Being a scientist is hard. Being a great scientist is even harder. And rare. What does it take to be a great scientist? Unfortunately, this isn't something taught in graduate school. Instead, the focus is often on experiments, classes, exams, teaching, grading, experiments, more experiments, publishing, defending, and hopefully graduating. Where is the time, then, to learn to be great. Alfredo Quiñones-Hinojosa at Johns Hopkins University in Baltimore, Maryland says you need to work hard to be great. Other's disagree. Vehemently. While hard-work is important, several hard-working scientists have not gone on to greatness. So then what is required to be a star? Several messages on Twitter and the comments below preceding this post described the technical skills or necessary to do science or strategic positioning of a scientific career to be a great scientist. But being a great scientist is more than that. Being a great scientist requires a few key qualities:

1. To be a great scientist, you need to love science. "There's a statistic that over 90% of people go home at the end of the day feeling unfulfilled by their work. This is the difference between liking your job and loving your job. You can like your job, but do you love your job? Over 90% of the people who work these days don't. [Simon Sinek]" This sentiment is echoed in every field of work, ranging from **business** [Steve Jobs Stanford University commencement address delivered on June 12, 2005][VIDEO!] to **technology** [Lifehacker top story] to **art** [HOLSTEE Manifesto]. Why is this sentiment echoed in so many fields? Because it doesn't matter what you do -- what matters is why you do it [short clip below; full length here].

No body will be good at any profession if they don't go home at the end of the day feeling fulfilled by the work done, feeling that they've contributed to something bigger than themselves, and this is especially true in science. Science is hard, and being a scientist is really hard. Life is too short to *not* love what you do. Mark Hirschey was a Professor of Business at the University of Kansas who died of Burkitt's lymphoma lymphatic cancer at the young age of 59. In his final lecture, he tells us to, "find a job you like so much that you'd do it for free. You'll be so good at it that you'll never have to worry about earning a decent living." He was right; whether you love science, or something else, love what you do.

2. To be a great scientist, you need to practice. Becoming a great scientist takes time -- a lifetime for most. No great scientist was born great. In fact, this idea is supported by research from K. Anders Ericsson, who is one of the world's experts on practice and expertise. Before Ericsson, the accepted assumption was that all ability was innate and geniuses were born, not made. However, Ericsson's research has debunked centuries-old assumptions about how people become exceptionally good at certain skills. His research has shown that practice, not potential, defines our level of ability. Studying everyone from athletes to typists, he found that a person's potential could commonly be surpassed, with focused effort and practice [Scott Young for the 99%]. Malcolm Gladwell recently popularized this idea in his book Outliers, and further described Ericsson's research on the 10,000 hour rule. In the early 1990s, Ericcson and his team divided students into three groups ranked by excellence at the Berlin Academy of Music and then correlated achievement with hours of practice. They discovered that the elite all had put in about 10000 hours of practice, the good 8000 and the average 4000 hours. No one had fast-tracked. This rule was then applied to other disciplines and Ericsson found that it proved valid.

In a great example of this, Ira Glass, host of the radio show This American Life, offers a helpful reminder that excellence in any field doesn't come automatically. It takes effort, years of it. And he revisits some of his early radio work in order to prove it. So be patient, and practice.

3. To be a great scientist, you need to learn from other successful scientists.
James Watson at Cold Spring Harbor Laboratory in Cold Spring Harbor, New York says "

you need to begin with luck, and then combine intelligence with willingness to not follow conventions."

Mary Klotman, the chair of Medicine at Duke University says,

"Strong Training; Passion for question; Solid collaborators; Always seek new technology; Be in the best environment; A little luck."

Elizabeth Blackburn, Nobel Prize winner and Professor at the University of California in San Francisco, offered the following advice,

"Go deep; Find a good mentor; Ask for advice; Collaborate; Focus on the science and do good research; Give a great talk; Consider all careers; Set your [family] boundaries and use your time wisely; Explore creative ideas, but know when to stop."

4. To be a great scientist, you have to be yourself.
In an interview with Big Think, Neil deGrasse Tyson says he is often asked by fans and admirers the question "What can I do to be you?" Tyson tells us "the only aspect of me that's 'doable'" is to perhaps recreate his academic pedigree. But what is more important than piling up degrees, according to Tyson, is to create the opportunity for yourself to "do what you do best" in a way that "layers onto the formal training you received."
In other words, don't aim to be a version of someone else. The greatest people in our society, Tyson argues, are those who have been able to "carve niches that represent the unique expression of their combination of talent."

Armed with this advice, go forth and be great.

This is the first post in a "How to:" series specifically aimed at scientists-in-training, including undergraduates, graduate students, and post-doctoral fellows. I'd like to acknowledge Casey Bergman and Dave Bridges for contributing to the discussion before publishing; Bob Lefkowitz and Sally Kornbluth for input on 'Practice'; Frederic Terral of RightBrainTerrain for designing the blog entry artwork and creating awesome art in the public domain; Simon Sinek, Steve Jobs, Mark Hirschey, Ira Glass, Mary Klotman and Liz Blackburn for inspiration; and to the readers for making the writing of these thoughts worthwhile.