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Book Reviews

Teaching of mathematical modelling and applications by M. Niss, W. Blum and I. Huntley, Prentice–Hall, 66, Wood Lane End, Hemel Hempstead, Hertfordshire, HP2 4RG, England, 1991, pp. 427, $97.

Mathematical modelling has been the 'in' thing for quite some time. It is not at all uncommon to hear the eager and hopeful question "Can we do some modelling with this data that I collected over oh so many years?". While the process of using the mathematics to describe real-world phenomena began centuries ago, the fancy term 'mathematical modelling' seems to be of a more recent origin. In the good old days, people used to write good old differential equations to describe how different variables change with time; now they set up mathematical models! (It is the same case everywhere; recent batches of students – technobrats – no longer write computer programs, they 'develop software') Despite knowing all this, I was still unprepared to anticipate the extent to which these activities have proliferated—apparently, there have been numerous international conferences devoted to the teaching of mathematical modelling (and 'applications' thrown in for good measure).

The book under review is a result of one of such conferences, in fact, the fourth one – ICTMA-4, held at Roskilde University, Denmark, in July 1989. There are 44 articles by 56 authors from 13 countries, with UK contributing almost 50% share. India, the proud possessor of the second (third?) largest pool of scientific and technical manpower (rather, in deference to the recent fair and just nomenclature, 'personpower') is conspicuous by absence; but then so are USSR (Russia?), China, Japan and France, just to name a few superpowers. However, what the book lacks in representativeness from this angle is more than made up for in the coverage of mathematical topics, and especially in the very systematic organization of the sections and chapters.

The first section – surveys – is possibly the best part of the book, in terms of scope, information as well as entertainment. In the deceptively serious title 'Applied mathematics as a social instrument', P.J. Davis gives a clear, forthright and delightful description of what applied mathematics is all about, with a balanced mix of the philosophical thoughts, abstract language and down-to-earth examples laced with pithy prose. A couple of illustrations: ". . . the three goals are *description, prediction and prescription*; that is, tell me what is, tell me what will be, tell me what to do about it." or "Men have been sent to jail for practicing applied commercial mathematics which employs the wrong kind of axiom system" and the most quotable of all "Is modelling important in the federal decision making process? You'd better believe it In 1979, half a BILLION dollars were spent on development, use and maintenance of (mathematical) models".

In contrast, the ponderous sounding title of the next chapter by W. Blum is not deceptive at all. Terms such as modelling, application and even real-world problems are *explicitly* defined. On the one hand, one marvels at the orderliness of the mind (parallelling those who relish the exquisite beauty of the highly rigorous rules of Sanskrit grammar). On the other hand, at a cursory glance, the whole exercise looks so pointless and pompous—just an act of belaboring the obvious. This impression is strengthened by the various tables, which indicate the importance of the different topics by decorating them with one, two or three stars! A closer look at the chapter, however, brings out the important contribution made by the author by clearly indicating the very fundamental goals—not just of mathematical modelling, or even of mathematics, but of education in general. While everyone is familiar with these in a somewhat intuitive and nebulous way, the explicitness and clarity of the writing makes this a very readable and useful chapter. The thoroughness of the treatment can be judged by the fact that the discussion includes detailed arguments both for as well as *against* teaching of mathematical modelling. (Halfway through the chapter, I felt the exposition to be far too systematic to be of non-German origin, and a quick look at the author's institutional affiliation confirmed the diagnosis). However, this is no ivory tower sermon—practical aspects such as reluctance of students to take on anything which will make examinations more complex and demanding, reluctance of teachers to acquire more non-mathematical knowledge, etc., are described with a matter-of-fact frankness.

The next chapter on 'Building mathematics curricula' also retains such contact with the real-world situations, but describes them in a refreshingly lucid language. The diverse attitudes adopted by the teachers towards teaching mathematical modelling (some think that it can be taught only to the brightest; others, only to the poorest, students), the unimaginative nature of the many examples described in the routine courses (and the even less-imaginative ways of solving them) and the like have been commented upon with a wry sense of humour. The case for bringing a logical structure to the field of modelling (which otherwise is a maze of bewildering complexity of applications and techniques) has been very well presented. What is most useful, however, is the author's insight into the crucial factors which contribute to the difficulties of the students when it comes to grasping mathematical modelling—it is their unfamiliarity with the use of arithmetic! They have never been taught to 'play' with numbers, nor have they been familiar with the use of even the most basic mathematical operations in a way that connects them with real-life problems. Also instructive is the demonstration of the multiple meanings of even the most ordinary sounding words—number, for example, has six different connotations: count, measure, location, ratio comparison, code and a derived constant. The author's step-by-step approach towards defining the philosophy behind the designing of better curricula can be very profitably read by all instructors of mathematical modelling. Also fascinating are the snippets from history, for example, algorithms for multiplication and division were newly invented in the 15th century, and were therefore taught only to the students of university age!

The last of the surveys deals with computing mathematics, and lists some of the things that can be done with computers (apart from the trivial applications to numerical calculations) *e.g.*, interactive video, algebraic manipulations, special-purpose languages such as Hope, ML, Miranda which deal with functions, predicates, clauses, etc. In short, some very esoteric stuff. A few interesting problems and some unusual applications (bar codes on books) have been thrown in to give a flavour of what can be done in a class-room. A less than cogent and coherent treatment, compared to the previous three articles.

The next section deals with the theoretical aspects of mathematical modelling. This is a thoroughly mixed lot, and contains articles that are:

* Sublimely philosophical—"Platonism . . . is characterized by the belief that mathematics is the highest form of knowledge, and therefore the form of knowledge God must have used when he created the universe. . . . Unfortunately . . . the credibility of Platonism has suffered a series of devastating blows . . . discovery of the contradictions of set theory, Godel's incompleteness theorem and quantum theory, to the popular rejection of its historicist and elitist social assumptions".

* Passionately emotional—"Against ill-founded, irresponsible modelling", . . "Blind and powerful: ruthless, model-based, digitalized control" . . . "the vicious acceptance of the technological risks and the irrationalities of growth economy" . . . (and so on).

* Amusingly historico–social—"The two distinguishing trends in the international debate (on applications and modelling in mathematics instruction) are: the *pragmatic trends* from the English language area and the *scientific–humanist trend* from the Romance language area". ". . . appropriate understanding of mathematics . . . adequate attitude towards mathematics is needed for **becoming a human being**" (emphasis mine). "The German-speaking debate . . . shows three trends . . . the emancipatory, the science oriented and the integrating".

* Mix of optimistic, pedestrian and esoteric—"Future trends indicate a shift from *problem-doing* to *problem-solving*"; "Importance of teaching mathematical modelling in Bangladesh . . . as an efficient tool to assist in resolving complex problems such as population growth, floods, epidemics. . ."; "Role of the specification language Z, developed by the Programming Research group at Oxford, as taught at Sheffield City Polytechnique.

* Almost farcial—the question–answer sessions from a class, recorded as a part of a micro-ethnographical study: "Teacher· Mrs Sweet wants to get some strawberries . . . . Is price the only thing . . .? Student: If it's a long way away, and I come back with the strawberries and the road is rough or something, and the strawberries could go bad or something. [Laughter]"

The next three sections discuss in detail the experiences of teaching mathematical modelling at the Lower Secondary (ages 12–16), Higher Secondary (ages 16–19) and Tertiary (B.Sc./M.Sc.) levels. In the Lower Secondary section, the article by P. Abrantes from Portugal presents a very well thought-out curriculum, with many interesting examples. Laced with dry humour by the author ("this is a critical school level in Portugal because many students drop out due to successive failures, and mathematics strongly contributes to this situation") and the students (their responses to the course – " . . I liked Geometry because of the *mentalities* which we had to use"), the article puts forward many thought-provoking points of view, *e.g.*, the role of the teacher as one who organizes activities and gives suggestions instead of teaching how to do, and checking if answers are correct. Other equally enjoyable articles demonstrate, through the use of activity-based syllabi (designing board games, planning trips, making pop-up cards, drawing topological trees from results of volleyball tournament, running a petrol bunk), how the learning of mathematical modelling can be made very attractive as well as useful.

The chapters dealing with Higher Secondary level, in contrast, look more like a matter-of-fact account of what is being done in different countries. Again, the major innovation is the activity-based approach The projects at this level are rather more academic—traveling salesman, properties of the number 1729, applications of regression analysis to calibrate manometers, etc. A couple of articles continue to discuss (yaaaawn!) organizational and implementational aspects; while others are straight-forward single-theme tutorials—conic sections, automatic discrimination of written language, Weibull distribution, fossil fuels, consumption pattern analysis, the inevitable inclined plane for Newtonian mechanics and groundwater modelling. The only breath of fresh air in this section is the account of a very imaginative exercise in physical modelling by A. Kitchen from Manchester, UK. The students were taken to an amusement park, given joy-rides in merry-go-rounds, roller-coasters and the like, and encouraged to set up and analyze corresponding mathematical models. This wonderfully written and well-illustrated article has some irresistible quotes. "The standard of the work produced by the students has improved dramatically over the years . . . it may be that my expectations of them have changed". ". . (this course) is not just suitable for sixth formers; I have learned a great deal myself", and finally—"Why not visit an amusement park yourself? Try all the rides. Find some problems to solve. Have fun. That is what mathematics is all about".

The last section, for the tertiary level, begins with the most difficult aspect of the teaching of mathematical modelling—how to think up good problems? The article does illustrate a number of interesting ones—refraction through variable media, modelling of the performance of teachers (a sure winner for generating snide comments), rainfall run-off, reservoir contamination, etc. Almost each one of the subsequent articles is devoted to a specific, relatively advanced theme, presented in elaborate detail. These include water quality modelling, spread of the epidemic of rabies modelled in 1 and 2 dimensions, design of a ferry bridge, image compression techniques—just to name a few. All these could as well have been targeted for a pedagogical journal such as the *American Journal of Physics;* and so also the one on "how to, and how not to, use Laplace transforms". No section of this omnibus conference proceedings can be complete without philosophical musings, and the one included here give a very useful account of "good and bad modelling in mechanics".

On the whole, this book is a mixed bag. Sure enough, there is something in it for everyone connected with mathematical modelling, but the score is too broad for most readers. The price ($97 only) is stiff, especially when converted into Rupees, but not overtly high considering that these are conference proceedings—a notoriously pricy class of publications. For those who have the money, time and also the patience to wade through, this volume does contain many valuable nuggets.

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The self-avoiding walk by Neal Madras and Goldon Slade, Birkhauser Verlag AG, Klosterberg 23, CH-4010 Basel, Switzerland, 1992, pp. 442, SFr 108.

Self-avoiding walk—a path on a lattice that does not visit the same site—is simple to follow but to answer basic questions like, (a) how far an n-step self-avoiding walk typically travels from its starting point, or, (b) how many such walks there are, or many such important ones turns out to be quite difficult. This book provides an extensive survey of the results available to those questions. Though the main focus of the book is on the mathematically rigorous results it also keeps an account of the answers which are arrived through some nonrigorous methods and computer simulation and which are mostly accepted by the researchers in physics and chemistry communities and gives a nice comparison of those with the current state of rigorous result obtained

The first chapter brings out the basic questions and conjectures about the self-avoiding walk It also introduces many important notions like the two-point generating function, the bubble condition and bubble diagram, the inclusion–exclusion principle, all the critical exponent and Hammersley's classical work using the idea of concatenation for the existence of critical exponent $\mu = \lim_{N\to\infty} C_N^{1/N}$, where C_N is the number of N-step walk beginning at the origin. The ideas and techniques introduced in the first chapter gets culminated deeply in Chapters 3, 4, 5, 6 and 7. In Chapter 3, the 1961 work of Hammersley–Welsh on the upper bound of C_N is discussed This is improved by Kestern in 1964. Hammersley–Welsh's bound is still the best available for two dimensions and Kesten's for three and four dimensions. Bounds for the number of self-avoiding polygons are also proved here. The fourth chapter is concerned with Ornstein–Zernike's theory of decay of the two-point function Here, probabilistic renewal theory came into picture while introducing bridges In Chapters 3 and 4, subadditivity plays an important role in a subtle or direct way. Most of the proofs here are due to Chayes and Chayes. In Chapter 5, the lace expansion is derived using inclusion–exclusion principle and points out and some of its important application on lattice trees and animals and on percolation, whereas the sixth chapter uses the lace expansion technique which is due to Brydges and Spencer (1985) as a main tool to prove the results on more than four dimensions Most of these proofs and results are originally due to the authors themselves. These results, as pointed out, resemble the results of random walk and the proofs also use many techniques, used for the related results of random walk. The seventh chapter is devoted to Kesten's pattern theorem which guarantees that a pattern would occur some proportion of times on all N-step self-avoiding walk, except for an exponentially small fraction, if it can occur several times on a self-avoiding walk and its immediate application in the form of ratio limit theorem for the C_N and related quantities. In the ninth chapter we get an extensive survey of various Monte Carlo algorithms that have been used to simulate self-avoiding walk. Rigorous analysis of ergodicity properties and autocorrelation times are the main focus here. Chapters 8 and 10 are devoted to some assorted additional results like the upper bound for a critical exponent, comments on the walk with geometrical constraints, infinite bridge, weakly self-avoiding walk and 'true' self-avoiding walk while Chapter 2 discusses the various applications for the self-avoiding walk in physics and chemistry, and the nonrigorous results due to computational or other methods, including Flory, Fisher, de Gennes.

This book is very much self-contained and is quite accessible to graduate students and researchers in mathematics, physics and chemistry interested in this area, though some more explanation of various concepts or techniques which arise from some specific discipline, would have been better for readers of other disciplines. Unfortunately, some of the topics in Chapter 10 which are related to the random walk have been discussed very briefly, but overall, the book covers a wide and extensive area to describe the main results and applications of self-avoiding walk. Notes and comments at the end of each chapter are quite instructive and point out to appropriate references. Bibliographic references and the notational index are quite extensive, if not full. Since the authors themselves are on the forefront of research in this area, this book, quite expectedly, has become a well instructive and authoritative account for the reader

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Basic category theory for computer scientists by Benjamin C. Pierce, The MIT Press, 55, Hayward Street, Cambridge, Massachusetts 021 142, 1991, pp. 102, $ 17.95.

Category theory is the most general and abstract branch of pure mathematics and almost every structure in mathematics can be regarded as a category, often in several different ways It fulfils the computer scientist's quest for a purer view of functions, a theory of functions in themselves, not a theory of functions derived from sets[1] It provides a general framework for the theories of programming, which form the basis for the design and definition of programming languages and their associated software engineerig methods However, from the viewpoint of a computer scientist, the real problem has been identified to be the fact that category theoretic definitions and their properties are so much more complicated than those that computer scientists are used to Even apparently simpler definitions are usually expressed in terms of an alternation of universal and existential quantifiers. The existential quantifiers often take the complicated forms: "There exists exactly (or at most) some x such that. . " *This complication and unfamiliarity of the formulae make it difficult to acquire and develop the kind of intuitive skill at pattern matching that makes algebraic calculation such an effective method of mathematical reasoning*"[2]

Category theory can also be thought of as the science of the social behaviour of mathematical structures, whereby mathematical structures are meant such entities like groups, topological spaces, lattices and similar objects with internal structure[3] By *social behaviour* is meant that one is not so much interested in the how of each such entity is structured internally, but with the how of the interaction of the object with other objects. In particular, no distinction is made between the objects belonging to the different 'species', if the objects cannot be distinguished on the basis of their external behaviour

It is in this perspective, we feel, that the book should be perceived and received by a computer scientist The author, being a computer scientist himself, declares that the book is an outcome of his efforts at learning category theory, while he was a graduate student. The background of the author is indeed reflected to a certain extent in the description of the category theoretic concepts in the tutorial introduction in the first two chapters. The various definitions are explicated in terms of the entities familiar to a computer scientist. However, in our opinion, the author would have done well to discuss the hurdles and the mental blocks that he had experienced, when he first embarked on a study of category theory, for we feel that the narration of such experiences will help the computer science readership, many amongst whom still feel that category theory is an arcane and esoteric branch of mathematics with little or no relevance to the practice of theoretical computer science. The tutorial introduction to category theory thus falls short of that intuitive appeal any computer scientist would be looking for in a text of this kind.

In the third chapter, the author reviews some of the application areas of category theory in computer science, most notably in the areas of the theory of programming languages. The author does well in introducing the problem and its category theoretic formulation But the description again falls short of a comprehensive treatment when the solution procedure is being outlined. The author leaves the reader with a reference to the works of the original proponents of the solutions. It is here, that, we feel, the author could have been more elaborate, for, in our opinion, this is the most interesting part of the *junction between category theory and computer science*[4]. For, it has come to pass in present-day computer science, that it is the extensional or observational behaviour that is of much significance.

The bibliographical survey presented by the author is indeed quite extensive and does provide the interested reader with valuable pointers to 'where to look further'.

In the final analysis, we feel that the author could have taken a few more pages to explain in more detail the *whys* and the *hows* of the application and the applicability of category theory to computer science. Such a description would have been welcome.

References

1. SCOTT, DANA S. Relating theories of the λ-calculus. In *To H.B Curry Essays on combinatory logic, lambda calculus and formalisms* (Seldin, J P. and Hindley, J.R , eds), 1980, Academic Press.

2 HOARE, C.A R — Notes on an approach to category theory for computer scientists In NATO ASI Series F. Vol 55, *Constructive methods in computer science* (Manfred Broy, ed), 1989

3 SUBRAMANIAN, P S — Category theory and system design, Tech Rep. No. CS-90/3, Tata Institute of Fundamental Research, Bombay, India, 1990

4. GOGUEN, J A , THATCHER, J W , WAGNER, E G AND WRIGHT, J B — *A junction between computer science and category theory I Basic definitions and concepts*, Tech Rep RC-5098, IBM Research, 1976

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Linear algebra by Gunadhar Paria, New Central Book Agency (P) Ltd, 8/1, Chintamani Das Lane, Calcutta 700 009, India, 1992, pp. 232, Rs 55.

The reviewer feels that the book under review is not suitable for students as it is not self-contained. Neither it is useful for self-study as it is very confusing, nor will it meet the long-felt need of students for a fresh textbook on linear algebra which would have been a good companion for self-study as was claimed by the author.

The basic definitions and results (which should be there in any book on first course on linear algebra) regarding matrices and determinants are not developed in this book. Instead, the author prefers to refer to his own book on matrix and tensor (author refers to his own works only) which I have not seen. Another shortcoming is that it provides neither a bibliography nor an index

This book has several serious errors including conceptual, logical, notational, typographical (and probably many others which I might have not noticed). Some of these are listed (not exhaustive) below:

- Why call a vector 'multi-dimensional vector'?
- Why call a line (as one usually studies from high school) a 'hyperline' (see page 8)?
- Definition of vector space and that of linear vector space on page 13 is not rigorous; in fact, it is not even correct, *e.g.*, in the definition of linear vector space, it is written that: "*the quantity* λ *being a properly chosen arbitrary scalar*"
- The statements of the theorems are not clear. Probably they are titles of the subsections that the author would like to choose. For example, on page 35 is is written that:

  "**THEOREM 1.** *Norm of any degree (standard form)*"
- The definition of a right coset on pages 82–83 is not correct.
- On page 84, in example 1, it is written that: "*In* R^2, *let* $V = (x, y)$ *be a vector space, and let* $W = (x, y)$ *where* . . . ." This is very confusing as the notation (x, y) in R^2 is the standard notation for a point in the cartesian plane in coordinate geometry which all the students learn from higher secondary onwards.

Without spending (wasting!) much space and time, let me conclude this review with an advice to the student community to keep away from such a book; there are many excellent books on linear algebra available even in Indian print.

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Measures of noncompactness and condensing operators by A.S. Potapov, B.S. Sadovskij and A.E. Rodkina Birkhauser Verlag AG, P.O. Box 133, CH-4010, Basel, Switzerland, 1992, pp. 264, SFr 128.

There is a large class of practical problems arising in physical, biological, engineering and technological sciences which can be modelled by linear and nonlinear differential and integral equations. In operator theoretic setting such equations can be described by an operator equation of the form

$$x + Tx = y \tag{1}$$

in an appropriate Banach or Hilbert space.

If T is a compact operator then one can use the theory of rotation of compact vector fields, the Schauder–Tikhnov fixed point principle, Fredholm–Riesz–Schauder theory of linear equations to analyse the existence uniqueness and other information on the properties of solutions of such equations. However, there do exist concrete examples among the differential and integral equations typically of form (1), where the operator T under consideration falls short of being compact. The degree of noncompactness of the set is then measured by means of functions called measures of noncompactness. Instead of compactness of T one then looks for its condensing characteristic under which the image of any set is in a certain sense more compact than itself.

It turns out that condensing operators have properties similar to the compact ones earlier described which are very useful tools for investigating solvability of operator equations involving such operators. This book is aptly aimed to give a systematic description of such properties of condensing operators.

In Chapter 1, authors introduce the measure of noncompactness (MNC)–Hausdorff measure of noncompactness γ, the Kuratowskii measure of noncompactness α and the measure of noncompactness β The known properties of Kuratowskii MNC and Hausdorff MNC are stated and proved, including the derivation of a number of formulas that compute directly the value of Hausdorff MNC in some concrete spaces. Having defined MNC, authors study condensing operators in Banach spaces and its generalisation to include the notion of ultimately compact operators and K-operators.

In Chapter 2, Fredholmness of bounded linear operators on Banach spaces is discussed, with respect to MNCs. This is done as follows. Let $L\,(E_1, E_2)$ denote the space of bounded linear operators from E_1 to E_2 and BE denote the Banach space of all bounded sequences $X = (x_1, x_2, \ldots, x_n, \ldots)\ x_n \in E$. Denote by KE the closed subspace of BE, consisting of relatively compact sequences. Denote by E^+ the quotient space BE/KE with the natural linear operation and norm. Then $C \in L\,(E_1, E_2)$ induces an operator from BE_1 to BE_2: $CX = (Cx_1, Cx_2, \ldots, Cx_n, \ldots)$, $X = (x_1, x_2, \ldots, x_n, \ldots)$. $C \in L\,(\mathrm{BE}_1, \mathrm{BE}_2)$ and $C\,(\mathrm{KE}_1) \subset \mathrm{KE}_2$ and hence this gives rise to an operator $C^+ \in L\,(E_1^+, E_2^+)$ by the formula

$$C\chi = CX + KE_2\ (\chi = X + KE_2).$$

One of the important theorems stated and proved is

Theorem (Fredholm criterion): The operator $C \in L\,(E_1, E_2)$ is Fredholm iff C is bijective (*i.e.*, it is injective and $C^+E_1^+ = E_2^+$).

Using this theorem authors obtain the Freedholmness of an operator C in terms of MNCs. One of the results in this direction is as follows:

Theorem (Sufficient condition for Fredholmness): Let $C = D + A$; D, $A \in L\,(E_1, E_2)$ and D is Fredholm. Suppose in the space E_1 there is given an MNC ψ and suppose that there exists $k < 1$ such that

$$\psi\,(AX) \leq k\,\psi\,(DX) \text{ for all } X \in B\,E_1.$$

Then C is Fredholm and its index is equal to the index of D.

There is a section devoted to relationship between the MNCs of the operator and its conjugate and also to the spectra of A_n and A where $A_n \rightarrow A$. There is a nice result stated in terms of normal MNCs which gives a necessary and sufficient condition for closeness of the parts of the spectra of operators A_n and A lying outside some disc.

In the fixed point theory and its applications an important role is played by the following closely related notions: degree of a map, rotation of a vector field and fixed point index of an operator. Chapter 3 of the book deals with the fixed point index of a condensing operator, its definition, properties and computation This is then followed by derivation of fixed point indices of linear, asymptotically linear and Frechet differentiable γ-condensing operators. Further properties of the fixed point index and its generalisation to various classes of maps and to locally convex spaces are discussed in the remaining sections of this chapter. There is a separate section on the fixed point index of positive operators. The last chapter deals with the application of the concepts of MNCs and condensing operators to the theory of differential and integral equations. The main areas of applications are Cauchy problem for ordinary differential equation, Itoh's stochastic equation with deviating arguments, functional–differential equations of neutral type and Hammerstein integral equations.

The reviewer would have preferred to see a more systematic approach towards differential and integral equations. For example, Itoh's stochastic equation need not have been introduced right after Cauchy problem. There is a need to dwell more on the deterministic aspect before going over to stochastic analog May be authors have had their own constraint which the reviewer is not aware of.

A book giving full treatment concerning condensing operators was very much needed and this job is well done in this book. All those working on applicable functional analysis would very much relish reading the book. The only prerequisite is the knowledge of elementary functional analysis.

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The world of Bohr and Dirac by N. Mukunda, Wiley Eastern Ltd, 4835/24, Ansari Road, Daryaganj, New Delhi 110 002, 1993, pp. 90, Rs 70.

The phrase 'pleasant duty' commonly used in our public functions is seldom meant seriously but this writer can honestly say that the duty (of reviewing) that he has been asked to perform is truly an enjoyable task. Prof. Mukunda is a physicist of great distinction, unfortunately not so well known as he deserves to be but held in high esteem in circles that really matter. A shy and retiring personality, he lives happily in his world of equations. However, bowing to public pressure, he has in recent years emerged from his cloister to write essays and deliver popular lectures on personalities as well as the texture of physics. The volume under discussion is a compilation of five lectures/essays prepared for quite different occasions; yet they blend beautifully to form a charming little volume, with a "unifying thread running through . . . involving both personalities and ideas."

The opening essay on Dirac is a tribute to the great master published soon after his death. Instead of the usual biographical memoir, one is offered a delicate portrait *via* a stimulating *bhashyam* on select papers of Dirac. As Mukunda says, "Dirac burst on the scene in late 1925. Thereafter he kept going like a house on fire, with a steady and staggering profusion of fundamental ideas and discoveries."

It all started with a visit by Heisenberg to Cambridge in July 1925, during which he delivered a seminar on the recent breakthrough he had achieved. Dirac could not attend the seminar but a couple of months later his thesis adviser Fowler passed on to him the proof sheets received from Heisenberg. At first Dirac did not pay much attention to what Heisenberg had to say but a week later he suddenly saw that it opened up a whole new world. Mukunda adds: "One of Dirac's key contributions in this phase was the exposure of the link between classical and quantum mechanics. This was the most beautiful expression of the Correspondence Principle [of Bohr] and, said Dirac, it had given him the most pleasure of all his discoveries."

Dirac's papers are noted for clarity and lucidity. They have a style of their own about which Mukunda says:

> Those familiar with the plays of Bernard Shaw are aware of the beautiful essays that appear at the end of the plays—rivalling the plays themselves for wit and insight A somewhat similar statement could be made about the introductions to Dirac's papers. He developed his style of reviewing in his own way the most important recent developments in a particular area, expressing his opinions about problems and progress and putting things in perspective, before going on with a presentation of his own results in each paper.
>
> A collection of the introductory sections of his papers would be most interesting . . . .

One also learns that as early as 1931, Dirac had (essentially) introduced the concept of fibre bundles into physics, "decades ahead of the rest of the world." And in a paper in the *Reviews of Modern Physics* published in 1949, Dirac has this "remarkable sentence."

> I do not believe there is any need for physical laws to be invariant under these reflections, although the exact laws of nature so far known do have this invariance.

This is seven years before Lee and Yang questioned parity conservation in weak interactions.

I once heard a well-known French physicist describe Dirac's classic book *The Principles of Quantum Mechanics* as the book of the century. Mukunda goes even further According to him, "There is little doubt that in the times to come it will be Dirac who will be remembered as the physicist of the century "

The Universe, they say, began with a bang So did this century as far as the world of physics is concerned for it was in 1900 that Planck ushered in a revolution in human thought with his discovery of the quantum concept. Then followed a confusing but exciting period which culminated with the discovery of quantum mechanics, and Dirac's discovery of the relativistic wave equation (now appropriately named after him). Gamow once described this turbulent era as "thirty years that shook physics." Many were privileged to participate in this exciting drama (Dirac is reported to have said that it was a period when second-rate people could do first-rate work) but of these, two who stand out are Niels Bohr and Dirac; it is around these two central characters that the second essay is woven.

An essay on Bohr and Dirac is necessarily a study in contrasts for one cannot easily come across two strikingly different personalities. And yet in their own subtle ways they wonderfully complemented each other to weave a fabric of great beauty and marvellous texture.

There was a gap of almost a generation between Bohr (b. 1885) and Dirac (b. 1902). But, they worked in tandem "to accept and alter the fabric of classical physics to accommodate Planck's quantum of action." After a bright start in Denmark, Bohr landed in England around 1910 to pursue higher studies. He went to Cambridge to work with Sir J.J. Thompson the discoverer of the electron but the experience proved disappointing. Armed with a copy of *Pickwick Papers* (to improve his English), he then went to Rutherford's lab in Manchester where he struck the jackpot. Rutherford had discovered the atomic nucleus and the crying need of the hour was a decent model of atomic structure. Many ideas were floating around but none of any practical value. However, to Bohr the problems and possibilities immediately became clearer. He realised that "it was essential to bring in Planck's constant." And thus was born the celebrated Bohr model of atom. These days it is taught in high schools and one scarcely appreciates what a great conceptual advance it was when first proposed. In one sweeping stroke, as if by an edict, Bohr "suspended" classical mechanics in the realm of the atom, making way for "the application of Planck's idea to the dynamics of matter, which Dirac was to later describe as the most difficult first step. . . ."

The Bohr model was a sensation but after the first flush of success it was realised that it too had problems. A logically consistent framework was still lacking and Bohr alone could grope in the jungle, guided by his famous Correspondence Principle. The resolution of the crisis finally came in 1925 with Heisenberg's discovery of matrix mechanics. This was the spark that ignited Dirac who "soon elaborated, practically in isolation, his own version of quantum mechanics, giving it a particularly abstract and elegant structure."

Between 1925 and 1927 events moved in a high gear, with major contributions (apart from Dirac) by Heisenberg, Born, Jordan and Schroedinger. "During this period Bohr was in a sense watching from a distance, with a critical but approving attitude. . . . When the stage was set to find the meaning of the mathematical structure [of the new theory] Bohr reentered the scene." The reference here is to the philosophical interpretation of quantum mechancis which Bohr painstakingly developed and honed. Mukunda quotes Heisenberg to say: "Bohr was primarily a philosopher, not a physicist, but he understood that natural philosophy, in our day and age, carries weight only if its detail can be subjected to the inexorable test of experiment."

This then was the fundamental difference between Bohr and Dirac; whereas the former was primarily a philosopher (interested in natural philosophy, lately known as physics), Dirac was "a master craftsman in the art of theoretical physics." With the new mechanics, both were needed. A mechanics which cannot be put to practical use is of little value. Tools for manipulation had to be created which Dirac did with great dexterity, appealing to considerations of mathematical symmetry on the one hand and working in the abstract on the other. The result was a strange theory where quantities like position and momenta had to be represented by arrays instead of numbers as in classical physics. It needed a Bohr to provide insight into the structure of the theory and it came about because "of an intense occupation with actual phenomena, such that it was possible for him to sense the relationships intutively rather than derive them formally."

Dirac first met Bohr in May 1925 when the latter delivered a lecture in Cambridge. Mukunda does not discuss this but it is interesting to quote from Abraham Pais about what Dirac said referring to this visit by Bohr:

> People were pretty well spell bound by what Bohr said. . . . While I was very much impressed by (him), his arguments were mainly of a qualitative nature, and I was not able to really pinpoint the facts behind them. What I wanted was statements which could be expressed in terms of equations, and Bohr's work very seldom provided such statements.

In 1926 Dirac went to Copenhagen to spend time at Bohr's Institute. And about this visit Dirac later said (quote from Abraham Pais): "I admired Bohr very much. We had long talks together, long talks in which Bohr did practically all the talking."

Dirac and Bohr differed in writing styles too and about this Mukunda says:

> Dirac's writings have a characteristic and unmistakable directness, simplicity and beauty. Bohr on the other hand is much harder to read because each long sentence of his contains a great deal of thought in compressed form He spent a lot of effort in the choice of each important word. Bohr's style of work was to have a junior collaborator sit at a desk and take down notes while he himself kept pacing up and down the room, forming and changing and reforming his phrases and sentences. Watching him at one such session, Dirac apparently said something to the following effect: "Professor Bohr, when we were young we were taught never to start a sentence until we knew how to finish it."

Mukunda is polite and kind in his references to Bohr. According to Pais, Einstein was exasperated by Bohr's writing and once said that Bohr thought clearly, wrote obscurely and considered himself a prophet!

From personalities the focus shifts, in essays three and four, to the style of modern physics. Here Mukunda is in his element. The essays are lucid and crystal clear and, in keeping with the demands of the occasion, shorn of mathematics. As such they can be read and enjoyed by one and all. I am not sure what the perception of the non-physicist reader would be but speaking for myself, as one who has stayed mostly at the ground level I found it an exhilarating experience to be lifted to a great height and given an overview of the subtle patterns that eludes one when one is preoccupied with 'nuts and bolts'.

In a sense, the style of modern physics, (which is the central theme of the third essay) was set by Dirac who recognised that the fundamental laws of Nature control a substratum of which we cannot form a mental picture and which must necessarily be dealt with through mathematical abstraction. And, as far back as 1931, Dirac clearly foresaw that the process of increasing abstraction would continue in the future as indeed has happened.

One important feature of theoretical physics today is the heavy reliance on symmetry. In practical terms, one exploits the machinery of what is called group theory. Once considered difficult and esoteric, group theory is now routinely taught at the graduate if not even lower levels. However, most of the applications invoke symmetry in a static sense. It is only in the study of elementary particles that the use of symmetry concepts has reached very sophisticated levels because there one is not merely dealing with space–time symmetries but the so-called internal symmetries as well. Symmetry is now used in a fundamental sense, in relation to a dynamical system with intricate degrees of freedom rather than being confined merely to geometric aspects. All this has made theoretical physics increasingly formal and to many forbidding as well. As Mukunda remarks, "It has been said that each generation of physicists feels that the next generation is too mathematical." One thing is certain. We can no longer assert as Lord Kelvin did during last century that understanding a physical system implies being able to build a mechanical model of it. Parenthetically one might also remark that theoretical physics has set the pace and style for many neighbouring disciplines as well, and many of the manipulative tools which were once the preserve of physicists are now freely used in disciplines like control theory, optical engineering and neural networks.

The mathematical structure of quantum mechanics receives special attention in the fourth essay because of its "rich and beautiful" structure. Quantum mechanics has been around for more than sixty years and has been amazingly successful in its practical applications. But when it comes to physical interpretation things are not so easy, in spite of Bohr's guidelines. The main reason for this is the fact that "many of its (*i.e.*, QM's) predictions run counter to intuition developed from 'common sense' ". The reader is given a rapid but interesting tour of the nuances of quantum mechanics including the difficulties of interpretation. And when it is time to conclude, Mukunda leaves the reader pondering about Heisenberg's aphorism: If the mathematics is clear, the physics is not, and conversely!

The last essay deals with the interplay between physics and biology. At first one is struck by the title because Mukunda is known to carefully avoid lectures on topics far from his domain. One's curiosity is naturally aroused and down the line, the reason for this unusual foray by the author becomes clear.

In ancient times there was no sharp boundary between philosophy (in relation to spirituality) and natural philosophy or, in other words, between metaphysics and physics. In the post-Renaissance period there was a parting of company and scientists like Galileo and Newton were able "to free themselves from the metaphysical traditions of their time." A new style of investigation and enquiry into natural phenomena was introduced and, as one knows, science progressed by leaps and bounds leading eventually to that revolution in human thought, *viz.*, quantum mechanics. Now "an important statement [of quantum mechanics] is that an atomic system has no numerical properties of its own unless and until it is subject to experiment and observation. This has led to the idea that an external consciousness—of the experimental observer—is an essential part of the whole scheme of quantum mechanics."

True this point of view does not have universal acceptance. Nevertheless, for the first time, physics is directly confronted with the question of consciousness, leading to what might be called the "mind–matter question." At a somewhat lower level let us ask as to how humans acquire and accumulate knowledge. Here Mukunda refers to the contributions of the philosopher Immanuel Kant. Kant viewed knowledge as partly drawn from experience and partly a priori. His idea was that for science to be pursued there must exist "*synthetic,* **non-empty truths or knowledge that had *necessarily* to apply to actual experience but could not be *derived* from it.**"

This leads to another question: "If these synthetic truths are not the result of experience, where do they really come from? How is it that our minds already possess this machinery which then fits experience so well and precisely?" This takes Mukunda to Delbruck's book *Mind from matter*? in which Delbruck says:

> **It appears that two kinds of learning are involved in our** dealing with the world One is *phylogenetic* **learning, in the sense that during evolution we have evolved very sophisticated machinery for perceiving and making inferences** about a real world. The second kind of learning involved in dealing with the world is *ontogenetic* **learning, namely, the lifelong acquisition of cultural, linguistic and scientific** knowledge.

In a nutshell, the a priori categories of thought which Kant invoked in order to justify Galilean–Newtonian physics are biologically evolved. However, biological evolution has turned out physical perception only to the "world of middle dimensions" Obviously our survival does not call upon us to be sensitive to happenings on an atomic scale, for example. But once science acquired "artificial senses" as Schwinger put it and began exploring the world of small dimensions, problems arose in reconciling the new experience with what we expect from common sense. As Gamow once said, "Our mind becomes so accustomed to these notions (of space, time and motion) that later on we are inclined to believe that our concept of the outside world based on them is the only possible one. . ." When one considers what happens when objects move with speeds close to that of light or what goes on inside an atom, one is confronted with facts quite contrary to what our perception faculties have prepared us for. And if one delves deep into the philosophical foundations of quantum mechanics, one is faced with questions like: Does consciousness have any role to play in science? Is mind distinct from matter? Can life be understood within the framework of physics and chemistry? Ancient philosophers had their views about life but for the modern scientist this last question has become an all important one. Mukunda tells us that according to Bohr, "the understanding of life would require something beyond quantum mechanics and yet to be discovered, not within quantum mechanics itself" In other words, in Bohr's view the property of life and the understanding of routine cell functions in terms of physics and chemistry might be mutually exclusive or complementary.

What about Delbruck? Mukunda has this answer "In his book (*Mind from matter?*) referred to earlier, describes the attempt (to see whether Bohr's idea was necessary to understand the life process) and comes to the conclusion—like some others before him—that the principle of complementarity is not necessary in this context. . . ." Obviously this and other questions relating to physics and biology can be argued back and forth endlessly and so Mukunda deftly winds up by transmitting his own "puzzlement" to the reader. The latter can't just put the book down and relax. There is homework to do—he has to think!

And now to the more mudane aspects without which "book criticism" is never complete. I would first of all like to compliment the publisher on good production values One is so used to shabby printing and shoddy get up that a job well done deserves a pat. At the same time, I would enter a general plea that in this scientific age, publishers in India should equip themselves to handle mathematical symbols with ease. As an author with painful experience on this score, I found I was in good company for Mukunda too is having problems with ν and $\hbar$. The editor should have been more careful about proof correction to ensure that $P = \hbar k$ and not $h k$ as one finds on pages 30 and 31. I am sure the manuscript would have had these right. The book is embellished with nice portraits of eminent scientists but one wonders who is the artist who rendered them, or if the pictures have been reprinted from elsewhere, what the original source is.

Typical of Mukunda, he has taken the trouble to include a comprehensive bibliography as a "guide to further reading." Urging the reader to refer at least some of them, Mukunda adds: "Some of the books listed, while they have become classics of the literature, may be hard to come by. We have included them as a challenge to the more motivated reader"—the teacher peeping out!

The book is the second in the series of educational monographs being published by the Jawaharlal Nehru Centre for Advanced Scientific Research and clearly it sets a high standard for the authors to follow. I would expect a book of this class should be sold world wide and I am confident it would receive a good reception everywhere. I am therefore a little unhappy about the publisher's caveat that this book "is not to be sold outside the country to which it is consigned. . . ." I can understand this in the case of a low-cost reprint volumes but surely original monographs written in India fall under a different category. I do hope the publisher has some arrangement with his principals whereby this book (and others like it) can be marketed globally. I would like to take the opportunity to strongly urge the Indian Association of Physics Teachers to see that this volume is included in their low-cost book programme.

The appetite grows by what it feeds on. This book has whetted my appetite for more of a similar nature from the pen of Mukunda. May we expect another one at least, say on Srinivasa Ramanujan, Harish Chandra, Chandrasekhar and possibly Bhabha? Professor Mukunda, are you listening?

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Symmetries, gauge fields, strings and fundamental interactions, Vol. 1: Mathematical techniques in gauge and string theories by Tulsi Dass, Wiley Eastern Ltd, 4835/24, Ansari Road, Daryaganj, New Delhi 110 002, 1993, pp. 506, Rs. 450.

Quantum field theory was developed in trying to understand the quantum behaviour of systems with an infinite number of degrees of freedom. While it has proved to be very useful in many areas of condensed-matter physics, it displays its full elegance and power in the field of high-energy or elementary particle physics where it is combined with the special theory of relativity. Another important concept in high-energy physics is that of local gauge invariance and gauge fields. By the mid-70s, three of the four fundamental forces of nature (strong, weak and electromagnetic interactions) had been incorporated into a gauge theory called the Standard model. This is in complete agreement with all experimental observations so far. This success has led many field theorists to try to incorporate the force of gravity into a complete quantum theory of all particles and interactions. The most popular of all such models is called superstring theory.

All these developments have necessarily led to an increasing mathematical sophistication of the subject. While Lie group theory had already become an essential tool by the early 60s, other concepts like topology, instantons and magnetic monopoles became important during the 70s. Supergravity and superstring theories brought in the full arsenal of differential geometry. The BRST formalism was developed to deal with the more complicated kinds of field theories. All this means that a researcher in modern quantum field theory has to be conversant with a great variety of mathematical techniques. Unfortunately, there is no single source from which one can begin to learn so many different topics. Traditionally, high-energy physicists have had to learn these things in bits and pieces from a variety of sources including discussions with their colleagues.

Tulsi Dass has planned a three-volume series which will cover the basic mathematical foundations of gauge and string theories in Vol. I, the Standard model and related topics in Vol. II, and speculative subjects like Kaluza–Klein, supergravity and superstring theories in Vol. III. The idea seems to be to develop and then use unified language for presenting the entire subject. Volume I has now appeared and it does justice to this ambitious project. Besides all the items mentioned in the previous paragraph, this volume also deals with some of the standard quantum mechanics and field theory topics like symmetries, functional integration, constrained systems and multiple vacua in non-abelian gauge theories.

The pace is leisurely and a large number of simple illustrative examples and proofs are provided. Even basic notions like set theory, tensor analysis and manifolds are discussed so that someone with a minimal knowledge of modern mathematics and quantum field theory can go through the book on one's own. It is also possible to use parts of this book to teach a course on a particular topic in mathematics for M.Sc. Physics students. Each chapter ends with a list of books and papers for more advanced reading. Altogether a vast amount of material is covered. Though the book is somewhat steeply priced for individuals, it would be very useful for libraries to acquire the entire series for the benefit of students pursuing research in this area.

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Bertrand Russell and the origins of the set-theoretic paradoxes by Alejandro R. Garciadiego, Birkhauser Verlag AG, P.O. Box 133, CH-4010 Basel, Switzerland, 1993, pp. 264, SFr. 98.

It is ironical that the set-theoretic paradoxes of Cantor and Burali Forti were never meant to be paradoxes. They were merely contradictions arrived at in a *reductio ad absurdum* proof, attempting to prove the Trichotomy law did not hold for cardinal and ordinal numbers. It was at this time, in the last decade of the 19th century, that the British mathematician and philosopher Bertrand Russell discovered the paradox of the greatest cardinal number and his own argument of the class of all classes, which are not members of themselves. The mathematics scene at that time is described in Garciadiego's book, where he "reconstructs and reinterprets" the role played by Russell in the origin of the set-theoretic paradoxes.

Even as a teenager, Bertrand Russell had a dream of finding knowledge that one could consider certain. He was convinced that mathematics was more likely to be certain than any other form of general knowledge. Russell was taken up by the idea of two British thinkers, Clifford and Mill, who had tried to formulate philosophical systems that would contribute to a gradual social progress, individual freedom and human happiness, which included the advancement of science.

Russell joined Cambridge in October 1890 and spent three years studying mathematics. After the Tripos in 1893, he spent the fourth year studying philosophy. He wrote his dissertation "An essay on the foundations of geometry" under a neo-Hegelian influence. Neo-Hegelians were indifferent to contradictions, because their systems were nourished by them. It is then understandable why Russell would be discussing contradictions as something natural and innate in each science.

The deep effect of Cantor's ideas on Russell is emphasised throughout thé book. Strangely, in 1896 Russell had even refused to discuss the possible mathematical uses of Cantor's theory of transfinite numbers. Cantor had proposed a second number class ω, $\omega+1$, $\omega+2$, . . ., beginning with the first number ω larger than any of the first class, that is, the ordinary natural numbers. Russell questioned the philosophical validity of Cantor's method. He argued that if the natural numbers were unlimited, there was not even a chance for ω to arise. To Russell, Cantor's transfinite numbers were impossible and self-contradictory.

In July 1898, Russell was working on a book on the principles of mathematics, which had been his "chief ambition ever since the age of eleven" By this time, his negative reaction to Cantor's work was slowly changing. This was probably due to: 1) his reading of Couturat's *De l'infini mathèmatique*, 2) Moore's rejection of neo-Hegelian philosophy, and 3) his own doubts about the role of symbolic logic in mathematics. In July 1899, he read Cantor again and began working on yet another draft of the principles of arithmetic which he now entitled "The Principles of Mathematics". The impact of Cantor's work is found throughout the manuscript. Russell explicitly mentioned that Cantor was the source of most of his definitions and theorems. Russell accepted Cantor's ω, but argued that there was a limit to the sequence of transfinite cardinal numbers. Russell's examination of Cantor's proof that there is no greatest cardinal number led him to formulate the contradiction of the class of all classes which are not members of themselves. "Some classes are members of themselves, some are not, the class of all classes is a class, the class of not-teapots is a not-teapot. Consider the class of all classes not members of themselves; if it is a member of itself, it is not a member of itself; if it is not, it is" (*The principles of mathematics*). By the end of May 1902, Russell finally finished his "Big" book on the principles of mathematics containing 8 parts and 59 chapters. It supported his thesis that pure mathematics could be derived from the principles of symbolic logic. However, Russell was disappointed with the book even before it was finally published in May 1903. Letters to colleagues and friends show his dissatisfaction, probably because he was unable to cope with the inconsistencies and provide a solution to them. He had set out to find a consistent explanation of the principles of mathematics, but the treatise when complete presented certain contradictions, which seemed even more difficult to explain and solve than the earlier paradoxes.

The book includes an appendix with Russell's correspondence "which reflect his emotional health" at the time of writing *The principles of mathematics* as well as those which exemplify the growth and development of his ideas.

The task of the author was made more difficult because of a number of contradictory facts, regarding the discovery of the set-theoretic paradoxes. The author painstakingly ferrets out the most convincing arguments and then arrives at his conclusions, some of them opposing Russell's own statements regarding historical facts. The book provides interesting reading and tells the reader all he wants to know about the set-theoretic paradoxes and Russell's role in their discovery.

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Space safety and rescue 1991 by Gloria W. Heath, American Astronautical Society, Univelt Inc., P.O. Box 28130, San Diego, California 92198, USA, 1993, pp. 260, $ 50.

This volume contains 16 papers presented at the Symposium of International Academy of Astronautics held at Montreal in conjunction with the 42nd International Astronautical Federation Congress, 1991. The papers are grouped under two sections—Safety and rescue in space and Space activities impact on the environment, followed by appendices, one of which summarises the international issues involving GEO debris.

Despite the four decades of familiarity with space activities, the subject matter of the book remains fascinating. The volume succeeds in driving home the point that the problems of space debris, collission chain reaction and the accident scenarios are no more imaginary but so much real as to demand a plan of action from the space club. More regulations and also more cooperation in space activities at the international level are bound to follow in the coming decades.

In the first part on Safety and rescue, the focus is on manned mission where the risk per person happens to be higher than any other transport and industrial activity. Space safety needs to be discussed in terms of both preventive actions and rescue contingencies. On the prevention side, human factor right from design, planning and certification to crew training and response assumes great importance. It is revealing to read that nearly 90% of all catastrophic failures occur during the ascent phase. Rescue options here are the use of ejection seats with or without encapsulation followed by smooth landing at a safe site away from the launch pad. But it is in the relatively low-risk phase of 'on-orbit' period or prolonged stay in space stations, that the options become technological challenges. Fascinating details of the specially constructed rescue modules and vehicles, hand-held maneuvering units for self-rescue during extra vehicular activities or the hull protection against meteoroids and debris by 500 kW lasers (obviously, SDI inspired) can be found in this volume. All these and a variety of statistics on space missions, accidents and performance record of rescue systems make an absorbing reading. Manned space missions themselves are wonderful, but successful rescue operations such as return of Apollo-13 or repair of Mir station border on fantasy.

Quoting Prof. Lust of ESA: *"The sheer immensity of space is the main obstacle to the recognition of space debris. The ocean too, for centuries was considered a bottomless sink and yet today we see the consequences of dumping toxic waste and of having accidents result in oil slicks"*. The environmental pollution caused by man is extending to space and the threat of collisions in space by uncontrolled growth of space debris is real.

Beyond an altitude of 800 km, the self-cleaning effect of the Earth's atmosphere is missing. The low-Earth orbits in the range 900 to 1600 km and the geosynchronous orbits are being littered with debris which will assume serious proportions in the next 50–100 years. Of the objects in the most sought-after orbits, only a tiny percentage is active payloads the rest being inactive payloads, rocket bodies, launch and fragmented debris. In addition, there are enormous number of dust-like objects <1 cm which escape any radar observation, but are quite dangerous considering their hyper velocities of the order of 10 km/s.

Each one of the topics discussed under detection and quantification of orbital debris, analyses of possible collisions and their chain reactions and the counter measures and their effectiveness serves to enhance one's concern for orbital environment. The lone article on the impact of chemical propulsion on stratospheric ozone, toxicity, acid rain and green house effects—the concerns at low altitudes bring us down to earth with somewhat comforting conclusions. In all the measures towards rescue of man or environment in the space activity, there is a penalty in terms of payload mass or eventually in terms of high cost. Prevention is better than cure like in any other field of activity.

On the whole, this is a very useful collection of papers and references that the space scientists and technocrats may like to have in their shelves. For others, this may trigger their imagination of what is likely to unfold in distant space and yet of concern to those on Earth.

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Structural tools for the analysis of protein–nucleic acid complexes by D.M.J. Lilley, H. Heumann and D. Suck, Birkhauser Verlag AG, Klosterberg 23, CH-4010 Basel, Switzerland, 1992, pp. 470, SFr. 118.

The book is a collection of original and review articles on protein–nucleic acid interactions. Protein–nucleic acid interactions are responsible for the condensation of DNA on nucleosome core particles. They control gene expression and are involved in RNA maturation and translation. A large part of present research in molecular biology is concerned with protein–nucleic acid interactions. The articles in this volume are well organized and provide a balanced view of the developments in the field. On the whole, the book presents an overview of the work being carried out in the European subcontinent and somewhat underrepresents the work of the United States.

Three articles grouped together as the introductory chapters present methods used in elucidating nucleic acid structure or protein–nucleic acid interactions. Several articles in other sections also provide short descriptions of methodologies. These discussions on techniques are adequate to appreciate the validity of the results and are not comprehensive.

DNA structure and its various polymorphic forms are covered in four separate articles. As this field of investigation is fast expanding, the information provided covers only a part of the total activity. Protein–DNA interactions are covered in six articles. Although Suck (pp. 127–142) reviews the principal results obtained by X-ray crystallographic studies on protein–nucleic acid complexes, this section does not cover all systems that have been investigated in equal detail. Particularly, the work carried out in the US is underrepresented. Also, several notable publications such as the structure of the TATA-binding protein have appeared since the publication of this volume. It would have been worthwhile to include some articles on virus structures and the nature of protein–nucleic acid interactions seen in viral capsids in this section.

The most valuable portion of the book is the section on RNA–protein interactions and RNA structure. This section is also likely to have a much longer useful bench life in comparison with the other sections. The articles in this section cover the basic enzymology of RNA polymerases as well as studies on protein–RNA interactions in a number of systems. Theoretical methodologies that could be of use in predicting RNA folds, functional aspects of small nuclear ribonucleoprotein particles, studies on elongation factors, *t*-RNA synthateses, HIV reverse trascriptase, Qβ replicase, possibilities of RNA other than *t*-RNAs possessing well-defined three-dimensional structure are some of the topics covered in this section.

It is difficult to provide totally comprehensive coverage of the vast field of protein–nucleic acid interactions and their biological implications in a collection of articles running to less than 500 pages. However, most of the articles presented in this volume are very readable and provide a valuable source material for investigators interested in this area.

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The visual system from genesis to maturity by Roberto Lent, Birkhauser Verlag AG, P.O. Box 133, CH-4010 Basel, Switzerland, 1993, pp. 286, SFr. 158.

Despite significant advances in the study of various aspects of the visual system, the fundamental questions remain the same. We still do not understand how the diverse neural cell types of the visual system are generated and the regional patterns defined. Cellular and molecular mechanisms which guide developing axons to the synaptic targets and establish topographic maps in the visual pathway too await clearer understanding. Even less is known about how the formation and refinement of synaptic connections control the visual behaviour. The structural organisation and functioning of different parts of the visual system from photoreceptors to cortical columns and modules continue to hold mysteries which need to be unfolded.

Some of these issues have been brought to the reader once again in this book which is an outcome of a meeting held on the subject. The contributing authors have reviewed the current knowledge and the approaches being used by them to study these aspects providing interesting summaries and some directions to future development With the new generation of jurnals such as *Current Opinion in Neurobiology* and *Trends* series which provide regular updates on the latest in the field from the experts, one wonders whether there is a niche for summaries such as these. There may be, if the book provides comprehensive coverage of the subject area in a volume such as this.

The book begins with an overview by Pasko Rakic describing briefly the schedule of developmental events in the visual system of the rhesus monkey starting from the retina to the visual cortex. The first seven chapters of the section on 'Genesis' are devoted to the retina which forms a relatively simple model system to study the basic principles of development and differentiation. Intracellular and molecular cytoskeletal-dependent mechanisms regulating photoreceptor differentiation in retinal culture system, regulation of glutamate decarboxylase enzyme expression by GABA in the avian retina, involvement of 9–0 acetylated ganglioside in neuronal migration and axonal outgrowth, role of activity and NMDA receptor in development and maintenance of the retinotectal topographic projection, role of afferent activity, glutamate receptor and intraretinal dendrodendritic influences on retinal ganglion cell development have been discussed. The generation of diverse cell types studied by following the cell lineage with recombinant retroviruses and developmental strategies of olfactory commissural and visual callosal fibres are the only two aspects covered with regard to the visual cortex development.

The second section of the book delves into diverse aspects of the mature visual system such as the organisation and possible functions of the catecholaminergic amacrine cells in the rhesus monkey retina, effects of GABA and glutamate analogs and antagonists on vertebrate eye movements after intracranial and intraocular drug administration as well as the existence of an inhibitory pathway between the nuclei of the optic tract (NOT) of both sides in the opossum which may play a role in the horizontal optokinetic reflex. Explanations have been sought for the mismatch between retinal ganglion cell density and cortical V1 magnification factor in lateral eyed mammals. Differences of functional architectural organisation of layers of cortical columns in striate and extrastriate areas, concepts of basic canonical microcircuits to understand the complex functions of neocortex, dynamic properties of single neurons in primary visual cortex that are related to completion phenomenon in the optic disc region, properties of neurons and their connections in the inferior temporal cortex of infant and adult macaque monkeys concerned with recognition and storage of information about visual form and colour as well as reorienting of visual spatial attention are some of the other problems that have been discussed.

The book provides an overview of vision from its inception to maturity. Though the book essentially compacts extensive knowledge on the visual system it may not satiate the appetite of those familiar with the state-of-the-art on the subject. However, for the general neuroscientists, opthalmologists and optometrists it is certainly a resource of current information in this field and would be a useful addition to the bookshelf.

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Formation and regeneration of nerve connections by S.C. Sharma and J.W. Fawcett, Birkhauser Verlag AG, P.O. Box 133, CH-4010 Basel, Switzerland, 1993, pp. 260, SFr. 148.

This book is a collection of papers presented at a meeting in Edinburgh, Scotland, in 1991 to commemorate the retirement of Prof. R.M. Gaze, a pioneer in the investigations of developmental neurobiology of visual system and the role model and inspiration to the large number of neuroscientists to continue in the same field. The main theme of the book is the state-of-art information on the mechanisms of development of visual pathway mainly in lower vertebrates like xenopus and Gold fish contributed by Prof. Gaze's erstwhile students and associates. A certain overlap and repetition are understandable as most of them are dealing with the same system and developmental mechanisms.

As befitting, the first chapter is by Jacobson who traces the evolution of perception of specificity and plasticity in relation to the nervous system from theory to scientific facts contributed by Gaze and his associates. The second chapter deals with the stages of development of retinal projection to the tectum and the factors controlling each stage. Role of different factors and cell death in the precise projection are discussed clearly in this chapter. Retinotopically ordered termination pattern in the tectum and thus the map formation are presented by Tylor in Chapter 3. The role of tract of postoptic commisure in the guidance of the optic fibres is elegantly demonstrated by experimental manipulation and HRP tracing. The above aspects of retinotectal projection are discussed in the *in vitro* system by Gooday in Chapter 4. According to him the order of projection is a multistaged process and precision increases gradually in the grouping of fibres which takes place at different places in the optic pathway. Role of glia at each stage is also mentioned. Chapters 5 and 6 deal with the plasticity in the binocular visual maps in the tectum and the role of visual sensory input and the NMDA receptors at the tectum in the organization of connections.

Chapter 7 is on experimental transplantation of mammalian retina into host brain and the functional response of the grafted retina to photic stimulation. Lund *et al* explain in this chapter that the developmental pattern in the lower vertebrates and mammals is the same and hence xenopus or Gold fish is a good model to study development though due to evolution of functional complexity finer structural modifications can be followed up only in the mammalian system. Fawcett has compared (Chapter 8) the topographic retinotectal map in frog and fish with that of birds and mammals According to him the axonal path finding in lower vertebrates is more orderly because of slower growth and reduced input whereas the marked input and faster growth induce some discorded initial connections in mammals. One of the reasonings given for the wrong initial connections is to mark the ganglion cells for death so that final wiring and topography are pruned. In Chapter 8 Peters describes the mechanisms and details of the formation of vertical modules in the visual cortex of rat with the support of very elegant photomicrographs and electron-micrographs. Developmental theme is extended to the spinal cord sensory fibre projection in Chapter 10. Though physiological property remains the same at sensory neuronal levels there may be a difference in the synaptic transmission based on the modulatory activities at each level

In Chapter 11 explants of Gold fish retina conditioned to injury are studied to compare the regenerative processes *in vivo* and *in vitro*. A previous conditioning accelerates the regenerative processes after a second injury by enhanced metabolic activities. Chapter 12 deals with comparative morphology of developing and regenerating retinal ganglion cells in birds and mammals and report that most of the qualitative features are similar and only in quantity there is a difference. Morphogenetic steps in anuran retina are described in Chapter 13 and the organization of the adult retina is based on the spatiotemporal sequence of cell generation which occurs at the ciliary margin. The same neuroepithelial cell is programmed for types, number and regional differences in distribution of the various neurons. Chapter 14 is on activity-driven sharpening of retinotopic connections at tectum in Gold fish. Blocking of NMDA receptors, sodium and calcium channels has elicited the information that the sharpening of final connections for function is dependent on the molecular mechanisms at the synapses. Ontogeny repeats phylogeny and the essential features of development of vertebrate eye have been established thus. Chapter 16 rationalises how simple mechanism of development paves the way to the understanding of the complex nature of development in vertebrates.

Chapters 15 and 17 are on mathematical modelling and computational neuroscience. Emphasis is laid on adopting collective activity of individual neurons or modular system of neuronal assemblies rather than sticking to neuron doctrine. Models of network are easier to make and are essential to test functional hypothesis. Willshaw (Chapter 17) quotes Prof. Gaze and cautions that repeated modification of the artificial model will be necessary based on the ever increasing and new experimental data in neuroscience.

In summary, this book deals with developmental neurobiology of the visual pathway of lower vertebrates and mammals by experts in the forefront of this area. This book provides sufficient stimulus to an aspiring neuroscientist to initiate studies in developmental neurobiology. To a confirmed neurobiologist it is a useful review to give new directions in researching developmental neurobiology.

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Neurotransmitter interactions and cognitive functions by Edward D. Levin, Birkhauser Verlag AG, P.O. Box 133, CH-4010 Basel, Switzerland, 1992, pp. 362, SFr. 168.

The book has effectively put together studies covered in 22 chapters and carefully examined the relationships among neurotransmitter systems operating in the basal forebrain that provide the basis for understanding the integrative neural functions underlying learning and memory. The rationale for this endeavour has been provided in the initial chapter which lays empahsis on considering the brain as an integrative organ. The next two chapters are devoted to detailed anatomic bases for the interactions between the cholinergic forebrain and its telencephalic targets including the input–output organization of transmitter—specific synapses such as GABA and glutamate, peptides—like substance P, enkephalin, somatostatin, neuropeptide Y, vasopressin, galamin and monoamines — noradrenaline, adrenaline, dopamine and serotonin. In subsequent chapters the book then proceeds to delineate the importance of both muscarinic and nicotinic cholinergic receptors along and in combination and their interactions at different levels with D_1, D_2 dopamine, α_1, α_2 and β noradrenaline and serotonin receptors in formulating the cognitive processes. Of particular significance is the suggested critical role of septohippocampal system and the prelimbic sector of the frontal cortex in the mnemonic function. The importance of neurotensin–acetylcholine, dopamine–acetylcholine, noradrenaline–acetylcholine, serotonin–acetylcholine functions in these areas *vis-a-vis* raphe and septal strucutres in formulating working representational memory *versus* reference dispositional memory has been examined critically by various authors. It is emphasized that such interactions can take many forms; they might be cooperative interactions or may involve a balance of opposing effects. Interactions may also be serial in nature, with one neurotransmitter system regulating the function of another In addition, the form of interactions between the same two neurotransmitter systems can clearly differ depending on the particular behaviour involved in the anatomic site of interaction Therefore, complex systems can often produce apparently conflicting results: while Normile and Altman suggested that serotonin blockers ameliorate deficits induced by clolinergic dysfunction, Ritcher–Levin and Segal, and Vanderwolf and Penara experiments suggested the opposite in that disruption of serotonergic activity potentiates impairments produced by induced cholinergic dysfunction. Such a possibility is also hinted by Olton and Peng in their chapter "Interactions of neurotransmitters and neuroanatomy: it's not what you do, it's the place that you do it".

It is opportune to have a few chapters on the influence of GABA–benzodiazepine systems on the forebrain cholinergic activity in modulation of the memory processes as it has become easy to study these mechanisms/interactions with the availability of specific neurochemical connections between the two systems. Further, benzodiazepines represent one of the most widely prescribed class of pharmacotherapeutic agents and in addition to their therapeutic actions, these agents can also produce undesirable side effects, such as amnesia, confusion, depression and fatigue indicative of cognitive dysfunction The last chapter by the editors themselves as an 'appreciation of the concert' of interactions of a number of neural systems that use a variety of neurotransmitters *via* multiple receptors which provide the bases for a complex system like cognitive function is indeed a treat to the reader.

To summarize, the book has highlighted the work of eminent scientists to clearly bring out the role of neurotransmitter interactions in cognitive functions. It also provides food for thought to open new vistas for the development of treatment for cognitive dysfunctions. The cited studies suggest that even transmitter systems relatively unaffected in disease like Alzheimer's may be important to consider for therapy. Rather than directing treatments at a system that is severely comprised by the disease, it may be a better therapeutic strategy to direct treatment at systems that are involved in the same functions as the affected system, but are still relatively intact.

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