

## Intellectual Curiosity and the Scientific Revolution

### *A Global Perspective*

Seventeenth-century Europe witnessed an extraordinary flowering of discoveries and innovations. This study, beginning with the Dutch-invented telescope of 1608, casts Galileo's discoveries into a global framework. Although the telescope was soon transmitted to China, Mughal India, and the Ottoman Empire, those civilizations did not respond as Europeans did to the new instrument. In Europe, there was an extraordinary burst of innovation in microscopy, human anatomy, optics, pneumatics, electrical studies, and the science of mechanics. Nearly all of those aided the emergence of Newton's revolutionary grand synthesis, which unified terrestrial and celestial physics under the law of universal gravitation. That achievement had immense implications for all aspects of modern science, technology, and economic development. The economic implications are discussed in the concluding epilogue. All these unique developments suggest why, for at least four centuries, the West experienced a singular scientific and economic ascendancy.

Toby E. Huff is a research associate at Harvard University in the Department of Astronomy and Chancellor Professor Emeritus in Policy Studies at the University of Massachusetts, Dartmouth. He has lectured in Europe, Asia, and the Middle East and has lived in Malaysia. He is the author of *The Rise of Early Modern Science: Islam, China, and the West*, second edition (Cambridge University Press, 2003); coeditor with Wolfgang Schluchter of *Max Weber and Islam* (1999), and author of *An Age of Science and Revolutions, 1600–1800* (2005).

# Intellectual Curiosity and the Scientific Revolution

*A Global Perspective*

TOBY E. HUFF

*University of Massachusetts, Dartmouth*



Cambridge University Press  
 978-0-521-17052-9 — Intellectual Curiosity and the Scientific Revolution  
 Toby E. Huff  
 Frontmatter  
[More Information](#)

**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  
 79 Anson Road, #06-04/06, Singapore 079906

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](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9780521170529](http://www.cambridge.org/9780521170529)

© Toby E. Huff 2011

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2011

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

*Library of Congress Cataloging in Publication data*

Huff, Toby E.

Intellectual curiosity and the scientific revolution : a global perspective / Toby E. Huff.  
 p. cm.

Includes bibliographical references and index.

ISBN 978-1-107-00082-7 (hardback) – ISBN 978-0-521-17052-9 (pbk.)  
 1. Science – Europe – History. 2. Science – Experiments – History. 3. Discoveries in science – Europe – History – 17th century. 4. Science – Europe – History – 17th century.  
 5. Science – History. I. Title.

Q127.E8H84 2010

509.4-dc22 2010021876

ISBN 978-1-107-00082-7 Hardback

ISBN 978-0-521-17052-9 Paperback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

## Contents

<i>Illustrations</i>	page vii
<i>Preface</i>	ix
<i>Acknowledgments</i>	xiii
PART I. SOMETHING NEW UNDER THE SUN	
1 Introduction	3
2 Inventing the Discovery Machine	22
3 The New Telescopic Evidence	48
4 The “Far Seeing Looking Glass” Goes to China	72
5 The Discovery Machine Goes to the Muslim World	115
PART II. PATTERNS OF EDUCATION	
6 Three Ideals of Higher Education: Islamic, Chinese, and Western	145
PART III. SCIENCE UNBOUND	
7 Infectious Curiosity I: Anatomy and Microbiology	171
8 Infectious Curiosity II: Weighing the Air and Atmospheric Pressure	209
9 Infectious Curiosity III: Magnetism and Electricity	234
10 Prelude to the Grand Synthesis	253
11 The Path to the Grand Synthesis	267
12 The Scientific Revolution in Comparative Perspective	292
Epilogue: Science, Literacy, and Economic Development	301
<i>Selected References</i>	321
<i>Index</i>	341

## Illustrations

2.1	Medieval Cleric Wearing Spectacles	<i>page</i> 25
2.2	Galilean or “Dutch” Lens System	27
2.3	Keplerian Lens System	27
2.4	Thomas Harriot’s Moon Sketch, 1609	40
2.5	Galileo’s Ink Wash of Shadowed Moon Surface	42
2.6	Transcripted Printing of Galileo’s Jovian Satellite Observations	45
3.1	Galileo’s Pencil Sketch of Jupiter’s Shape	52
3.2	Huygens’ Systematic Representation of Saturn’s Appearances	54
3.3	Phases of Venus in Two Systems Compared	60
3.4	Tycho Brahe’s Geoheliocentric System	63
4.1	Chinese Brochure of 1615 Describing Galileo’s Telescopic Discoveries	77
4.2	First Chinese Representation of the Telescope ca. 1626	85
4.3	New Instruments in the Beijing Observatory ca. 1687	107
5.1	The Mughal Empire, 1605–1707	117
5.2	Recent Photograph of the Taj Mahal	119
5.3	Mid-Sixteenth-Century Portrait of Mir Musavvir	121
5.4	The Royal Instrument (Samrat <i>yantra</i> ) of Jaipur	127
5.5	Function of the Aperture Gnomon of the Royal Instrument	128
7.1	Fourteenth-Century Mansurian (Persian) Muscle System	183
7.2	Vesalius’ Muscle Man	185
7.3	Hooke’s Microscope	189
7.4	Swammerdam’s Queen Bee Interior	194
7.5	De Graaf’s Ectopic Pregnancy	196
7.6	Replica of Leeuwenhoek’s Glass Bead Microscope	199

7.7	Leeuwenhoek's Bacteria	202
8.1	Agricola's Triple-Lift Suction Pump	215
8.2	Constant Height of Mercury in a Vacuum	222
8.3	Von Guericke's Horses Pulling on an Evacuated Hemisphere	227
8.4	Von Guericke's Piston and Vacuum Experiment	228
8.5	Newcomen's Steam Engine	231
9.1	Gilbert's Versorium	241
9.2	Kepler's Magnetic Attraction	244
9.3	Hauksbee's Electrostatic Generator	249
10.1	Eccentric Transformation Device	257
11.1	Kepler's Law of Equal Areas	271
11.2	Alarm Caused by Comet of 1680	276
11.3	Newton's Diagram of the Path of the Comet of 1680	278
11.4	Newton's Area Proof of an Elliptical Path	284

## Preface

Those who think about the long cycles of science and civilizations and the question of why the Western world succeeded as it did may need to anchor their speculations in several mundane facts. When the scientific revolution occurred in the seventeenth century, the United States of America did not yet exist. In 1609, when Galileo made his revolutionary telescopic discoveries, a hardy band of English settlers attempted to establish the Popham Colony on the forbidding coast of Maine. Owing to the harsh winters of New England, the ill-fated colony was gone a year later.

In 1776, when the thirteen colonies banded together to form the United States, the inhabitants of those often wilderness regions numbered perhaps six million. China and India at the time counted more than 100 million subjects each, dwarfing the population of the struggling American colonies. No one would have predicted that the educational, political, and economic institutions being fashioned in those embryonic United States would propel it to become the dominant power in the twentieth century.

Similarly, a population comparison of Western Europe with China and India in the seventeenth century would find a huge excess of nearly 50 percent more people in the Asian regions. Some would say that India and China were then richer in material goods than Europe.

Third, as the present narrative will show, whatever glories ancient China, India, or the Islamic Middle East may have enjoyed in the past, their contributions to the making of modern science were minor. This conclusion will seem shocking to many readers, largely because of the romantic views of China that can be found in histories of it. Likewise, as I suggest in Chapter 10, the Arab-Islamic achievements in mathematics

and astronomy have often been discussed, but their direct influence on Copernicus, Tycho Brahe, Galileo, Kepler, and Newton, among others, has yet to be shown.

Nevertheless, there is little doubt but that the seventeenth-century scientific revolution of Europe gave that part of the world a huge bundle of intellectual capital that was not to be found outside the West for more than 350 years. All the great revolutionary advances in science that occurred from that time to the present were largely, if not wholly, fashioned in the ambience of the West. Given the resistance to the efforts to disseminate the telescope and other scientific advances to other parts of the world in the seventeenth century, described in this study, more searching reviews of the cultural heritages of China, India, and the Islamic Middle East may be needed. At the same time, those who think that we have entered a “Pacific century,” with Asian powers greatly outstripping the Western world, will want to ask themselves just how this might be accomplished. The question is how those Asian societies and civilizations can so rapidly remake themselves as leaders in science, education, and political development against a background of stagnation for centuries between the sixteenth and the present centuries.

Can a resurgent Confucianism now emerging in China give it the necessary twenty-first-century grounding essential for a modern, democratic, borderless economy? Can the growing Hindu nationalism and ultranationalism (Hindutva) of India give it the foundation for the same modern postindustrial, global economy now emerging? And can the new Islamist orientation that has swept the Muslim world in the twentieth century provide the transformative intellectual foundations required for full participation in the increasingly secular, high-tech, knowledge-based economy?

Anyone who ponders the existence of the World Wide Web and its origins in the United States and Europe will doubtless come to the conclusion that many aspects of the extraordinary economic and technological growth of the early twenty-first century were made possible by scientific and technological advances designed in the West. Their globalization has brought seemingly infinite possibilities to all parts of the world. Great economic powers have come and gone, which makes one think that there may be far more gold in properly designed educational institutions and deep commitments to scientific inquiry than there appears to be in the ubiquitous marketplace.

On the roads to modernity, we are accustomed to identifying the Industrial Revolution of the eighteenth century as a great landmark. The



*Preface*

xi

present inquiry will lead us to consider whether that great transformation could have taken place without the scientific revolution and, above all, Newton's *Principia Mathematica* and the related developments in astronomy and the science of mechanics that occurred uniquely in Western Europe. It may be more than coincidence that the absence of those developments in other regions of the world had something to do with the economic and political stagnation that persisted outside Europe (and Europe overseas) all the way to the mid-twentieth century. Such are some of the questions that need to be examined in an age of apparent instant thought and communication that has everyone wired.

## Acknowledgments

While writing this book, I benefited from the knowledge of a very broad range of scholars around the world. They generously answered my questions and supplied me with new materials, invaluable insights, important contacts, and translations of obscure documents. For all their assistance, I want to thank S. M. Razaullah Ansari, David Arnold, Cemil Aydin, Zaheer Baber, Zhang Baichun, Marvin Bolt, Rainer Brömer, Christopher Cullen, Eric Dusteler, Anne Goldgar, S. Irfan Habib, Gottfried Hagen, Al van Helden, Alan Hirshfeld, Minghui Hu, Ekmeleddin Ihsanoğlu, Colin Imber, Cemal Kafadar, Mustafa Kajar, S. R. Karma, Rajesh Kochhar, Chai Choon Lee, Henrique Leitao, Rudi Lindner, Peter Louwman, Debin Ma, John Moffett, Ali Paya, Kapil Raj, Eugene Rudd, Seth Schulman, and Henik Zoomer. Numerous unnamed others aided my enterprise, for which I express my gratitude. To Elfie Raymond, I express appreciation for keen editorial insights. Thanks also go to Jill Rubalcaba for her editorial encouragement during the early phases of writing this book.

I owe a very special debt of gratitude to Owen Gingerich, who read (and reread) all my chapters while supplying me with a wealth of insights, corrected translations of critical passages in Galileo and Copernicus, and an abundance of detail about the history of astronomy. Our almost monthly luncheons during the last four years while I was a research associate in the Department of Astronomy at Harvard were a seminarian's delight, sometimes taking the form of Introduction to Ptolemy 101. Any errant or wayward statements remaining in the book are entirely mine.

I should also express my deep appreciation of the extraordinary resources of Widener Library and its staff, who helped me procure any book or journal article that aided my cause.