# Preface

## Origin

Traditionally, much of the study of networks has focused on structural features. Indeed, mathematical subjects such as graph theory have a rich history of investigating network structure, and most early work by physicists, sociologists, and other scholars also focused predominantly on structural features. The beginnings of the field of "network science," which one can characterize as the science of connectivity, also started out by focusing on network structure (i.e., literal connectivity). Although some scholars (e.g., many control theorists) have traditionally stressed the importance of dynamics in their study of networks, many network-science practitioners who were trained in fields like dynamical systems and nonequilibrium statistical mechanics (which are both concerned very deeply with dynamical processes) have written myriad papers that seem to focus predominantly or even exclusively on structure. This is valuable and we ourselves have written papers on network structure, but one also needs to consider dynamics, and it is good to wear a dynamical hat even for investigations whose primary explicit focus is on structure. Indeed, a major purpose for studying network structure is as a necessary prerequisite for attaining a deep understanding of dynamical processes that occur on networks. How do social contacts affect disease and rumor propagation? How does connectivity affect the collective behavior of oscillators? The purpose of our monograph is to provide a tutorial for conducting investigations that explore (and try to answer) those types of questions. We will occasionally discuss network structure in our tutorial, but we are wearing our dynamical-systems hats.

## Scope, Purpose, and Intended Audience

The purpose of our monograph is to give a tutorial for studying dynamical systems on networks. We focus on "simple" situations that are analytically tractable, though

it is also valuable to examine more complicated situations, and insights from simple scenarios can help guide such investigations. There is a large gap between toy models and real life, and it is crucial to worry about what insights the very simplistic models that we know and love are able to reveal about the much more complicated situations that occur in real life. Our monograph is intended for people who seek to study dynamical systems on networks but who might not have any prior experience with graph theory or networks. We hope that reading our tutorial will convey why it is both interesting and useful to study dynamical systems on networks, how one can go about doing so, the potential pitfalls that can arise in such studies, the current research frontier in the field, and important open problems. We touch on a large number of applications, but we focus explicitly on simple models, rules, and equations rather than on realism or data analysis. We do, however, include pointers to references that consider more realistic scenarios. As the eminent philosopher (and baseball player) Yogi Berra once said, "In theory, there is no difference between theory and practice. In practice, there is."

We expect that our tutorial will be most digestible for people who have already had introductory courses in linear algebra and dynamical systems, and some prior experience with probability will also occasionally be helpful. Despite the many contributions from scholars in fields such as statistical physics and sociology (and others), we do not expect our monograph's readers to have any background whatsoever in such subjects. We hope that our tutorial will provide an entry point for graduate students, sufficiently advanced undergraduate students, postdoctoral scholars, or anybody else from mathematics, physics, or engineering who wants to study dynamical systems on networks. It can also perhaps serve as textbook material for the final parts of a course on dynamical systems or statistical physics. Additionally, our tutorial can also be part of the core material in a course on networks or on appropriate topics within networks (e.g., dynamical systems on networks, to give a "random" example), and ideally experts in dynamical systems and network science will also enjoy and benefit from reading our monograph. We have purposely included numerous pointers to interesting papers to read, and we hope that our tutorial will facilitate readers' ability to critically read and evaluate papers that concern dynamical systems on networks. To give a brief warning, our monograph is *not* a review (or anything close to one) on dynamical systems on networks, and we are citing only a small subset of the existing scholarship in this voluminous area. As a complement to citing "classical" pieces of scholarship in the area, we have also purposely included pointers to very recent papers that discuss ideas that we find interesting. New articles on dynamical systems on networks are published or posted on preprint servers very frequently, so we couldn't possibly cite all of the potentially relevant articles even if we tried. See Chapter 7 for a list of books, review articles, surveys, and tutorials on various related topics.

Oxford, UK — Mason A. Porter
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