# The Psychology of Science and the Origins of the Scientific Mind

**Gregory J. Feist**

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# Contents

# Preface

Scientific thinking is a hallmark intellectual achievement of the human species. Science involves myriad cognitive and intellectual processes, including abstract and symbolic thought; reasoning and logic; pattern recognition; planning; problem solving; creativity; hypothesis testing; mathematical, analytical, and spatial reasoning; intuitive hunches; chance associations; and the art of coherent and cogent verbal expression and persuasion, to mention but a few of its qualities. Science is first and foremost a cognitive activity of the highest order.

Scientists also think and behave in social contexts; have particular talents and aptitudes; grow up in specific households with particular family structures and influences; have unique personalities that make scientific thought and behavior more rather than less likely; and are motivated by curiosity, intrinsic pleasure of discovery, and the triumph of figuring out how things work. That is, scientific behavior, interest, talent, and achievement stem from basic topics of focus in the field of psychology. Psychological principles are at work with all scientific thought and behavior. Simply put, there is a psychology behind science.

The chief objective of this book is to justify the need for a fully developed discipline of the psychology of science and to lay the foundations for such a field. To this end, I have two related yet distinct ambitions. One is to organize and codify the nascent discipline of the psychology of science and thereby demonstrate the field's potential for joining the ranks of the major science studies disciplines (history, philosophy, and sociology). The second is to examine the evolutionary and historical origins of the scientific mind. If we wish to understand something as complex as scientific thinking and behavior, a basic understanding of how the human mind evolved is in order. The book is divided according to these two goals, with part 1 focusing on the development of scientific interest and talent within certain groups of individuals, and part 2 on the development of science within our species.

The guiding assumption behind the psychology of science is that a complete understanding of scientific thought and behavior requires a psychological perspective. As one prominent psychologist of science, Dean Keith Simonton, wrote in *Scientific Genius:* "Without the addition of a psychological dimension, I believe, it is impossible to appreciate fully the essence of the scientific imagination. And without this appreciation, the origins of science, the emergence of new ideas about natural phenomena, must escape our grasp. Psychology is mandatory if we wish to comprehend the scientific genius as the generator of science." This is what the psychology of science is all about: to understand scientific thought and behavior we must apply the best theoretical and empirical tools available to psychologists. And what psychology has to offer the studies of science is indeed unique. For instance, only psychologists of science bring the experimental method (that is, random assignment of participants to conditions and manipulation of an independent variable) to the study of scientific thought and behavior. Also, in contrast to the history and philosophy of science and in common with the sociology of science, psychology tests hypotheses by means of statistical analysis of data.

In addition to the experimental technique and hypothesis testing, psychology can borrow from historians and examine case studies and apply principles of behavior gleaned from the laboratory to the analysis of great figures in science. Consider the case history of one of the best-known and most influential scientists of all time, Charles Darwin. In *The Descent of Man* he wrote: "I have no great quickness of apprehension or wit . . . my power to follow a long and purely abstract train of thought is very limited . . . [but] I am superior to the common run of men in noticing things which easily escape attention, and in observing them carefully." Darwin's own self-evaluation of his strengths and

weaknesses gives a glimpse into his own self-concept—clearly a psychological concept. Moreover, ability with abstract thought, attention, and focus on details are very much psychological in nature; cognitive psychologists among others have much to say about these aptitudes. What precisely is the association between Darwin's life and personality and his science? In this book I propose that we can fruitfully apply the methods and theories of modern psychology to shed light on these sorts of questions.

To a psychologist of science it is obvious that scientific thought and behavior are the outcomes of a person's cognitive style and aptitudes; affective, motivational, and developmental histories and proclivities; and their unique and stable personality traits and social influences. These topics, after all, are the bread and butter of current psychological inquiry and psychological science. And given the importance and uniqueness of scientific thinking and behavior over the course of history, one would think that a large number of psychologists would have long ago systematically applied their theories and empirical methods to understanding science. Surprisingly, until the late 1970s there was little accumulated knowledge concerning topics in the psychology of science. As Michael Mahoney wrote in a 1979 article in *Social Studies of Science,* "In terms of behavior patterns, affect, and even some intellectual matters, we know more about alcoholics, Christians, and criminals than we do about the psychology of the scientist."

Twenty-five years later, however, this paucity of psychological research on the nature of scientific interest, thinking, creativity, and achievement no longer holds. This book summarizes, organizes, and critiques the vast literature on the psychological processes of science and scientists by offering one of the first comprehensive views of a nascent discipline. One major thesis throughout the book is that numerous studies exist that inform questions of the psychology of science, but until now they have not been contextualized as such.

If the psychology of science has been late in developing, the same does not hold for the three major studies of science, namely, history, philosophy, and sociology. For instance, the history of science began to emerge around the 1840s, the philosophy of science around 1900, and the sociology of science around 1930. These "studies of science" (or "metasciences") devote systematic attention to such questions as what distinguishes scientific from nonscientific knowledge, what is the historical context to great scientific discoveries (for example, the theory of evolution or quantum mechanics), and what are the sociological and political forces behind becoming a have or a have-not in science. By understanding how and when other major studies of science emerged and became

viable independent disciplines, psychologists of science will be better positioned to facilitate their own field's development and independence. In chapter 1 I consider these issues.

In chapters 2 through 6 I review the empirical literature in the psychology of science by summarizing and organizing it along the lines of the major subdisciplines of psychology, namely, biology-neuroscience, development, cognition, personality, and social. In addition to reviewing and organizing the literature, I also argue that scientific thought and behavior deserve more attention from psychologists and that the psychology of science deserves more attention from philosophers, historians, and sociologists of science. These chapters show how the psychology of science has grown beyond the amorphous field it was just twenty-five years ago. I also propose some parameters for the psychology of science and trust that in doing so I might inspire researchers at the core and periphery of the field to codify their interests and to stimulate the field's emergence as a major player in science studies.

In the last chapter of part 1 (chapter 7), I explore the applications that an informed and well-developed psychology of science might stimulate, as well as what needs to be accomplished before we have journals, societies, and conferences on the psychology of science. Specifically, it behooves the gatekeepers of science (scientists, teachers, mentors, editors, grant administrators) to be well informed of the empirical research that demonstrates which specific psychological qualities (neuroscientific, cognitive, developmental, personality, and social) are the most reliable and robust predictors of real-world creative achievement in science, mathematics, and technology. In other words, if we are to recognize, recruit, and retain the best young scientific talent available to the science professions, we must understand the psychology behind scientific talent, how to identify it early on, and ultimately how to encourage those with high-level skills and talent to enter the math and science workforce. Accurate, reliable, and valid psychological measures can only aid this process.

In addition to exploring the evolutionary and historic origins of scientific thinking, I address in part 2 of the book the complex interplay between scientific, pseudoscientific, and antiscientific thinking in modern life. More specifically, in the second half of the book I ask the questions "Why do humans—and no other species—do science?" and "How did we go from *Australopithecus* (non-homo hominid species) to early *Homo* (for example, *habilis, erectus,* and *neanderthalensis*) to living in a world of high-energy subatomic particle physics, sequencing the entire human genome, being able to send space craft out of our solar system, and having machines that can outplay any human in the world in

chess?" In examining these questions I was taken much further and deeper than I expected into many areas beyond psychology—archeology, neuroscience, genetics, anthropology, history, philosophy, and sociology, to name but the most obvious ones. One lesson I have learned from this foray into the evolutionary origins of scientific thinking is that formal science—science as we know it—is but one specific expression of scientific thinking. Elements of scientific thinking have their origin in our distant preverbal ancestors, with most of these elements taking implicit rather than explicit form. As I argue in chapter 8, a basic grasp of principles of evolution in general and human cognitive evolution in particular allows one to explore and even provide answers to the fascinating and otherwise unanswerable question of how scientific thinking came to be in our species.

Of course, an evolutionary perspective takes us on a journey that is not specific to science and scientific thinking, but rather on a journey that explores the modern human mind in general. Symbolic, abstract thought, language, literature, art, music, and other pinnacles of human cognitive and aesthetic capacities are also unique expressions of the modern human mind. In chapter 9, therefore, I delve into the prehistoric and historical developments that made modern scientific thinking possible—in all of its forms and variations—as well as what distinguishes science from other higher-order cognitive capabilities. Science and scientific thinking consist of developing and testing mental models of how the world works, be they of the physical, biological, or social worlds. The essence of these mental models is coordinating theories (models) with the evidence (data). Specifically, it is a process of observing events, recognizing patterns, testing hypotheses, and making causal connections between the observed events. Early in the development of our genus (*Homo*) and now early in the development of modern individuals (that is, *Homo sapiens sapiens*), these processes were and are mostly implicit—outside conscious awareness. With both phylogenetic and ontogenetic development, however, they gradually become more and more explicit, part of conscious awareness, and ultimately we developed the capacity to be aware of our awareness; that is, to think metacognitively. Science as we now know it is a metacognitive act, one that combines logic and reason with empirical observation. The outcome of such reasoning is the complex melding of innate skepticism with openness to go wherever the evidence takes us. In chapter 9 I explore in more depth both the phylogenetic and historic origins as well as the trademark characteristics of scientific thinking.

There are other important questions related to a psychological understanding of scientific thinking. One is, "How do we distinguish it from pseudoscien-

tific thinking?" Some individuals in the modern world claim to be doing science and even have co-opted the name "science." Upon further examination, these methods and practices are little more than ideology couched in scientific-sounding language. Why might such "pseudoscientific reasoning" hold such strong appeal for a large section of the population? Again, a psychological perspective allows us to address questions such as these, and I do so in chapter 10.

In chapter 10, I also examine the psychological foundations for the anti-science movement in and out of academia. In particular, I explore the attraction for some scholars and lay people to knock science off its "privileged" pedestal and argue that science is little more than stories or fictions of how the world works that are afforded hegemonic control over other forms of knowledge. This control, they argue, comes from the status and power scientists are awarded in modern society. Scientists, these scholars continue, can make no more valid claims for understanding how the world actually works than stories by children, artists, writers, musicians, and philosophers. Science is socially constructed—like all knowledge—and therefore devoid of any inherent meaning and validity. Deconstruction is an act of meaning the reader not the author/scientist places on the scientific text.

Needless to say, many scientists as well as others in the studies of science and even some in the humanities take issue with these claims and counter that scientific knowledge is of a special kind, not inherently but rather because the methods on which its knowledge is based are socially shared, open, reproducible, systematic, and empirical. The scientific method is neither capricious nor a mere social construction. Scholars like Paul Gross and Norman Levitt in *Higher Superstitions,* for instance, defend science, reason, and rationality against claims of meaningless, absurdity, and extreme constructivism. I examine this debate not so much as to offer a solution to it, but rather to again demonstrate how psychological theory and empirical evidence from psychology can better inform such debates. I end the chapter and the book with an analysis of the current state of the psychology of science and make recommendations for what must be done if the discipline is to become the full-fledged discipline it is capable of becoming and, from my vantage point, should and must become.

*The Psychology of Science* is my attempt to uncover some of the mysteries of the scientific mind and how it came to be, both within individuals and within our species. If I have done my job, then you—the reader—will come away convinced that psychological research and theory add a crucial and even necessary perspective to our understanding of the scientific mind, and that other

studies of science can no longer turn a deaf ear to what psychologists of science have learned. Psychologists of science now know too much about the nature of scientific thinking, the developmental origins of theory construction, scientific personality, scientific motivation, scientific interests, and scientific creativity and achievement for these insights not to be integrated and synthesized in one place. Science is a fascinating accomplishment of the human mind, and so, too, is the psychology of science.