BOOK REVIEWS

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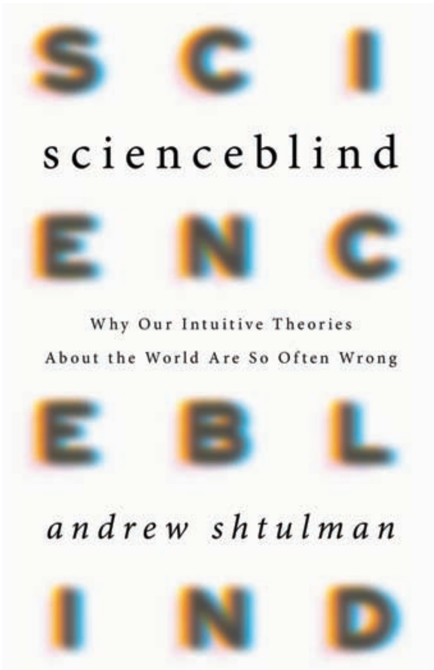

PUBLIC PERCEPTIONS OF SCIENCE

Scienceblind: Why Our Intuitive Theories About the World Are So Wrong. By Andrew Shtulman. 2017. Basic Books. (ISBN: 9780465053940). 311 pp., illus. Hardcover $30.00.

Science denial has been a major issue of concern in recent years. Many factors have been proposed as the cause of science denial, including political ideology, religious ideology, and purveyors of misinformation and doubt like antievolutionists, anti-vaccination proponents, and climate change skeptics. In *Scienceblind*, Andrew Shtulman, associate professor of psychology and cognitive science at Occidental College, discusses yet another factor that contributes to skepticism about established science. Shtulman provides an overview of intuitive theories about the world that develop early in life, have been consistently found in people of all ages, across many different cultures, and throughout history. These intuitive theories can pose barriers for students trying to learn many of the well-established, but counterintuitive, theories central to the biological and physical sciences. Shtulman argues that, "To get the world right we need to do more than just change our beliefs; we need to change the very concepts that articulate those beliefs. That is, to get the world right, we cannot simply refine our intuitive theories; we must dismantle them and rebuild them from their foundations" (p. 5). This poses particular challenges for designing science instruction.

Scienceblind provides a very readable introduction to a vast literature on science misconceptions that stretches back to the early 1980s. The book opens with a chapter entitled "Why we get the world wrong," providing an overview of the concept of intuitive theories. Most of the remainder of the book is divided into two parts, one summarizing research on intuitive theories in the physical sciences and the other, the biological sciences. An example of an intuitive theory of adaptation familiar to biologists is the inheritance of acquired characteristics where species evolve due to environmental pressures that cause a need for change, and all individuals in the population simultaneously respond to this need by adapting their anatomy, physiology, or behavior in order to survive. The well-established scientific theory is, of course, Darwin's theory of natural selection, which is a two-step process involving the generation of random variation followed by selection. In Darwin's theory many individuals die without having successfully passed on their genes to the next generation. Only a select few successfully reproduce. This causes the population to evolve, not the individual organisms.

Intuitive theories are grounded partly in innate expectations and partly in concepts that emerge early in a child's development. By school age these foundational concepts form students' common-sense intuitions about the world, and when scientific ideas clash with them, the common-sense ideas usually win out (Bloom & Weisberg, 2007). For example, essentialism is a foundational belief that objects have a set of observable characteristics determined by an immutable underlying nature that cannot be seen, but that gives the object its identity. Essentialism is important for learning concepts, but can interfere with learning natural selection. Students who view evolutionary change through an essentialist bias see evolution as the simultaneous transformation of the essence of all individuals in a population, rather than as the survival and reproductive success of only a select few organisms from each generation.

In addition to the intuitive theory of adaptation, the section of the book on intuitive biological theories also includes chapters on life, growth, inheritance, illness, and ancestry. A careful reading of the chapter on ancestry will help the reader understand why nonscientists continue to challenge evolution by asking, "If humans evolved from chimpanzees, then why are chimpanzees still around." The section of the book dealing with intuitive theories of the physical world also contains chapters that may be of interest to biologists. For example, the chapter on intuitive theories of energy may be relevant for helping students to understand energy transformations at the cellular and molecular level. There is also a chapter that addresses intuitive theories of the earth (continental drift) and climate that may interest biologists.

The book closes with a chapter entitled "How to get the world right," where Shtulman discusses some educational implications of our knowledge of intuitive theories. He concludes that science denial is unavoidable. Grounded in innate expectations and our earliest attempts to understand causal relationships in the world, intuitive theories are coherent and robust.

But there is hope. Many of the chapters on the various intuitive theories discuss educational interventions that have been successful in helping students overcome the barrier that an

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intuitive theory can impose to learning a well-established scientific theory. Shtulman writes, "Any educator who wants to help students confront and correct their intuitive theories needs to tailor his or her instruction to those theories" (p. 245). The key is to guide students through an evaluation of the intuitive theory and its well-established scientific counterpart. Students need a clear demonstration of how the intuitive theory fails to adequately explain the phenomenon in question, followed by a clear demonstration of how the scientific theory adequately explains the phenomenon. *Scienceblind* is a book that all science teachers should read, if only to sample the chapters relevant to their discipline, whether it be biology, chemistry, physics, or earth science. The ideas in this book have important implications for designing instruction and planning both formative and summative assessments that will challenge students to confront their intuitive theories and rebuild their understanding of the world. *Scienceblind* provides a fine illustration of how cognitive science can inform the practice of science teaching, just as the biological sciences inform the practice of medicine.

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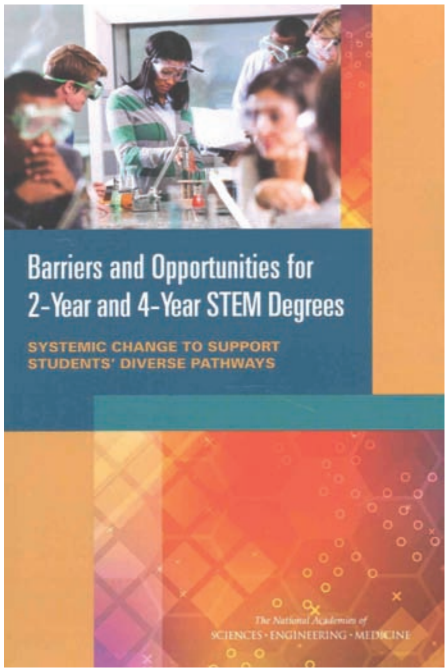
Reference

Bloom, P., & Weisberg, D. S. (2007). Childhood origins of adult resistance to science. *Science 316*, 996–997.

SCIENCE PATHWAYS IN EDUCATION

Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways. By National Academies of Sciences, Engineering, and Medicine. 2016. (ISBN: 978-0-309-37357-9). Paperback. $54.00.



Barriers and Opportunities for 2-Year and 4-Year STEM Degrees is generated from many white papers compiled on a multitude of factors affecting undergraduate STEM student success. The data extracted from these white papers illuminates the numerous influences that can affect STEM degree attainment. The book begins with two overarching questions: (1) Why do so many students who start out pursuing STEM lose interested before degree completion, and (2) How can we improve the quality of the STEM educational experience? The authors go a step further and identify several common barriers to STEM education success: poor advising; not prepared for rigor; stereotypes from faculty or peers; unwelcome environments; and uninspired teaching.

Early on in the book, we are re-acquainted with some hopeful facts and figures that are likely familiar. For instance, those holding STEM degrees have higher salaries and lower levels of unemployment than other fields. Also, the pay gap between male and female workers is less for those holding STEM degrees than other fields. And in the classroom, with much praise to the *Vision and Change Call to Action*, best practices such as active learning, group work, and feedback from instructors have shown improvements in the learning and culture in STEM classrooms. The first chapter also points out some tidbits that may be less widely known. Did you know that most people with STEM degrees are not working in STEM fields? And that there are more minority and single parent students pursuing STEM degrees than ever before? Interestingly, in active learning environments, the achievement gap between black and white students is decreasing. Furthermore, the achievement gap between first-generation and traditional students was eliminated altogether!

But after that, the picture starts to get a bit grim, particularly for two-year college STEM students. Two-year college students make up over 40 percent of the total undergraduate population, yet two-year college STEM students are switching out of STEM majors at higher rates than their four-year college counterparts. Unfortunately, the authors did not provide any reasons for this attrition or possible solutions. However, they did provide several excuses: it is natural that some students would switch out, and perhaps students are switching to majors that are more suited to their perceived abilities.

This is in direct contradiction to an earlier statement in the book that we (students, advisors, instructors, administrators) should not base students' chance of STEM success on their perceived natural abilities. I thought they made a good point in this section, as they mention that perceived abilities are most likely attributed to early exposure to science and math. Since it is likely that students in low socio-economic environments for their primary and secondary education would not have early exposure opportunities, they would never even have the chance to build their abilities in science and math aptitude.

The most interesting aspect of the book is the discussion of the role that the "culture of science" plays in pushing students out of STEM. The idea that some students are naturally inclined toward science are outdated, but still largely perpetuated. The lack of visible scientists of color has a negative impact on the perceptions of students of color. The highly competitive nature of introductory science courses and the rigid structure of course sequencing delays movement through the majors. Institutions do not incentivize and rarely support the use of best practices and professional development. Even if institutions invested in this area, this is unlikely to make a large impact, because these practices have been shown to be most effective in introductory-level courses, which are widely taught by part-time instructors who typically don't have access to institutional professional development programs.

In the end, the authors assert that research shows that STEM classrooms can be unwelcoming. But they also make it clear that there is not enough data to really understand the effect of barriers or best practices in STEM education. If you consider yourself an engaged instructor and use best practices in science education in your classrooms and labs, this is probably not the book for you. However, if you are looking for data to support funding and programming for STEM retention and success programs on your campus, or if you are an administrator who would like to support or promote such efforts, then this book has all the data you need to build a strong case for the work ahead.

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