

# The Science Mystique

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## The Science Mystique



Many of my German high school teachers were intellectual remnants of the “68er” movement. They had either been part of the 1968 anti-authoritarian and left wing student protests in Germany, or they had been deeply influenced by them. The movement gradually fizzled out, and the students took on seemingly bourgeois jobs in the 1970s as civil servants, bank accountants, or high school teachers, but their muted revolutionary spirit remained, on the whole, intact. Some high school teachers used the flexibility of the German high school curriculum to infuse us with the revolutionary ideals of the 68ers. For example, instead of delving into Charles Dickens in our English classes, we read excerpts of the book *The Feminine Mystique* (1) written by the American feminist Betty Friedan.

Our high school level discussion of the book barely scratched the surface of the complex issues related to women’s rights and their portrayal by the media, but it introduced me to the concept of a “mystique.” The book pointed out that seemingly positive labels such as “nurturing” were being used to propagate an image of the ideal woman who could fulfill her life’s goals by being a subservient and loving housewife and mother. She might have superior managerial skills, but they were best suited to run a household and not a company, and she would need to be protected from the aggressive male-dominated business world. Many women bought into this mystique, precisely because it had elements of praise built into it, without realizing how limiting it was to be placed on a pedestal. Even though the feminine mystique has largely been eroded in Europe and North America, I continue to encounter women who cling on to this mystique, particularly among Muslim women in North America who are prone to emphasize how they feel that gender segregation and restrictive dress codes for women are a form of “elevation” and honor. They claim these social and personal barriers make them feel unique and precious.

Friedan’s book also made me realize that we were surrounded by so many other similarly captivating mystiques. The oriental mystique was dismantled by Edward Said in his book *Orientalism* (2), and I have to admit that I myself was transiently trapped in this mystique.

Being one of the few visibly “oriental” individuals among my peers in Germany, I liked the idea of being viewed as exotic, intuitive, and emotional. After I started medical school, I learned about the “doctor mystique,” which was already on its deathbed. Doctors had previously been seen as infallible saviors who devoted all their time to heroically saving lives and whose actions did not need to be questioned. There is a German expression for doctors that is nowadays predominantly used in an ironic sense: “*Halbgötter in Weiß*,” or “Demigods in White.”

Through persistent education, books, magazine and newspaper articles, TV shows and movies, many of these mystiques have been gradually demolished.

It has become common knowledge that women can be successful as ambitious CEOs or as brilliant engineers. We now know that “orientals” do not just indulge their intuitive mysticism but can become analytical mathematicians. People readily accept the fact that doctors are human, they make mistakes, and that their medical decisions can be influenced by pharmaceutical marketing or by spurious squabbles with colleagues. One of my favorite TV shows was the American medical comedy *Scrubs* (3), which gave a surprisingly accurate portrayal of what it meant to work in a hospital. It was obviously fictional and contained many exaggerations to increase its comedic impact, but I could relate to many of the core themes presented in the show. The daily frustrations of being a physician-in-training or a senior attending physician, the fact that physicians make mistakes, the petty fights among physicians that can negatively impact their patients, the immense stress of having to deal with patients who cannot be helped, financial incentives, physicians and nurses with substance abuse problems – these were all challenges that either I or my friends and colleagues had experienced.

One lone TV show such as *Scrubs* cannot be credited for taking down the “doctor mystique,” but it did provide a vehicle for us physicians to talk about the “dark side of medicine.” Speaking about flawed clinical decision-making and how personal emotions can affect our interactions with patients is not easy for physicians because this form of introspection can lead to paralyzing guilt. All physicians know they make mistakes, and even though we ourselves do not buy into the “doctor mystique,” we may still feel the burden of having to live up to it. I remember how I used to discuss some of the *Scrubs* episodes with other physicians, and these light-hearted conversations about funny scenes in the TV show sometimes led to deeper discussions about our own personal experiences and the challenges we faced in our profession.

Being placed on a pedestal is a form of confinement. Dismantling mystiques not only liberates the individuals who are being mystified, but it can also benefit society as a whole. In the case of the doctor mystique, patients are now more likely to question the decisions of physicians, thus forcing doctors to explain why they are prescribing certain medications or expensive procedures. The Internet enables patients to obtain information about their illnesses and treatment options. Instead of blindly following doctors’ orders, they want to engage their doctor in a discussion and become an integral part of the decision-making process. The recognition that gifts, free dinners, and honoraria paid by pharmaceutical companies strongly influence what medications doctors prescribe has led to the

establishment of important new rules at universities and academic journals to curb this influence. Many medical schools now strongly restrict interactions between pharmaceutical company representatives and physicians-in-training. Academic journals and presentations at universities or medical conferences require a complete disclosure of all potential financial relationships that could impact the objectivity of the presented data. Some physicians may find these regulations cumbersome and long for the “mystique” days when their intentions were not under such scrutiny, but many of us think that these changes are making us better physicians and improving medical care.

As I watch many of these mystiques crumble, one mystique continues to persist: The Science Mystique. As with other mystiques, it consists of a collage of falsely idealized and idolized notions of what science constitutes. This mystique has many different manifestations, such as the firm belief that reported scientific findings are absolutely true beyond any doubt, scientific results obtained today are likely to remain true for all eternity, and scientific research will be able to definitively solve all the major problems facing humankind. This science mystique is often paired with an over-simplified and reductionist view of science. Some popular science books, press releases, or newspaper articles refer to scientists having discovered *the* single gene or *the* molecule that is responsible for highly complex phenomena, such as a disease like cancer or philosophical constructs such as morality. I was recently discussing a recent paper on wound healing, and I came across an intriguing comment in a public comment thread: “When I read an article related to science it puts me in the mindset of perfection and credibility.” This is just one anecdotal comment, but I think that it captures the Science Mystique held by many non-scientists who place science on a pedestal of perfection.

As flattering as it may be, few scientists see science as encapsulating perfection. Even though I am a physician, most of my time is devoted to working as a cell biologist. My laboratory currently studies the biology of stem cells and the role of mitochondrial metabolism in stem cells. In the rather antiquated division of science into “hard” and “soft” sciences, where physics is considered a “hard” science and psychology or sociology are considered “soft” sciences, my field of work would be considered a middle-of-the-road, “firm” science. As cell biologists, we are able to conduct well-defined experiments, falsify hypotheses, and directly test cause-effect relationships. Nevertheless, my experience with scientific results is that they are far from perfect, and most good scientific work usually raises more questions than it provides answers. We scientists are motivated by our passion for exploration, and we know that even when we are able to successfully obtain definitive results, these findings usually point out even greater deficiencies and uncertainties in our knowledge. Stuart Firestein’s wonderful book *Ignorance: How It Drives Science* (4) is a sincere and eloquent testimony to the key role of ignorance in scientific work. A thoughtful “I do not know the answer to this” uttered by a scientist is typically seen as a sign of scientific maturity because it shows humility of the scientist and indicates a potential new direction for scientific research. On the other hand, when a scientist proudly proclaims to have found *the* most important gene or having defined *the* most important pathway for a certain biological process, it frequently indicates a lack of understanding of the complexity of the matter at hand.

One key problem of science is the issue of reproducibility. [Psychology is currently undergoing a soul-searching process](#) (5) because many questions have been raised about why published scientific findings have such poor reproducibility when other psychologists perform the same experiments. One might attribute this to the “soft” nature of psychology because it deals with variables such as emotions that are difficult to quantify and with heterogeneous humans as their test subjects. Nevertheless, in my work as a cell biologist, I have encountered very similar problems regarding reproducibility of published scientific findings. My experience in recent years is that roughly only half the published findings in stem cell biology can be reproduced when we conduct experiments according to the scientific methods and protocols of the published paper.

This estimate of 50% reproducibility is not a comprehensive analysis. We only attempt to replicate findings that are highly relevant to our work and that are published in a select group of scientific journals. If we tried to replicate every single paper in the field of stem cell biology, the success rate might be even lower. On the other hand, we devote a limited amount of time and resources to replicating results because there is no funding available for replication experiments. It is possible that if we devoted enough time and resources to replicating a published study, tinkering with the different methods, trying out different batches of stem cells and reagents, we might have a higher likelihood of being able to replicate the results. Since negative studies are difficult to publish, these failed attempts at replication are buried, and the published papers that cannot be replicated are rarely retracted. When scientists meet at conferences, they often informally share their respective experiences with attempts to replicate research findings. These casual exchanges can be very helpful because they help us ensure that we do not waste resources to build new scientific work on the shaky foundations of scientific papers that cannot be replicated.

In addition to knowing that a significant proportion of published scientific findings cannot be replicated, scientists are also aware of the fact that scientific knowledge is dynamic. Technologies used to acquire scientific data are continuously changing, and the new scientific data amassed during any single year by far outpaces the capacity of scientists to fully understand and analyze it. Most scientists are currently struggling to keep up with the new scientific knowledge in their own fields, let alone put it in context with the existing literature. [As I have previously pointed out](#) (6), more than 30 to 40 scientific papers are published on average on any given day in the field of stem cell biology. This overwhelming wealth of scientific information inevitably leads to a short half-life of scientific knowledge, as Samuel Arbesman has expressed in his excellent book *The Half-Life of Facts*. (7) What is considered a scientific fact today may be obsolete within five years. The books by Firestein and Arbesman are shining examples among the plethora of recent popular science books because they explain why scientific knowledge is so ephemeral and yet so important. Hopefully, these books will help deconstruct the Science Mystique.

One aspect of science that receives comparatively little attention in popular science discussions is the human factor. Scientific experiments are conducted by scientists who have human failings, and thus scientific fallibility is entwined with human frailty. Some degree of limited scientific replicability is intrinsic to the subject matter itself. A paper on cancer cells published by one group of researchers may use a different set of cancer cells obtained from

their patients than those available to other researchers. At other times, researchers may make unintentional mistakes in interpreting their data or may unknowingly use contaminated samples. One can hardly blame scientists for heterogeneity of their tested samples or for making honest errors. However, there are far more egregious errors made by scientists that have a major impact on how science is conducted. There are cases of outright fraud, where [researchers just manufacture non-existent data](#) (6), but these tend to be rare. When colleagues and scientific journals or organizations become aware of these cases of fraud, published papers are retracted, and scientists face punitive measures. Such overt fraud tends to be unusual, and of the hundred or more scientific colleagues who I have personally worked with, I do not know of any one that has committed such fraud. However, what occurs far more frequently than gross fraud is the gentle fudging of scientific data, consciously or subconsciously, so that desired scientific results are obtained. Statistical outliers are excluded, especially if excluding them helps direct the data in the desired direction. Like most humans, scientists also have biases and would like to interpret their data in a manner that fits with their existing concepts and ideas.

Human fallibility not only affects how scientists interpret and present their data but can also have a far-reaching impact on which scientific projects receive research funding or the publication of scientific results. When manuscripts are submitted to scientific journals or when grant proposals are submitted to funding agencies, they usually undergo a review by a panel of scientists who work in the same field and can ultimately decide whether or not a paper should be published or a grant funded. One would hope that these decisions are primarily based on the scientific merit of the manuscripts or the grant proposals, but anyone who has been involved in these forms of peer review knows that, unfortunately, personal connections or personal grudges can often be decisive factors.

Lack of scientific replicability, knowing about the uncertainties that come with new scientific knowledge, fraud and fudging, biases during peer review – these are all just some of the reasons why scientists rarely believe in the mystique of science. When I discuss this with acquaintances who are non-scientists, they sometimes ask me how I can love science if I have encountered these “ugly” aspects of science. My response is that I love science despite this “ugliness,” and perhaps even because of its “ugliness.” The fact that scientific knowledge is dynamic and ephemeral, the fact that we do not need to feel embarrassed about our ignorance and uncertainties, the fact that science is conducted by humans and is infused with human failings, these are all reasons to love science. When I think of science, I am reminded of the painting “Basket of Fruit” by Caravaggio, which is a still-life of a fruit bowl. Unlike other still-life paintings of fruit, Caravaggio showed discolored and decaying leaves and fruit. The beauty and ingenuity of Caravaggio’s painting lies in its ability to show fruit how it really is, not the idealized fruit baskets that other painters would so often depict.

The challenge that we scientists face is to share our love for science despite its imperfections with those around us who do not actively work in the field of science. I remember speaking to a colleague of mine in the context of a wonderful spoof of a Lady Gaga song called [Bad Project](#). (8) We both agreed that the spoof was spot on, showing frustrations of a PhD

student not being able to get experiments to work, having to base experiments on poorly documented lab notebooks, and the tedious nature of scientific work. My colleague was concerned that if such spoofs ridiculing laboratory work became too common, it would embolden the American anti-science movement that is already very strong. Anyone who closely follows American science politics knows that creationists and global-warming deniers are constantly looking for opportunities to find any flaws in scientific studies and that they use rare occasional errors as opportunities to suggest that well-established and replicated scientific results or theories should be discarded. In addition to the agenda of these specific anti-science interest groups, there are also many groups lobbying for severe budget cuts, many which would negatively impact U.S. research funding that is already at an alarmingly low level.

My response to these concerns is that it is our job as scientists to convince fellow citizens how important science is, despite its limitations and flaws. The fact that scientists recognize the uncertainties and limitations of scientific knowledge is not a weakness but a strength of the scientific approach and makes it ideally suited to help us understand our world. Enabling a false mystique of science as being definitive and perfect is not going to benefit science nor society in the long run. Instead, recognizing our failings and limitations in science and openly discussing them with our fellow citizens is going to help us improve how we conduct science. I think that anyone who carefully looks at Caravaggio's "imperfect" painting eventually sees its beauty and falls in love with it. I hope that we scientists will be able to share the Caravaggio view of science with the general public.

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