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BOOK REVIEWS

First step towards space edited by Frederick C. Durant III and George S. James. American Astronautical Society History Series, Vol. 6, American Astronautical Society, P.O. Box 28130, San Diego, California 92128, 1985, pp. 320, $ 35 (Orders to Univelt, Inc., P.O. Box 28130, San Diego, California 92128).

This volume contains the proceedings of the first and second History Symposia organised by the International Academy of Astronautics in 1967 and 1968, reprinted in 1985 from the earlier publications. It basically covers the history of rocketry in this century up to the Second World War. Of the total of 27 papers contained in the volume, seven are about developments in the US, eight in the USSR, three each in Italy and Germany, two each in France and Czechoslovakia, and one each in UK and Sweden. Some of the papers concern very specific developments in rocketry; for example, jet propulsion formulae developed in Italy, and development of regeneratively cooled liquid rocket engines in Austria and Germany. Others describe the work of individual engineers, including such well-known pioneers as Tsiolkovsky, Goddard, Esnault–Pelterie and Oberth, and in particular the problems many of them encountered finding support for their ideas!

The period covered here may, I think, be legitimately considered as leading to the second revival of rocketry. The first had occurred in India, during the late 18th century in the Mysore of Hyder and Tipu as they were fighting the British, and spread to Europe during the next 50 years. (Europe had once before learnt the technology from the Chinese, who had used rockets in war as early as the 13th century. Rocketry is thus a very Oriental subject; surely it was a historic moment when the Chinese recently offered to launch satellites for the Americans after the Shuttle disaster.) During the latter half of the 19th century rockets fell into disuse, having been overtaken by artillery as a military weapon system. It is interesting that the 20th century revival was largely driven by dreamers of space travel and scientists interested in upper atmospheric research, although the military angle was never completely out of the picture.

With the hindsight provided by the spectacular development of space technology in recent decades, it is fascinating to find out from this volume how time and again rockets were dismissed as either viable weapon systems or tools for scientific research. In 1920 the *New York Times* wrote, regarding a suggestion made by Goddard, that "A professor of physics should know better than to make space flight proposals as they violated the fundamental laws of dynamics". A secret report submitted by the French pioneer Robert Esnault–Pelterie in 1928 was returned by French military authorities as of absolutely no interest (the sad course of his later life is poignantly sketched in this volume). As late as

1938, a few months after private industry had shown interest in the use of rockets to assist aircraft take-off, and a few months before a major programme was approved by American Defence authorities, a senior officer of the US Army visiting Caltech told the rocket research group there that there was little possibility of using them for military purposes! Rockets were considered scientifically so disreputable that when eventually Caltech decided to proceed with a formal research programme in the subject, von Karman thought it prudent to call the organisation set up for the purpose the Jet Propulsion Laboratory, avoiding the use of the word rocket in its title!

Those among us who clamour for greater use of technology assessment and forecasting in making our plans should be daunted by our dismal record in estimating the true potential of rocketry even as late as the 1950s.

At the same time, this volume also shows how, in spite of having to face much ridicule, pioneers went ahead to conceive a variety of ideas and projects, quite a few of which eventually turned out to be viable. The final stream of technological triumphs that began to be visible from the 1950s was however possible only because of the application of what can only be called engineering science, and a few words on this theme are necessary.

When work on rockets started at Caltech in the late 1930s, Malina (who is the author of a very interesting paper in this volume) found that although Goddard's work gave some good leads, it was very difficult to find out exactly what he had done; Malina reports a visit he made to Goddard in 1936 at the request of Robert Millikan (who was interested in the possibility of using rockets for cosmic ray research), acknowledging "your kindness in allowing me to inspect *that part of your work which you consider permissible under the circumstances*" (emphasis mine). Goddard unfortunately (although understandably, in view of having been the victim of the scorn of such formidable institutions as the *New York Times*) was secretive about his work; less understandably, he did not carefully document it.

A realistic assessment of the status of rocketry at the time led the Caltech team to the conclusion that it was not then possible to design a sounding rocket which would go higher than a balloon! So, following the 'engineering science' spirit of von Karman's teaching, the group defined simple programmes which would lead them to a better understanding of the problems involved – to the utter disappointment of two enthusiastic (but not highly educated) volunteers who had wished to join the programme anticipating spectacular developments. However Karman eventually agreed to certain proposals put forward by Malina, and even admitted the two 'unqualified' volunteers on the project although they could be neither students nor staff (imagine the problems that such action would pose here in Bangalore!). With some further support from Robert Millikan the programme finally got off, with the participation of A. M. O. Smith and H. S. Tsien, both of whom became such distinguished engineers in later life, as did the volunteers. One had to wait for another decade before these studies bore fruit, and the anticipated spectacular developments finally started to materialise, chiefly as a result of an organised programme of engineering research.

There are many other interesting papers in this volume, recounting developments in other countries; and for lack of space I must let the reader find them for himself. Being a collection of papers, there is no effort in the volume to see a pattern or a moral; but the raw material for doing so is available. However the papers reinforce a point made by Esnault–Pelterie while arguing for more chairs in the history of science and technology (is it not high time we had at least one in this Institute?): it is often more interesting to study that history than the texts in their definitive form, as the latter "leave the student under the illusion that 'Everything came about by itself'."

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The Cambridge guide to the material world by Rodney Cotterill. Cambridge University Press, Cambridge, UK, 1985, pp. 352, £ 17.50/$ 34.50.

It is often said that the compartmentalisation taking place in science is its most serious threat; and that the unity of science must be maintained if science has to be saved! Scientists generally agree with these sentiments; yet their loyalties to their "own" disciplines prevent them from taking any step to integrate science. The growth of very specialised journals is symptomatic of these trends. Science is being broken up into small fragments – islands separated by unbridgeable gaps. One is therefore delighted to see this book wherein the author makes a valiant effort to unify one aspect of science and present it as a whole. It is this universality of dealing with materials that makes this book attractive and which persuades me to recommend it to be read by one and all.

There is another aspect of this book which is again significant even to a specialist in materials science. The definition of materials science depends greatly on the practitioner of the art. In the early days this name was applied to semi-conductor physics and later due to the efforts of Fredrick Seitz it got extended to many solid-state materials. The chemists and metallurgists then got into the show and now materials science encompasses ceramics, glasses and even many exotic materials like composites, organic fibres, conducting plastics, organic super-conductors, etc. The author of the book under review takes a much larger view of materials. He deals not only with the conventional materials but also with almost every material under the sun including proteins, nucleic acids, DNA, cells, bacteria, nerves, brain, etc. Indeed more than a fourth of the book deals with biological material – a field to which material scientists are normally not exposed. But they have perforce to take greater interest in these areas now with the coming of DNA technology.

The general treatment of the subject is non-mathematical. The author has succeeded in presenting a coherent picture of materials at a fairly high scientific level, keeping as much rigour as possible. The presentation of each chapter begins at an elementary level, starting with some historical information (sometimes new even to specialists). Essential information is given at an early stage so that fairly complex phenomena could be explained later.

The narrative has continuity. Theory and experiment are interwoven in a manner so that one sees that modern materials can only be understood by a combination of these two at every stage.

The author does not disdain from dealing with the commoner garden materials like cement, brick, wood, natural fibres, etc., which do not normally form part of any university curriculum. The illustrations, the quotations, and some strange connection make the book fascinating. One sees, for example, almost the mystic preoccupation of thinking men from Plato to Kepler to fit in geometric figures into the pattern of the universe.

The titles of chapters indicate the manner in which the author develops the theme and the continuous thread that runs through them.

1. Solo atoms: Electrons, nuclei, and quanta; 2. Atomic duets: The chemical bond; 3. Atoms in concert: States of matter; 4. Patterns within patterns: Perfect crystals; 5. The inevitable flaw: Imperfect crystals; 6. The great mediator: Water; 7. From mine, quarry and well: Minerals; 8. Almost forever: Ceramics; 9. Monarchs of the cave: Metals; 10. The busy electron: Conductors and insulators; 11. A mysterious harmony: Glass; 12. To the organic world: Carbon; 13. Strangeness in proportion: Liquid crystals; 14. Of snakes and ladders: Polymers; 15. The vital threads: Biopolymers; 16. The essential bag: The cell; 17. A place in the sun: The plant; 18. Mandatory hunter: The animal.

Because the jacket is colourful and the chapters have catchy titles one must not get the idea that it is a very popular book. It is not easy to present good science in simple language. The author does not err on the side of superficiality. So the book is for those who have had some training in science or engineering. In certain places it is rather heavy reading. But much of what is stated is correct and is good science and that too, said well.

When a single author tries to cover such enormous ground there are bound to be errors but such errors in the book can only be detected by experts (and purists). These errors are few and far between and do not at all detract from the quality of the book.

Will not such a book get dated? Of course. Even today many new aspects have been discovered (new types of liquid crystals, new concepts by which inorganic glasses can be made at near room temperatures, new composites, new advances in engineering ceramics and so on).

Even so I like the book. I read it from cover to cover. I feel that this should form the basis of a course for all students of science or engineering so that they can not only wonder at the material world which surrounds them but also get to know how these materials can be used.

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The connection machine by W. Daniel Hillis. The MIT Press, 28, Carleton Street, Cambridge, MA 02142, USA, 1985, pp. 190, $ 25.88. (Indian orders to Affiliated East-West Press Pvt. Ltd., New Delhi 110 001).

This book describes a new non-Von-Neumann type of computing engine called 'Connection machine'. This book is an outgrowth of the 1985 annual contest for the best doctoral dissertation in computer-related science and engineering conducted by ACM in cooperation with the MIT Press and is based on the doctoral thesis of the author.

There are two important factors that have motivated work in the area of non-Von-Neumann architectures. Firstly, there was a time (1950s) when computer scientists thought that thinking machines were around the corner. It has taken us twenty odd painful years to develop theories in artificial intelligence (AI), which have just started resulting in relatively simple engineering products (expert systems). We still have a long way to go in building an experimental test bed for trying out ambitious theories in AI. Secondly with the growing need for high-speed computing, it was recognised in early 1970s, that Von-Neumann machine structure with a memory and a processor connected through a narrow tube suffers from fundamental limitations. A few years later it was given to Backus (1978) to coin the phrase 'Von-Neumann Bottleneck'. Connection machine is a new concept that takes us a step closer to a thinking machine, as well as provides scope for high speed concurrent computation overcoming some of the limitations of Von-Neumann structures.

In the first chapter, the author attempts to place the connection machine in perspective. It is a general purpose parallel computer with a dynamically configurable interconnection mechanism. There is a lucid explanation of the parts and the working of the machine. The author illustrates the ideas using examples drawn from graph theory, (the path length algorithm), from AI (the semantic net representation of knowledge), image processing and VLSI simulation. The discussion on issues related to designing parallel machines stands in isolation. Comparison with other architectures lacks depth and it is a little surprising that data flow and reduction approaches hardly find a mention in the body of the text.

Chapter 2 deals with extension features to Common LISP that is used to program the connection machine exploiting concurrency present in the problem. The reader must be familiar with LISP to understand and appreciate the extension features. LISP is only one of the possible languages for a connection machine. Others include functional, logic, database and dataflow languages. It would have been nice to see a comparative treatment of the features of at least some of the major options. Apparently, the choice of LISP seems to have been governed as much by sociological issues as the technical issues.

In chapter 3 the author discusses the design considerations for a connection machine. The discussion appears in three broad categories of processor/memory size, communication network and system level control. The concept of virtual processors is introduced to take into account the possible mismatch of power required by the natural structural units of a problem and that available in the processor. Topological options and routing algorithm choices for the communications network are highlighted. In addition to the discussion on SIMD or MIMD option for system level control, the author also touches upon a number of other related issues such as fault tolerance, input/output and extendability. The chapter concludes with a list of evaluation criteria for the machine. It is surprising that this list includes only raw speeds and capacities which hardly tell us about the true performance of a machine. In chapter 1, the author points out that one of the main drawbacks of the Von-Neumann machine is that only a very small percentage of the hardware is active at any instant of time and this is not the case in the connection machine. Accordingly, one would have liked to see performance measures like hardware utilisation, idle time of processors, etc., instead of total memory capacity, memory bandwidth, etc.

Chapter 4 is an exciting one giving a vivid description of a prototype connection machine that is being currently constructed at Thinking Machines Corporation, USA. The key component of the machine is a VLSI chip with 16 processors connected in the form of a grid and a router to manage communication over the network. Each processor has associated with it 4 K units of memory and there are 64 K such processor/memory cells in the machine. The 4 K routers in the machine are connected in the form of a Bollean *n*-cube.

An important aspect of problem solving with computers is how the abstract data structures such as arrays, graphs and sets are represented in the hardware of the machine. While this problem has been studied extensively in the context of the Von-Neumann contiguous memory, very little is known about their representation on parallel computers like the connection machine. The author rightly deals with this topic in chapter 5 and gives a lucid explanation of the representation mechanisms for different data structures on the connection machine. There are essentially two representations *viz*. cells connected by pointers and structure implied by the addresses of the cells.

Chapter 6 deals with parallel storage allocation strategies for the connection machine. The author starts with a straightforward serial allocation scheme and presents algorithms of increasing complexity, parallelism, efficiency and fault tolerance through random, rendezvous and wave allocation techniques. He also discusses a block allocation strategy suitable for abstract data structures like arrays, butterflies and induced trees. Finally, the author deals with other storage-allocation-related functions like garbage collection, compaction, swapping, etc.

Chapter 7 is an unconventional one in a book of this nature but is a very interesting one. The text of the chapter has been adapted from a paper originally published by the author in the *International Journal of Theoretical Physics* in 1982. The author contends in this chapter that the present models of computation lack sound physical principles as they are very different from the models of the physical universe. As examples, in physics many fundamental quantities are conserved whereas in computation data can be created and destroyed at will. In computation there is no concept of distance and two processors far apart may interact heavily (obviously inefficiently), whereas two very close processors may not interact at all. There is no mechanism by which interacting units come closer together or group themselves, such that they obey laws similar to the natural ones like the force of attraction. The author fondly hopes, giving supporting arguments, that the new wave of architectures like the connection machine would lead to the convergence of physical and computational laws in the future.

When one reads a book which deals with aspects such as design considerations and prototype details of a machine, one expects that the material would enable the reader to prepare himself for the design of a similar machine. The book falls far short of expectations in this direction. For those who are familiar with the developments in this area and more so for those who have been following the research in this field, the treatment is disappointing as it lacks in rigour and depth.

On the whole, this is an excellent introductory book on the connection machine.

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Physical meteorology by Henry G Houghton. The MIT Press, 28, Carleton Street, Cambridge, Massachusetts, 02142, USA, 1985, pp. 442, $ 43.13. (Indian orders to Affiliated East-West Press Pvt. Ltd., New Delhi 110 001.)

The title of the book may be somewhat misleading. The book concentrates primarily on radiative transfer and cloud microphysics and hence may not be appropriate for a first course in physical meteorology. The special stress given to radiative transfer and cloud microphysics in this book is a refreshing departure from the neglect of these topics in standard books on physical meteorology.

The first chapter deals with atmospheric aerosols. The author sums up in a lucid manner the recent work in atmospheric aerosols. He avoids lengthy derivations and concentrates on presenting the important results with great clarity. The second chapter on scattering is a good introduction to this difficult topic. In the third chapter on solar radiation the author discusses solar geometry, absorption of solar radiation by gases, aerosols and clouds. In the fourth chapter thermal radiation from atmosphere and earth is discussed in great detail. The use of band models and emissivity methods is discussed in great depth. The fifth chapter is devoted to a discussion of methods of calculating radiative heating and cooling rates in the atmosphere. The use of radiation charts like Kew Chart and Elsarrer Chart have been delineated. The first five chapters thus represent an excellent introduction to radiative transfer in the atmosphere and hence can be used in a course on atmospheric radiation.

In chapter six the nucleation of water drops and ice has been discussed. In chapter seven the mechanism of growth of rain drops and ice particles has been presented. In chapter eight the dynamics of precipitation processes have been elaborated. Thus chapters six, seven and eight represent an excellent introduction to cloud microphysics. In chapter nine common optical phenomena such as mirage, rainbows, glories, coronas, etc., have been explained qualitatively based on principles developed in the earlier chapters. The last chapter is devoted to atmospheric electricity and covers topics such as lightning and thunderstorms.

This is a useful addition to the books on physical meteorology. The author has explained difficult topics in a lucid manner. It will be a very good supplementary reading for courses on radiative transfer and cloud microphysics and will be a welcome addition to any university library.

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Handbook of mechanical design by G. M. Maitra and L. V. Prasad. Tata McGraw-Hill Co. Ltd., New Delhi 110 002, 1985, pp. 666, Rs. 297.

The authors recommend their 666-page publication to practising engineers and students for use as a comprehensive source of reference on mechanical engineering design. More than 50% of the book is devoted to the topics – mathematics, mechanics of solids, materials, limits, fits and tolerances, standard mechanical components, common engineering standards, and engineering drawing standards.

The chapter on mathematics deals briefly with SI units and the conversion factors for some commonly used units, trigonometric functions and formulae, common curves and their equations, brief tables of integrals and derivatives.

Chapter 2 on mechanics of solids starts with an incorrect statement that it deals with the study of the behaviour of *rigid* bodies under the action of external forces and the stresses and strains produced in them. The problem of design for fatigue under combined stresses is not covered. Even the simple case of the effect of stress concentration on fatigue strength under fluctuating normal stresses is not dealt with.

Chapter 3 on materials deals briefly with heat treatment of steels, classification of standard steels, nonferrous metals and alloys and non-metals. The information presented in the section on rolled-steel sections is not significant. Section 3.2 dealing with the influence of alloying elements on properties of steel is unnecessary in a handbook of mechanical design. However, Table 3.1 is interesting and useful. The authors state on page 97 (para 2) rather incorrectly that increase in hardness increases *stress* instead of stating that it could improve the strength properties.

In the chapter on limits, fits and tolerances, the authors could have given the salient features of the relevant Indian standards and offered suitable guidance for their use.

Chapters 5 and 6 on standard mechanical components and common engineering standards respectively are mostly reproduction of data from relevant standards. The design information in these chapters is not significant.

The design of spur and helical gears is well presented along with interesting data from German sources. But the treatment of the topic–Bevel gearing design–is rather brief and incomplete. There is adequate coverage of design data on machine elements like V-belts, wire ropes and chains, couplings, shafts and springs. However, the presentation on the design of bearings is not at all comprehensive.

The reviewer is of the view that the chapters on mathematics and engineering drawing standards could have been easily omitted and the chapters on gears and machine elements made more comprehensive by pruning the material in the other chapters. It is advisable to give sources of information for all important data provided in the form of tables or figures.

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Circuit theory by T. S. K. V. Iyer. Tata McGraw-Hill Publishing Company Limited, 12/4 Asaf Ali Road, New Delhi 110 002, 1985, pp.520, Rs. 39.

The author has felt a need for a text-book which will take off from fundamentals and lead on to applications. He feels that such a book, "should take into account the mathematical background of the present-day student, the shortened duration of the first degree programme, the advances in science and technology and the emergence of the 'Systems' era". The book assumes a knowledge of calculus, elements of linear algebra and complex variables.

The author states that, "circuit theory is an effective practical demonstration of linear ordinary differential equations with constant coefficients". If the objective of the text book was to consider linear time invariant circuits only, the title should have been different.

The book is well written and covers the following topics: Kirchhoff's Laws and circuit elements. The differential equation approach, Steady-state system functions, Node and mesh analysis, Laplace transforms and circuit analysis, Network theorems, Properties of network functions, Two port parameters and ideal two port devices, Elements of passive network synthesis, Image impedance and classical filters, Modern filter theory and active RC-filters, State variable method of circuit analysis.

Brief accounts of Fourier series and Fourier integrals are given in two appendices.

Each chapter contains a number of worked examples, review questions and problems for the students to work out. Well thought of multiple choice questions along with the answers should prove to be valuable for the student in stimulating his thought process.

The reviewer agrees with the author that the first six chapters can serve as a one semester course for engineers and scientists *other than EEE* (Electrical and Electronics

Engineering) students and the remaining chapters are adequate for a second course of one semester's duration.

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Laboratory techniques in electroanalytical chemistry edited by P. T. Kissinger and W. R. Heineman. BAS Press, 2701, Kent Ave., West Lafayette, Indiana 47906, 1984, pp. 751, $ 34.75.

Electroanalytical chemistry is one of the growing branches of chemistry since it deals with rapid analysis of chemical constituents that are of importance in environmental aspects, health and hygiene. This book presents 24 excellent chapters including an overview written by one of the authors. The books that have been edited wherein a good number of working scientists contribute are really worthy of reading. This volume deals with the diverse aspects of electroanalytical chemistry that are of interest to a large number of chemists. The contents of each chapter are carefully chosen and covers an entire area. The chapter on fundamental concepts is lucidly written and provides a comprehensive knowledge necessary to follow and appreciate the subsequent chapters. The chapter on digital simulation on electrochemical problems is quite well developed and provides practical information concerning the data analysis. This reviewer is particularly happy to read the last few chapters dealing with application aspects, photoelectrochemistry and EPR methods. They provide practical details one often wishes to know before embarking on experiments. Each chapter is appended with good reference material. On the whole, the book is well presented with neat and useful diagrams and books of this kind are extremely useful for laboratory course in the universities. This reviewer is too happy to recommend it to all interested in electroanalytical chemistry.

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X-ray microanalysis in biology edited by M. A. Hayat, Macmillan, 1981, pp. 488, £ 30.

This book is a collection of contributions from ten distinguished scientists and academicians and is edited by an equally eminent figure in the field of X-ray microanalysis as applied to biology. Specimen preparatory measures have been rightly emphasized in this book since they are significant limiting factors in the case of biological specimens, though, of course, the principles of X-ray microanalysis and instrumentation have been elegantly discussed by Dr. Marshall. The specimen preparation procedures described include conventional (Wet chemistry) techniques and cryo procedures. Understandably, the procedures for preparing hydrated frozen specimens have been discussed in depth since preservation of structural details is of paramount importance in biological specimens. A notable feature of this book is the consideration of the factors involved in the preparation and examination of bulk specimens and thin sections separately. Studies of muscle and isolated cells as well as liquid droplets have been included as examples of biomedical problems.

In what follows a brief account is given of individual chapters.

The first chapter deals with principles and instrumentation, treated from the point of view of biological X-ray microanalysis and the features particularly important for biological analysis are stressed. Analyses of both thick and thin sections are considered.

The second chapter deals mainly with wet chemical preparation techniques, the principles of which are also applicable to other techniques that rely on the intervention of fluid phases. Some specific modifications which make the techniques suited to microprobe analysis of biological specimens are also discussed.

The third chapter deals principally with the preparation and analysis of bulk specimens in the fully frozen-hydrated state. The principles of quantitative analysis are discussed and the example of an analysis is given.

The preparation and analysis of frozen-hydrated sections is separately discussed in the fourth chapter. It is pointed out that the optical and analytical resolutions would be better with sections rather than bulk specimens, making sections more advantageous under some circumstances.

The fifth chapter deals with preparation and analysis of freeze-substituted specimens which offer the major advantage of relatively easy sectioning on conventional ultra-microtones, as compared to the sectioning of frozen-hydrated specimens.

The influence of specimen topography is discussed in the sixth chapter, the topics including recognition of topographic effects and minimization of errors due to topographic effects.

The special considerations required for microanalysis of skeletal muscles are emphasized in the seventh chapter while the techniques developed by Bonventre *et al.* for the analysis of liquid droplet are described in the eighth chapter. The latter are applicable to the determination of any elemental component above atomic number 5, in a biological sample. The ninth chapter deals with procedures for quantitatively measuring intercellular electrolyte concentrations using X-ray microprobes.

The tenth chapter is aimed at providing an understanding of X-ray microanalysis of biological specimens. The topics include quantitative procedure involving separation of peaks and background to determine the net and relative peak intensity. The preparation and use of standards for biological microanalysis are also discussed. Experimental difficulties such as contamination, mass loss and extraneous background are also considered in detail. Important applications of quantation in biological X-ray microanalysis are also reviewed.

The get-up is attractive and the illustrations are of high quality. It is inevitable that there are repetitions in a collection of related topics, but it is to the credit of Dr. Hayat, the Editor, that these have been kept to the minimum without prejudice to the wholesomeness of individual contributions. This book is highly recommended to those involved with the correlation of morphological appearance with chemical composition.

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The language lottery: Toward a biology of grammars by David Lightfoot. The MIT Press, Cambridge, Massachusetts, 1982, pp. 224, $ 20.13. (Indian orders to Affiliated East-West Press Pvt. Ltd., New Delhi 110 001).

A 'paradigm shift' in any branch of science could be likened to a change of spectacles; with the new pair, one sees things more clearly, in a new light and perspective, and sees more things. Issues and concerns not considered as existing or as relevant to the pursuit of knowledge in a particular field suddenly acquire an urgency and interest. The emergence of the Chomskyan paradigm in linguistics represented a coming into focus of problems and questions that had not been raised in connection with linguistics research till then.

One question which has been central to the Chomskyan or transformational generative model is: What is language such that it is acquired by normal human beings in a very short span of their life? Another: What is man such that he learns any language he is exposed to in infancy? Undoubtedly the two questions are intimately related, and the attempts to answer them adequately have taken researchers to fields of investigation as diverse as genetic epistemology, cognitive psychology, and neurology, to name but a few.

The transformationalist answer to these questions, simply stated, is that each human child is born with an innate, *i.e.*, genetically determined, capacity to learn the languages(s) of its immediate social environment. This capacity consists of expectations about what a human language, and a possible grammar of such a language, should look like. What the adult speaker finally arrives at is a finite, internally represented system of rules that helps him produce and understand an infinite variety of sentences in his language. We are born with a general linguistic theory *i.e.* a set of principles of grammar construction in terms of which we construct a grammar of the language of our experience. In other words, the grammar of the language internalised by individual speakers of that language, and by implication grammars of all particular languages, are but phenotypical variations of the same invariant genotype, *viz.*, Universal Grammar.

The book under review is an examination of this genetic basis of the human language capacity. Its title – The language lottery – is a variation on Jacques Monod's 1972 classic *Chance and necessity*, and suggests that Monod's concept of living things as marked by largely internally directed structuration and development holds interesting implications for the study of language and its biological bases. Lightfoot's book admits to being within the abstract biological framework represented by the molecular revolution in biosciences that followed the 'rediscovery' of Gregor Mendel.

The book, therefore, also denotes a change in the nature of the relationship between biology and the science of language. The success of biological classification system provided a model for inquiry and accounting in pre-Chomskyan linguistics, *i.e.* comparative philology and structuralist or taxonomic linguistics. Chomskyan linguistics, on the other hand, uses the terms and concepts of modern biology as a source of evidence and arguments, and views language as an organ of the mind.

The book follows the standard transformationalist procedure of using arguments from biology to make a strong empirical claim, *viz.*, that language growth in humans has a base as biological as, for example, that behind the development of binocular vision. If binocular vision develops according to the course charted for it by a genetic programme, there is no reason to believe that language growth follows a path independent of a genetic blueprint. Lightfoot adduces evidence from different data fields to prove this point.

One of these fields is language acquisition research. The innateness – or genetic – base, -hypothesis is shown to be necessitated by the observable and commonplace fact that the richness and refinement of the language structure internalised by a child contrast sharply with the poverty and poor quality of the language experience it is exposed to in the first few years of its life. Children demonstrate in their linguistic performance, knowledge of a kind that goes beyond what they have encountered in real life. One of Lightfoot's examples goes as follows:

> Parents do not teach children that while, "Who do you want to succeed?" may mean either, "Who is the person such that you want to succeed him?" or, "Who is the person such that you want him to succeed?", "Who do you wanna succeed?" (with a contracted form) has only the former meaning.
> (P. 19)

A linguist requires years of formal training, exposure to a wide range of data, and a mastery of sophisticated terminology and representational formalism to explain the ambiguity of the sentence with the 'want -to' form and the non-ambiguity of the sentence with the 'wanna' form.[1]

Yet, no child growing up in English-speaking surroundings makes an inappropriate choice between the two forms. Doesn't it show that the child is born with what the linguist has struggled hard to achieve, *viz.*, a theory of the possible terms of the grammar of a human language? Or, more specifically, doesn't it make sense to say that the notion 'subject of' is available to the child in an innate form? If it does, it implies that this notion has a genetic or biological base. Because there is no other conceivable base! Note, however, that this notion is not specific to any particular language. The bio-base claim, on the contrary, makes it imperative for any grammar of any human language to employ this notion in its rules. This is a very strong and empirical claim, which may be falsified by the discovery of a human language that does not use this notion.

Given that notions such as these, and constraints on the formulation of rules employing these notions constitute Universal Grammar, and that Universal Grammar, functioning as a theory of grammar, is an innate capacity, it logically follows that the child's construction of the grammar of the language of its social surroundings involves theory-laden observation and analysis of experience and imposition of a pattern or structure on this experience in conformity with the stipulation of Universal Grammar.

By insisting that the three terms (Universal Grammar, Grammar and Experience) are "closely related", and that "changing the claims about or concept of one involves changing those of others", Lightfoot tries to correct the common misreading of Chomskyan theory by some to the effect that there is no place in the theory for 'society'. In fact the importance of the social trigger is stressed by the argument from biology which states that experience is as essential for language growth as is nutrition for the unfolding of the genetic programme underlying physical growth. The UG-hypothesis or equivalently the genetic-base hypothesis militates not against the 'necessity' of experience, but against the claim that it is 'sufficient' to account for both the emergence of language in the human species and its growth in individuals.

Lightfoot's unambiguous stance with regard to the importance of the social trigger, along with the argument that the biological endowment of language is universal, serves to save transformational theory from charges of rigid biological reductionism or determinism. The world-view associated with the theory, *viz.*, that all human beings come to possess cognitive skills of equal complexity irrespective of their race, language, or geographical distribution is invested with empirical content by the contention of the biological reality of Universal Grammar. The theory therefore uses 'nature' or 'genotype' not to support but to controvert racist theories of intelligence and cognitive capacities. On this view, it makes no sense to say that one language is more logical than another, and by extension to argue that one race is superior to another. However, it still makes sense to talk of one language as being 'richer' than another *i.e.*, more capable of handling, for instance, modern scientific information, just as it makes sense to talk of one society, country, or individual as being more 'affluent' than another. For the equivalence among language is to be sought not at the 'functional', but at the 'structural' level. Functional differences are bound to be there among languages, as functionally differentiated dialects are bound to exist within one language.

Now, it seems intuitively clear that despite their superficial differences, these functional varieties share a common structural core, structural in the sense that it is a level of abstraction at which a sentence from any of the varieties can be given a description essentially identical to that of a sentence from any other variety. This structural core represents the unity that underlies the diversity of superficial phenomena. If this is the case with varieties of one language, why should it be otherwise in the case of various languages? Isn't it significant and interesting to search for a common core that recaptures the essential unity that is belied by the diversity of the world's languages? In any case, isn't it in keeping with the accepted principles of scientific search to look for generalisations of ever-increasing scope? Considered in this light, the structure-centricity of the transformationalist research programme, turns out to be an inherent theoretical obligation with profound philosophical significance and not a case of methodological opportunism as some rival theorists would have us believe.

The argument from the universality of the language capacity to the need for positing biological bases for it would be nothing more than idealist rhetoric but for an important piece of observational data that Lightfoot skilfully exploits in this book, *viz.*, the ability of the human child to pick up any language it is exposed to irrespective of the language of its parents.

The fact that all and only human beings are capable of language[2], in other words the species-specificity of language, provides the crowning evidence for the argument from biology. It is only logical to relate the uniquely human attribute of language to a uniquely human genotype *i.e.*, to suppose that the quantum jump from the pre-linguistic to the linguistic stage in evolution was accompanied by a qualitative change in genetic configuration. The argument that language grew out of the requirements of collective labour (the so-called Marxist position) or of social interaction (the socio-linguistic position) need not be a counter-argument to the position outlined here. For modern biology would support the contention that evolution tends to strengthen and perpetuate genetic characteristics that give selectional advantages to the species. Therefore, if labour and interaction proved advantageous, language, which facilitated these, could be considered as having been evolutionarily reinforced through genetic representation and stabilization.

The sub-title of the book 'Toward a biology of grammars' probably tempts one to expect some enlightenment on the neurological (neuronal, neurochemical, or electrophysiological) correlates of grammatical rules and linguistic processing involving these rules. The book doesn't throw any new light on this issue. This will, however, not disappoint readers who can understand the difficulties involved in experimentally accessing the mechanisms of healthy human brains. Data from the defective speech of brain-damaged patients are used by Lightfoot in refining hypotheses about the location of language and language-related abilities in the brain. But what specific neuronal configurations or neurochemical properties of these language areas help them specialise the way they do is a question difficult to answer at present, given the constraints under which neurological research as a whole has to work. Your reviewer, however, should like to express the wish that someday some ingenious experiments could be designed, which, without infringing the constraints would yield results that would have interesting consequences for the genetic-base hypothesis of language, as well as for a general theory of mind. Then will linguistics have graduated to the status of a branch of "cognitive neuroscience" the advent of which field has already been heralded by Gazzaniga's recent book of the same title.

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Notes

1. The contraction of 'want to' into 'wanna' is conditional to the requirement of identity between the subject of '*want*' and the subject of the embedded infinitive clause *to succeed i.e.* when the sentence has 1.b as its deep structure. In 1.b "you" is co-indexed (indicated by an identical subscript) in the two instances of its occurrence to demonstrate the fact that it is the subject of both the matrix sentence (the superordinate *S*) and the embedded *S* (the *S* directly dominated by the VP node).

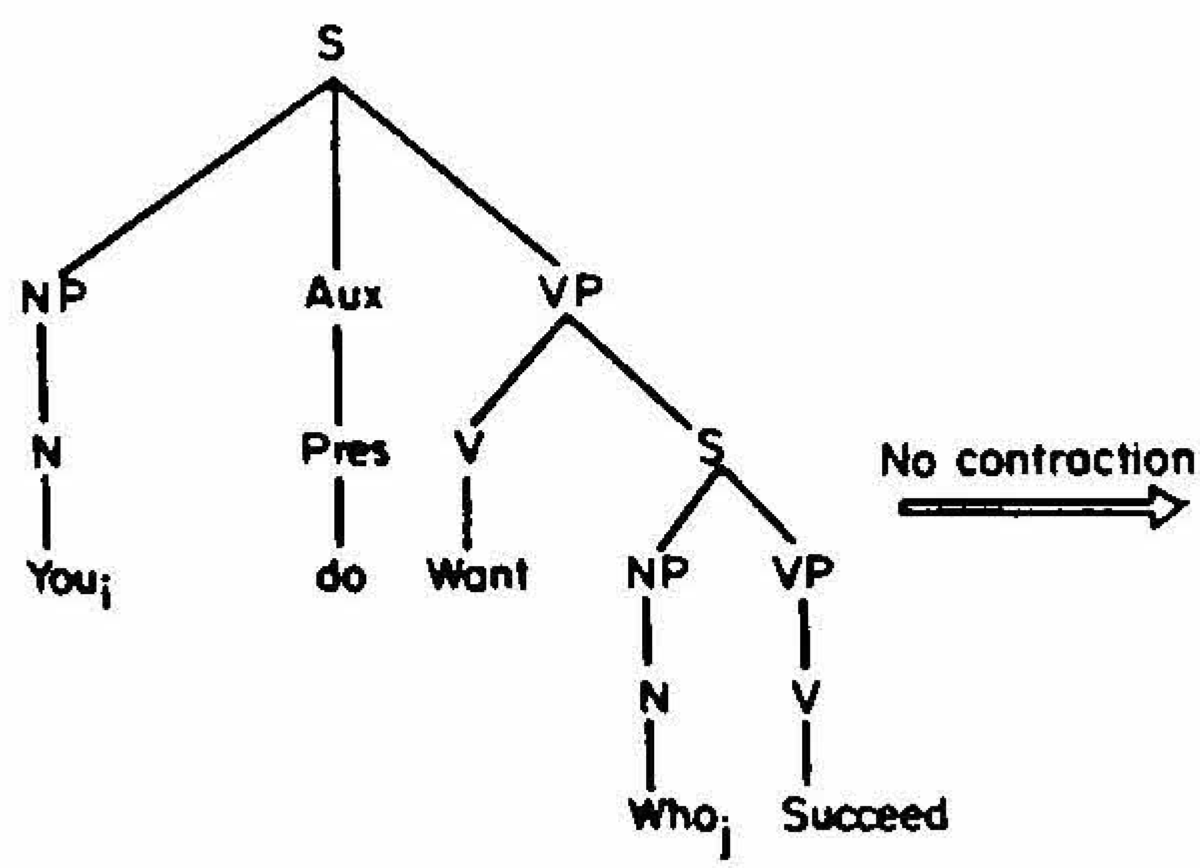

FIG. 1a.

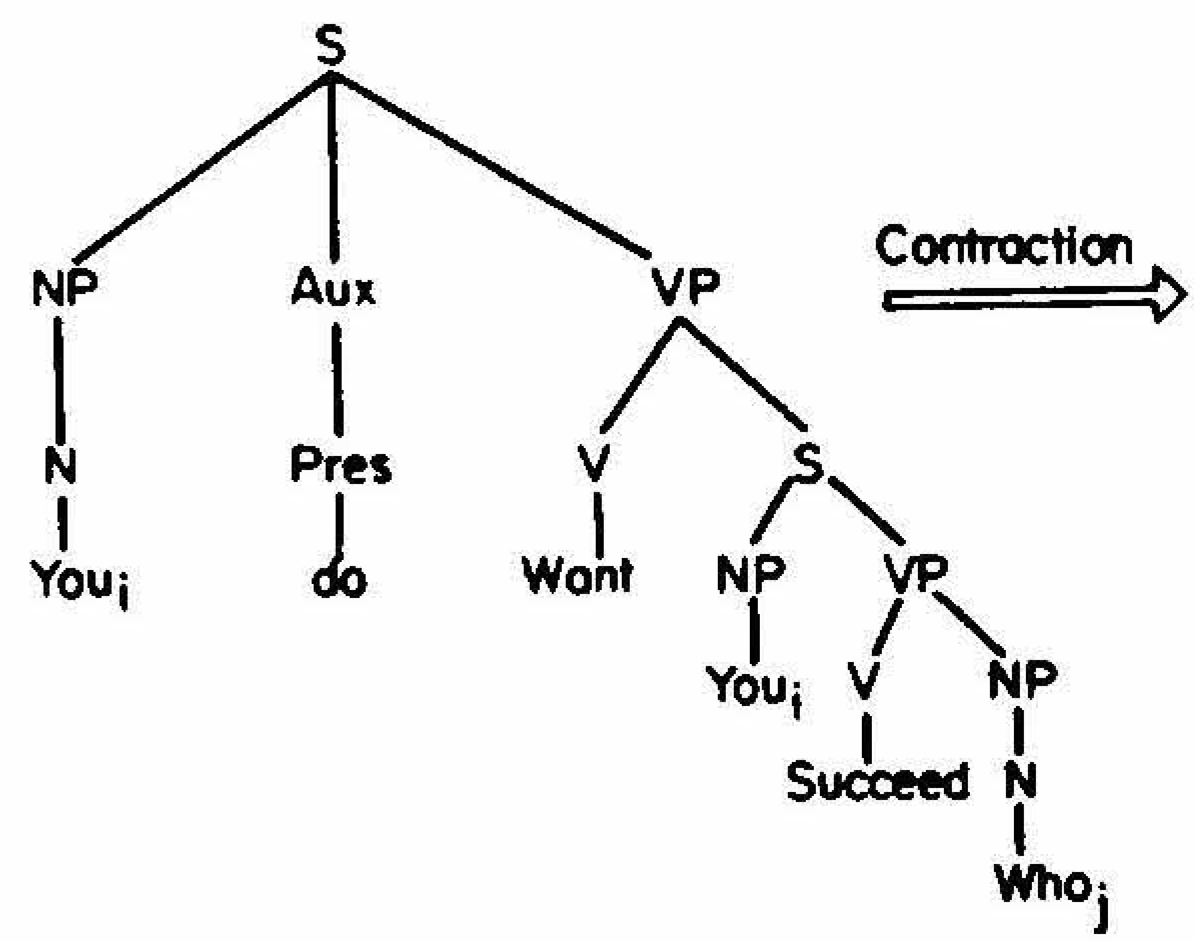

FIG. 1b.

2. The most charitable interpretation of experiments with chimpanzees and apes designed to disprove this contention is that they hinge on a figurative meaning of the term 'Language'. These animals, after intense training, were able to exhibit some 'language-like' skills.

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