An Introduction to the Science of Cosmology. D. J. Raine and E. G. Thomas. Institute of Physics Publishing, Bristol. 220 pp. Price: $ 50.

Last few decades have seen the spectacular emergence of cosmology as one of the most active topics of research in astrophysics and physics in general. Its beginning at the turn of the last century was looked upon as being too speculative and starved of real data. The march of cosmology to become one of the central arenas of research has been steady after the discovery of the cosmic microwave background radiation in 1965. It is now the era of sophisticated telescopes detecting faint glows of galaxies from far back in the past, that would have been considered impossible even a decade ago, of vast surveys of galaxies with a giddying amount of data and of very high resolution measurement of the cosmic microwave background radiation. All these data are being used to determine the underlying physics of the cosmos.

This rise of cosmology has ensured that graduate students of astrophysics do not view it as an optional course to study any longer. It has become one of the core courses and in the last few years, many textbooks have appeared to cater to this growth of interest. There have been, however, a dearth of textbooks that could explain the basics to the undergraduate students, without depriving them of the excitement of the results coming from the forefront of research. It has been so mostly for the reason that it is impossible to appreciate the subtleties of cosmology without learning the general theory of relativity, and it is difficult to do justice to all this in a small volume.

The new book written by Raine and Thomas wonderfully fills up this gap. In their lucid presentation of the details of the cosmological models of the universe, they laudably avoided the temptation of taking shortcuts and yet managed to convey the excitement of research on cosmology at the present epoch.

Let me take an example to explain the difficulty involved. The evidence of the expansion of the universe came from Hubble's discovery of redshifted spectra of galaxies. Although the redshift is usually interpreted in such textbooks as a Doppler shift, the correct interpretation is provided by the general theory of relativity through cosmological redshift. The redshift is not due to large velocities of galaxies relative to space, but is an artifact of the expansion of the space itself (although any 'peculiar velocity' that the galaxy may have would add to the redshift). Many authors usually avoid making this distinction to keep the exposition easy and in the process sow the seeds of serious confusion in the minds of students. For example, one wonders what would happen to the velocity of galaxies at large redshifts. Some authors even go to the ridiculous extent of applying special relativistic corrections to their 'Doppler' formula for cosmological redshifts. Raine and Thomas have done well to heed the advice of Edward Harrison (whose book *Cosmology* has been a classic and a notable exception to this cacophony of misinterpretations), whose papers they cite while drawing the distinctions between velocities and cosmological redshifts.

Another refreshing difference in the book by Raine and Thomas is that they begin not by describing theoretical ideas (and prejudices) behind modern cosmology but by describing astrophysical observations relevant for cosmology. It must be noted that the study of cosmology has become what it is mainly through the extraordinary developments in observational techniques in the last few decades. Most of the efforts of modern cosmologists have gone into interpreting the potpourri of data obtained by astrophysicists based on existing theoretical ideas. Students studying this book will have a clear perspective of what is known and what must be understood in the framework provided by cosmological models.

The chapters I enjoyed most were chapters 5, 6 and 7, which form the core of the book, and describe the motivations behind the cosmological models, the models themselves and the implications of the models as far as the past history of the universe is concerned. The arrangement of the material is splendid, and the presentation is lucid. The authors have attempted to bring out as many interesting features of the cosmological models as they could in the short space available to them. One example is their discussion (section 5.17) on the past light cone, bringing out the subtleties of the space–time metric of cosmological models that is rarely found in textbooks targetted for such an audience (Harrison's book is again an exception that comes to mind).

The last two chapters on inflation and formation of structure are comparatively less clear, but a more detailed exposition of these topics admittedly belongs to a more advanced level textbook. Students will nevertheless find the discussions here useful before plunging into more advanced books.

The authors have put a lot of effort in providing relevant figures, at times from recent technical papers, to make their discussions more attractive. The problems offered at the end of the chapters are also thoughtful; they are designed to bring out different aspects of the topics discussed, and at the same time are not tedious.

There are a few typos but thankfully they are of a sort that can be easily spotted. The expression for the phase space volume for particles on p. 133 has a unnecessary equality sign. The expressions for the entropy densities of electron–positron pairs on p. 158 have a wrong temperature dependence.

In brief, Raine and Thomas have written a marvellous book for undergraduate students interested in cosmology. Although it is mainly written for undergraduate students, in my opinion even graduate students would gain a lot from studying this book.

BIMAN NATH

Raman Research Institute,
Bangalore 560 080, India
e-mail: biman@rri.res.in

Alfred Russel Wallace –A Life. Peter Raby. Princeton University Press, 41, Princeton Street, Princeton, NJ 08540, USA. 2001. 340 pp. Price not mentioned.

In the folklore of evolution, Alfred Russel Wallace is probably destined to remain the Other Man. At any rate, such has been his fate over the past 100 years and more. Considering that along with Charles Darwin, he discovered the one unifying concept encompassing all of biology, the principle of evolution by natural selection, this is grossly unfair. Raby's book goes some way in restoring to Wallace the credit that is rightly his. While doing so, he points out that Wallace's reputation was at no time ranked as highly as it deserved to be. Much of the responsibility for this must be laid at the door of Wallace himself. Modest, self-effacing and – in particular when it came to comparing himself with Darwin – diffident to a fault, Wallace always tended to downgrade his achievements. Viewed in the light of the way science functions today, this looks like self-destructive behaviour; but it happens to be true.

Wallace was born in England near the Welsh border in 1823 (which made him 14 years younger than Darwin). His father was a poor manager of money and quickly dissipated what had been a steady income. From then onwards financial problems were to dog the family almost without respite. Being forced to earn a living, the young boy was apprenticed to a surveyor at the age of fourteen. Those were the great days of the growth of the railways, and he developed a taste for adventure and the outdoors that lasted all his life. A passion for reading flowered quite early and he claimed to have read almost every book that was said to be 'celebrated or interesting'. Along with reading, Wallace enjoyed collecting insects, especially beetles – a trait in which he resembled the young Darwin. There were portents of what was to become most meaningful in his life. Darwin's *The Voyage of the Beagle*, which came out when he was nineteen, was a book that Wallace went through carefully and made notes from. Another early hint of his eventual calling came from the impression made by Robert Chambers's sensational and anonymously published *Vestiges of the Natural History of Creation* that appeared in 1845 (nine years after Darwin returned from the Beagle voyage). Chambers made two bold assertions: that the living world too was governed by natural law and that species could change. Both struck a chord with Wallace; but because *Vestiges* remained silent about possible mechanisms, the assertions remained vaguely unsatisfactory. Most important of all, he read Reverend Malthus's celebrated *Essay on the Principle of Population*. Its message was to remain locked up in his mind for a further twelve years before emerging transformed in a burst of feverish creativity.

The turning point in Wallace's life came when he set off by boat on a collecting trip to the Amazon jungle in 1848. The twin lures were the prospect of seeing an exotic world and the desire to make a living by doing what he enjoyed. Henry Bates, an old friend, was his companion on the voyage. As with Wallace, Bates too belonged to the lower middle-class, was a self-taught naturalist and was to achieve fame in the annals of evolutionary biology (in his case for work on mimicry). In one sense the Amazon trip, which was to last three years, was a failure. The specimens that he shipped back to England made little money; and on the return voyage, a fire on board destroyed all his sketches, notes, drawings and precious insect collections. But in a larger sense the tropical rain forest did for Wallace what it had done much earlier for Darwin: it opened his eyes to the sheer variety of living forms, their abundance and their extraordinary adaptations. By the time he came back, his name was well-known in naturalist circles.

Not long after returning from America, Wallace started planning for his next journey. This time it was to be to the Malay Archipelago. He was away for eight years; the trip turned out to be 'the central and controlling incident' of his life. In February 1854, just before setting off, Wallace had come across a 'polarity theory' of evolution based on a 'Divine scheme of organized nature' put forward by Edward Forbes as part of a presidential address to the Geological Society in London. The 'ideal absurdity' of Forbes's postulates spurred him on to do some thinking of his own. The outcome, written up in a house at the mouth of the Sarawak river, was an essay titled *On the Law which has Regulated the Introduction of New Species*. In Wallace's own words, the central idea – the law – was that 'Every species has come into existence coincident both in time and space with a pre-existing closely allied species'. One species could change 'either slowly or rapidly into another'; it remained unclear how. Though some way from formulating the idea of natural selection, he was getting close. As an explanation for the affinities that species displayed when they were found in close proximity, he claimed that his law was superior to previous hypotheses. He went on to add that if the law were true, deductions made from it would be as valid as the deduction of elliptical planetary orbits from the law of universal gravitation. The evocation of Newtonian law was symbolic of what was a goal for Wallace as it was for many others working on biological problems: physical science had set the benchmark by which other areas of human endeavour had to be judged if they were to be accorded scientific status. One might note here that later, in the famous last paragraph of *The Origin*, Darwin explicitly drew attention to the analogy between natural selection and gravitation as laws of nature. The desire to validate all of science by applying the standards of mathematical physics has not been an unmixed blessing. Some, for example Ernst Mayr, have considered it a positive hindrance; in his trenchant phrase, 'Physics envy is the curse of biology'.

Darwin had been slowly chewing through the implications of natural selection for some twenty years when the Sarawak paper (published in 1855) came to his attention. It did not make much of an impression. 'Nothing very new' was the annotation he made in the margin of his copy. As Raby hypothesizes, Darwin would seem to have been misled by Wallace's use of 'created' where he meant 'evolved' and by 'antitype' when he really meant (in referring to a species) 'prototype'. In any case, he saw no cause to feel worried by the prospect of being forestalled. On the other hand, his good friend Charles Lyell, whose geological researches provided crucial support to the thinking of both Darwin and Wallace, immediately grasped what Wallace was getting at. Lyell warned Darwin that he stood the risk of being scooped. Darwin re-read the paper; this time he was slightly shaken. Nevertheless, he carried on with his enterprise – producing a major book on evolution at his own measured pace – much as before.

The blow fell in 1858. Wallace had been laid low by malaria on the island of Ternate. The forced leisure made his thoughts return to the problem of how species might change. Malthus's essay, read long ago, came back to his mind and provided him with the key to understanding natural selection – in a flash, as it were. Malthus had held that war, hunger and pestilence, all direct or indirect consequences of unchecked human population growth, fostered a struggle for existence in which those least able to compete were weeded out. To Wallace this immediately suggested how a similar mechanism, natural selection, might act on all living forms. In an amazing coincidence, Darwin had hit upon the very same mechanism after being inspired by the same book. In his exuberance, Wallace could think of no better adjudicator of his theory than Darwin. He wrote him a letter and enclosed a short manuscript in which the essential idea was elaborated; Darwin was requested to forward the manuscript for publication if he approved of it. The rest of the story – Darwin's dismay, his fear of acting in a less than honourable fashion, how Lyell and Hooker convinced him that the correct thing would be to present his ideas *and* Wallace's simultaneously, and, most of all, Wallace's extraordinary sense of fairness and decency throughout what followed, is well known. The actual presentation took place at a special meeting of the Linnean Society arranged because the one scheduled previously had to be cancelled on account of the death of its President, the famous botanist Robert Brown. There was no response from the audience. Later, Darwin, for once bestirred to act in what was for him a hurry, published his theory in 1859 as *The Origin of Species* (he continued to maintain that the book was merely an abstract of a fuller version, a version that never appeared).

Wallace's reaction to *The Origin* was handsome beyond belief: 'Mr Darwin has given the world a *new science*, and his name should, in my opinion, stand above that of every philosopher of ancient or modern times'. To Bates he said 'I do not know how, or to whom, to express fully my admiration of Darwin's book. To *him* it would seem flattery, to others self-praise;. with however much patience I had worked and experimented on the subject, I could *never have approached* the completeness of his book . . . '. Darwin reciprocated just as warmly, and with keen understanding: 'You must let me say how I admire the generous manner in which you speak of my Book: most persons would in your position have felt some envy or jealousy'. When Bates passed on to Darwin one of Wallace's letters to him, Darwin replied 'He rates me much too highly and himself much too lowly . . . But what strikes me most about Mr Wallace is the absence of jealousy towards me: he must have a really good honest and noble disposition. A far higher merit than mere intellect'.

I hope I have given some idea of the main scientific thread that runs through this admirable book. There are other threads as well: Wallace's ever-growing reputation as a superb naturalist (he lays claim to be called the founder of biogeography, the study of the distribution of animals and plants in space), his perennial problems with money (to be only partly solved thanks to Huxley and Darwin's mediation which resulted in a government pension), his enthusiasms that at times verged on impetuousness, his opposition to vaccination (he thought the claims for success were not based on solid data), his credulous belief in spirits, his strong feelings on the subject of women's rights, his advocacy of land reforms, his socialist tendencies, his belief that what people needed most was a sense of self-respect, his conviction that if humans were to have a future at all, it lay in cooperation, not competition, and so on.

In all these respects, Darwin was the recluse who wanted to have only so much to do with the world of human affairs as he was compelled to. Wallace was just the opposite. He was the man with a broad social philosophy of whose correctness he was convinced and to which he wanted to convert others. On one occasion Wallace tried to persuade Darwin of the truths to be found in a 'startling novel and original' book on economics that he had come across; he failed entirely. Instead, his advocacy elicited a tart rejoinder that some might approve of even today: 'I read many years ago some books on political economy, and they produced a disastrous effect on my mind, viz. utterly to distrust my own judgement on the subject and to doubt much everyone else's judgement'. He called himself lazy, but was punishingly hard-working (as was Darwin of course); his publications include 22 books and 700 articles. He abhorred pomp and always retained a sense of his own absurdity. Wallace lived till he was 90 and remained intellectually agile and vigorous to the end. He was invited to contribute to a volume being brought out to mark the centenary of Darwin's birth in 1909 but declined, apparently because he was dubious about the company he would have been forced to keep – William Bateson and Hugo de Vries in particular. One would love to know exactly why he felt that way, just as one would love to know how he reacted to the rediscovery of Mendel's laws in 1900. Raby is silent on both points.

There was one aspect to Wallace that bothered all Darwinians (he counted himself as one, going so far as to write a book titled *Darwinism*). This was his refusal to agree that humans too were products of natural selection. He would not accept that the human mind could be explained in the same manner as other aspects of the living world; there had to be something else to it. No, the mind was 'itself the living proof of a supreme mind'. The phenomenon of consciousness and the powers of the mind were so astonishing that they must have resulted from *artificial* selection, meaning from a scheme of selection carried out with a purpose in view. A Higher Intelligence must have been involved in the development of the human race in the same way that humans had developed races of cows or horses in order to serve special ends. Darwin, Huxley and many others differed from Wallace on this, and 'grievously' at that, as Darwin told him apologetically.

In ending, let me make a few general remarks. This biography forms an interesting counterpoint to the recent biographies of Darwin. I have in mind the one by Desmond and Moore especially. That book succeeded brilliantly in portraying Darwin as a product of his times: a rich, upper-class British gentleman of leisure whose intellectual development took place in, indeed was shaped by, a Victorian world in which social inequalities were rife and some people were manifestly more successful than others. The approach was acclaimed by many and criticised by others who saw it as making Darwin appear to be almost an inevitable consequence of social forces. With Wallace, though, at least as Raby portrays him (which is not all that different from what one had known or guessed), the assessment must be rather different. Here was a man, with neither wealth nor connections, only boundless curiosity, in certain aspects also a product of his times, who went on to indulge his curiosity to the fullest, even though prudence and common sense, not to say convention, might suggest a more regular, more stable, more 'normal' career. Based on what we know, there does not seem to be any way in which Wallace's life can be understood other than as being based on a highly individualistic set of choices. The point is that these were choices that would have been opposed, not fostered by, societal expectations. To be sure, the choices that he made had to mesh with, even exploit, the exigencies imposed by an external world. Raby puts it nicely. Wallace's was an astonishing intellectual odyssey which was at the same time 'fed by the Victorian institutions of self-help, the mechanics' institutes and local lending libraries, popular journals and magazines'.

We are often tempted to force explanations of human behaviour within a simplistic Nature-versus-Nurture framework. If one were to do so, Wallace's life could be said to be dominated by the Nature end of the range of inputs. Luckily there is an interesting 'control experiment' available for us to compare with Wallace. He and Bates were friends and contemporaries, had similar backgrounds, aspired to similar careers, made similar choices and, most importantly, were intrigued by similar questions (as early as 1847, Wallace is writing to Bates about a possible 'theory of the origin of species'). Yet Wallace discovered natural selection whereas Bates did not.

Finally, a striking fact that comes through this biography is that Darwin and Wallace saw themselves preeminently as theorists. Both were convinced of the central importance of theory even in a field as rooted in observation as natural history. Wallace has been quoted above. Here is Darwin to Wallace, in a letter that went to Ternate and just predated Wallace's momentous announcement to him: 'I am extremely glad to hear that you are attending to distribution in accordance with theoretical ideas. I am a firm believer, that without speculation there is no good and original observation'. That was in 1857, approximately fifty years before genetics and developmental biology began to provide two more theoretical underpinnings to biology and about a hundred years before neurobiology ushered in a third. We would do well to ponder the irony here. Namely, modern biology, whose practitioners tend to look down on old-fashioned descriptive botany and zoology, often seems to involve little more than accumulating facts for their own sake. It has become in its turn a refuge for stamp collectors, only this time the stamps are molecule-sized.

VIDYANAND NANJUNDIAH

Indian Institute of Science,
Bangalore 560 012, India and
Jawaharlal Nehru Centre for Advanced Scientific Research,
Bangalore 560 064, India
e-mail: vidya@ces.iisc.ernet.in

Bioinformatics for Beginners. K. Mani and N. Vijayaraj. Kalaikathir Achchagam, Coimbatore. 2002. 276 pp. Price: Rs 260.

Bioinformatics comes in many flavours. There is the mathematical flavour, in which the subject is indistinguishable from rarefied computer science. There is the database flavour, the essence of which is management of enormous quantities of data. There is the biological flavour in which the most important thing is the new biological knowledge generated. And there is the biotechnological flavour, where IT and biotechnology skills (and sometimes lack of them) are sought to be 'leveraged' to generate money. With regard to the last, a perceptive observer of the scene, not entirely unconnected with *Current Science*, recently likened the development of bioinformatics to the inflation of a balloon. Like all balloons, this one too, I suppose, requires a constant supply of hot air to keep it aloft and moving. My very first impression of the present book was that it was nothing more than an attempt to fulfil some of the great demand for this insubstantial commodity, much like a couple of other such books published recently from Hyderabad. My second impression, however, was more positive. The printing, binding and the general production qualities of this volume are of a superior level, and obviously some care and effort has gone into it.

The book is divided into three sections, somewhat whimsically named information *in vivo*, *in cybo* and *in silico*. I have no complaints against whimsy, but after a famous series of books overloaded with this quality, I now feel like a dummy whenever I encounter it in a technical book. This book is however written for beginners, not dummies. Appropriately, the first section introduces modern molecular biology. This is apparently aimed at non-biologists who are looking for a quick digest of the subject. Biologists studying bioinformatics, presumably, would already be familiar with the topics addressed here. Nevertheless, there is something for such students too. Several words and phrases frequently used in the context of bioinformatics, such as ESTs and contigs, are explained in this section. There are several useful diagrams such as the one that presents the contents of the human genome in the form of a tree (Figure 1.4.3). However, the section, and therefore the book, starts off poorly. The first paragraph, entitled 'The Biological Concepts for Bioinformatics' (*sic*) is an overambitious attempt to start at the very beginning. Unfortunately, science is still undecided about the details of the beginning of life on earth, and the authors state as facts, hypotheses which are by no means universally accepted, such as the Cairns–Smith's theory of clay providing a scaffolding for a self-replicating system. Another complaint I have against this section is that it pays scant attention to structural biology, but perhaps now *I* am being overambitious.

The book continues *in cybo*, which apparently means 'on the Internet'. This consists of a probably redundant section on 'Internet Basics', though I must confess to frequently meeting students, even those who are city-educated, who have had no previous exposure to this resource, and who therefore will find this tutorial-like description useful. A list of interesting URLs, an overview of databases accessible over the Internet, a whiff of relational database theory, and details of MS Access as an example of an RDBMS, constitute the rest of this third of the book. All the profuse illustrations here are screen shots, in black and white, though the high quality of the printing makes up for the lack of colour. All in all, this is a well-written and useful section, though somewhat elementary. The fact that the book is meant for beginners probably justifies the large amount of space given to this topic.

The final section of the book is entitled *in silico*. It begins with a chronology of the major events that led to the development of bioinformatics. This table seems to have been paraphrased from a commercial handout, perhaps downloaded from the net, and is full of references to the founding of various companies, almost all of them American (of course). The rest of the section reinforces this suspicion, viz. that it has been rewritten