines the sex of a newborn animal?'. Sex determination will be one of the most fascinating areas of biology in the 21st century, as evidence accumulates that epigenetic as well as genetic factors play a critical role in sex determination – even in mammals. Thus, there are many opportunities for rich rewards for young investigators who attack this exciting field of research.

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RAJKUMAR S. RADDER

*The School of Biological Sciences A08,
University Sydney,
NSW 2006, Australia
e-mail: rajju@mail.usyd.edu.au*

Sneaking a Look at God's Cards. Giancarlo Ghirardi. Princeton University Press, 41 William Street, Princeton, NJ 08540, USA. 488 pp. Price: \$ 22.95.

Ever since its conception in the beginning of the twentieth century, quantum theory has profoundly influenced not only science and technology, but also humankind's thinking and philosophy. Debates about fundamental issues in quantum mechanics such as nonlocality and the measurement paradox, that sprang up almost as soon as the theory was formulated, have

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yet to find a clear-cut resolution even today. A few years ago, the turn of the century witnessed yet another triumph of quantum theory, namely, the idea that quantum systems can be exploited to perform very fast computation (quantum computing) and to achieve a perfectly secure means for the transmission of information (quantum cryptography). The book under review is aimed at the scientific layman interested in keeping abreast of all these developments, and attempts to explain in detail the theoretical constructs as well as the latest experimental results in the field. The book begins with a quote attributed to the physicist Isaac Rabi, 'It's a great pity that the general public has very little inkling of the tremendous intellectual and emotional excitement that goes on in the advanced fields of physics'. This seems particularly true for quantum theory. Think of particle physics or cosmology, and the books by Steven Weinberg and Stephen Hawking immediately spring to mind, as do the books by Gamow on Relativity and the 'New Physics'. Stirring accounts of other theoretical constructs of reality, ranging from string theory to Darwinian evolution, can be found in a number of books accessible to the layman. Considering that all of modern technology (including innovations like semiconductors, superconductors, computers and nuclear energy, to name a few) and much of the paradigm of modern science are based on the principles of quantum mechanics, it is indeed surprising that there are not many books that 'popularize' quantum theory. Ghirardi's book, in part, is an attempt in this direction.

The book tries to build from scratch the scaffolding of the theory. The triumphs of classical theory are clearly summarized in the introductory chapter, and the reader unfamiliar with the history of physics is given a mini-tour of the development of scientific thought, beginning from the contributions of Galileo, Newton, Lagrange and Hamilton in formalizing the fundamental laws of physics. The mechanical explanation of thermodynamic processes by Gibbs, Boltzmann and Maxwell, and the unification of light, electric and magnetic phenomena under the umbrella of the electromagnetic field by Maxwell, are also dealt with in detail. We then get a glimpse into the tremendous intellectual churning that led to the quantum understanding of reality, and

the story of the crisis in the classical world that led to this quantum picture is well told. Examples are given of physical processes (dependence of the colour of objects on temperature; a planetary model of the atom as a tiny sun with electrons revolving around it) that defied classical understanding. Ghirardi uses polarization states of the electromagnetic field to illustrate the principles of quantum theory. Experiments with filters and birefringent crystals are described and all wave processes analysed from a classical perspective. There are lots of diagrams to help the reader with an aversion to mathematical equations. Quanta, chance events, indeterminism, and the intrinsic probabilistic nature of quantum mechanics are dealt with next. Poincaré's distinction between a truly probabilistic theory and the deterministic chaos caused by extreme sensitivity to initial conditions is explained in some depth. The chapter on the principle of superposition as applied to quantum states, begins with an apt quote by Dirac about the clear distinction one has to make between classical superposition in wave mechanics and the superposition that occurs in quantum mechanics, which demands indeterminacy in the results of observations. Ghirardi's exposition is for the most part intelligible to the novice but tends to be repetitive and the more advanced reader can afford to skim over this part lightly.

At this stage, the book makes an interesting digression into the sociology of physics and scientific thought. We are treated to an engaging discussion of how great quantum thinkers like Bohr, Schrödinger and Heisenberg grappled with the problem of 'visualizing' quantum phenomena and how their very individual ways of tackling the problem verily shaped the conceptual framework of quantum mechanics. Philosophical positions such as materialism, positivism, etc., are defined and set out in terms accessible to the reader unfamiliar with these concepts. The positions taken by various scientists involved with quantum theory in the early years are then discussed in detail. The great debates between Bohr and Einstein, the EPR paradox, Bohm's hidden variables, Bell's inequality and nonlocality and the resolution of the EPR paradox form the contents of the next few chapters.

Quantum cryptography and quantum computing are the buzzwords of the moment, and the book spends some time in

explaining the basics of these applications. The cryptography chapter has a few dramatic anecdotes about ancient cyphers and the American vs Japanese secret-code-breaking operations during the Second World War. Using photons to develop an unbreakable quantum cryptographic system (wherein Alice and Bob are able to communicate secretly, always thwarting Eve's attempts to eavesdrop) is explained in some detail. Quantum computing is an exciting new field, with researchers trying to find physical realizations of quantum systems that will be able to perform computational tasks much faster than any classical computer. Unfortunately, this topic has been covered rather cursorily in the book, and should either have been omitted altogether or discussed in greater depth.

Finally, the book discusses a major problem with quantum theory, namely, the quantum measurement problem: the emergence of macroscopic 'classical reality' from a microscopic quantum world. This is a formidable task indeed, and the book makes a brave attempt. However, at places one misses the clarity and crispness of prose one normally expects from a book intended for a non-expert audience. Many arguments are longwinded and tend to lose steam halfway, though there are flashes of physical insight. Overall, there is a clear bias towards the spontaneous collapse model evolved by the author and his collaborators for the resolution of the measurement problem. Many other directions of research which are perhaps equally good candidates for the resolution of the measurement problem, such as the decoherence approach and the consistent histories approach, are somewhat under-emphasized. It is not unlikely that the interested reader who has been following Ghirardi's perambulations through quantum theory is going to feel bewildered at this stage, and somewhat let down by the lack of a truly dramatic finale to ring the curtain down on what is otherwise quite an absorbing theatrical production.

ARVIND*
KAVITA DORAI

*Department of Physics,
Indian Institute of Technology Madras,
Chennai 600 036, India
e-mail: arvind@quantumphys.org