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PREFACE

The best way to know a thing is in the context of another discipline.

—Leonard Bernstein, *Norton Lectures*

This is a book about *urban science*, about what we can know about cities that is *generalizable*. By generalizable, I mean observable processes or signals that we can experience or measure across history and throughout the world despite different geographies, cultures, levels of development, and so on.

This is also a book about bringing together different ways of thinking. This is always a clarifying exercise that can guide us through complex and multifaceted phenomena. The objective is to create a comprehensive approach to discovering the general processes by which cities form and grow and to explain why they are such singular sources of change in human societies. I hope to show that different ways of thinking across traditional disciplines can fit together well to form a new body of theory and a set of mathematical models that can generate the mesmerizing complexity and open-endedness of cities.

This approach and objectives may appear controversial and even a little heretical. I have experienced three types of objections that I would like to get out of the way or at least ask the reader for their patience and to hold their judgment until later.

The first is that cities are such complex systems—the products of so many decisions and accidents and so rich in history—that any attempt at a synthetic mathematical description is futile and therefore misguided. To that argument, I would note that the same can be said, perhaps with more substance, of biology, where we have a more advanced scientific understanding of the phenomena involved. Such an understanding brings together structural aspects dictated by physics and biochemistry with a theory of natural history and learning in the form of evolution by natural selection. Such a theoretical synthesis has matured only relatively recently, thanks

to a profusion of evidence, experiments, and theory development across scales of organization. There will be a number of parallels, but also some innovations, in this comparison.

Second, scholars trained in the humanities and sometimes in the social sciences often treat references to *science* and *data* in their realms of expertise with suspicion. They have good reason, as appeals to science have too often been used in policy (and politics) to justify control, normalization, standardization, and associated social injustice and oppression. I want to acknowledge this concern as absolutely valid, something that we must always keep in mind in urban science.

However, such appeals to the putative authority of science refer to it only in name, not in spirit. Science is a body of contingent and collaborative knowledge that nevertheless improves over time. Science is plural, a deeply humanizing experience based on curiosity, collaboration, creativity, and humility in the face of the facts that shape our experience—it stands in opposition to dogma. Thus, good science is never a technocratic exercise in the service of oppressive bureaucracies but rather an act of imagination following the human instinct to discover how the world works and how it could be better. This certainly includes engaging with the richest depths of the human experience, many of which are associated with cities.

Third, from a philosophical perspective, many see any incursion of science, and especially of mathematical methods, into the realm of human societies as entailing a tragic loss of freedom and humanity. This is a terrible misunderstanding that I hope some of the material in this book can help repair. The things that we will use as constraints to build mathematical theories of people in cities are very few and absolutely mundane. They include simple facts, such as that we all live in space and time and that we must balance our energy budgets and/or bank accounts over some period of time. Almost everything else is left free: all our detailed behavior, our thoughts and desires, our successes and failures.

This growing comfort with uncertainty has not been typical of classical approaches in the social sciences, where individual “rationality” or structural determinism has often been taken as absolute. Studying real lives in real cities forces us to dispel such simple assumptions. In this sense, we will be able to understand—even mathematically—why each city, each place, each life course is indeed unique. What may be surprising is that some of the statistical averages over time and over the behavior of groups of people still bear a trace of the environments we build and the shared costs and benefits underlying our diverse living experiences. This will give us a background of aggregated predictive statistics that form a methodological basis for urban science.

In this light, being special is always a relative state: any sense of uniqueness requires a background pattern of general mechanisms and facts against which it can be appreciated. Such a pattern is not a description of—or a model for—individual behavior! It represents instead aggregated social statistical tendencies that are very familiar to us all, long exploited by successful businesses such as insurance companies or casinos.

We will use this analytical device in different ways throughout the book to show how each city and every one of its people is the result of the aggregation of many choices, accidents, and influences from their compounded joint history. Interestingly, the resulting statistical properties of cities will be more than the sum of these parts.

The most important thing we can do with science is to “see the world from a different point of view,” to borrow physicist Richard Feynman’s words. There is nothing more critical or more exciting intellectually than sneaking up to an old and difficult problem from a different perspective that renders it clearer and simpler. Finding new perspectives and insights, and discovering new ways in which the world comes together to reveal its mysteries, is the greatest joy of any curious mind. I hope the reader sees, as I do, the enormous power of looking at cities from a different point of view and the many insights that follow.

Why invoke science and not concentrate on other forms of inquiry to understand cities? Science is the only collective human process I know that can learn extraordinary new things from the accumulated experience of myriads of people. Science as a process is uniquely good at creating insights that vastly transcend our daily experience and intuitions.

This allows us ultimately to escape the mental and institutional traps we live in today and helps us imagine—but does not determine!—how we may build a better tomorrow. These general features of science are what make it such a critical and powerful human endeavor on any subject, but I feel that these features are even more important in the context of urban science, because cities feel so familiar to us all. Science is not a substitute for other practices of scholarship, especially in the humanities, but it does have its unique and powerful role to play.

This book has been the work of a lifetime, as I joyfully experienced many different cities, and almost six years of dedicated learning, research, and teaching. Writing it feels to me like assembling a colossal puzzle that, as it comes together, reveals to me a new picture, where old ideas make sense alongside new ones, emerging data and methods acquire surprising new uses, and a long view of what cities have been and what they could become starts to come into focus. I hope that this book settles some old questions but also that many new ones arise.

The ideas of this book are the result of discussions and collaborations with a large number of people across many disciplines, each of them important to the final result. It is difficult to single out some without naming them all. However, a small number of people have been key. José Lobo has been a dear friend, intellectual partner, and kind collaborator from the beginning, when we met at the Santa Fe Institute in 2003. We started out in a common position, asking cheeky questions from the back of the room in a series of seminars. We asked primarily why speakers manifesting interesting but sometimes (to us) fanciful ideas about cities had not used more data to test them. Doing so ourselves opened up the floodgates of urban scaling analysis. Geoffrey West motivated us to use scaling as an analytical framework, which ultimately

created a new cornerstone for urban science while also exposing some of the similarities and differences between cities and other complex systems. Deborah Strumsky opened my eyes to phenomena of innovation in cities and the riches of patent data. Scott Ortman walked into my office one day and asked me to explain urban scaling theory, only to tell me afterward that what I was saying was not really about cities. He noted that it should apply equally well to any other settlement, including the ones he studies in archeology. This opened up the doors to a new quantitative comparative analysis of settlements throughout history and also shed light on the origins of settlements themselves. Michael Smith amplified these ideas, pointing out that common assumptions of industrialization or modern political organization had to be overcome to truly understand the origins of settlements and early cities and opening up new lines of continuity on issues of socioeconomic organization throughout history. Celine D’Cruz and Anni Beukes became friends and collaborators during a challenging project on informal settlements, which exposed me to the difficult but hopeful realities of contemporary African and South Asian cities. Christa Brelsford became a wonderful, brave collaborator formalizing some of these rich observations toward a better understanding, and new methods, of human development in neighborhoods.

Many others contributed to shaping the ideas of this book through collaboration, discussions, encouragement, or criticism. They include Clio Andris, Elsa Arcaute, Michael Batty, Marc Berman, Elizabeth Bruch, Kate Cagney, Charlie Catlett, Rudy Cesaretti, Andres Gomez-Lievano, John German, Marcus Hamilton, Joe Hand, Jack Hanson, Colin Harrison, Dirk Helbing, Christian Kühnert, David Lane, Sander van der Leeuw, Taylor Martin, Nicholas de Monchaux, Daniel O’Brien, Juval Portugali, Denise Pumain, Carlo Ratti, Celine Rozenblat, Diego Rybski, Horacio Samaniego, Robert Sampson, Markus Schlöpfer, Karen Seto, Devin White, Vicky Yang, HeyJin Youn, and Daniel Zünd.

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This book was started at the Santa Fe Institute. Its beautiful environment of radical interdisciplinary scholarship and its encouragement of adventurous and fun collaborations were key in sowing the seeds for a new systemic perspective on cities and urbanization and providing contrasts and connections to many other complex systems. This book was finished at the University of Chicago, whose rich history of urban scholarship propitiated another set of encounters at the interface between critical concepts and practice from the social sciences and new methods and data. I owe an enormous debt of gratitude to both these institutions for nurturing the origins

and development of this work and to the Mansueto Institute for Urban Innovation for the challenge of putting it into practice.

As I finish this book, I hear more and more frequently of the advent of urban science or of a “science of cities” and learn with great pleasure of new publications or discoveries big and small. I also hear of new institutes and centers dedicated to the field, developing in many different places and in many different ways. To me, this is a state of grace when urban science feels young and open, fast and full of vitality, perhaps much like so many of the cities it studies. Any discipline requires a common framework, without which knowledge cannot be tested and accumulate. I hope this book contributes to that effort.

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