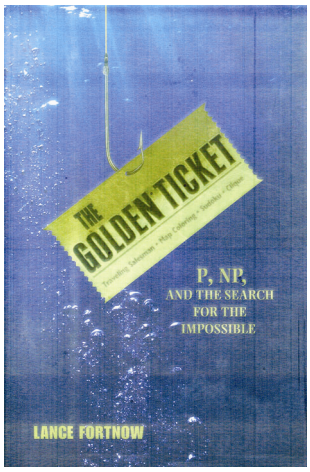

The Golden Ticket: *P*, *NP*, and the Search for the Impossible. Lance Fortnow. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 2013. x + 176 pp. Price: US$ 26.95.

The *P* versus *NP* problem, which is one of the most fundamental problems in mathematics on the nature of efficient computation, has intrigued mathematicians and computer scientists for over four decades. At an intuitive level, the *P* versus *NP* problem asks the following question about computational problems: Are there problems whose solutions are easy to verify but hard to find using a computer? A typical example in this context is the computational task of solving a Sudoku puzzle: Given a solution to a Sudoku puzzle, a computer can verify its correctness very fast, but finding a solution does seem to take a lot more time. If *P* is not equal to *NP*, then we will know for sure that solutions to problems like Sudoku cannot always be found in a short time by a computer.

Ever since the classes of problems *P* and *NP* were defined formally by Stephen Cook and Leonid Levin in the 1970s, an enormous amount of research effort has gone into resolving the *P* versus *NP* problem. But, it does seem we are still quite far from a proof, making the problem one of the greatest challenges of mathematics (and also one of the seven Millennium Problems posed by Clay Mathematics Institute with a million dollar reward on each). Despite an eluding proof, researchers have been incredibly successful on many fronts. The notion of *NP*-completeness (the hardest problems in *NP*); identifying proof strategies like 'relativization', 'natural proofs' that are unlikely to deliver a proof of the *P* versus *NP* problem; approximate solutions to *NP*-complete problems, hardness of approximations and probabilistically checkable proofs; efficient algorithms for problems like linear programming and primality testing; use of randomness in computation; secure cryptographic protocols; and quantum computations are some of the mathematical achievements of the past few decades that were spurred by the formalization of the notion of efficient computation. The story of the present state of affairs around one of the most fascinating problems in mathematics needed to be told in a way that is accessible 'not just to scientists but to a much broader audience'. I must say, Lance Fortnow has done a wonderful job doing so in writing the book under review.

The style of writing in this book is informal (in fact, formal definitions of the complexity classes *P* and *NP* never appear in the book) and aptly so, as this book is not meant to be a technical one. Yet, Fortnow has succeeded in conveying and explaining the ideas using simple 'examples and stories'. The book begins by going right into the heart of the *P* versus *NP* problem, exhibiting how the search space grows astronomically for moderate sized instances of the Travelling Salesman Problem and the partition puzzle, thereby, making 'Perebor' (a Russian term for brute force search) highly inefficient. But, a seemingly large search space does not necessarily make a problem hard to solve computationally and this is also pointed out in the very first chapter of the book using the example of the shortest path finding problem.

A problem with a seemingly large search space might admit a clever algorithm that prunes the search space considerably and converges to a solution rapidly. This fact, which in a way captures the reason why it is a very tricky task to prove that a problem is computationally hard, is brilliantly upheld in this book using many contrasting examples, like min-cut and max-cut finding problems, Eulerian path and Hamiltonian path finding problems, matching and clique finding problems, etc. However, Fortnow has ensured that all these are said in a way that is simple, at times amusing, making the book a really enjoyable read.

The organization of the content of the book is well thought out keeping in mind a broader audience. One of the chapters provides a brief historical account of the formulation of the *P* versus *NP* problem in both the East and the West. Starting from the work of Alan Turing on creation of a formal model of computation, the work of Sergey Yablonsky's group on the apparent requirement of brute force search for certain combinatorial problems to the notion of *NP*-completeness developed by Cook and Levin, this chapter neatly traces out some of the developments in those early years. In another chapter, Fortnow sketches out an imaginary 'beautiful world' that might come into being if someone ever shows $P = NP$. Almost every computational task becomes easy and efficient in such a hypothetical world leading to unexpected great progress in science and technology from curing diseases with specialized medicines to accurate weather prediction many days ahead. On the down side though, modern day public-key cryptosystem might completely collapse in such a 'beautiful world' causing loss of privacy. Such implications of $P = NP$, although imaginary, are to a great extent true.

If *P* not equals *NP*, certain problems will remain computationally hard to solve in all instances. Fortnow argues how one can attempt to cope with hard computational problems in the real world by other means like heuristics, approximations, parallel computing, or perhaps by simply altering the problem at hand a little bit, although probably no single strategy will work to tame the difficulty of all *NP*-complete problems. There is also a chapter discussing some of the attempts on proving '*P* not equals *NP*', how they generated initial high hopes among researchers who only discovered later why such proof strategies are likely to fail. 'I encourage you to try, for you cannot truly understand the difficulty of a problem without attempting to solve it' – these are a few words of wisdom from Fortnow for those who might be willing to try to solve this great problem.

In a span of a little over hundred and fifty pages, Fortnow has touched upon many important aspects of the current state of affairs of the *P* versus *NP* problem using easy to grasp examples (like the explanation of the concept of zero knowledge proofs using Sudoku puzzle) and sometimes humorous anecdotes. Overall, this book provides a window

to an uninitiated reader to gain an understanding, appreciation, and perhaps in the end admiration for one of the greatest problems in mathematics.

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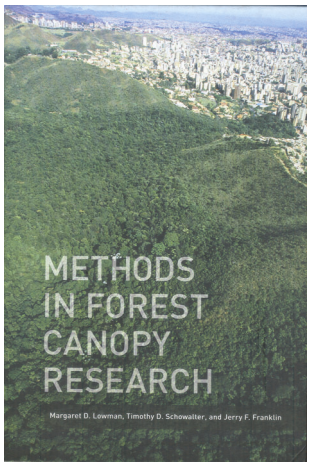


Methods in Forest Canopy Research. Margaret D. Lowman, Timothy D. Schowalter and Jerry F. Franklin. University of California Press, Berkley and Los Angeles, CA, USA, 2012. xviii + 221 pp. ISBN: 978-0-520-27371-9. Price: Rs 3600/US$ 60.

A few forest trees were also in blossom; and it was a truly magnificent sight to behold a great tree covered with one mass of flowers, and to hear the distant hum of millions of insects gathering together to enjoy the honeyed feast. But all is out of reach of the curious and admiring naturalist. It is only over the outside of the great dome of verdure exposed to the vertical rays of the sun that flowers are produced, and on many of these trees there is not a single blossom to be found at a less height than a hundred feet. The whole glory of these forests could only be seen by sailing gently in a balloon over the undulating flowery surface above: such a treat is perhaps reserved for the traveller of a future age.

– Alfred Russel Wallace, 4 July 1842

The forest canopy, an eighth continent in plain sight, has been looked up to in awe since time immemorial. As we descended from the trees and evolved into terrestrial bipeds, the lure of the trees has been irresistible. For the resources that they harbour which often times were out of reach and for safety that they provided from the dangers of a terrestrial life.

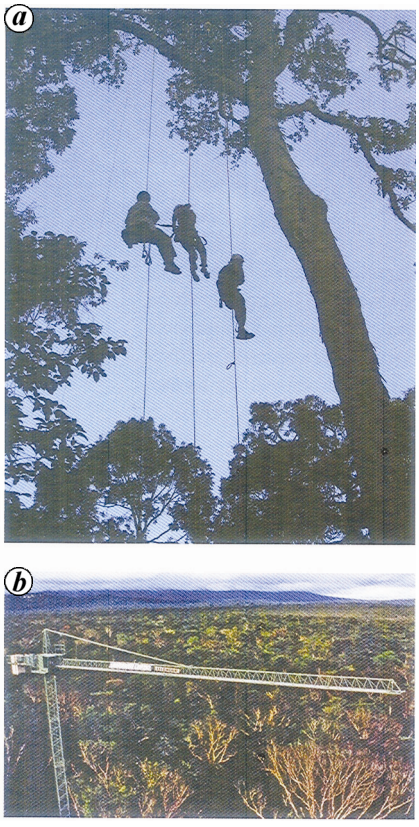
But only recently, has scientific curiosity been the motivation to 'reach up'. Canopy access was perceived as too perilous and difficult in the early days. From the use of native climbers and monkeys for collecting samples to using canopy cranes and LiDAR, canopy research has come a long way in the past five decades. The authors of this book are pioneers, being among the first to initiate quantitative and experimental research on the forest canopies. Using their collective experience and contributions from scientists from around the world, they present a compendium of tried and tested techniques as well as new methods in canopy research.

The book begins by tracing the history and development of canopy research, defining the canopy layer. It looks at why research in the 'high frontier' has lagged behind its terrestrial counterparts and how the role of the canopy researcher has changed from being an explorer to answering critical questions about the forest canopies under the spectre of climate change. Chapter 2 deals with describing forest types and sites. Older ground-based methods as well as hi-tech techniques using MODIS and LiDAR are discussed in the context of describing site characteristics and forest types. These methods are particularly important in a south Asian context, as we have only recently adopted them for research. Forest development models such as BIOME-BCG that predict effects of climate change on distribution of forest types are touched upon and would be useful to explore in the Indian context.

The subsequent chapter deals with the history of canopy access and helps with choosing appropriate techniques with the research target in mind. There is a description of canopy walkways and cranes and how their adoption has significantly improved our ability to perform replicable science in the canopy.

Chapters 4 through 7 can be regarded as prescriptive and provide guidelines on how research in the canopies can be conducted. These chapters describe the planning of canopy research, measuring the physical attributes of the canopy such as vertical stratification, foliage distribution, crown spacing, etc. The methods and sampling units for these measurements are touched upon. The sampling of the biotic components of the canopy makes for fascinating reading and is an exhaustive compilation of studies and techniques on various biota in the canopies from tardigrades (water bears) to mammals. The section on statistical considerations here, is particularly well written and should be made compulsory reading for students and scientists considering canopy work so as to avoid potential pitfalls such as pseudoreplication.

The book concludes with espousing the relevance of canopy research in conservation, policy and science outreach with case studies that successfully engaged multiple stakeholders. There are informative green boxes as topic inserts within the chapters. These are invited contributions from canopy scientists



Methods used to study treetop biodiversity, physical attributes and biological processes. ***a***, Single rope technique (India); ***b***, Construction crane used for canopy access (Venezuela).