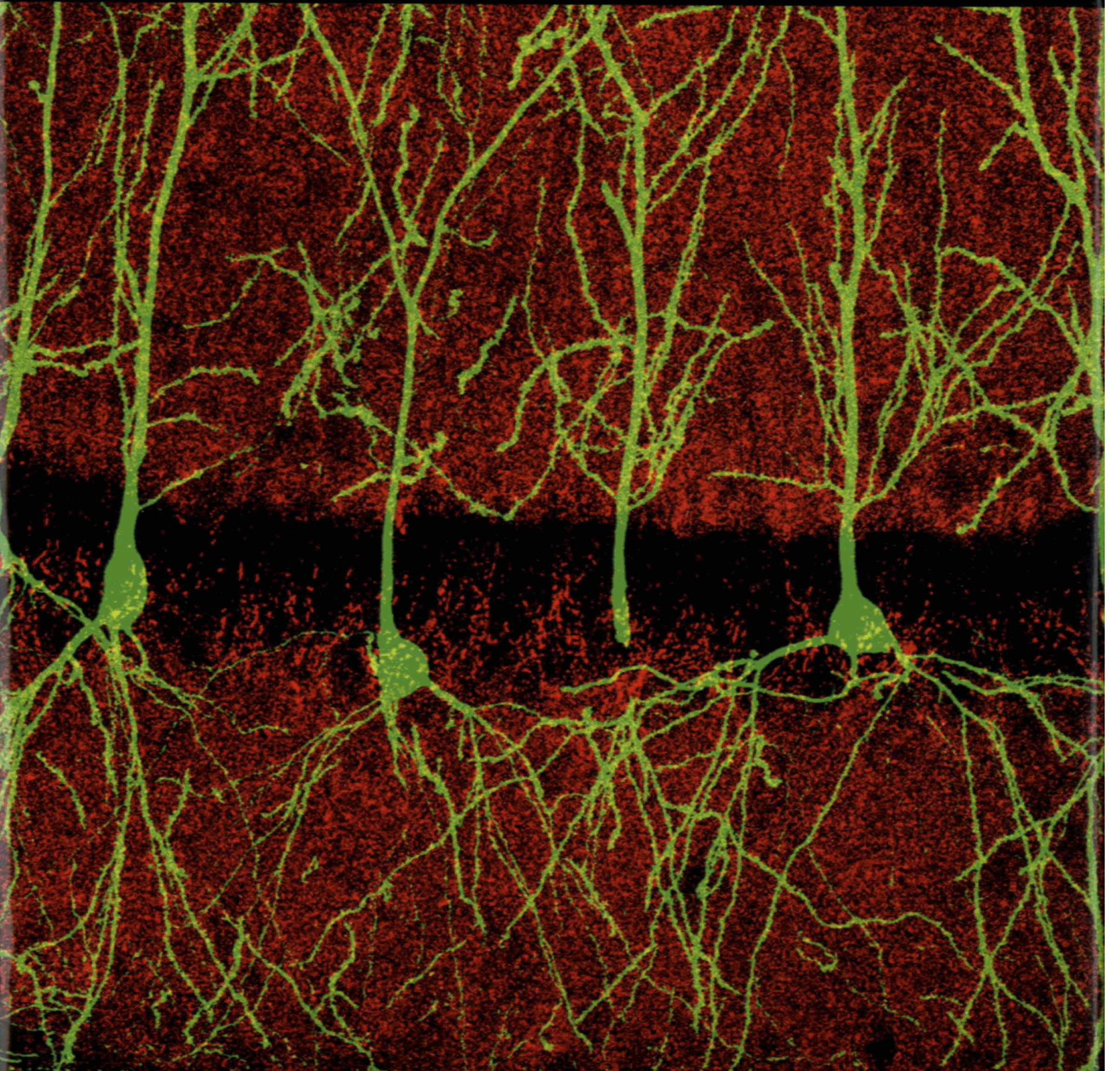
23 Problems in Systems Neuroscience

Edited by J. Leo van Hemmen · Terrence J. Sejnowski



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Preface

As long as a branch of science offers an abundance of problems, so long is it alive; a lack of problems foreshadows extinction or the cessation of independent development.

—David Hilbert in Paris, 8 August 1900

When invited in 1899 to give the opening address at the second International Congress of Mathematicians (ICM) in Paris the following year, David Hilbert (1862–1943), one of the greatest mathematicians of the last century and the father of Hilbert space, was facing the beginning of a new century. Henri Poincaré, who had a similar task in addressing the first ICM in Zurich, extolled the virtues of what had previously been accomplished in pure mathematics. Rather than focus on the glories of the past, Hilbert chose to make a break with tradition and instead emphasize what was *not* known. At the ICM on August 8, 1900, he outlined twenty-three key open mathematical problems as challenges to mathematicians for the twentieth century. These problems were influential in shaping the direction of mathematics.

To understand Hilbert's motivation, let us retrace his reasoning in the introduction to his lecture entitled *Mathematical Problems*[1]:

[1] The German text appeared in 1900 directly after the Paris meeting in *Nachr. Kgl. Ges. d. Wiss. zu Göttingen, math.-phys. Klasse* 3, 253–297. It can also be found in volume 3 of Hilbert's collected works (1935, 290–329). The translation above is by Dr. Mary Winston Newson and was published in 1902 in *Bull. Amer. Math. Soc.* 8: 437–479; it reappeared in 2000 in *Bull. Amer. Math. Soc.* (new series) 37: 407–436.

> History teaches the continuity of the development of science. We know that every age has its own problems, which the following age either solves or casts aside as profitless and replaces by new ones. If we would obtain an idea of the probable development of mathematical knowledge in the immediate future, we must let the unsettled questions pass before our minds and look over the problems which the science of to-day sets and whose solution we expect from the future. To such a review of problems the present day, lying at the meeting of the centuries, seems to me well adapted. For the close of a great epoch not only invites us to look back into the past but also directs our thoughts to the unknown future.
>
> The deep significance of certain problems for the advance of mathematical science in general and the important role that they play in the work of the individual investigator are not to be denied. As long as a branch of science offers an abundance of problems, so long is it alive; a lack of problems foreshadows extinction or the cessation of independent development. Just as every human undertaking pursues certain objects, so also mathematical research requires its problems. It is by the solution of problems that the investigator tests the temper of his steel; he finds new methods and new outlooks, and gains a wider and freer horizon.
>
> It is difficult and often impossible to judge the value of a problem correctly in advance; for the final award depends upon the grain which science obtains from the problem. Nevertheless we can ask whether there are general criteria which mark a good mathematical problem. An old French mathematician said: "A mathematical theory is not to be considered complete until you have made it so clear that you can explain it to the first man whom you meet on the street." This clearness and ease of comprehension, here insisted on for a mathematical theory, I should still more demand for a mathematical problem if it is to be perfect; for what is clear and easily comprehended attracts, the complicated repels us.

As for systems neuroscience, why add more, if—*mutatis mutandis*—it has all been said so clearly a century ago? The same text, with "mathematical science" replaced by "systems neuroscience," applies to the twenty-first century. The complexity of the brain and the protean nature of behavior remain the most elusive area of science and also the most important. There is no single brilliant individual who could serve as the David Hilbert of systems neuroscience, so we have invited twenty-three experts from the many areas of systems neuroscience to formulate one problem each.

We thank the Max Planck Society for hosting a wonderful meeting on "Problems in Systems Neuroscience" in Dresden on September 4 to 8, 2000, that formed the core of the authors in this collection. We have asked several other colleagues to contribute to the twenty-three challenging questions in systems neuroscience that are included. It took Hilbert two years to get his problems published in English. It took us even longer to get the twenty-three different essays collected together in this volume. Although it is not comprehensive, and it is, like Hilbert's original list of problems, idiosyncratic, nonetheless it may serve as a source of inspirations for future explorers of the brain.

We have organized the chapters into five themes that range from evolution to qualia, each theme posed as a general question. Although each of the chapters was independently written and can be read separately, there are some common issues that reflect contemporary concerns.

J. Leo van Hemmen
Terrence J. Sejnowski

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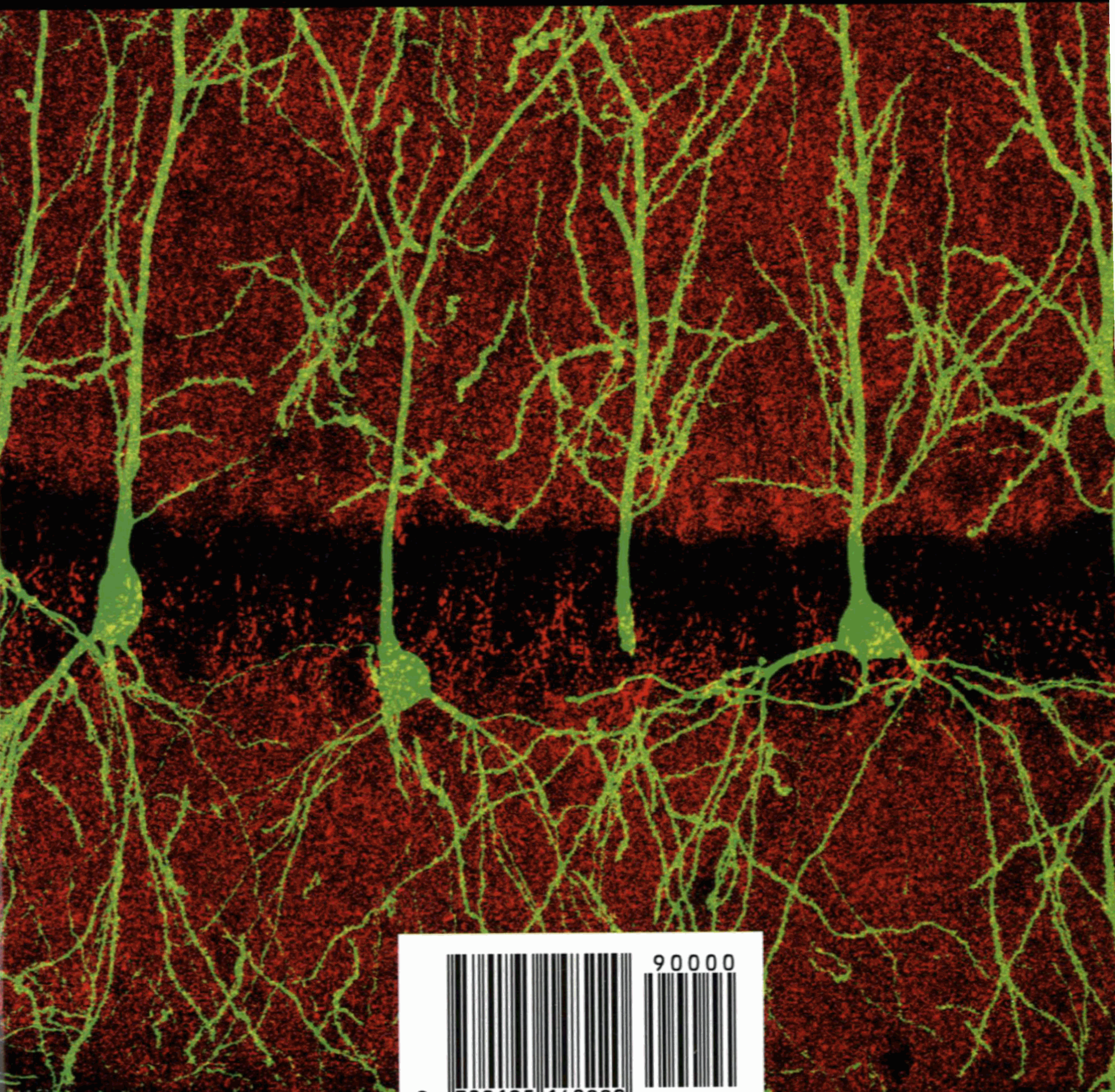

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