**Preface**

**序言**

Theoretical analysis and computational modeling are important tools for characterizing what nervous systems do, determining how they function, and understanding why they operate in particular ways.

理论分析和计算模型是确定神经系统做什么（What），如何工作（How）以及它们为什么以特定的方式工作（Why）的重要的工具。

Neuroscience encompasses approaches ranging from molecular and cellular studies to human psychophysics and psychology.

从分子和细胞研究到神经物理学和心理学都是神经科学的研究范畴。

Theoretical neuroscience encourages cross-talk among these sub-disciplines by constructing compact representations of what has been learned, building bridges between different levels of description, and identifying unifying concepts and principles.

理论神经科学鼓励跨上述子学科的交流。通过对已知事物建立紧密的表述，在不同层次的描述之间建立桥梁，并且确定统一的概念和原则。

In this book, we present the basic methods used for these purposes and discuss examples in which theoretical approaches have yielded insight into nervous system function.

本书中，我们提出了一些可以用来解决上述问题的基础方法，并且讨论了一些例子，在这些例子中理论方法已经对神经系统的功能有所洞见。

The questions what, how, and why are addressed by descriptive, mechanistic, and interpretive models, each of which we discuss in the following chapters.

在神经学中，对于“什么”、“如何”和“为什么”的问题，通常分别被称为“描述性模型”、“机械性模型”和“解释性模型”。在接下来的章节中，我们将分别讨论这几种模型。

Descriptive models summarize large amounts of experimental data compactly yet accurately, thereby characterizing what neurons and neural circuits do.

描述性模型简介又不失精确地总结了大量的实验数据。因此代表了神经元和神经回路**做什么。**

These models may be based loosely on biophysical, anatomical, and physiological findings, but their primary purpose is to describe phenomena not to explain them.

这些模型可能是松垮地基于生物物理学，解剖学以及生理学的发现，但他们的主要目的是来**描述现象而不是解释现象**。

Mechanistic models, on the other hand, address the question of how nervous systems operate on the basis of known anatomy, physiology, and circuitry.

相反，“机械性模型” 基于已知的解破学、生理学以及电路描述了神经系统**如何工作**。

Such models often form a bridge between descriptive models couched at different levels.

这样的模型通常为在不同级别训练了的描述性模型之间建立了桥梁。

Interpretive models use computational and information-theoretic principles to explore the behavioral and cognitive significance of various aspects of nervous system function, addressing the question of why nervous system operate as they do.

解释性模型，用计算和信息论理论来探索多种**神经系统功能在行为和认知**中发挥的重要**作用**，表述了为什么神经系统这样工作。

It is often difficult to identify the appropriate level of modeling for a particular problem.

对一个特定的问题，同城很难确定合适的层次进行建模。

A frequent mistake is to assume that a more detailed model is necessarily superior.

假定一个包含更多细节的模型一定是更优越的模型，是一个常见的错误。

Because models act as bridges between levels of understanding, they must be detailed enough to make contact with the lower level yet simple enough to yield clear results at the higher level.

因为模型的作用是在不同层次的理解之间建立桥梁，它们必须有足够多的细节来和更低层进行交流，却又足够简单以至能在较高层次产生清晰的结果。

**Organization and Approach**

**组织和方法**

This book is organized into three parts on the basis of general themes.

本书依据通用主题分为三部分。

Part I (chapters 1-4) is devoted to the coding of information by action potentials and the represention of information by populations of neurons with selective responses.

第一部分（第1章至第4章）致力于 描述 通过动作电势实现信息的编码以及通过神经集群的选择性回应来再现信息。

Modeling of neurons and neural circuits on the basis of cellular and synaptic biophysics is presented in part II (chapters 5-7).

第二部分（第5章至第7章）是基于细胞和突触生物物理学对神经和神经回路进行建模的相关内容。

The role of plasticity in development and learning is discussed in Part III (chapters 8-10).

第三部分（第8章至第10章）是关于发展和学习的可塑性的相关内容。

With the exception of chapters 5 and 6, which jointly cover neuronal modeling, the chapters are largely independent and can be selected and ordered in a variety of ways for a one- or two-semester course at either the undergraduate or graduate level.

这些章节（除了第5章和第6章，这两章共同地讲述神经建模）大部分是独立的，并且可以有选择性的，或以其他顺序的作为本科生或研究生一个或两个学期的课程。

Although we provide some background material, readers without previous exposure to neuroscience should refer to a neuroscience textbook such as Kandel, Schwartz & Jessell (2000); Nicholls, Martin & Wallace (1992);Bear, Connors & Paradiso (1996); Shepherd (1997); Zigmond, Bloom, Landis & Squire (1998); Purves et al (2000).

尽管我们提供了一些背景资料，没有预先学习过神经科学的读者应该参考一些神经学教材，比如 Kandel, Schwartz & Jessell (2000); Nicholls, Martin & Wallace (1992);Bear, Connors & Paradiso (1996); Shepherd (1997); Zigmond, Bloom, Landis & Squire (1998); Purves et al (2000).

Theoretical neuroscience is based on the belief that methods of mathematics, physics, and computer science can elucidate nervous system function.

理论神经学是建立在如下的观念之上的：数学、物理学以及计算机科学的方法可以阐明神经系统的功能。

Unfortunately, mathematics can sometimes seem more of an obstacle than an aid to understanding.

不幸的是，数学有时毋宁说是对理解的障碍而非帮助。

We have not hesitated to employ the level of analysis needed to be precise and rigorous.

我们毫不犹豫的采用了需要准确严谨的级别的分析。

At times, this may stretch the tolerance of some of our readers.

有时，这可能会考验我们读者的容忍度。

We encourage such readers to consult the mathematical appendix, which provides a brief review of most of the mathematical methods used in the text, but also to persevere and attempt to understand the implications and consequences of a difficult derivation even if its steps are unclear.

我们鼓励这样的读者参考数学附录，该附录简要回顾了本书中使用的大多数数学方法。同时，对一些困难的推导，即使推导的过程不甚明了，也要坚持并试图理其背后的含义和结果。

Theoretical neuroscience, like any skill, can only be mastered with practice. We have provided exercises for this purpose on the web site for this book and urge the reader to do them. In addition, it will be highly instructive for the reader to construct the models discussed in the text and explore their properties beyond what we have been able to do in the available space.

同其他任何技能一样，理论神经学只有通过练习才能掌握。为此，我们在此书的网站上提供了练习题，我们强烈建议读者做这些习题。对读者来说，这些习题对本书所讨论的模型建模具有高度的指导意义；同时也能帮助读者探索这些模型因篇幅所限而未能讨论的性质。

**Referencing**

In order to maintain the flow of the text, we have kept citations within the chapters to a minimum.

为了维持文章的流畅性，我们尽量减少每章中所保留的引用。

Each chapter ends with an annotated bibliography containing suggestions for further reading (which are denoted by a bold font), information about work cited within the chapter, and references to related studies.

每章最后都带有注释参考书目，其中包含进一步阅读的建议（用粗体字表示），本章引用的作品信息以及相关研究参考。

We concentrate on introducing the basic tools of computational neuroscience and discussing applications that we think best help the reader to understand and appreciate them.

我们致力于介绍计算神经学所使用的基本工具并讨论，以及我们认为能最好的帮助读者来理解并喜爱这门学科的应用。

This means that a number of systems where computational approaches have been applied with significant success are not discussed.

这意味着，一系列已经取得巨大成功的计算方法的系统没有被在本书中囊括。

References given in the annotated bibliographies lead the reader toward such applications.

在注释参考书目中给出的参考文献引导读者走向这样的应用。

In most of the areas we cover, many people have provided critical insights. The books and review articles in the further reading category provide more comprehensive references to work that we apologetically have failed to cite.

在本书涉及的多数领域，很多人都提出了重要的见解。“进一步阅读”类别中的书籍和评论文章，对我们暂时无法引用的工作提供了更全面的参考。

**Acknowledgments**

We are extremely grateful to a large number of students at Brandeis, the Gatsby Computational Neuroscience Unit and MIT, and colleagues at many institutions, who have painstakingly read, commented on, and criticized, numerous versions of all the chapters. We particularly thank Bard Ermentrout, Mark Kvale, Mark Goldman, John Hertz, Zhaoping Li, Eve Marder, and Read Montague for providing extensive discussion and advice on the whole book. A number of people read significant

portions of the text and provided valuable comments, criticism, and insight: Bill Bialek, Pat hurchland, Nathanial Daw, Dawei Dong, Peter F¨oldi´ak, Fabrizio Gabbiani, Zoubin Ghahramani, Geoff Goodhill, David Heeger, Geoff Hinton, Ken Miller, TonyMovshon, Phil Nelson, Sacha Nelson, Bruno Olshausen, Mark Plumbley, Alex Pouget, Fred Rieke, John Rinzel, Emilio Salinas, Sebastian Seung, Mike Shadlen, Satinder Singh, Rich Sutton, Nick Swindale, Carl Van Vreeswijk, Chris Williams, David Willshaw, Charlie Wilson, Angela Yu, and Rich Zemel. We have received significant additional assistance and advice from: Greg DeAngelis, Matt Beal, Sue Becker, Tony Bell, Paul Bressloff, Emery Brown, Matteo Carandini, Frances Chance, Yang Dan, Kenji Doya, Ed Erwin, John Fitzpatrick, David Foster, Marcus Frean, Ralph Freeman, Enrique Garibay, Frederico Girosi, Charlie Gross, Mike Jordan, Sham Kakade, Szabolcs K´ali, Christof Koch, Simon Laughin, John Lisman, Shawn Lockery, Guy Mayraz, Quaid Morris, Randy O’Reilly, Max Riesenhuber, Sam Roweis, Simon Osindero, Tomaso Poggio, Clay Reid, Dario Ringach, Horacio Rotstein, Lana Rutherford, Ken Sagino,Maneesh Sahani, Alexei Samsonovich, Idan Segev, Terry Sejnowski, Haim Sompolinksy, Fiona Stevens, David Tank, Alessandro Treves, Gina Turrigiano, David Van Essen, Martin Wainwright, Xiao-Jing Wang, Max Welling, Matt Wilson, Danny Young, and Ketchen Zhang. We apologise to anyone we may have inadvertently omitted from these lists. Karen Abbott provided valuable help with the figures. From MIT Press, we thank Michael Rutter for his patience and consistent commitment, and Sara Meirowitz and Larry Cohen for picking up where Michael left off.