Second Edition

Research Ethics for Scientists

A Companion for Students

C. Neal Stewart, Jr.

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To Sara, the love of my life and the most ethical person I know.

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Preface

The second edition of this book was written in the midst of the chaos that was the COVID-19 pandemic accompanied by my own deliverance to new abodes on the banks of the Tennessee River: changes and more changes ruled these years.

From my new digs I watched the river flow along with flotsam and jetsam, which included all manner of biomass, architectural remnants, and the broken products of human ingenuity. Also all sorts of boats comprised my daily entertainment: from pontoons, cruisers, runabouts, the occasional sailboat, kayaks, huge barges, to the dozens of bass boats launching toward the day's catch in search of winning an elite fishing tournament.

In my head played Bob Dylan's 1971 breakthrough hit that escorted him into the realm of rhythm and blues a la Leon Russell: "Watching the River Flow." He sings:

> People disagreeing everywhere you look
> Makes you wanna stop and read a book
> Why only yesterday I saw somebody on the street
> That was really shook
> But this ol' river keeps on rollin', though
> No matter what gets in the way and which way the wind
> does blow
> And as long as it does I'll just sit here
> And watch the river flow

I am certain that many people view scientific research in the same vein as winning a fishing tournament: a competition that values speed, cunning, strategy, and persistence. I suppose you can count me as one of them. The majority of professional anglers play by the rules. Still, cheaters exist. One particular stunt comes to mind. A couple of anglers had a difficult day on the water and decided to stuff their few landed fish full of lead to escalate the weight of their catch. They apparently got hooked on this scam since they were not immediately detected. And so, they became repeat offenders. Unfortunately for them, they were eventually trapped in a net of their own deceit. And, the honest anglers were incensed at the lack of integrity invading their sport. Telling a fish story in one thing, but blatant cheating was intolerable.

The same is true in science: cheating can never be acceptable in research. Sad to say, one of the main motivations for updating Research Ethics for Scientists with this second edition is that dishonest researchers have found numerous new ways to falsify, fabricate, and plagiarize. I tried to cover all the dastardly innovations in the book as well as the defenses. Despite the negatives, I am convinced that the overwhelming majority of scientists are honest to the bone. They continue to do the hard work of scientific research to benefit humankind.

Thus, the river of science keeps on rollin' even though it is sometimes riddled with flotsam and jetsam and the occasional bad player.

I hope this does make you wanna stop and read the book.

Louisville, Tennessee, USA
March 2023

Acknowledgments

I am greatly indebted to many people who played an important role in this second edition. My able assistant and lab manager Cassie Halvorsen keeps my professional world organized. She also helped with finding and managing figures and tables. Thanks to Lannett Edwards who has co-taught the graduate course of Research Ethics each fall for the past 17 years. I continue to learn from her as well as the hundreds of students who have taken the course. Thanks to my lab group who challenge me in all the right ways and keep me honest each day. Of course, there is the occasional ones who challenge me in not-so-helpful ways, but I manage to learn from them too. I really appreciate Daniel Anderson and Bob Langer for providing updated interviews for the book. It still amazes me that with their busy schedules, they are so quick to respond to my questions. Thanks to people who gave me permission to use their material in the second edition. I am grateful to all of them, especially Ivan Oransky of Retraction Watch and Michael Lauer of Open Mike fame at the NIH. I continue to appreciate my mentor at the University of Tennessee: Oz Augé. Even in retirement he continues to send me nuggets of ethical gold via email. Finally, thanks to Rebecca Ralf and the great team at Wiley for making the second edition a reality.

To God be the glory.

About the Companion Website

This book is accompanied by a companion website.

www.wiley.com/go/stewart/researchethics2

This website includes:
✓ Case Studies
✓ Figures from the book as PPTs

Chapter 1

Research Ethics: The Best Ethical Practices Produce the Best Science

ABOUT THIS CHAPTER

- Research science is increasingly complex with pitfalls and temptations.
- Global competition and cooperation will likely change the face of science in the future.
- Science is an iterative loop of ideas, funding, data, publication, leading back to more ideas and research.
- Ethics can be a guide toward best practices.
- Best scientific practices lead to the best science results and discoveries.
- Best practices and mentorship give rise to the best scientists.

It is increasingly difficult to be a research scientist. The number and complexity of rules, electronic forms, journals and publishing, and university regulations are ever-growing. The competition for funding is often ruthless, and the criteria exacted to warrant publication in good journals also seem to be on the rise. Indeed, not just the pressure to publish, but the pressure to publish the right papers in the right journals is also increasing. Nominally, the preparation of proposals and publications has been ostensibly made simpler by computer technology, yet the potential for real- and faux-research productivity has also been enabled by computers. Technology is a double-edged sword, enabling high levels of knowledge creation as well as enabling research fraud and shoddy science. Thus, ethical dilemmas seem to

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be appearing at an increasingly rapid pace, with research misconduct regularly being the subject of news articles in *Science, Nature*, and *The Scientist*. Even people who do not keep up with science news are familiar with breakthroughs in science and controversial developments such as CRISPR babies. While the most notorious cases of misconduct have occurred in higher-profile fields of science, such as physics and biomedicine, it is clear that no area of science is immune to unethical behavior (Judson 2004; Ritchie 2020).

We live in a "multi" world. Multitasking, multidisciplinary work, and multiauthored papers, to name a few, are ingrained in the fabric of science culture and certainly multi-multi is expected in order to succeed and move up the scientific ranks. The isolated small laboratory with the lone professor and few staff (see Weaver (1948) for a perspective) has given way to larger labs interacting in complex collaborations in interdisciplinary science. Complex relationships are accompanied with tough decisions regarding authorship, dicing the funding pie, and how to treat privileged data, and immense amount of data at that, which are shared (or not) and curated in useful and meaningful ways (or not). In all this mix, the temptation to cheat, cut corners, and misbehave seems to be at its zenith for scientists wishing to compete at the highest levels of science, become tenured, and then become rich and famous. Well, ok, realistically, most of us are challenged to name more than a handful of scientists who ever became rich or famous. Of course, one alternative to honest competition and competence, as seems to be the case for some scientists, is to con their way to the top. Cheating is front page news in business, politics, and sports news alike. Perhaps a bigger problem to outright fraud is cutting ethical corners. Thus, we have an apparent paradox – the antithesis of this chapter title – that the best (or highly rewarded) science is compromised with seemingly endless ethical issues. Whereas the lone professor and his or her graduate student worked in simpler and more linear paths in the past, modern science seems far too convoluted for its own good (Munck 1997). How can we win? How can sound science prevail in the face of all the obstacles?

If the situation is not complicated enough, it seems that there are growing concerns about the abuse of graduate students and postdocs by their mentors. Some senior scientists feel that coercion, micromanagement, and general overbearance of their trainees are effective means to ensure high productivity. While research misconduct garners headlines, causing all sorts of angst upon university administrators, it might be the case that defective mentorship is actually a much weightier problem than outright cheating (Shamoo and Resnik 2003). But is it possible that these two problems could be interconnected? Mentorship is a perennial hot topic in science that has spawned cottage industries, self-help books, and strategizing among faculty members and university administrators alike. Everyone knows that finding good mentors is crucial for the young (and sometimes not-so-young) scientist wishing to be propelled into a sustainable career in the academic world of research and teaching or the private sector of research. Mentors, after all, know the unwritten rules of science and can share these with their trainees. Mentors are responsible to explain how these rules are intermeshed with research ethics and advice on best practices. Mentors should help their students and postdoctoral trainees fulfill their dreams (should their dreams involve being a scientist). Indeed, these features define good mentorship. Bad mentors can shatter dreams and stagnate their trainees' careers. But perhaps even the best mentoring is not effective to deter certain research misconduct.

Research misconduct is a major threat to science. As much as some scientists wish to point fingers at politicians and the public as the principal bad players responsible for lack of appreciation and funding that science deserves, I think the real enemy is within our own ranks. Indeed, Brian Martin (1992) maintains that modern science, the "power structure of science," is to blame for much misrepresentation in research. Essentially, publishable data (indeed, stories) must be novel to be publishable in the sorts of journals that scientists need to publish in. According to Martin scientists are not allowed to "tell it like it is" and must "sell" publishable stories (he calls them "myths"). Nonetheless, blatant untruths in publishing are typically rooted out as research misconduct. Papers found to contain false information – created either by misconduct or honest error are typically retracted. Research misconduct is insidiously damaging to the credibility of science and scientists in society since it erodes trust – not only in the individual researchers but in the system of science itself. Self-patrolling the profession from within is critical to reverse this damaging trend; the major pinch points for detecting research misconduct are when grant applications are submitted and when manuscripts are assessed at the editorial level and peer reviewed.

The ethical dilemmas in data collection, collaboration, publication, and granting are likely to become even more complex and vexing in the future. More than ever, graduate students and postdocs must master more techniques, technologies, and concepts in order to become and stay competitive in science. At the same time, scientists must generate good ideas and raise increasingly scarce funds to make their research a reality. Global competition from scientists in rapidly developing countries, especially in Asia, is a new fact of life for the researchers in the West, who were quite accustomed to the deck stacked in their favor. Researchers in China, India, countries in the Middle East, and in other rapidly developing countries are enjoying increased levels of new funding and increased status in the world of science. These new resources are coupled with even higher government and institutional expectations – not only for results and publications – but groundbreaking publications in the most prestigious journals. From East to West, being a practicing scientist is certainly not getting any easier. The picture is not all doom and gloom, however. Honestly, I can think of no more exciting time to be a scientific researcher than today with the booming innovations and opportunities to be found around every corner. For example, between the publication of the first edition of this book (2011) and the second edition, I essentially reset my lab to perform synthetic biology research with new funding sources and collaborators. This transformation has led to new facilities and innovations. Such innovations are also enabled by our ability to connect with other scientists and stakeholders across the globe nearly instantaneously these days. Certainly, the positive science news outweighs the negative news and complications, but there is great consensus among scientists and others that the science system, while considered to be self-correcting, can go awry.

It was around 2006 and 2007 that I became convinced, for all the above reasons (as well as others discussed later in this chapter), that a new course at my university needed to be taught on research ethics to graduate students. Thus, I embarked on learning a lot more about ethics, research integrity, and the many topics that touch responsible conduct in research. After a couple years teaching this new graduate course, I decided that a book of this sort could be helpful to support it, but also as a general help to young scientists just starting their research careers. A few years later, the first edition of this book was published. Over a decade later, I found that a lot had changed (well, mainly, people had come up with new ways to cheat), and a second edition was due.

This book could be viewed as part guidebook, part virtual mentor, and part friendly polemic that should be helpful in addressing pragmatic problems that all research scientists experience. While virtual mentoring was part of my motivation, to substitute any book for finding a real mentor would be a mistake, which is one main reason a couple chapters on mentorship are included. This book is on research ethics, users' guide to success in science by following the rules that scientists largely agree are requisites for success. This book will not focus on greater issues of morality or bioethics; those are vastly different topics than the one we are embarking on here.

And with that, I'll state up front that I do not have all the answers. I think I do ask most of the pertinent questions, but like most things in life, asking the questions is a good bit easier than answering them. One of my main goals in asking the questions is to enable the readers to judge themselves with regards to best practices. When I started in science, I expected that there would be clearly illuminated a singular correct way to do experiments, analyze the data, and write up the papers. It did not take long to learn that this was not the case, and indeed, I judged myself then and ever-frequently now in how I could improve. Science is very creative and individualistic. There are many ways to answer scientific questions, and many ways also to go wrong. That is not to say that we cannot learn from our mistakes and at least not doom ourselves in repeating the same mistakes over and over again.

So, I urge the reader to think about the questions and the answers. I further ask readers to think about opinions expressed here, especially analyzing the case studies for current and future action where applicable, so that an individualistic way forward is clearly seen for each scientist embarking on the individualistic and exciting journey that is research science. I've found it valuable to discuss topics presented in the book with colleagues and mentors. If the topics in this book are discussed more widely in labs, hallways, and classrooms, then the best ethical practices will be advanced throughout fields of science. After I began teaching about responsible research conduct and practices, I found the new lively hallway discussions about various topics related to our course content was proof positive that our new effort toward promoting best practices was worthwhile.

Judge yourself

✓ Why are you interested in research ethics?
✓ What are your motivations for pursuing research?
✓ What ways are these motivations synergistic or antagonistic with one another (research ethics vs. research)?

Morality vs. ethics

What is the difference between morality and ethics? If morality is the foundation that ethics is built upon, research ethics is the top floor that is visible from the air. The moral foundation often has religious or spiritual ingredients and is engrained in substance that is far beyond the scope of this book. Ethics is sort of practical morality or professional morality that enables fair play in research. If we think of problems not so much as in terms of right and wrong, but in terms of ought and ought not, then I think we understand how to parse morality vs. ethics. Many people are uncomfortable discussing morality, religion, and politics. In contrast, most scientists are happy to share their opinions on ethics of their fields and science in general. Most experienced scientists understand standard practices in their fields and can recognize deviations from standard practices. If we move to a higher level that encompasses all fields of science – the big picture – then there is a general agreement of standard practices among scientists. The big picture of items included in this book includes research misconduct (it is bad), mentorship (it is critical), publication ethics and authorship (it can be tricky at times but science must be published), data integrity, and preservation (without it we are sunk). One way to think about research ethics is in terms of best practices in conducting all aspects of research science – to maximize benefits and minimize harm. A very important ethics concept is nonmalfeasance: doing no harm (Barnbaum and Byron 2001). While the definitions and delineations on research ethics might seem a bit squishy, let us keep in mind that there is plenty of room for opinion. Indeed, this book includes topics that are often debated, such as peer review, grants and externally funded research, and conflicts of interest.

This book is about practical research ethics as opposed to the theoretical ethics that may be of interest to a philosopher. This book is for scientists. This book is about integrity in performing research. Summed up, this book is about scientific integrity and the scientist's role in preserving it.

For our purposes here, I view this book as mainly about how to be a successful scientist. It can easily be argued that philosophers have thought about ethics much longer (e.g., Plato and other ancient Greek philosophers) than scientists have thought about science (a word not coined until the 1800s (Shamoo and Resnik 2003)). There are many viewpoints that philosophers have taken to conceptualize ethics. A few of these are utilitarianism, deontology, and virtue ethics.

Utilitarianism is an example of teleological theory, which is based on outcomes rather than process. Utilitarianism seeks to do the most good for the most people; it is important to consider others and not just yourself. The utilitarian essentially does cost–benefit analysis to guide a person's path and decisions, and one that is widely implemented these days as a thought process (Barnbaum and Byron 2001).

Deontology is the ethics of duty. It strives to universalize rules that apply to everyone in guiding actions. One example here is the Golden Rule (or the rule of reciprocity), which is stated as, "Do unto others as you'd have them do unto you." "Morality as a public system" (Gert 1997, p. 24) applies to research ethics in that all scientists know the rules to be followed and is not irrational for the people who agree to participate in the system.

Virtue ethics focuses on living the good life. In this system, a person is guided to do what a virtuous person should do. Similar with the other two systems above, virtue ethics considers the potential for harm and avoids doing things to harm others, as that is what the virtuous person ought to do.

A last self-centered way to look at ethics is through the eyes of egoism (Comstock 2002). Egoism states that a person ought to do what is in their own self-interests. If a scientist wants to have a long and fulfilling career, then they should follow the rules and perform the best science. It is also in my own self-interest, especially in the long run, to care about others and tell the truth in science.

As a scientist, it is difficult for me to actually decide which of these various systems is most effective. To me, they all point to the same guide for behavior and context. If we mash them up, a virtuous scientist will seek the truth for the better good of humanity in following the rules that most scientists agree upon because it serves the self-interest of individual scientists. Scientists, by definition, should desire to maximize benefit and minimize harm (normative principles).

Onward and upward

This book will be about the best practices in all the major areas of research management and practice that are common to scientific researchers, especially those in academia. Aimed toward helping the scientist in formative career stage, it will critically examine the key areas that continue to plague scientists, both young and old.

The book is arranged into functional themes and units that every experienced scientist recognizes as crucial for sustained success in science: ideas, people, data, publications, and funding. For example, relative to "ideas" there will be chapters on plagiarism, credit, and fairness. Note that there is some overlap between topics (e.g., plagiarism relates also to publications), but the book seeks to integrate topics into a structure that should help students and professional scientists see the interconnectedness of components leading to successful research. Herein, I will acknowledge my own opinions and biases and weaknesses and frailties. In our research ethics course, my co-teacher and I argue (discuss) facts and opinions. If we accept that there is plenty of room for difference of opinion, then ethics discussions are a lot of fun and help clarify the way we think about doing science. Of course, it also helps to differentiate between facts and opinions.

Inauspicious beginnings

Other than the standard morality lessons about right and wrong that most children are taught, I do not remember enjoying any formal teaching on professional ethics. Well, there were the standard mandates against plagiarism and cheating on tests. I had a bit of immersion in responsible conduct of research when I was selected to be the chief justice of my university's graduate honor system (and I really do not know why I was nominated or how I was selected). For the three years during my PhD program, I presided over panels that heard cases about graduate student plagiarism, data fabrication, and falsification. I suppose I learnt the rules of science by observing the real-life cases of students breaking the rules. Even then, I reasoned that everyone valued common sense ethics and there was no need to understand the details other than do not break the rules. I viewed my "chief justice gig" – which waived my university tuition and fees and gave me a faculty parking pass – as having little to do with my own PhD research. I had compartmentalized ethics from my scientific interests. In my mind, this singular focus of research during my graduate program was by necessity. I had found myself so far over my head and out of my comfort zone in science with the main need to learn so much so fast, that it took every drop of energy I could muster, especially in the early part of graduate training, to keep from drowning. Even then, at times, I felt I was floundering in my classes and research. I think I would have considered any training or discussion about ethics, best practices in science, or even how to *be* a scientist a real distraction from science itself. How wrong I was!

Let us imagine a mechanical engineer who is fascinated with cars. The engine design, drivetrain, tires, chassis, brakes, the whole thing is an obsession. Now after studying the theory of everything automotive, our ambitious engineer designs and builds a fully functional 500 hp machine that is capable of going 0–60 mph in less than four seconds. And after all these years, our engineer will now finally drive his first car – ever – his first car being the one of his own design. Unfortunately, before taking the wheel he never learnt the rules of the road. He does not know what that octagonal sign means, whether to drive on the right or left side, and let us not even think about common courtesy. No, our engineer considered all these things to be a distraction from what was really important – the car itself – the engineering. A disastrous crash and the destruction of the beautiful work of motoring machinery is highly likely. Sad to say, the unpleasant result could have been avoided by a short course on how to drive while sharing the road with others.

While this might seem like a ridiculous example, it illustrates how many young scientists, myself included, approach learning science and being a scientist, seemingly by osmosis. One might argue that our automotive engineer would gradually learn the traffic laws and the accepted motoring behavior, maybe even from a good, personalized driving instructor over time. But how much damage could be done in the meanwhile? As more and more students come into my lab and leave as budding scientists, I've become thoroughly convinced that learning best ethical practices earlier rather than later in a research career results in a big payout to both the scientist and the science itself. There is merit to having a driving course and a handbook.

How science works

The illustration below summarizes the flow of science, at least how it is currently practiced, with all of its necessary components. Science is actually a reiterative loop in which successes beget successes and failures cause the research loop to be broken. One of the primary drivers for success (completed and reiterative loop) or failure (broken loop) is scientists themselves. Having the best trained people who are eager to do best practices are at the heart of all successful science (Figure 1.1).

For the sake of discussion, we will designate a spot in the loop as the logical endpoint: publications. The end product of science is actually new knowledge, which must be canonized as peer-reviewed journal articles. Although there are other legitimate outlets for knowledge dissemination, such as presentations in professional meetings, books, book chapters, patents, and oral histories, the "gold standard" for credible science is peer-reviewed journal articles. This has largely been the case since 1660, when the first journal, the *Philosophical Transactions of the Royal Society*, was published.

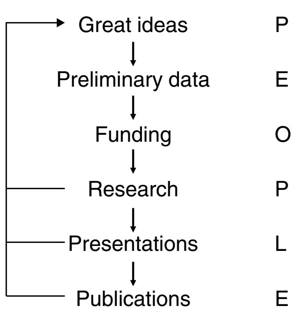

Figure 1.1 The flow of research. Research ultimately starts with great ideas and ends with publication of the research; i.e., new knowledge. Ethics is intertwined with the various steps in research and integrated with the people involved.

In most cases, a science paper is built on data from well-designed experiments that test hypotheses. While professors might likely have a hand in designing experiments and formulating hypotheses, it is graduate students, postdocs, and other bench scientists who actually collect and analyze data and do most of the writing. Actually doing science from inception to publication is the rare luxury that few tenured professors enjoy today. While the old-professor-in-the-white-lab-coat myth continues to live in popular culture, professors are producing fewer and fewer data with their own hands in the lab; in the grand universe of data, the professor-collected data is miniscule.

That is because they are busy writing grant proposals and performing administrative duties! Writing the second edition of this book was first delayed by COVID-19 and all the administrative hoops I jumped through to keep my lab running through the pandemic. When I was ready to write, I found that I had a once-in-five-years opportunity to simultaneously participate in six grant proposals, one of which I led. Last week I attended a research conference and submitted two research studies for publication. Grant proposals (whether as a principal investigator (PI) or co-PI) are necessary to fund research. The PI is the scientist taking the lead in the proposal, and a co-PI is a key person helping to write a multi-person team proposal. In most colleges and universities, the only scientists who are typically paid from "hard" funding, that is from university-level funding, are professors (and then again, in US medical schools, even professors are responsible to raise much of their own salaries). Ironic is the world of science in that the least productive people, data-wise, are the ones who have a tenure system to protect their employment status and salary stability. Everybody else – the ones doing the work – are typically on "soft" (grant) money. Why the disparity? A partial explanation is that faculty teach and are paid from university tuition income, but it is widely known that professors who attract a lot of grant funding and those with high research productivity (read, publications) are the scientists who are most esteemed in science and by higher education administration. In science, these professors are typically the scientists with the highest statures and salaries. Again, why? They are the ones who enable the funding of science to collect the data to publish the papers. Famous papers containing groundbreaking science in turn yield status to institutions (and more money), thus the financial circle is completed. Universities successful in research have greater reputation and funds enabling them to get even richer, hire more faculty members,