

What Your Colleagues Are Saying . . .

“This book is urgently needed. In a time when political tribalism turns even basic scientific facts into targets of cynicism, Bybee offers educators a clear path forward. His work reminds us that teaching the nature of science is not optional—it’s essential if we want students who can think critically, recognize evidence, safeguard truth, and sustain the civic foundations Jefferson saw as vital to the preservation of liberty.”

Robert Pletka

Superintendent, Fullerton School District
Carlsbad, CA

“Dr. Bybee encourages his audience to think, reflect, and implement better teaching practices. I appreciate the work that he has done in providing references for his examples, supporting his claims with citations, and writing clearly for readers. His audience should include not just classroom teachers but also administrators, school board members, and even parents.”

Beverly R. DeVore-Wedding

President, National Science Teaching Association
Meeker, CO

“Today, science denial is pervasive, and teaching some scientific ideas can be challenging. Dr. Bybee offers a powerful yet practical approach to using the 5E Instructional Model that leverages the nature of science to enhance learning across K–12. This book is an invaluable resource for pre-service and experienced teachers as they explore the natural world with students, encourage evidence-rich classroom conversations, and confidently maintain the integrity of science.”

K. Renae Pullen

Science Specialist, Caddo Parish Public Schools
Shreveport, LA

“Dr. Bybee addresses combating science denial with research-based methods and easy-to-use examples that focus on the history and enterprise of science, and how to get others to experience the wonder of the natural world around them, ask questions, and learn ways to gather and assess information. This couldn’t come at a better time for education programs and already practicing educators.

“Now is the time to implement change in science education. Dr. Bybee offers a strong plan for teaching students and others how to evaluate their own conceptions while setting aside politics, public opinions, and their own beliefs.”

Julie Olson

Assistant Professor of Biological Sciences, Dakota Wesleyan University
Mitchell, SD

“This timely reflection of a career in science education is a reminder that science teachers and education leaders have what we need to repair the road to strong science thinking. This book takes the reader through the development and evolutionary histories of the 5E learning cycle and framework for teaching. Using the nature of science as a basis for imagining scientific enterprise in the classroom, the reader can use this book as a blueprint for building lessons that drill down the point that science is a human endeavor.”

Joy Barnes-Johnson

Director of STEM, Foundation Academy Charter School
Willingboro, NJ

“Rodger Bybee has provided science educators with a comprehensive process to address the lack of confidence in science we are facing in this country. The book uses an effective and well-researched teaching and material development strategy that includes suggestions for policies and programs coupled with classroom activities for all levels.”

Harold Pratt

Past President, National Science Teaching Association
Former Executive Director for Science and Technology,
Jefferson County Public Schools
Lakewood, CO

“Science is under attack from all sides and with social media providing students with misinformation, science educators may wonder what they can do to defend it. In this book, Rodger Bybee defines the current problem and provides a practical solution that all science educators can integrate into their classroom.”

Mark Salata

Biology Teacher, LMEC High School
San Diego, CA

“How can teachers address the tidal wave of anti-science rhetoric in today’s media? How about getting down to basics and teaching the science inquiry process using the tried-and-true 5E model?”

Bertha Vazquez

Education Director, The Center for Inquiry
Coral Gables, FL

“Rodger Bybee’s new book draws on his diverse life-long experiences and presents his well-articulated, inspiring case for engaging students in developing an understanding of the scientific enterprise and not just the content of science. His 5E lessons provide easy-to-implement ways to get started and his personal encouragement will bolster teachers in taking on this challenge.

“Our country desperately needs legions of teachers embracing his urgent plea to collaborate with colleagues, turning away from the current anti-science craze, and collectively advocating for learners of all ages to genuinely engage in science thinking and doing science.”

Karen Hollweg

Independent Consultant
Boulder, CO

“*Navigating an Era of Science Denial Using the 5E Instructional Model* reminds us that science education is inseparable from the health of our democracy. Rodger Bybee brings unmatched credibility to this work, weaving together the 5E Instructional Model, the nature of science, and contemporary standards into a coherent and compelling response to anti-scientific thinking. This book provides educators with a practical, research-based approach to teaching the nature of science at a time when it matters most.”

Jim Short

Program Co-Lead, Catalyst Fund for Science Education
Renaissance Philanthropy

NAVIGATING AN ERA OF SCIENCE DENIAL Using the 5E Instructional Model

*For Kathryn Bybee, who
devoted her educational career to
helping students and teachers who
needed it most.*

NAVIGATING AN ERA OF SCIENCE DENIAL Using the 5E Instructional Model

A Guide for
Teachers

Rodger W. Bybee

A Joint Publication

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Contents



Preface	xiii
Organization of This Book	xiv
Closing Reflections	xv
Acknowledgments	xvii
About the Author	xxi
Section I: Is the American Scientific Enterprise Sailing, Drifting, or Sinking?	1
Chapter 1. Maintaining the Integrity of Science: A Contemporary Crusade	3
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Reflections on the Role of Science in Society	4
“A Crusade Against Ignorance”	5
A Crusade to Maintain the Integrity of Science (and Other STEM Disciplines)	6
Conclusion	7
Chapter 2. Teaching About the Scientific Enterprise in an Era of Science Denial	9
<hr/>	
A Vision and Plan: Something You Can Do in Your Science Classroom	11
Background: Understandings About Science	12
Reintroduction of the 5E Instructional Model	14
Conclusion	15

Section II: A Helm for Science Teachers to Grasp 17

Chapter 3. The 5E Instructional Model: A Reintroduction and a Review of the Model's Efficacy 19

A Little Background	19
The 5E Instructional Model	21
How Students Learn	24
Constructivism Emerges	26
Conclusion	32

Chapter 4. Using the 5E Instructional Model in Your Classroom: Reflections and Recommendations 35

How the 5E Instructional Model Works in a Classroom	35
Classroom Testimony: A Case Study of Uptake of the 5E Instructional Model by <i>Janet Carlson</i>	39
Conclusion	42

Chapter 5. Frequently Asked Questions About the 5E Instructional Model 45

Answering Questions About Using the 5E Instructional Model to Situate the Model Within <i>Your Classroom</i>	45
Conclusion	54

Section III: A Course for Teachers to Steer 55

Chapter 6. Contemporary Science Standards and the Scientific Enterprise 57

The Need to Teach About the Scientific Enterprise: Current and Past	57
A Framework for the Nature of Science	59

Learning Outcomes for the Activities That Appear in the Chapters That Follow	62
Classroom Testimony: Advancing Students' Knowledge About the Nature of Science by Peter J. McLaren	68
Conclusion	72
Chapter 7. Applying the 5E Instructional Model in Grades K–2	73
Lesson Plan: Looking for Patterns and Order	75
Conclusion	79
Chapter 8. Applying the 5E Instructional Model in Grades 3–5	81
Lesson Plan: Using Tools for Measurement and Observations	83
Conclusion	88
Chapter 9. Applying the 5E Instructional Model: An Example for Middle School	89
Lesson Plan: The Basis for Scientific Knowledge and Rules for Empirical Evidence, Grades 6–8	91
Classroom Testimony: Teaching About the Nature of Science: A New Challenge by <i>Kenneth Huff, Heather Kurtz, and Teresa Guadagna</i>	105
Planning and Carrying Out Instruction	105
Results	107
Conclusions and Recommendations	107
Conclusion	109
Chapter 10. Applying the 5E Instructional Model: An Example for High School	111
Overview of the Unit	112
The Instructional Perspective	112
Lesson Plan: Beluga Whales in the St. Lawrence River: What Is the Scientific Question? Were Scientific Investigations Adequate?	114
Conclusion	130

Section IV: A Port for Teachers to Seek	131
Chapter 11. Applying the 5E Instructional Model to Improve and Implement Units of Your Own Curriculum	133
Basic Principles for Your Unit's Improvement and Change	135
Analyzing Your Unit	139
Conclusion	148
Chapter 12. Meeting the Challenges of Maintaining the Integrity of Science (and Related Disciplines)	149
Examples of Maintaining the Integrity of Science	150
Recap	151
An Example of Science Teacher Leadership	152
Conclusion	153
References	155
Index	161



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Preface



Recent times have witnessed an extraordinary array of concerns, doubts, denials, and disregard for science as the basis for explaining issues related to personal and community health, use of resources, environmental quality, and natural and human-created hazards.

At the federal level, there are numerous examples of the fact that science has been marginalized or denied in the formation, execution, and maintenance of policies. Examples of the consequences of limited or no scientific advice and the marginalization of science include

- The disbanding of science advisory boards
- Reduction of personnel at the National Oceanic and Atmospheric Agency (NOAA)
- Severe reductions in workforce and budget for the National Science Foundation (NSF)
- Research and academic program cuts at universities across the United States
- Appointments of key administrators with questionable qualifications to other mission-oriented agencies such as the National Aeronautics and Space Administration (NASA), Environmental Protection Agency (EPA), and National Institutes of Health (NIH)
- Significant brain drain of scientific expertise

These examples signal to the scientific and science education community that now, more than ever, it is essential to maintain the integrity of science in science education. In this book I argue that this goal can be partially accomplished by explicitly introducing core ideas about the scientific enterprise and the nature of science in science education.

Certainly, science teachers have concerns about the aforementioned issues and ask, What can I do that is professionally appropriate and personally achievable? Teaching students *about* science along with the content is one positive answer to the question.

Organization of This Book

The book presents a sequence of topics, background, and actions that accommodate science teachers' social and professional concerns and contribute to students' knowledge about science. The content uses perspectives that are societal, historical, philosophical, and psychological but always emphasize the practical issues of professionals' teaching and students' learning.

To achieve these broad goals, I have written the chapters to speak directly to you, classroom teachers and school leaders, who have concerns about contemporary anti-scientific views and your need to respond with positive and effective instructional programs.

In the first section, we will discuss the state of the American scientific enterprise. Chapter 1 calls for a contemporary "crusade" to maintain the integrity of science. Chapter 2 introduces the scientific enterprise and also introduces the 5Es of the instructional model on which this book is organized.

Section 2 presents foundational knowledge all teachers need to teach science. In Chapter 3 we delve deeper into the 5E Instructional Model and also discuss its contemporary implications. Chapter 4 explains in detail how to implement the model in your own classroom. Chapter 5 presents frequently asked questions.

Section 3 presents a roadmap for K–12 science teachers. It begins with Chapter 6, which lays out the framework for the eight categories of the nature of science according to the *Next Generation Science Standards* (NGSS). The framework includes learning outcomes for each of the categories at grade levels K–2, 3–5, middle school, and high school. The chapter discusses how categories and learning outcomes can be used as the basis for instructional materials based on the 5E Instructional Model.

Chapter 7 discusses how to apply the 5E Instructional Model with an example for Grades K–2, Chapter 8 discusses an example for Grades 3–5, Chapter 9 presents an example for middle school, and Chapter 10 offers an example for high school.

The last section of the book, Section 4, begins by presenting in Chapter 11 a process to show educators how to begin and answer the

question, “What can I do in my classroom?” This chapter focuses on allowing you to read the suggestions today and implement tomorrow. In Chapter 12 the book concludes with a call to action, so that science teachers today will be equipped and motivated to meet the challenges of maintaining the integrity of science.

Closing Reflections

I wrote this book from the perspective of a science educator who was initially concerned about the reduced potential for educational changes due to the denial and misinformation about a variety of science- and health-related educational problems.

With time I realized one challenge clearly involved the continued lack of understanding about the scientific enterprise and the nature of science within the general population. One place to address this challenge is within K–12 science education.

The science and education communities need a concerted, coordinated, and sustained effort to bring content, understanding, and abilities from the farthest reaches of the disciplines into prominent positions in national and state policies, school programs, and classroom practices.

There is an immediate need for the science education community to recognize its role as the significant representative of the scientific enterprise to all students as future adult citizens. We must think differently about school programs and classroom practices. The actions recommended in this book are reasonable, measured, and certainly timely.

The effort to improve science, and by extension STEM education, can and must begin with K–12 classroom teachers. The action plans proposed in this book recognize the contemporary situation and the unique circumstances of classroom teachers. I have tried to answer the common question

“What can *I* do?”

with instructional changes that include

- Content about the scientific enterprise in general and the nature of science in particular
- An effective instructional model
- Learning outcomes from contemporary standards

- The opportunity to adapt a general instructional sequence to accommodate teachers' unique knowledge and understanding of their school, and especially their students

I realize the complexity of the problems associated with the pervasiveness of anti-science views and acknowledge that introducing students to the scientific enterprise and the nature of science does not address the larger problem.

But it may help.

And it is something you can *do*.

Rodger W. Bybee
Golden, Colorado
January 2026

Acknowledgments



This book had a unique beginning. In March 2025, Debbie Hardin, executive content leader for Corwin, contacted me about writing a book on the 5E Instructional Model as a way to increase scientific literacy—a requirement we both recognized in light of the escalating political tension around both education and science. The initial discussion was positive and ideas for the book progressed rapidly.

So did the timeline.

We realized the urgency of the book as the current administration continued to reduce priorities for science in the United States. In response, we decided to accelerate the publication of this book because we believed (and believe) that we needed to help educators equip students for the future by offering ways to teach the scientific enterprise as a method of navigating the science denial era. And we knew we needed to do it *now*.

With the book published, I'd like to acknowledge the many individuals who expressed support; several deserve special gratitude:

- Lyn Massey, my assistant since 2023, who had not worked in the world of publishing books with the associated issues of unique editing, demanding timelines, multiple drafts, and response to reviewers. Lyn met these and other related challenges with interest, motivation, and the wonderful capacity of grace—the capacity to be understanding and helpful. Unfortunately, Lyn had to conclude her work on the project in September 2025.
- As a final deadline approached, Pamela Berkman joined the project. From the beginning she recognized the situation and accepted the challenges, some small, others large. I extend a considerable measure of gratitude to Pam.

- Byllee Simon also contributed to the manuscript's preparation of several sections for final submission. My appreciation for Byllee's contributions is deep and sincere.
- My wife, Kathryn, whose understanding of this project was special, sincere, and continuous. As an experienced teacher and science coordinator for San Diego Unified School District, she brought helpful criticism, contemporary insights, and unconditional support for the themes.

In addition, Janet Carlson, who was on the original team that developed the 5E Instruction Model, was helpful. Her review of my initial ideas for this book and later recommendations and contributions are all sincerely appreciated.

In addition to Janet Carlson, Peter McLaren and the team of Kenneth Huff, Heather Kurtz, and Teresa Guadagna provided insightful essays expressing their understanding and support for the book's topics and practical contribution for teachers. The insights and contributions are greatly appreciated.

Harold Pratt has been a colleague and friend for five decades of my career. During many breakfast discussions, he has not hesitated to give his honest advice, which is grounded in a deep understanding of science and education.

Reviewers of an earlier proposal for this project gave insights and recommendations that resulted in changes and improvement of the book. Those reviewers include Beverly Devore-Wedding, Bertha Vazquez, Jim Short, Cyndi Long, and Karen Hollweg. Additional reviewers of the manuscript included Peter McLaren, Kenneth Huff, Joy Barnes-Johnson, and Mark Salata.

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With My Deepest Appreciation to All,
Rodger

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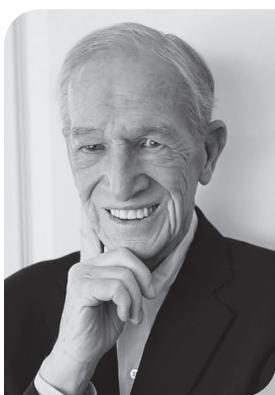


Photo Credit: Kathryn Bybee

Rodger W. Bybee is a leading voice in science education, renowned for heading a team of colleagues at the Biological Sciences Curriculum Study (BSCS) in developing the BSCS 5E Instructional Model, a dynamic framework that empowers students to learn through inquiry and discovery. Likewise, he was instrumental as a writing team leader for the *Next Generation Science Standards* (NGSS). Dr. Bybee completed his PhD in science education at New York University.

Throughout his career, Dr. Bybee spearheaded national efforts to modernize science curricula and expand professional development for educators. His academic career spans all levels of teaching, from elementary classrooms to university lecture halls, and includes a professorship at Carleton College. Dr. Bybee also served as executive director of the National Research Council's Center for Science, Mathematics, and Engineering Education, where he played a pivotal role in shaping the 1996 *National Science Education Standards* and chaired the content working group for that initiative. He advised on science content for the National Assessment of Education Progress (NAEP) and Trends in Math Science Study (TIMSS), and he was chair of the science expert group for the 2006 Program for International Student Assessment (PISA).

A prolific author and respected scholar, Dr. Bybee has written several foundational texts, including *Achieving Scientific Literacy: From Purposes to Practices* and *The BSCS 5E Instructional Model: Creating Teachable Moments*. His work with the National Academies, the U.S. Department of Education, and the National Science Foundation reflects

his deep commitment to advancing STEM education at the highest levels. These contributions have earned him numerous accolades, such as Outstanding Science Educator of the Year, the Distinguished Service to Science Education Award by the National Science Teachers Association (NSTA), the first-ever American Institute of Biological Sciences Education Award, and the Robert H. Carleton Award (the highest honor from the NSTA) for his leadership and impact on science education. Through both scholarship and practice, Rodger Bybee has inspired generations of educators to make science accessible, engaging, and relevant.

Is the American Scientific Enterprise Sailing, Drifting, or Sinking?

Author and historian Henry Adams (1838–1918) once said, “The President resembles the commander of a ship at sea, he must have a helm to grasp, a course to steer, a port to seek” (Adams, 1870/1958, p. 197). These three important insights inspired me in the organization of this book.

Denial, *dismantling*, and *crisis* are all terms that describe a pervasive contemporary view of the scientific enterprise in the United States. So, continuing the maritime metaphor, in our current situation we certainly are not sailing: we are drifting at best and sinking at worst. This evaluation is based on the chaos and confusion relative to the current administration’s approaches to funding research programs in federal agencies and priorities concerning significant state, regional, national, and global challenges concerning personal and community health, natural resources, environmental quality, and natural and human-induced hazards.

In this section, I reflect on the role of science in contemporary society and call for a “crusade against ignorance” that culminates in advice about what classroom teachers can do to act against the science denial we are seeing throughout the United States.

Maintaining the Integrity of Science

1

A Contemporary Crusade

In this chapter, we will

- **Review contemporary challenges to the scientific enterprise**
- **Propose a response by the science education community**

We are living through an extraordinary and disturbing historical era for science and science education. Conspiracy “theories,” “alternative facts,” misinformation, mistrust, denial, dismantling, and rejection are terms that describe a pervasive view of anti-science. The implications for individuals and society are already significant and will get worse. I’m confident that many, if not most, in the science education community are having the same concerns. These concerns may be expressed as helplessness because the problem is seemingly beyond an individual’s control.

So, what can we *do*?

I argue that this situation presents us all as educators with the grand challenge to maintain the integrity of science. How? The science education community can teach students *about* the scientific enterprise and the nature of scientific work, so that they are more discerning, skeptical consumers of media and more informed citizens.

I wrote the first draft of this chapter in late April 2025, the time frame within the current administration’s first 100 days. At this time the administration had laid off thousands of scientists working in federal agencies, for example, meteorologists at the National Weather Service and experts for pandemic preparedness at the Center for Disease Control; ended the contract for the U. S. Global Change Research Program; and eliminated the scientific component of the Environmental Protection Agency. The administration had also already cut \$2.7 billion in National Institutes of Health (NIH) research funding; and the National Science Foundation (NSF) had discontinued funding of 1,400 grants that amount to \$1 billion. The list goes on and on (and since April, more cuts have occurred). It is

clear that the current administration has targeted the American scientific enterprise for significant reduction.

As if this wasn't enough, in addition, the administration wants to change what defines and differentiates science for other disciplines—in other words, what *counts* as science. For example, there's indication the administration supports the propagation of conspiracy theories and at the same time wants to eliminate grants to study misinformation and reduction or avoidance of politically off-message topics. That is, for the administration, only research that confirms its political positions should be supported—not the scientific research that presents the facts, in other words, the truth. This position should be stunningly alarming to all in the scientific and science education communities.

The American scientific enterprise has revolutionized weather forecasting, especially for severe weather events; brought cures for numerous diseases and prevented others; and contributed to the Intergovernmental Panel on Climate Change. To state the obvious, the United States has provided national and global leadership around science, and this will all change under the current administration. But of deepest concern should be the administration's desire to redefine what counts as science. This alarming change is a compelling reason for K–12 science education to teach *about* the scientific enterprise and especially the nature of science.

Reflections on the Role of Science in Society

Throughout history, individuals and societies have observed the natural world and sought explanations for their observations. In addition, individuals and societies have confronted various problems that required solutions to better satisfy basic human needs, enhance safety, and achieve personal and social aspirations. In the sense just described, science, technology, engineering, and mathematics (STEM) developed and helped humans adapt.

In contemporary society scientists, technologists, engineers, and mathematicians continue pursuing their aims of gathering knowledge and solving problems. An excellent example occurred in 2021 when, with federal support, Pfizer and Moderna, two pharmaceutical companies, developed, tested, and had Food and Drug Administration (FDA) approval for Covid-19 vaccinations, all less than a year after the pandemic began.

In contrast to the positive advances in science and health are contemporary publications such as *Unscientific America* (Mooney & Kirshenbaum, 2009), *The War on Science* (Otto, 2016), *The Death of Expertise* (Nichols, 2017), and *Science Denial* (Sinatra & Hoffer, 2021). The literature just

cited and the continuing discord about science and related disciplines have resulted in confusion, distrust, and denial about the causes, consequences, and solutions to the Covid-19 pandemic and global climate change. For example, some citizens refused vaccinations while others argue that climate change is a hoax. (There's even a growing, albeit still small, contemporary belief in a flat Earth.) The widespread incomprehension, resistance, and renouncement of science and STEM present a grand challenge, one that underlies Covid-19 and climate change and extends to the future.

It is time for us as educators to acknowledge the marginal success of past methods of teaching the integrity of science. We need to establish different approaches that support the integrity of science in school programs and present an appropriate professional position for how science works (i.e., the nature of science) as a way to answer science denial. This chapter and the next answer the question, "What should the science education community do?"

Here is my short answer: while still teaching the content of science and other STEM disciplines, we should increase our emphasis on developing students' understanding of the scientific enterprise, including the nature of science.

While still teaching the content of science and other STEM disciplines, we should increase our emphasis on developing students' understanding of the scientific enterprise, including the nature of science.

"A Crusade Against Ignorance"

In 1786, Thomas Jefferson wrote George Wythe, his friend and advisor. In that letter Jefferson stated his pleasure that the Virginia legislature had finally agreed to enact a statute for religious freedom that he had proposed seven years earlier. In the same letter, Jefferson expressed concern about a bill that still had not passed. The latter addressed a need "for the diffusion of knowledge among the people. No other such foundation can be devised for the preservation of freedom and happiness." Jefferson admonished his friend,

Preach, my dear Sir, a crusade against ignorance; establish and improve the law for educating the common people. Let our countrymen know that the people alone can protect us against these evils, and the tax which will be paid for this purpose is not more than the thousandth part of what will be paid to kings, priests, and nobles which will rise up among us if we leave the people in ignorance. (Cited in Lee, 1961, pp. 99–100)

Our approach should shift from pointing out the numerous errors of science and reasoning among those who try to subvert the science to providing all citizens with a deep and rich understanding of the history and nature of science in general and of contemporary challenges in particular.

Continual attacks and dismissal by some individuals and groups bring to light the irony of Jefferson's plea for diffusion of knowledge among the people. Because the denial and dismissal of science continues and past strategies have been less than effective, we must mount a contemporary crusade against ignorance. The STEM education community in general should reexamine where we want to go with this crusade, so that we shift from attempts to deflect those who attack constructive educational efforts for our future citizens. Our approach should shift from pointing out the numerous errors of science and reasoning among those who try to subvert the science to providing all citizens with a deep and rich understanding of the history and nature of science in general and of contemporary challenges in particular.

A Crusade to Maintain the Integrity of Science (and Other STEM Disciplines)

Relative to public policy and the ability to address issues such as climate change and a global pandemic, the STEM disciplines are essential, yes, but alone they only point toward what *can* happen, not what society *should* do (or should *not* do). Evidence from science or plans from engineers can help to moderate, avoid, or reduce the consequences of science-related grand challenges. Knowledge from science (and STEM disciplines) and the efficacy of that knowledge to provide the best policies is predicated on the integrity of the processes that produced the scientific knowledge, engineering designs, technological products, and mathematical analysis.

So, while science can provide answers for basic questions, like What can happen? What are the odds? How do scientists, technologists, engineers, and mathematicians know what *will* happen? STEM professionals do not directly answer the question, "What *should* we do?" The answer to that question must consider comprehensive human dimensions. But to consider only personal, political, or economical views is to proceed on a path headed for disaster because emerging and reemerging infectious diseases can and will continue. Another pandemic can happen. As global climate changes continue to increase, the frequency and severity on social consequences such as weather events will also increase. With the current administration's changes to the scientific enterprise, adequate and appropriate responses will be lacking or deficient. In short, as a society we will not be able to react quickly and effectively. We need citizens who understand and support the integrity of science.

I am not alone in having these concerns about the support for the integrity of science. Bruce Alberts, past president of the National Academy of Science and a strong advocate for education in the sciences, suggests “a major rethinking of the goals and methods of science education at all levels—from kindergarten through college” (Alberts, 2017, p. 1353). He goes on to make clear the aim of producing citizens who understand the nature of the scientific enterprise and making sure that “every student understands exactly how scientific knowledge is generated” and learning that evidence and logic for decision-making should become the central goal of all science education (p. 1353). Other prominent scientists have affirmed the importance of scientific integrity and the need to recognize the fundamental role of science in society (see, e.g., Holt, 2016, 2021; McNutt, 2015; Schaal, 2017).

Are K–12 science education programs and practices providing all they should do for citizens’ participation in a democratic society? Given the current evidence, the answer must be for us all: no.

There is an obligation for all of us to ask: are K–12 science education programs and practices providing all they should do for citizens’ participation in a democratic society? Given the current evidence, the answer must be for us all: no.

Conclusion

The current administration’s negative perspective on basic scientific knowledge and accumulated evidence sent sharp and clear signals to the science community and many citizens. Dismissing knowledge about the global pandemic and evidence about the world’s changing climate escalated the urgency for educators to introduce activities that educate students about the nature of science.

Science education has a history of goals aligned with the nature of science. Research indicates, however, that those goals are seldom attained by students and recognized by teachers (see, e.g., Abd-El-Khalick, 2014; Lederman & Lederman, 2014). In later chapters I will point out that the *Next Generation Science Standards* (NGSS Lead States, 2013) *does* include the nature of science. And I will continue to argue that now is the time to give the scientific enterprise and the nature of science priority in school science programs.

The essence of this chapter is a rationale for an educational response to the dismissal of scientific expertise and the science denial that pervades society. The science education community must pause and ask, What is a constructive and appropriate response to the devaluation of the integrity of science and related disciplines? I have proposed a general answer: science educators should assume the responsibility of developing

