Scientific Method in Brief

The general principles of the scientific method, which are applicable across all of the sciences, are essential for perspective, productivity, and innovation. These principles include deductive and inductive logic, probability, parsimony, and hypothesis testing, as well as science's presuppositions, limitations, ethics, and bold claims of rationality and truth. The implicit contrast is with specialized techniques confined to a given discipline, such as DNA sequencing in biology. Neither general principles nor specialized techniques can substitute for one another, but rather the winning combination for scientists is mastery of both.

The purposes of this book are to enhance perspective on science by drawing insights from the humanities and to increase productivity by fostering a deep understanding of the general principles of scientific method. The examples and case studies span the physical, biological, and social sciences; include applications in agriculture, engineering, and medicine; and also explore science's interrelationships with disciplines in the humanities such as philosophy and law.

This book engages a great diversity of viewpoints on science, both historical and contemporary, and responds by affirming science's rationality. Informed by position papers on science from the American Association for the Advancement of Science, the National Academy of Sciences, and National Science Foundation, this book aligns with a distinctively mainstream vision of science. It is an ideal resource for anyone undertaking a systematic study of scientific method for the first time, from undergraduates to professionals in both the sciences and the humanities.

Hugh G. Gauch, Jr., is a Senior Research Specialist in the College of Agriculture and Life Sciences at Cornell University, New York. He teaches Cornell's course on scientific method, and for the last four decades his research has focused on the statistical analysis of ecological and agricultural data. He is author of *Scientific Method in Practice* (Cambridge, 2002), which is the basis for this more concise and student-focused text.

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CAMBRIDGE UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi - 110025, India

103 Penang Road, #05-06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107666726

First published 2012
3rd printing 2014

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging in Publication data
Gauch, Jr., Hugh G., 1942–
Scientific method in brief / Hugh G. Gauch, Jr.
p. cm.
ISBN 978-1-107-66672-6 (pbk.)
1. Science – Methodology. I. Title.
Q175.G3368 2012
001.4′2 – dc23 2012016520

ISBN 978-1-107-66672-6 Paperback

This book is dedicated to my esteemed Cornell colleagues,
Gary Warren Fick, Charles Christopher Fick, and
Justin David McGeary.

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Foreword

Approximately halfway through her Ph.D. program in the biological sciences, my first doctoral student requested that we meet to review progress toward the degree. Knowing that both the courses and research of this student were progressing nicely, I entered the appointment confident of a glowing report both for graduate student and major professor. However, the conversation took an unexpected twist as we finished discussing the items on my agenda.

When and how, the student asked, do we get to the more philosophical part of this Doctorate of Philosophy degree in science? Was it true that this program that I and the guidance committee had designed would not include even one course in science philosophy or no structured examination of the logical underpinnings of science? The final question had an unintended sting for me as major professor – something to the effect of "Will I graduate feeling worthy of more than a technical degree?"

Stunned and befuddled, I sent the student on her way with lame excuses: there simply wasn't sufficient time in modern science training for students to become renaissance scholars and well-published researchers capable of competing successfully for grant dollars. Moreover, to venture into science philosophy required an unhealthy tolerance for time wasted in silly, perfectionistic arguments over whether or not the sun will rise tomorrow. The better path to becoming a successful scientist, I argued, was to function as an apprentice to successful researchers and get on generating data from real-world experiments. After all, I concluded, the quality of your Ph.D. program will be at least equal to my own. Had not my Ph.D. landed me a great postdoctoral experience at Cornell University and an enviable tenure-stream Assistant Professorship at Michigan State University?

To this day, my former student does not realize how that conversation awakened my conscience to the awesome responsibility that educators shoulder in passing the scientific torch across intellectual generations. Although it came too late for my first Ph.D. student, that conversation whetted my sustained appetite and commitment for seeking suitable teaching materials to put some Ph. back

into the Ph.D. degree in science. For three decades now, I have taught a graduate seminar course entitled "The Nature and Practice of Science." This course seeks to leaven the minds of graduate students from across our university with sufficient science philosophy, logic, and best practices for high-impact careers as scientists and educators. Finding no suitable text for such a course, we rely on diverse readings, including John Platt, Karl Popper, Thomas Kuhn, Ronald Giere, and others. Unfortunately, these scholars use differing terminologies that can be confusing, and large gaps are left that cause students and instructors to struggle mightily when attempting to build a unified whole. Due to the limited time graduate students are typically given to pursue this type of interest, our coverage is merely introductory. We lacked an appropriate resource to which interested students could be pointed for further self-study.

It was with relief and enthusiasm that I served as a reviewer for *Scientific Method in Practice* by Hugh G. Gauch, Jr., the predecessor to *Scientific Method in Brief*. Here at last was a comprehensive and up-to-date treatise on the fundamentals of science philosophy and method between the covers of one book and written from the pragmatic perspective of a credible science practitioner with whom researchers could identify. Here would have been the book I should have handed to my first Ph.D. student at the time of her request.

Scientific Method in Brief is more precisely targeted to the needs of both developing scientists and those who have long been doing research but remain open to lifetime learning and improvement. Here is the distilled yet complete version of Gauch's lifetime search for a coherent and practical version of science philosophy for practitioners. Moreover, the current book will be a boon to science educators because it brings into focus the core issues of how and with what degree of confidence we can know scientific truths. Here is a boat to escape from that tiny and intellectually impoverished island of the "classical scientific method" that has held sway for far too long.

Scientific Method in Brief is an eminently readable, understandable, and well-grounded philosophical book in its own right. This book belongs on the shelf of scholars across the intellectual spectrum. Gauch's books represent contributions on a par with the great philosophers of science, many of whom left the field in as much disarray as they found it. As a science practitioner and educator, *Scientific Method in Brief* restores my confidence and commitment in keeping Ph. in front of the D. in Ph.D. Finally, this knowledge is now accessible to anyone who can read and reason.

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