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On Being a Scientist

A Guide to the Responsible and Ethical Conduct of Research: Fourth Edition

Committee on Science, Engineering, Medicine, and Public Policy

Science and Technology Policy and Law Program Area

Center for Advancing Science and Technology

Consensus Study Report

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This Consensus Study Report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report nor did they see the final draft before its release. The review of this report was overseen by **SUSAN L. BRANTLEY**, Pennsylvania State University and **BARBARA A. SCHAAL**, Washington University, St. Louis. They were responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

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The committee held a public data-gathering session on July 18, 2025. We thank the following invited speakers for that session, some of whom later joined project panels. Andrea Christelle, vice provost for research, Diné College; Mohammad Hosseini, assistant professor, Northwestern University; Luisa Maria Diele-Viegas, professor, Federal University of Bahia, Brazil, postdoctoral researcher at University of Mississippi, and member of Global Young Academy; Cary Funk, senior advisor for Public Engagement with Science, Aspen Institute; David Guston, associate vice provost and professor, Arizona State University; Andrea Joseph, assistant professor, Syracuse University, and former chair of the Postdoctoral Council, National Postdoctoral Association; Michael Kalichman, founding director of Research Ethics Program, University of California, San Diego; Lisa M. Lee, senior associate vice president for research and innovation, Virginia Tech; Gary E. Machlis, university professor of environmental sustainability, Clemson University; Camille Nebeker, professor of public health, University of California, San Diego; Naomi Oreskes, professor of the history of science, Harvard University; Suzanne Ortega, former president, Council of Graduate Schools; Daniel Smith, director of content and education, CITI Program; Nicholas H. Steneck, professor emeritus of history of science, University of Michigan; and Ludwig Zhao, CEO and president, National Association of Graduate and Professional Students and doctoral candidate at University of Pennsylvania.

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Preface

Research in science, engineering, and medicine builds on the work of previous generations and operates within a long-standing contract with society. This contract obligates the research community not only to share research outputs, but to engage in meaningful, two-way dialogue that informs both the public and the research community. The public trust underpinning the research enterprise is continuously earned through transparency, responsiveness, and genuine engagement.

The National Academies have published three previous editions of *On Being a Scientist* (1989, 1995, and 2009) that introduce the values and professional standards of research as well as some personal and professional issues that researchers may encounter in their work. This revised, expanded, and online version of *On Being a Scientist: A Guide to the Responsible and Ethical Conduct of Research* provides guidance to researchers in a new easy-to-use, modular format. This collection of chapters explores the practice of research and what it means to be a researcher, including the values that guide the work, the communities that sustain it, and the commitment to both rigorous inquiry and ethical conduct that defines the enterprise. It uses the terms "scientist" and "researcher" somewhat interchangeably, recognizing that the principles of responsible conduct apply across the full spectrum of roles in the

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research enterprise. Whether working in universities, government laboratories or agencies, corporate research centers, or other settings, those engaged in the systematic pursuit of knowledge share common obligations and opportunities for contributing to human understanding. While directed primarily toward undergraduate and graduate students, postdoctoral scholars, and early-career researchers working in academic, industry, or government settings in the United States, this guide is also useful for faculty members teaching research ethics and established researchers who mentor students or others in research activities.

Many topics that have been central to previous editions of *On Being a Scientist* remain critical to the effective functioning of the research enterprise and to maintaining public trust in research and researchers. For example, rigor, integrity, openness, and transparency in science have gained even greater attention in recent years. At the same time, the national and global research enterprise has evolved significantly since the guide was last published in 2009. Researchers are increasingly working in large, multidisciplinary teams that collaborate with other teams or community members. International research cooperation has become the norm for producing much of today's scientific advances. Maintaining research integrity, protecting intellectual property, and adhering to other ethical practices are becoming more and more important for multi-institutional, multidisciplinary, or international partnerships to ensure that they have the intended benefits and safeguard against malicious exploitation. Rapidly emerging technologies over the past decade, such as artificial intelligence, genomic vaccines, and the use of the CRISPR-Cas9 system, have raised new ethical issues, some of which have implications for research norms or practices, including data management, authorship, peer review, and publication. The Internet, social media, enhanced computing capabilities, and new and faster methods of sharing research outputs have enabled rapid and globalized access to enormous quantities of scientific data, information, publications, and data analysis tools. In addition to accelerating the advancement of discoveries and technologies, these developments provide increased opportunities for international collaboration and engagement with the public and policymakers.

As the research landscape continues to evolve, *On Being a Scientist* will guide graduate students and early-career researchers and help to set norms for ethical practice within research, encourage responsible practices that promote the use

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of research for societal benefit, and transparently name unethical and harmful research practices so that early-career scholars and others can recognize and raise concerns about such practices.

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GUIDE FOR USE

The research enterprise has undergone immense change in recent years, shaped by increasing collaboration, global competition, and emerging technologies such as artificial intelligence and CRISPR that raise new ethical questions for researchers in the fields of science, engineering, and medicine. *On Being a Scientist* is a resource designed to help graduate students and early-career researchers navigate this complex and evolving research landscape, while providing a framework for responsible research practices for the entire scientific community.
With previous editions published in 1989, 1995, and 2009, O*n Being a Scientist* has become one of the most widely distributed guides to research ethics for students across science, engineering, and medicine. This fourth edition tackles critical and timely issues facing researchers today, from professional standards for collaboration and maintaining trust to research security and responsible conduct.

How can I use this guide in my classroom?

This guide builds on the 2009 edition to reflect changes in the current national and international research enterprise relevant to the conduct of research and to address professional conduct that limits or harms individual researchers, research advancement, and the scientific record. *On Being a Scientist* helps the reader approach the complexities of different situations by grounding them in the values of research conduct and exploring the reasons for specific actions. The guide can be used in formal settings, such as in orientations, courses, and research groups, to stimulate discussions, as well as for individual readings and reflections. The guide includes illustrative examples that are hypothetical in nature and based on the authors' cumulative experience with and knowledge of similar situations. These illustrative stories and associated reflection questions can be valuable to the group discussions by introducing different scenarios and thus fostering a productive discussion.

In this rapidly changing environment, a guide such as *On Being a Scientist* can provide only an introduction to the responsible conduct of research. In addition, although each chapter has some useful citations, they are illustrative, not exhaustive or solely explanatory. Users are thus encouraged both to explore the existing citations and links in the chapters and to use the "Resources for Further Reading" section of the website (www.nationalacademies.org/obas) to find further material that explores this discourse.

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ACRONYMS AND ABBREVIATIONS

AAAS	American Association for the Advancement of Science
AAMC	Association of American Medical Colleges
AGU	American Geophysical Union
AI	artificial intelligence
APS	American Physical Society
ASU	Arizona State University
AToRT	Appropriate Treatment of Research Trainees
CARE	Collective benefit, Authority to control, Responsibility, and Ethics
CFC	chlorofluorocarbon
COC	conflict(s) of commitment
COI	conflict(s) of interest
COPE	Committee on Publication Ethics
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
EAR	Export Administration Regulations
FAIR	Findable, Accessible, Interoperable, and Reusable
GPS	Global Positioning System
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
GREAT	AAMC Group on Research, Education, and Training
HIPAA	Health Insurance Portability and Accountability Act
IACUC	Institutional Animal Care and Use Committee
IRB	Institutional Review Board
ITAR	International Traffic in Arms Regulations
NAE	National Academy of Engineering
NASA	National Aeronautics and Space Administration
NASEM	National Academies of Sciences, Engineering, and Medicine
NIH	National Institutes of Health
NSF	National Science Foundation
ORI	Office of Research Integrity, U.S. Department of Health and Human Services
PI	principal investigator
SDSS	Sloan Digital Sky Survey
STEM	science, technology, engineering, and mathematics
STEMM	science, technology, engineering, mathematics, and medicine

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DEFINITIONS

Collaborative Research: "Multi-investigator, interdisciplinary research [in] research teams where sometimes no one member can understand the details of all of the science encompassed by the research. In such circumstances, collaborative research must include structures that coordinate and verify the integrity of separate contributions to the overall research effort" (NASEM, 2017, p. 19). Collaborative research can also occur within disciplines.

Disciplinary Steward: "[S]omeone who will creatively generate new knowledge, critically conserve valuable and useful ideas, and responsibly transform those understandings through writing, teaching, and application." More fully, the steward is the individual to whom "we can entrust the vigor, quality, and integrity of the field" (Golde and Walker, 2006, p. 5). "Upon entry into practice, all professionals assume at least a tacit responsibility for the quality and integrity of their own work and that of colleagues. They also take on a responsibility to the larger public for the standards of practice associated with the profession" (Golde and Walker, 2006, p. 10).

Detrimental Research Practices: A broad category of "behavior that clearly damages research…such as the misleading use of statistics that falls short of falsification and failure to retain sufficient research data…. Detrimental research practices also should be understood to include irresponsible or abusive actions taken by research institutions and journals in addition to the actions of individual researchers" (NASEM, 2017, p. 25).[1]

Interdisciplinary Research: "A mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice." Sometimes a new discipline is formed because of successful interdisciplinary research (NAS, NAE, and IOM, 2005, p. 2). This research requires members of a team to integrate the theories, methods, and concepts from their disciplinary perspectives to solve complex problems (NASEM, 2018a).

Open Science: "Public access (i.e., no charge for access beyond the cost of an Internet connection) to scholarly articles resulting from research projects, the data that support the results contained in those articles, computer code, algorithms, and other digital products of…scientific research, so that

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the products of this research are findable, accessible, interoperable, and reusable (FAIR), with limited exceptions for privacy, proprietary business claims, and national security" (NASEM, 2018b, p. 18). Another feature is that the aim "to ensure the free availability and usability of scholarly publications, the data that result from scholarly research, and the methodologies, including code or algorithms that were used to generate those data" (NASEM, 2018b, p. 1).

Open Data: "Open data is data that can be freely used, re-used and redistributed by anyone—subject only, at most, to the requirement to attribute and sharealike" (Open Knowledge, 2018).

Openness: "In the scientific enterprise, openness refers to the value of being transparent and presenting all the information relevant to a decision or conclusion.... Openness also means making the data on which a result is based available to others so that they may reproduce and verify results or build on them. In some contexts, openness means listening to conflicting ideas or negative results without allowing preexisting biases or expectations to cloud one's judgment" (NASEM, 2017, p. 1).

Questionable Research Practices: One of three categories of behaviors that compromise research integrity, these are "actions that violate traditional values of the research enterprise and that may be detrimental to the research process" (NASEM, 2017, p. 16).

Replicability: "Obtaining consistent results across studies aimed at answering the same scientific question, each of which has obtained its own data," in other words, collecting and analyzing new data using similar methods and measurements as a previous study (NASEM, 2019, p. 1).

Reproducibility: "Computational reproducibility—obtaining consistent computational results using the same input data, computational steps, methods, code, and conditions of analysis"; in other words, a study using the original data, code, and measurements from a previous study (NASEM, 2019, p. 1).

Research: "[C]omprises creative and systematic work undertaken to increase the stock of knowledge—including knowledge of humankind, culture, and society" (OECD, 2015, p. 44) "in fields including but not limited to economics, education, linguistics, medicine, psychology, social sciences, statistics, and research involving human subjects or animals" (OSTP, 2000).

Research Misconduct: "Fabrication, falsification, or plagiarism in proposing, performing, or reporting research" (NAS, NAE, and IOM, 1992).

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These assume intent; honest errors are included in detrimental or questionable research practices. Research misconduct and detrimental research practices are all behaviors that undermine public and the scientific communities' trust in the scientific record.

Research Security: "Safeguarding the research enterprise against the misappropriation of research and development to the detriment of national or economic security, related violations of research integrity, and foreign government interference." (Joint Committee, 2022, p. 24)

Security: A broad term that may include research security, cybersecurity, software security, biosecurity, security of personally identifiable information, economic security, national security, and others.

Teams: "Teams are characterized by multiple information sources and intensive communication, task-relevant knowledge with meaningful task interdependencies, affective and attitudinal factors that influence group dynamics, and coordination among members with specialized roles" (NASEM, 2024, p. 36).

1. See also chapter 4 of NASEM, 2017.

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1

Introduction: The Joys, Benefits, and Responsibilities of Being a Researcher

The joys of discovering something about the world are at the heart of the research endeavor in science, engineering, and medicine. Research is a creative pursuit involving systematic and iterative ways of testing ideas that results in new knowledge and technologies. Outcomes from research include new treatments and cures for diseases, predictions about natural hazards, new services and technologies that improve the quality of life and enhance economic and national security, and a better understanding of ourselves and the society in which we live.

Research in science, engineering, and medicine builds upon foundations in those fields as well as knowledge from other fields (e.g., ethics, history, management, communication). Research is not conducted in a vacuum but is shaped by societies, cultures, economies, labor systems, natural resources, and outside pressures (see, e.g., Herrmann, 2002). Research has been built on (often in unacknowledged ways) Indigenous knowledge systems (see, e.g., Alum, 2024), Eastern traditions, African and Global South knowledge systems (see, e.g., Nakamura et al., 2023), and Western traditions.

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Building so much from the work of others in the past and present, current research also carries responsibilities, some of which are established through tradition and regulation and some that have emerged organically from the processes of discovery and innovation as researchers navigate new questions and unexpected findings.

This volume examines the practice of research and what it means to be a researcher—the values that guide the work, the communities that sustain the enterprise, and the commitments to both rigorous inquiry and ethical conduct that defines research practice. This guide uses the terms "scientist" and "researcher" interchangeably, recognizing that principles of responsible conduct apply across the full spectrum of roles in the research enterprise in science, engineering, and medicine. Whether working in universities, government laboratories, corporate research centers, or other settings, individuals engaged in the systematic pursuit of knowledge share common obligations and opportunities for contributing to human understanding (Kretser et al., 2017).

Research advances through relentless curiosity and the willingness to ask questions that others dismiss as naive. Consider Erasto Mpemba, a 13-year-old Tanzanian student who, in 1963, noticed something generations of scientists had either overlooked or ignored: that hot liquids can freeze faster than cold ones. His discovery came not from a carefully designed experiment but from the practical urgency of claiming freezer space before his classmates during class projects. His insistence on pursuing the question outside of his classroom eventually reached Denis Osborne, a physicist who had the intellectual honesty to take the boy's observation seriously, go home, and test it himself.

What emerged was a 1969 paper that not only investigated the idea but modeled something equally important about scientific practice: Osborne listed Mpemba as first author, honoring the student's role as the originator of the inquiry (Mpemba and Osborne, 1969). In science, credit is a form of currency, and the decision about who receives it shapes careers, institutions, and the culture of inquiry itself. Credit should follow contribution, regardless of the contributor's age, rank, or institutional affiliation. Although journal article authorship is valuable for those in the research community, for some contributors outside the research enterprise

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(e.g., members of a community who participated in the research) the work required to co-author an article outweighs any benefit they might receive. However credit is given (authorship or as part of an acknowledgments section), the failure to share it honestly is a failure of scientific integrity as much as any falsified data and falls into the category of a detrimental research practice.

The story of the Mpemba effect illustrates how a single curious observation, properly pursued, can open into entirely new landscapes of knowledge. Over the past decade, researchers have uncovered analogues to Mpemba's original finding in crystallizing polymers, magnetic materials, and quantum systems involving single ions suspended by lasers. Technologies that stand to benefit include carbon capture materials and the biodegradable plastics used in 3D printing. This was set in motion because a young student in Tanzania asked questions about his experience in the world and a visiting physicist took it seriously and examined the phenomenon more closely.

The motivational underpinnings of scientific discovery, such as curiosity, joy, and satisfaction from contributing to basic knowledge or solving a problem,[1] build our collective capacity to conceive futures we have not yet contemplated. The research enterprise is fundamentally oriented toward developing increasingly accurate and complete understanding of phenomena through systematic investigation, evidence-based reasoning, and computational modeling. Researchers investigate the complexities of life at the molecular level, understand ecosystem dynamics, examine social phenomena, design novel materials, forecast weather patterns, map distant galaxies, and develop technologies that contribute to public health and quality of life, environmental sustainability, national security and safety, economic development, and other societal needs (NAE, 2008; NAS, NAE, and IOM, 2007).

Across these fields, researchers share a common commitment to fact-seeking, supported by rigorous qualitative, quantitative, or mixed methods and peer review as safeguards against bias. Scientific progress takes many forms—at times emerging

[1] See "I Was Born" video series https://scienceandentertainmentexchange.org/events-programs/programs/i-was-born.

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through steady, cumulative advances, and at other times through transformative leaps, often driven by new technologies, bold high-risk ideas, pressing societal questions, or simple curiosity. Instead of unfolding in a straight line, research arises from multiple entry points, differs across fields and methods, and may include moments of retracing steps after mistakes or shifting direction as new information is discovered and understanding deepens. Researchers also have responsibility to their work after it is published. Because science is a communal process of discovery, converging on the truth takes time.[2] Mistakes are expected, but the research record serves many different individuals, such as other researchers designing new experiments, doctors and pharmaceutical companies, and public policymakers. It is therefore critical that problems are caught and communicated to these individuals as early as possible. When that does not happen, the costs are real for young researchers who waste precious early-career time building on faulty work and for taxpayers and policymakers who bear the downstream consequences. Researchers have a principal role in safeguarding the accuracy of the record by using their expertise to spot, communicate, and correct problems both before and after results are published.

SCIENTIFIC VALUES

Research in science, engineering, and medicine is underpinned by a set of core values (NASEM, 2017; NIH, 2025; NSTC, 2021). These shared values of objectivity, honesty, openness, accountability, fairness, stewardship, and mutual respect shape and guide the behaviors of all involved in the research enterprise. How to interpret, embrace, and uphold these values is something to be learned by students, modeled by mentors, reinforced and encouraged among colleagues in the research enterprise, and demonstrated to society more broadly. The discussion about how these values should be understood has been going on for a long time and likely will continue long into the future.[3] That said, it is important to remember

[2] For example, in 2016, researchers failed to confirm the Mpemba effect (Burridge and Linden, 2016).

[3] See debates over the nature of objectivity, bias, and other topics in *Stanford Encyclopedia of Philosophy,* 2020, Scientific objectivity, https://plato.stanford.edu/entries/scientific-objectivity/.

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that although these values are not shared by all individuals, cultures, and governments, yet, in research, they are foundational.

Objectivity involves approaching and conducting research with impartiality, skepticism, and attention to reducing biases. This value is fundamental to the scientific method of posing a hypothesis that is then tested with relevant evidence and sharing the results clearly to allow replication and further examination. Other forms of research, such as hypothesis-generating or exploratory research, are meant to be more flexible and responsive to what the data show. Yet in these methods, there are still practices that have been developed to keep researchers honest and minimize bias. These practices include recording the research question of interest in study pre-registration, carefully keeping track of decisions that were made over the course of the research process, and employing replication as a routine part of the research program (recognizing that this does require sufficient resources). Objectivity requires scientists to minimize bias, preconceptions, interests, or external pressures in their work, by designing experiments that utilize rigorous methods and that allow the possibility for the hypothesis to be rejected. Objectivity also requires keeping conflicts of interest and commitment to a minimum and clearly reporting them when they arise. This does not mean that scientists are emotionless automatons or that they approach their work without passion or interest in particular outcomes (Merton, 1942). Rather, it means that researchers should dedicate themselves to being objective in designing and conducting their research because it is the best guard against producing biased results. Objectivity also requires sharing the details of research design and results so that other scientists can detect bias (see "Openness"). They should also build in safeguards and checks and balances to their objectivity, such as peer review.[4]

Honesty in research demands truthfulness and full disclosure in reporting methods, data, funding, results, and conclusions, and in reviewing or assessing research (NASEM, 2026). Scientists are expected to resist pressures that might lead them to be dishonest because dishonesty undermines not only the results of the specific research but also the entire scientific enterprise itself. Similarly, the

[4] See NASEM, 2017; see also "Adhering to Expectations of Rigor and Quality" in chapter 5.

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systems and institutions in the research ecosystem could work to reduce the pressures and perverse incentives that lead researchers to be dishonest (Edwards and Roy, 2017). Dishonesty in research includes embellishing findings, selectively reporting results, falsification (manipulating, changing, or omitting results or data), fabrication (making up results or data), plagiarism (using someone else's words or ideas without giving credit),[5] and presenting work in misleading ways. Honesty also applies to authorship, including some self-citation practices,[6] undeserved authorship (Allum et al., 2023), or coercive editorial practices (Fong et al., 2023). With the increasing use of artificial intelligence (AI) in research, lack of transparency about how AI was deployed in the process of conducting research and reporting research results is widely perceived to amount to dishonest practice. Dishonesty in research extends beyond outright fabrication or falsification to include more subtle forms of distortion or leaving out relevant information (Xie et al., 2021), such as choosing statistical analyses based on what produces the most favorable results (known in some disciplines as p-hacking; Tsang, 2025) or failing to acknowledge limitations and uncertainties in research findings.[7] See Box 1-1 for a detailed example of breaking the honesty value.

Openness involves fully sharing to the extent possible, both within the scientific community and with the broader public, information relevant to research decisions or conclusions, such as methods, data, and findings. This value is what enables other researchers to build upon previous work, verify results through replication, and identify errors or alternative interpretations. Researchers are also expected to be open to considering conflicting ideas or negative results, reconsidering their conclusions when presented with new evidence (Hoekstra and Vazire, 2021), or changing their minds or practices based on data and evidence-based practice (Merton, 1942).[8] Although important considerations of

[5] Office of Research Integrity, Department of Health and Human Services, Definition of research integrity, https://ori.hhs.gov/definition-research-misconduct.

[6] See a news article on excessive self-citations by Van Noorden and Chawla (2019).

[7] See NASEM, 2017, p. 31; see also chapters 3 and 5.

[8] See also https://www.nature.com/collections/idajfifcfg.

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Box 1-1 Detailed Example of Breaking the Honesty Value

"Dishonesty can take many forms. It may refer to out-and-out fabrication or falsification of data or reporting of results or plagiarism. It includes such things as misrepresentation (e.g., avoiding blame, claiming that protocol requirements have been followed when they have not, or producing significant results by altering experiments that have been previously conducted), nonreporting of phenomena, cherry-picking of data, or overenhancing pictorial representations of data. Honest work includes accurate reporting of what was done, including the methods used to do that work. Thus, dishonesty can encompass lying by omission, as in leaving out data that change the overall conclusions or systematically publishing only trials that yield positive results. Another example of dishonesty by omission is failing to report all funding sources where that information is relevant to assessing potential biases that might influence the integrity of the work. Conversely, dishonesty can also include reporting of nonexistent funding sources, giving the impression that the research was conducted with more support and so may have been more thorough than in actuality."

SOURCE: NASEM, 2017, p. 32.

intellectual property,[9] competitive advantage, sensitive personal information, or national security may sometimes limit certain aspects of openness, particularly for research conducted outside of academia or research conducted with funding from companies or the military, the default presumption when conducting research should favor sharing and accessibility. These behavioral norms

[9] Exemptions on sharing data for published work can occur with embargoes in clinical trials (Siebert and Ioannidis, 2024) and with the Small Business Innovation Research and Small Business Technology Transfer grants awarded by NIH, which allows grantees to withhold data for 20 years after the award (https://grants.nih.gov/faqs#/data-management-and-sharing-policy.htm?anchor=56550). In addition, industry-sponsored research agreements may require publication delay for up to several months to allow industry to file a patent.

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differ across research disciplines, but this represents variability in the tolerance of detrimental or questionable research practices by individuals in different disciplines rather than actual support for those research practices by the disciplines (Tedersoo et al., 2021). As with the values of objectivity and honesty, organizations and institutions within the research ecosystem also have an obligation to address incentive structures and systems that may discourage, disincentivize, or prevent researchers from being open with their data and work (Trueblood et al., 2025).[10]

Accountability means taking responsibility for and standing behind one's work, statements, actions, and roles in the conduct of the work, and being willing and able to explain and justify work, decisions, and actions. Researchers should be prepared to defend their methods and conclusions while remaining open to skepticism, criticism, and correction (see "Openness" and "Objectivity"). Accountability includes acknowledging errors when they are discovered and taking appropriate steps to correct the scientific record and prevent recurrence of similar errors in the future. The need to be accountable applies not only to all authors who wish to take credit for the work but also to all people involved in the research enterprise (e.g., researchers, institutional administrators, sponsors, research publishers) and it is mutual, meaning that the different people and groups within the research ecosystem are accountable to each other. Accountability refers to both formally defined policies and regulations and to less formally or legally defined responsibilities, such as supervisors being accountable for attending to the educational and career development needs of their students, postdoctoral fellows, professional staff, and junior researchers even though this is not stipulated in research regulations. Accountability also includes consideration and mitigation of any potential negative societal and environmental impacts of research.[11,12] Ultimately, accountability extends beyond one's own work to ensuring that the broader scientific community maintains high standards and moves

[10] See NASEM, 2017, p. 33; see also chapters 3, 4, and 5.

[11] See AAAS Statement on Scientific Freedom & Responsibility, https://www.aaas.org/programs/srj/sfr.

[12] See International Science Council's report on free and responsible practice of science (CFRS, 2021).

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forward using rigorous methods, thus contributing to trust in the research enterprise (link to the chapter on Trust). The scientific enterprise is most effective when researchers themselves and the research community, rather than external authorities, ensure that these values are being followed and that the integrity of the field is maintained.[13]

Fairness refers to the equitable treatment of collaborators, students, trainees, colleagues, fellow researchers, and human participants, as well as the ethical treatment of animal subjects and the natural environment. This means making professional judgments based on appropriate, reasonable, and transparent criteria, avoiding discrimination and harassment (Erosheva et al., 2020; NASEM, 2018), using processes that avoid or prevent bias from determining outcomes, and treating human participants and those whose data become part of research respectfully and animal subjects humanely. This also includes giving appropriate credit for contributions, acknowledging those who conducted prior work (e.g., citing relevant work used in the research process), ensuring that processes used to determine opportunities and resources (e.g., grant funding, publication acceptance, promotion, advancement, awards) have been appropriate, protecting against unfair incentive structures or preexisting cultural biases, and conducting research in ways that do not exploit or take advantage of research participants. Just like the earlier values, upholding this value is the responsibility of both the individual researchers and the organizations and institutions in the research ecosystem. Researchers should treat others fairly, and organizations and institutions have an obligation to develop systems and processes to treat all individual researchers fairly and to foster ethical behavior by researchers.[14]

Stewardship in science encompasses two important aspects. The first is the responsible management of scientific funds, data, resources, and people associated with their own projects.

[13] See NASEM, 2017, p. 34; see also "Designing the Collaboration: Agreements, Roles, and Norms" in chapter 2, "Trustworthiness for Researchers" in chapter 3, "Openness, Sharing, and Access as a Default in Science" in chapter 4, and "Responsible Use of Resources During Research Conduct" in chapter 5.

[14] See NASEM, 2017, p. 35; see also "Doing the Work Together: Dynamics, Safety, and Inclusion" in chapter 2, "Openness, Sharing, and Access as a Default in Science" in chapter 4, and "Authorship, Credit, and Attribution" in chapter 5.

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Management in research settings is an extremely important and complex skill set that researchers learn over the course of their careers (NASEM, 2017).

Separately from the management aspect of research, a steward of the discipline is "someone who will creatively generate new knowledge, critically conserve valuable and useful ideas, and responsibly transform those understandings through writing, teaching, and application" (Golde and Walker, 2006, p. 5). Disciplinary stewardship involves careful attention to the relationships that sustain the research ecosystem—from teams and institutions to the broader connections between the scientific community and the public and private funders who support it. Within this ecosystem, stewardship involves respectful treatment of colleagues; mentoring and training the next generation of scientists[15]; passing on and upholding rigorous research practices and core values; and contributing service to institutions, disciplines, and the wider enterprise by taking on roles such as reviewer, editor, and committee member.

Further, scientists are also stewards of the scientific enterprise and scientific process, sharing as appropriate the methods and approaches that scientists use to reach their conclusions. When stewardship extends to the relationship between science and the public, it requires researchers and institutions to represent research faithfully, respect the contributions of funders of contracts or cooperative agreements, maintain transparency about the use of taxpayer dollars and federal funding, and remain responsive to public interests and concerns.[16]

Mutual respect is a shared value, exercised among those involved in research (e.g., students, technicians, faculty, funders, collaborators, and relevant internal and external audiences) in which everyone is free to contribute knowledge, perspectives,

[15] There are examples of negative mentoring and training experiences, such as those experienced by women conducting remote fieldwork in the Arctic and Antarctic (Dance et al., 2024). Some organizations, such as the American Association for the Advancement of Science, honor mentors who "demonstrate extraordinary leadership to increase the participation of underrepresented groups in science and engineering fields and careers" https://www.aaas.org/awards/mentor/about.

[16] See NASEM, 2017, p. 36; see also "Obligations to Communities and Society" in chapter 1, "Designing the Collaboration: Agreements, Roles, and Norms" in chapter 2, "Trust When Working with Communities" in chapter 3, "Data Governance" in chapter 4, and "Responsible Use of Resources During Research Conduct" in chapter 5.

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and effort without fear of retribution or inappropriate criticism. It requires treating others with professionalism, dignity, and openness, regardless of differences in field of study, seniority, personal characteristics, or viewpoints. Mutual respect supports the free exchange of ideas and encourages constructive questioning, civil debate, and positive outcomes. Respect also entails acknowledging the intellectual contributions of others through proper attribution, transparent communication, and fair recognition of work. Researchers demonstrate mutual respect by listening carefully to colleagues, considering alternative viewpoints and hypotheses, and engaging in disagreements in a professional and evidence-based manner. Mutual respect further extends to the responsible management of shared resources and data, as well as adherence to ethical standards in conducting and reporting research. Ultimately, mutual respect builds trust among collaborators, within the broader scientific community, and with the public.[17]

HOW RESEARCH COMMUNITIES FUNCTION

Research is both an individual and a collective endeavor, embedded within a deeply collaborative enterprise and shaped by communities that span institutions, disciplines, and national borders. Research occurs in diverse settings: university laboratories, government research institutions, hospitals, schools, technology companies and other private industries, field stations or other remote locations, or in local community settings with community partners. Collaborations often include teams of researchers spanning multiple disciplines and at different career stages to implement studies, share data and code, build upon prior and concurrent discoveries, and provide critical analysis through experimentation and peer review (Specht and Crowston, 2022).

Research communities operate through complex networks of formal and informal relationships that enable the sharing of ideas, resources, and expertise while also providing mechanisms for quality control and accountability. These communities offer peer-to-peer support and friendship to early-career researchers, both social structures that are critical for mental health. Professional

[17] See also chapter 2.

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societies, journals, funding agencies, and other organizations establish standards, facilitate communication and debate over important issues, and provide recognition for achievement. These institutions have evolved significantly in recent decades, adapting to changes in technology, demographics, and social expectations. Increased unionization among graduate students, postdoctoral researchers, and faculty (of all appointment types) reflects growing awareness of labor issues (e.g., stagnant wages, benefit cuts, limited opportunity for advancement) in academic research.

International collaboration has expanded dramatically, creating opportunities for addressing global challenges while also raising questions about intellectual property, technology transfer, and research security. Mutual respect undergirds all research community interactions and provides the foundation for how researchers work with others.

While a researcher may work independently or with a team, their work always occurs within a broader context—supported by institutions, informed by previous work of others, and built upon shared discoveries, methodologies, and applications that are themselves continually changing and improved upon. Even when working independently, researchers operate within a community that depends on civil debate and respectful engagement, which encourages skepticism, critical thinking, and questioning while maintaining the commitment to evidence and logical reasoning. A research career involves recognizing and accepting responsibility for stewarding both the present and the future of the enterprise—research is an unending journey that requires each generation to inspire and train the next generation.

Research careers develop through many pathways, some through undergraduate and graduate programs, and others through bringing expertise from industry or clinical practice after foundational training, many crossing disciplinary boundaries. Some researchers enter the field through opportunities in a laboratory or fieldwork that sparked an interest and a lifelong pursuit. This nonlinear, cross-disciplinary pathway of discovery and application contributes to the collective research endeavor, creating a dynamic community where the term "researcher" entails a recognition of one's commitment to discovery and innovation as well as a shared

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belief that understanding the world is essential for humanity's progress and flourishing.

Longino (1990) identifies four features of scientific communities each of which is necessary and together enable those communities to be capable of objective knowledge production. These features are (a) avenues for the expression and dissemination of criticism, (b) uptake of or response to criticism, (c) shared and public standards for assessment, and (d) equality of intellectual authority among all qualified participants. These are key functions that scientific journals, peer review, presentations and publications, data and journal clubs, and more provide, and they are crucial to the success of contemporary research. Researchers should reflect on their own biases and work to minimize them, but individuals often cannot overcome or even detect every bias. Thus, the structure of research communities complements individual-level efforts.

Responsibilities and Conduct

Individual researchers have multiple responsibilities. These include maintaining honesty and integrity in their work, being rigorous in their methods, reflecting on and acting on the potential societal implications of their work, and ensuring the ethical treatment of research subjects, whether human or animal, and ethical treatment of fellow researchers, regardless of status. Researchers are responsible for both individual conduct and the health of the research communities to which they belong. This includes mentoring others, participating in peer review and other quality control processes, and working to address systemic problems that undermine research integrity, such as reforming how researchers are evaluated for research success, metrics that often reward speed, novelty, and positive results over rigor and replication. Conducting research work in a team environment can occasionally lead to some tensions in research collaborations.

Research relationships, whether between senior and junior researchers, between peer researchers, between researchers and human participants, or between researchers and partnering communities, are expected to avoid exploitative practices and work toward benefits for all parties. Both institutions and the individuals within them are expected to support efforts that ensure that

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scientific communities reflect the full range of human talent and perspectives.

Laboratories and research teams function as social organizations where members have mutual responsibilities based on trust, respect, and fairness. Principal investigators have an obligation to provide appropriate training, mentorship, and working conditions for students and staff, while team members should contribute their best efforts and maintain high standards of integrity in their work (NASEM, 2019). This mentoring relationship embodies commitments to the intellectual growth and professional development of early-career researchers, openness and fairness to them, and developing and providing intellectual resources to train and inspire the next generation. All researchers should be supported by their institutions when they must address misconduct by their seniors and supervisors. Understanding how to navigate these multiple, sometimes competing, responsibilities while maintaining individual integrity is essential for a successful research career.

At the same time, researchers operate within institutional structures and cultures that shape how research is conducted, and these institutions and organizations are responsible for creating environments that support ethical research conduct (APPE, 2024). This includes maintaining safe and respectful workplaces, providing clear and enforceable policies and procedures for addressing misconduct or conflicts, ensuring appropriate oversight of research involving human participants or animals, protecting data, structuring incentives to support sound and ethical scientific work, and fostering collaborative and respectful relationships between researchers.[18] Researchers are expected to maintain awareness of their organization's policies and procedures and can reach out to their research administrator's office with questions or for advice.

Ethical Conduct and Values

Although companies often fund research internally, and faculty occasionally conduct research without funding to build their

[18] Although considering societal impacts of research is also critical, in order to maintain scientific freedom the responsibility to consider societal impacts rests with the individual researchers, otherwise the institutions could step in and shape the research deeply. See Douglas (2003) for a discussion of this trade-off.

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research portfolio, research is often supported by grants and contracts from government agencies and private foundations. This funding generally includes legal, compliance, and administrative requirements. But researchers' responsibilities within their disciplinary communities and institutions go well beyond these.

Ethical conduct includes far more than avoiding fabrication, falsification, and plagiarism. Researchers are expected to mitigate bias in their research, handle data responsibly,[19] protect the welfare of human participants and animal subjects, increase knowledge through rigorous methods, avoid foreseeable societal harms from their research, and acknowledge and correct mistakes when they occur in conducting their own research or in mentoring others. At the same time, they encounter systemic challenges that can undermine research integrity, including publication pressures that favor positive results, a media environment that encourages overstatement of results or their implications, challenges associated with maintaining funding, influence that may compromise objectivity, and rapidly evolving technologies, all challenges for which existing ethical frameworks may not be a simple fit. Ethical frameworks for rapidly evolving technologies may exist but have not yet gained broad awareness or adoption, may not yet have been tested to understand if they are fit for purpose, or may not yet exist. Researchers have both an opportunity and a responsibility to shape and test adoption of these frameworks.

While each researcher is entrusted to uphold individual standards of integrity, they also work within teams and organizations, and have the responsibility to act ethically in order to improve the health of the broader systems that support scientific inquiry. Researchers are expected to understand and navigate this complex web of relationships and responsibilities. In addition, organizations should not misrepresent research conducted by their researchers, and policymakers should not misrepresent scientific evidence.

Researchers are responsible for considering the impact of their work on the rest of the world. Although researchers cannot anticipate or be held responsible for all eventual impacts of their

[19] The Ethical Guidelines for Statistical Practice from the American Statistical Association (ASA, 2022) provides guidelines for working with data: https://www.amstat.org/your-career/ethical-guidelines-for-statistical-practice.

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work, they are expected to anticipate foreseeable and plausible consequences, including those that might be harmful. Many historical examples exist that can help early-career researchers begin to develop tools for anticipating the foreseeable and plausible consequences of their work. See Box 1-2 for a historical example of the unintended consequences of research from Thomas Midgley, Jr. who invented both leaded gasoline, which solved the problem of engine knocking in cars, and chlorofluorocarbon, which improved refrigeration and air conditioning. However, both products were later found to be hazardous to human and planetary health.

In addition, there are many historical examples of research that exploited, extracted from, and harmed communities around the world. Although protections for communities now exist that make these examples less likely to happen, reflecting on the reasons why these studies were approved and conducted can help early-career researchers think about responsibilities to both furthering scientific knowledge and the communities that could be harmed in the process. The Tuskegee Syphilis Study[20] deceived Black men with syphilis and denied them treatment, even after penicillin became available, so researchers could observe the progression of the disease. The Guatemala STD experiments (Rodriguez and García, 2013) involved U.S. public health researchers intentionally exposing vulnerable people in Guatemala to syphilis, gonorrhea, and chancroid without their consent. And testing on nuclear materials by the United States in the Marshall Islands exposed island populations to radioactive fallout and displaced communities from ancestral lands.[21] The exploitation of human participants and communities is not justified by the pursuit of science. Researchers are also expected to remain aware of the possibility that dual-use research of concern—work that could be applied for both beneficial and harmful purposes—might arise in any field at any time as part of the unpredictable nature of discovery. Early-career researchers should be aware that virtually all research and technologies could be used in different ways, some beneficial, others detrimental

[20] See CDC (Centers for Disease Control and Prevention), 2024, About the Untreated Syphilis Study at Tuskegee, https://www.cdc.gov/tuskegee/about/index.html

[21] See Atomic Heritage Foundation, Marshall Islands, https://ahf.nuclearmuseum.org/ahf/location/marshall-islands/.

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BOX 1-2 Historical Example: Thomas Midgley, Jr. and Inventions that Led to Unintended Consequences

It is difficult to predict how or if fundamental research will benefit society even when its original goal was to solve a problem that the community was confronting. There is no better example of this dilemma than the story of two inventions created by Thomas Midgley Jr. General Motors was faced with an engine knocking problem in their cars. Engine knocking is essentially small explosions in an internal combustion engine that reduces the car's performance while also producing an annoying sound. Midgley, a chemical engineer, solved the problem by inventing leaded gasoline. He was celebrated for his achievement, but it soon became apparent that there was an increasing number of cases of lead poisoning. Today, we all notice that stations advertise "unleaded" gasoline on their pumps.

A few years later, Midgley was asked to improve refrigerant gases that were being used in refrigerators and air conditioners. The ones in use, such as ammonia were toxic, flammable, and could explode. His invention was freon or chlorofluorocarbon (CFC). The result was a huge success and had other applications such as being used as a propellant in aerosol products and asthma inhalers. CFCs are inert and can survive in the atmosphere for many decades. Once again, Midgley was celebrated and received several awards. It was approximately 30 years after his death that it was discovered that CFCs were drifting up into the stratosphere and reacted with the ozone layer to create a hole over the Antarctic. Left unchecked, the hole would continue to expand over time. The ozone layer protects us from dangerous radiation from space. Fortunately, the Montreal Protocol proposed the phasing out of CFCs and the ozone hole has been slowly shrinking.

It is both amazing and tragic that one individual could have created two products that were incredibly dangerous to the environment. The dangers of lead were known during his lifetime but there was no way of predicting the deleterious effects of CFCs. The latter is often used as an example of "unknown unknown."

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SOURCES: Britannica Editors. 2026, May 14. History: Thomas Midgley, Jr. https://www.britannica.com/biography/Thomas-Midgley-Jr.
Prisco, J. 2024. Once celebrated, an inventor's breakthroughs are now viewed as disasters—and the world is still recovering. *CNN World*, May 24. https://www.cnn.com/2024/05/24/world/thomas-midgley-jr-leaded-gas-freon-scn.

to health and society. Researchers should try always to frame their work in contexts that advance scientific understanding and/or societal well-being and should oppose harmful applications of their discoveries. In some instances, being a responsible scientist could involve notifying appropriate authorities about the dual-use concerns about implications of one's work, discussing the possible implications of work with colleagues (see, e.g., Urbina et al., 2023), and altering how research is shared.

Commitment to Openness, Collaboration, and Pursuit of Facts

The practice of research today involves navigating competing pressures, values, and interests. The pressure to publish frequently and attract funding can conflict with the time needed for careful, thorough investigation. The desire for innovation and competitive advantage should be balanced with the research community's commitment to openness, collaboration, and the pursuit of facts (see, e.g., Ball, 2019). The goal to see discoveries translated into societal advances, often involving commercialization, can create conflicts that need to be managed appropriately, and institutional resources exist to help researchers navigate these conflicts. The increasing specialization required for cutting-edge research must be balanced with the need for interdisciplinary approaches to complex problems. Successfully managing these tensions requires both individual integrity and collective commitment to the values that make scientific progress possible.

Researchers engage with uncertainty as an inherent aspect of inquiry, recognizing that different research approaches yield

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varying degrees of evidential strength in their findings. Research is also an activity characterized by continuous learning, because perspectives evolve as new questions arise, and researchers both develop expertise through engagement with emerging areas of inquiry and ensure that their own work is put in the context of and builds on the work of others. It is important to recognize that each field produces and evaluates knowledge in its own way, competition or comparison with other researchers differs across the disciplines, and collaboration norms can differ as well. Importantly, however, although methods and evidentiary assessment may differ, respect for the core values and basic responsibilities of research underlies those differences, and the ethical ideals of rigor, transparency, respect for human dignity, and respect for colleagues do not vary across research disciplines.

Expectations of research integrity have grown to include not solely avoiding fabrication, falsification, and plagiarism but also avoiding and preventing detrimental research practices. Even with this added complexity, there is continued respect for different approaches, especially as multi- and interdisciplinary collaboration expands. Research in all fields of science, engineering, and medicine has been improved by using methods and information from other disciplines, both within and outside of science. For example, mixed-methods research often draws on fields such as sociology, anthropology, education, psychology, and public policy. Team science depends on organizational behavior, leadership studies, communication, and conflict resolution. Translational science depends not only on technical discovery but also on implementation science, community engagement, ethics, economics, and public trust. A research career demands the capacity to formulate meaningful questions, design rigorous studies, interpret results with care, and communicate findings clearly to a variety of audiences, including the public and policymakers. All of this requires patience and resilience in the face of inevitable challenges and setbacks that are integral to the advancement of knowledge (Kahan, 2015).

The trust and effectiveness of the research enterprise depend on openness and integrity in all aspects of research and mentoring. Individual researchers are expected to conduct their work with honesty, openly share their methods and data to the extent possible,

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and subject their findings to independent verification. Responsible research includes openly acknowledging uncertainties, limitations, and the biases and values that shape how questions are asked and interpreted. Research also requires an open mind, able and willing to adapt as new evidence arises and challenges even long-held views (Droegemeier, 2023).

This individual commitment also operates within an institutional and community context that shares the responsibility for conducting research with integrity. Scientific knowledge advances both through the most rigorous of methods, as defined differently in each research field, and through open communication where experiments can be examined, results verified, and errors identified and corrected by the broader research community. Integrity in science requires that researchers report their findings accurately regardless of the outcomes, state their hypotheses clearly, disclose potential conflicts of interest, give appropriate credit to previous work, and maintain the highest ethical standards in their conduct. Transparency and integrity can be compromised through detrimental practices such as data fabrication, selective reporting of results, or failure to acknowledge previous work or sources of funding. This lack of scientific integrity erodes public trust, impedes the progress of knowledge on which society depends, and harms other researchers' abilities to pursue their work.

SCIENCE IN SERVICE OF SOCIETY: THE EVOLVING SOCIAL CONTRACT

Science operates within a contract with the rest of society that provides resources, autonomy, and trust in exchange for knowledge and innovations that can benefit society. This understanding has evolved over time, and the contract as understood today differs markedly from how it was conceived five decades ago (see, e.g., Bridgman, 1947; Bush, 1945; Douglas and Branch, 2024; Guston, 2000; Morgan et al., 2026).

Research is often funded, either externally or internally in some organizations, by governments, academia, industry, philanthropic individuals and organizations, and other sources, creating relationships with diverse stakeholders. Individual researchers pursue work along a spectrum that reflects both societal needs

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and intellectual curiosity. Sometimes science is called upon to respond to our most urgent problems: producing new vaccines for pandemics, identifying the viruses that cause disease, finding causes of and cures for cancer, predicting hurricanes and tornadoes better and earlier, making drinking water safe to consume, developing new materials for renewable energy, understanding and treating mental health conditions, or increasing transportation safety. These examples span the breadth of scientific disciplines and demonstrate how much of science responds directly to what is happening in society and works to make daily lives better and safer.

The social contract also encompasses curiosity-driven inquiry, which can also serve the public good when conducted responsibly and shared openly. Emerging global and technological developments, from AI to climate change, illustrate the growing complexity of this relationship between curiosity-driven and use-inspired inquiry. Each brings opportunities for innovation but also ethical and security considerations that demand careful stewardship and transparent dialogue (Owen et al., 2012). See Box 1-3 for more information about AI in scientific research.

Maintaining Trust

Earning and maintaining trust involves humility, especially when research intersects with contentious social or political issues. Researchers are expected to recognize that public skepticism may arise not from ignorance but from differing values, experiences, and needs (Lupia et al., 2024). Researchers are expected to uphold the values of honesty, objectivity, openness, and accountability while communicating their work clearly and responsibly with others.

Navigating these complexities involves sustained conversation among scientists, policymakers, and communities to consider ethical responsibility, openness, and security in specific contexts. The COVID-19 pandemic offered a vivid reminder of this dynamic—showing both the power of global collaboration to save lives and the challenges of communicating uncertainty and evolving knowledge in real time. These lessons highlight the continued importance of the social contract: science ultimately depends on society's trust, and that trust is renewed continually through honesty, accountability,

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BOX 1-3 Artificial Intelligence in Research

Artificial intelligence (AI) tools have entered research practice so quickly, and across so many domains at once, that the research community has not yet reached consensus on how to treat them. The speed of adoption is a reason to raise and answer central questions around the use of AI tools in science.

The most immediate questions concern disclosure and credit. When a researcher uses a large language model (LLM) to help draft a manuscript, analyze data, generate code, or synthesize a literature review, what is the obligation to disclose that use? The answer depends in part on what question is being asked. If the concern is reproducibility, the obligation is clear: any tool that materially affects how results were obtained or interpreted should be documented with enough specificity that another researcher could reconstruct the process. If the concern is authorship, the picture is more complicated. Most major journals and funding agencies have now stated that AI systems cannot be listed as authors, since authorship carries accountability that software cannot bear. But that consensus, while useful, leaves open the harder question of how to characterize AI contributions that go beyond minor assistance (e.g., copyediting of a manuscript) without rising to the level of intellectual origination. Researchers should be attentive to their institutions' and journals' current policies, which are evolving rapidly, and should err toward transparency when those policies are silent. When disclosing how AI or LLMs were used in drafting a manuscript, researchers are expected to think carefully about how to best describe their use.

Data openness raises a distinct set of concerns. One of the most significant risks of using AI tools in research is the inadvertent disclosure of sensitive information. Researchers who input patient data or other personally identifiable information, proprietary DNA or computer code sequences, unpublished findings, or confidential communications into a commercial AI system may be transferring that information to a third party in ways that violate institutional review board (IRB) protocols, privacy requirements, data use agreements, or the reasonable expectations of research participants. The fact that

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this transfer can happen through ordinary use of a convenient tool, rather than through any deliberate decision, makes it especially easy to overlook. In addition, the quality of the data used to train AI models affects the outputs, and researchers using AI to generate text or data should carefully consider the quality of the output. The questions worth asking before using the AI capabilities within any application with any sensitive material include: Where are these data going? Who can access the data? What quality is the output? Does that use fall within the terms under which the data were collected or shared?

There is also a broader set of concerns that some researchers hold about AI use on principled rather than practical grounds. The energy demands of large AI systems are substantial and growing, and scientists who are attentive to the environmental costs of their work have reason to weigh those costs honestly. Others raise concerns about the labor conditions embedded in AI supply chains, equity issues of who has access to AI or LMMs, or about the effects on the scientific workforce of widespread AI adoption, including in the training of early-career researchers if certain analytical and writing skills are increasingly delegated to automated tools or the cognitive impacts of AI use and how that could change education of the scientific workforce. These are concerns that the scientific community needs to engage collectively.

The development of AI formal verification methods for program design or mathematical proofs may greatly change how research is conducted in areas of mathematics, computer science, and other fields. For example, mathematics researchers have created the Leiden Declaration on Artificial Intelligence and Mathematics (https://leidendeclaration.ai/) as a call for action to address AI use in mathematics research.

The evidence base on how AI affects research quality, integrity, and productivity is itself still developing and expanding. Some studies have found that AI tools can reduce certain kinds of error while introducing others, that they can widen access to sophisticated methods while also enabling the production of plausible-sounding but unreliable outputs, and that their effects may vary considerably by discipline, tool, and

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use case. What that means practically is that researchers should treat claims about AI's benefits or risks with the same skepticism they would apply to any other empirical claim: ask about the evidence, consider the source, and be honest about what remains uncertain.

effective communication, and the visible alignment of scientific work with the broader public good.

One of the ways in which science serves society is by informing public policy. Science provides an evidential foundation for policymaking, though policy decisions ultimately rest on both available evidence and societal values, and those values also shape the evidence that is gathered. Further, policy decisions are made even as evidence continues to be gathered. Scientists contribute the evidence and analysis; policymakers weigh multiple considerations including scientific knowledge, societal values, economic factors, and competing interests. Understanding this distinction is important for scientists who wish to engage responsibly in policy discussions. Researchers should take care when communicating available evidence to be clear about the values that inform their framing of the issue and the limits of available evidence. Policymakers should consider the available evidence, ask questions when needed, and be sure to select competent researchers for advisory roles. In other words, both researchers and policymakers are expected to engage in honest dialogue to establish and maintain trust across their communities.

Scientific inquiry operates within a society where priorities, values, and norms continually shift and evolve. Some areas of research have become politically contentious, creating challenges for scientists committed to following evidence wherever it leads. The reality of doing science in contemporary society means that scientists may sometimes find themselves holding positions that differ from prevailing public opinion. Rather than avoiding these complexities,

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all researchers should understand that navigating these challenges while maintaining integrity to evidence and rigorous methods is part of the responsibility they accept (NASEM, 2024).

Importantly, scientists are often seen as among the most trusted sources (Tyson and Kennedy, 2024) to bring information forward for public consideration. Yet scientists can disagree with one another—and such disagreement is not only acceptable but often productive and necessary for advancing knowledge. Science provides our current state of understanding about the world but offers a time-bound view, as the current state of knowledge will evolve and change as new evidence emerges.

Moreover, not all scientific questions yield simple yes-or-no answers; many involve nuanced interpretations of data and results that account for uncertainties and complexities. Hurricane track forecasts offer a familiar example: the public understands that uncertainty exists, yet the forecast remains valuable and actionable despite that uncertainty. Deeper sources of uncertainty can exist in domains of clear public import, such as when novel viruses are emerging and their characteristics are as yet unknown. History also shows that the scientific outlier is sometimes correct, and the researcher whose interpretation differs from the consensus may ultimately prove right as new evidence accumulates. This dynamic nature of scientific understanding, where knowledge builds, shifts, and occasionally transforms, is fundamental to how research works. It is important that, as a part of scientists' engagement with the broader community, they help nonscientists understand this important and productive feature of how science progresses.

Obligations to Communities and Society

The relationship between science and society—whereby the public provides funding, resources, and trust to enable scientists to pursue knowledge—creates a fundamental obligation for researchers toward the communities that support their work. Central to the modern contract is the scientific community's obligation to engage meaningfully with the broader public—not merely to share results, but to foster an ongoing, two-way dialogue that informs both the public and science itself. This dialogue includes listening to community needs and concerns, not simply telling the public

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what they should know or value. Such engagement reflects the responsibility that scientists bear to society and acknowledges that public trust is developed and maintained over time through transparency, responsiveness, and genuine partnership.

The public good itself is both fragmented (i.e., what constitutes "good" for one part of the public may not be good for others) and not always self-evident or predetermined. To ensure the greatest success in enhancing the public good, scientists are expected to balance their expertise with genuine listening to communities and partners to understand what they want and need (NASEM, 2025). Well-intentioned scientists who assume that they know what communities want, without engaging with those communities, risk developing solutions that fail to serve the intended beneficiaries (Lambert et al., 2024). Establishing joint understanding of goals and needs allows research to genuinely serve the public good (Haelewaters et al., 2021).

When communities participate in activities such as clinical research, environmental health studies, public health surveillance, education research, or community-based studies, researchers have an obligation not only to collect data but also to return knowledge in ways communities can understand and use. Consider the example of environmental health research in communities affected by pollution. Residents may contribute their time, health histories, biological samples, local knowledge, and trust in the process. In return, researchers should communicate results clearly, explain uncertainties, avoid extractive relationships, and support pathways for the findings to inform policy, prevention, or community action. Listening to the public and partners to understand what they want and need is essential to earning the trust that enables the scientific endeavor to flourish. Scientific progress and its associated benefits to society depend on each generation of researchers embracing both the opportunities and the responsibilities that come with the privilege of contributing to human knowledge.

Beyond maintaining ethical standards in their individual practice, scientists also bear responsibility for fostering inclusive, ethical, and collaborative research environments. Research institutions and communities are expected to create structures and cultures that support and reward responsible conduct and collaborative

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environments. When institutional frameworks fall short, individual researchers—especially senior researchers—should work to improve them, as they have obligations to mentor the next generation, broaden participation in their fields, and promote and support policies and practices that strengthen the integrity of the scientific endeavor. The principles outlined in this guide provide a framework for meeting these responsibilities while preserving the creativity, curiosity, and critical thinking that make scientific careers both challenging and rewarding.

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2

Collaborating Responsibly

Science has always been a social enterprise. Even individual research draws on shared methods, prior discoveries, and ongoing disciplinary conversations. The scale and complexity of research have increased, and many contemporary problems require collaboration across science (including social science), engineering, and medical disciplines and institutions. Collaboration is no longer optional in most contexts; it is a central feature of contemporary scientific work and, for most researchers, a highly rewarding experience.

Because collaborations occur at many different levels, including between senior and early-career researchers, between mentors and mentees, between laboratory leaders and laboratory personnel, and between institutions, it can also be challenging. It brings together individuals with different training, assumptions, expectations, and constraints. Collaboration frequently involves power differences, including differences in seniority, access to resources, and representation within the research community (including when

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collaborating with community partners.[1] When collaboration functions effectively, it supports productive and innovative research. When collaboration does not function effectively, it can create conflict, reduce trust, and affect research quality. Recognizing and understanding the social dynamics of research teams affects whether teams succeed, whether all members can contribute fully, and whether the work is ethical, rigorous, and impactful.

This chapter examines how to collaborate responsibly, including how to enter collaborations intentionally, structure them, manage challenges, and learn from experience. No single chapter or resource can fully capture the range of situations researchers encounter as norms, laws, and geopolitical realities continue to evolve. What follows is a way of thinking about these issues rather than an exhaustive guide. The goal is to help researchers recognize the relevant considerations when they arise, ask the right questions, and know where to look for authoritative guidance.

COLLABORATION: THE LANDSCAPE OF MODERN SCIENCE

The shift toward collaborative science has been substantial and well documented. Research is increasingly conducted by teams rather than individuals, papers have more authors than they did a generation ago, and the most cited work is disproportionately the product of collaboration. The 2025 National Academies' report *The Science and Practice of Team Science* defines team science as "collaborative, interdependent research conducted by more than one individual," which is a deliberately broad definition that encompasses everything from a graduate student and a postdoctoral researcher working together on a shared project, to multi-institutional consortia involving hundreds of researchers across disciplines and time zones. In between those extremes lies most of contemporary science (NASEM, 2025).

The reasons for this shift toward collaborative research are not hard to identify. Complex scientific problems often require multiple forms of expertise. A clinical trial requires statisticians, clinicians, ethicists, and patient advocates. Environmental research may require ecologists, chemists, atmospheric scientists, and community

[1] See also chapters 1 and 3.

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liaisons. Genomics research routinely generates data at a scale that demands both computational and biological expertise. The complexity and number of problems have grown faster than any individual's ability to master all the relevant skills, and collaboration has filled the gap.

The Human Genome Project (1990–2003) illustrates both the scale and the complexity that modern collaborative science can reach. Involving more than 2,000 researchers across 20 institutions in six countries, the project required entirely new infrastructure for collaboration: notably, the Bermuda Principles, which committed all participating institutions to deposit raw DNA sequence data publicly within 24 hours of generation (Maxson Jones et al., 2018). This data-sharing agreement—unusual at the time and contested by some (Maxson Jones et al., 2018)—was a deliberate design choice that shaped how credit, competition, and publication rights were managed across the consortium. The project encountered in concentrated form the tensions this chapter addresses: between openness and competitive advantage, between the interests of large well-resourced institutions and smaller partners, and between the drive to publish quickly and the commitment to rigorous verification. The Human Genome Project's ultimate success depended on both the scientific capabilities of its participants and on the deliberate and repeatedly renegotiated design of its collaborative structures. Those structures are described in detail in the project's historical accounts (Collins et al., 2003) and serve as a reference point for large-scale team science to this day.

The Sloan Digital Sky Survey (SDSS),[2] now in its fifth phase spanning more than 25 years, is an instructive example of what deliberately designed large-scale collaboration looks like in practice, and how its design evolves over time. Beginning with first light in 1998 and entering routine survey operations in 2000, the SDSS brought together dozens of institutions across multiple countries to produce the largest digital maps of the universe then attempted, requiring simultaneous expertise in instrumentation, software engineering, database architecture, and astrophysics (York et al., 2000). From the outset, the collaboration committed to full public

[2] https://www.sdss.org/

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data releases, an openness principle that was a deliberate value choice, not a default, and one that has since made SDSS data the basis for thousands of independent publications by researchers who were never members of the collaboration. Managing credit within such a project required explicit, written agreements from the beginning. The SDSS Publication Policy, which has been revised with each successive phase of the survey, distinguishes between analysis groups who lead specific papers, infrastructure "architects" who earn standing authorship rights through substantial technical contributions, and other collaboration members who may request co-authorship on papers to which they have contributed. It establishes review periods, dispute resolution processes, and rules for how proprietary data may be shared with external collaborators (SDSS, 2022). These structures did not emerge spontaneously: they were negotiated, documented, and periodically renegotiated as the collaboration's scope and membership changed. The SDSS is, in this sense, a 25-year demonstration that good collaborative design is not a one-time event but an ongoing practice.

As shown by these examples, collaboration takes time to coordinate. It sometimes requires researchers from different disciplines that have their own technical language to learn to communicate with one another. It also places the responsibility on individual researchers to establish shared expectations for the group. It creates dependencies, as one team member's delay can stall everyone else's work, just as one error can become magnified through iteration. And it raises genuine questions about how credit should be allocated, how decisions should be made, and who is ultimately responsible if things go wrong. Understanding both the benefits and constraints of collaboration supports informed decision making about the practice of collaboration. The sections that follow outline the modern scientific landscape of collaboration, including social dynamics and collaboration—as research is an inherently social activity—teams and team science, human interactions with systems and technologies, authorship, and international collaborations.

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Social Dynamics and Collaboration

Behind the structural arguments for collaboration—the need for interdisciplinary expertise, the scale of modern data, the complexity of the problems—lies something more fundamental and less often discussed: research is a social activity that involves mutual respect, interaction, communication, shared interpretation, and willingness to innovate. Scientists do not simply pool skills. They bring curiosity, ambition, identity, and the desire to have their work understood and recognized by people who share their concerns. Collaboration supports development of ideas through discussion, critique, and integration of perspectives.

The sociologist Harold Garfinkel observed that shared problems naturally draw people into collaborative arrangements, and that researchers routinely incorporate others' frameworks, methods, and interpretations into their own working practice—building what might be called a shared intellectual kit from which the whole group draws (Garfinkel, 1967). This is not simply a matter of efficiency. It reflects the way that ideas develop through conversation, disagreement, and mutual challenge. Research that occurs in isolation tends to narrow; research that passes through other minds tends to expand.

That dynamic is well illustrated by the history of productive scientific partnerships. A well-documented example is the partnership between the pathologist Robin Warren and the young clinical fellow Barry Marshall, who together identified the bacterium *Helicobacter pylori* as the cause of gastritis and peptic ulcer disease, overturning the earlier view that ulcers were caused by stress and lifestyle. The Nobel Committee, which awarded them the 2005 Prize in Physiology or Medicine, noted that their complementary temperaments and work styles made the discovery possible in ways neither could have achieved working alone (Pincock, 2005). But collaboration can also go wrong in ways that carry serious consequences for credit and recognition, as happened in the case of Rosalind Franklin's work. Franklin's X-ray diffraction images provided critical data for Watson and Crick's 1953 model of DNA's double helix, yet her contribution went unacknowledged in their Nobel Prize and was largely invisible to the public for decades (Maddox, 2002).

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Research can also be isolating in ways that are difficult to articulate. Long stretches of work that feel invisible, uncertain, and disconnected from any broader community of practice are common in early-career science because researchers need to engage in significant training and self-development early in their scientific lives. Hafernik and colleagues (2015) note that while the independent nature of research can produce depth and focus, it can also become intellectually confining; collaboration can reduce isolation and broaden understanding.

The structural shift toward team-based research has been well documented. A landmark analysis of almost 20 million scientific papers along with over 2 million patent records found that work produced by teams is consistently cited more than work produced by individuals, and that this advantage has grown over time as science has become more collaborative and interdisciplinary (Wuchty et al., 2007). But the productivity of teams depends on conditions that cannot be taken for granted. Research on how teams function has found that psychological safety, which is the shared belief that members can speak up, raise concerns, and admit uncertainty without fear of embarrassment or reprisal, is one of the most important factors determining whether collaboration produces genuine intellectual exchange (Edmondson, 1999).

Research also shows that research groups are more productive when they have diversity within the team. Economist Scott Page demonstrates in *The Difference* that groups composed of people with diverse perspectives and problem-solving strategies consistently outperform groups of like-minded experts because a variety of cognitive tools, when combined, produce solutions that no single toolbox could generate alone (Page, 2007). A 2022 study by Specht and Crowston, drawing on data from 22 scientific working groups, found that team diversity across disciplines, institutions, and researcher demographics had a measurable positive impact on scientific output: more papers, more citations, and publication in a wider range of outlets. Interdisciplinarity, they found, mediates this effect: diverse teams produce more interdisciplinary work, and more interdisciplinary work tends to generate greater impact. Their findings also point to a complication that anyone who has worked in a diverse team will recognize: diversity can introduce challenges,

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including differences in expectations and communication styles. Gender balance and strong leadership both helped to counter this effect (Specht and Crowston, 2022). The takeaway is that the difficulties of collaborating are worth it and that diversity improves the potential of a team, but only when leaders seek to build trust through actions such as clarifying roles, managing conflicts, recognizing different forms of expertise, and creating conditions in which all team members can contribute. When diversity is well led and trust is cultivated, outcomes are substantially better than what homogeneous teams tend to produce.

Understanding collaboration as a social as well as a scientific practice can change how groups approach it. It means paying attention not just to the formal structures of roles and agreements but to the relational fabric of the team: whether people feel heard, whether differences are treated as assets rather than obstacles, and whether the culture of the group is one where honest engagement is possible.

Teams and Team Science

It is worth distinguishing between a scientific team and team science as a formal approach. A scientific team is a group of people working together on a research project. Team science is the systematic study of how such groups function—what makes them productive, what makes them fail, how their dynamics can be improved. A 2025 National Academies' report, *The Science and Practice of Team Science*, draws on decades of research in organizational psychology, management science, and scientific studies to offer an evidence-based understanding of how high-functioning science teams work (NASEM, 2025). One consistent finding is that effective teams succeed not just because of individuals that comprise them but because of how individuals work together—their communication norms, their structures for making decisions, their capacity to manage conflict, and their ability to learn collectively from experience.

For the early-career researcher, this is both reassuring and clarifying. Although individuals cannot always choose with whom they work, they can develop the skills and habits that make collaboration more likely to go well, whatever the circumstances.

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Humans Teaming Up with Systems and Technology

Collaboration increasingly includes not just other humans but computational systems and emerging technologies, including AI tools and automated processes. Data-sharing platforms, shared instrumentation, remote sensing networks, and large language models are all becoming part of what it means to do science. The contributions of these technologies raise their own questions about responsibility and attribution: When an artificial intelligence (AI) tool contributes substantially to data analysis, how should that contribution be acknowledged? When shared infrastructure generates a finding, who is accountable for its reliability? When automation handles a step that used to require human judgment, who checks the output? These questions do not yet have settled answers, but responsible collaboration means taking them seriously rather than treating them as someone else's problem.

For example, the release of AlphaFold2 by DeepMind in collaboration with the European Molecular Biology Laboratory in 2020 offers a concrete illustration of these questions arising in practice. Trained on well-curated datasets about proteins, AlphaFold2 predicted protein structures with unprecedented accuracy, transforming structural biology in a matter of months. But the collaboration immediately raised attribution and accountability questions that the field had not previously had to resolve at scale: How should AI-generated predictions be cited? When a prediction later proves incorrect, who is responsible—the tool's developers, the researchers who used it, or both? The subsequent release of a public database containing predictions for hundreds of millions of proteins has accelerated research globally while also raising questions about when computational predictions should be treated as established knowledge and what independent verification is required before building on them. These norms are still being actively negotiated by journals, funding agencies, and research communities. Researchers entering the field today will not simply encounter these questions; they will participate in answering them.

Authorship in Collaborations

Authorship reflects both credit and responsibility. Guidelines vary by discipline, and disputes often stem from unclear expectations rather

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than genuine disagreement about contributions. For example, first and last author priority differs across disciplines, complicating fair attribution of credit as research becomes increasingly collaborative and transdisciplinary. Clear expectations regarding authorship reduce conflict. Collaborating researchers should discuss authorship explicitly at the outset, identifying who will write, whose data will be used, and who will make other intellectual contributions, and then revisit these conversations as work progresses. Citations support attribution and allow readers to locate prior work. Data citations ensure recognition for those who create and curate datasets. Dissemination of authored work extends beyond publication to include accessible formats, code repositories, and engagement with nonspecialist audiences. AI tools now assist with literature search and drafting but introduce risks of distortion, inaccuracy, or ghost citations; researchers remain responsible for what they produce.

International Collaborations

For international collaborations, the general concerns of collaborative relationships are similar in kind to those of any collaboration, but operating across national and cultural boundaries can make them qualitatively different concerns. Awareness of those potential differences and having co-developed strategies in place to address them are essential to success. For example, co-developed strategies in international collaborations might include jointly agreed authorship and data-sharing expectations before the project begins; shared decision-making structures that include partners from all countries; clear agreements about sample ownership, intellectual property, publication review, student mentorship, and community engagement; and procedures for resolving disputes across institutions and legal systems. They may also include culturally informed communication norms, meeting schedules that do not always privilege one time zone, budget structures that equitably support all partners, and plans for recognizing local knowledge and leadership in the locations supporting the collaborations.

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ENTERING A COLLABORATION

Collaborations might be designed intentionally or might develop through shared interests or opportunities. A principal investigator identifies a complementary expertise, reaches out to a colleague, and the two of them shape a project together. Alternatively, a laboratory meeting discussion leads to a side project, a conference conversation turns into a grant application, a postdoctoral researcher joins a laboratory and finds herself folded into an ongoing consortium she had no role in designing. Early-career researchers often have limited control over which collaborations are joined, particularly within structured research environments, and may enter collaborations that are already in motion, with norms and expectations already established, and with power dynamics they did not negotiate. Some academic institutions also enter into collaborative research with industry partners. Although this might involve a contract or grant, sometimes there is no payment involved but merely an agreement to work collaboratively. This type of arrangement, which is common, comes with its own considerations for researchers at both institutions.

Even in constrained situations, individuals can make informed decisions about participation. Evaluating collaboration opportunities includes considering alignment with research goals, time commitments, decision-making structures, authorship expectations, and team culture.

Assessing Fit Before Committing

When faced with the opportunity to evaluate a potential collaboration before committing to it, it is worth doing so carefully and honestly. The dimensions of fit that matter most are not always the ones that seem most obvious. Scientific compatibility, such as overlapping expertise, shared methods, and complementary skills, is necessary but insufficient. What often determines whether a collaboration succeeds or fails is whether the people involved share values about how to work, how to treat each other, and what they are actually trying to accomplish.

Questions worth asking oneself before entering a significant collaboration include: What are the goals of this project? Do they align with how I am trying to build my career? For different team

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members who are already in the group, what is their favorite thing about working together, and what is the least favorite part? What are the expectations about time commitment? Who will have decision-making authority over key choices, and is that structure one I can work within? How does this group handle authorship, and does its approach seem fair? What is the culture of this laboratory or team and what do people who have worked there before say about it? Do I have the skills to effectively contribute to the team? Can I effectively evaluate the work of the others, so as to be able to sign off on a work product?

Understanding team culture involves consulting current or former team members. Ask them about their experience, about whether they felt their contributions were recognized, about how conflicts were handled. Culture is notoriously difficult to infer from the outside, but it tends to be remarkably consistent over time—and laboratory culture, in particular, tends to reflect the values and habits of whoever leads it.

Power Differentials and Early Recognition

In the National Academies' 2017 consensus study *Fostering Integrity in Research*, the committee indicates that for researchers to successfully demonstrate stewardship, they must "[be] aware of and [attend] carefully to the dynamics of the relationships within the laboratory, at the institutional level, and at the broad level of the research enterprise itself." This includes the responsibilities conveyed to those in positions of seniority, such as their duties to ensure the development of vulnerable trainees and the optimization of the research system (NASEM, 2017). The study pays specific attention to the idea that those who are most likely to raise concerns about research misconduct are those who are closest to the research itself, oftentimes vulnerable early-career trainees such as graduate students and postdoctoral scholars (NASEM, 2017).

Power differences are common in research collaborations and have been further explored by the National Academies through its work on sexual harassment in academia. The 2023 National Academies' issue paper *Preventing Sexual Harassment and Reducing Harm by Addressing Abuses of Power in Higher Education Institutions* identifies eight distinct types of power that operate in academic

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settings, including structural authority, control over resources, access to professional networks, and the power that comes from belonging to dominant social groups. Similarly, the 2025 National Academies' issue paper *Considerations for Supporting Postdoctoral Scholars Experiencing Sexual Harassment in Higher Education* further highlighted the power differentials across citizenship that are particularly common for postdoctoral scholars. Any of these can shape a collaborative relationship in ways that are not immediately apparent (Gary et al., 2025; Kleinman and Thomas, 2023).

As the Introduction chapter presents, research relationships, including those within collaborations, should never be exploitative. For early-career researchers, recognizing power differentials early is not about becoming cynical or defensive. It is about being realistic. A graduate student collaborating with an advisor is not in a symmetrical relationship, no matter how collegial the atmosphere. A postdoctoral researcher working within a large multi–principal investigator (PI) consortium is not in an equal position relative to the senior investigators. This asymmetry does not have to be abusive and most of the time it is not, but it does mean that the junior researcher has less room for self-advocacy, less ability to exit the collaboration without cost, and less protection when things go wrong.

The above-mentioned 2025 issue paper notes that postdoctoral scholars' reliance on their advisors for career advancement leaves them with less control over their employment stability and less decision-making authority over their own careers, a vulnerability that is not necessarily created by any individual's bad intentions but by the structure of academic science itself (Gary et al., 2025). Similarly, the issue paper indicates that because a large proportion of postdoctoral scholars in the United States are international scholars who depend on visas, there are additional structural factors inherent to the country's visa system of which to be aware (Gary et al., 2025). International scholars may also face challenges or delays in securing bank accounts, driver's licenses, housing, and other necessities of life that can leave them more reliant on their employers and potentially more vulnerable to abuses of power (Gary et al., 2025; NPA, 2022). Being aware of these structures is the first step toward navigating it wisely. Ongoing efforts to evolve the

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mentorship model from a single mentor to an assembly of mentor networks are a potentially promising way to reduce the vulnerability of young researchers (DeCastro et al., 2013; NASEM, 2019).

Autonomy and Its Limits

Early-career researchers can sometimes feel that they have no real choice about which collaborations to enter. In a strict sense, this situation is occasionally true: a graduate student might have little practical ability to refuse a collaboration that their advisor is committed to, or a postdoctoral scholar might need to work on whatever project the laboratory is funded to pursue. But within those constraints, there is usually more room for individual agency to ask questions, to negotiate expectations, to define a mentoring map[3] and then seek additional mentors or advocates to develop a network of mentors, to understand the formal policies that are supposed to govern the collaboration, and to know what options are available if things go wrong.

DESIGNING THE COLLABORATION: AGREEMENTS, ROLES, AND NORMS

Clear and deliberate design of collaboration structures supports effectiveness. Scientists who would not begin an experiment without a plan routinely begin collaborations without any shared understanding of how decisions will be made, how credit will be allocated, or what will happen if someone leaves. The 2025 *Team Science* report recommends the use of team charters—explicit agreements, revisited regularly, that document the goals, roles, norms, and processes of a collaboration (NASEM, 2025).

A team charter does not need to be a formal legal document; it can be as simple as a written record of a conversation. Although conventions for collaboration can differ across disciplines, in some cases the most senior individual on the project determines collaboration roles and also the order of names on research papers, but early-career researchers should feel free to ask for a longer conversation. What matters is that the conversation happens, that

[3] Cornell University, Faculty Advancing Inclusive Mentoring, https://faculty-inclusive-mentoring.cornell.edu/practical-toolkit-for-mentoring/strategically-developing-a-network-of-mentors/.

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the important questions get raised, and that there is some shared record of what was agreed. The same logic applies at the level of individual mentoring relationships, where mentoring compacts serve an analogous function: by making expectations about communication, feedback, authorship, and career development explicit from the outset, they reduce the ambiguity that most often generates conflict later. The Center for the Improvement of Mentored Experiences in Research, based at the University of Wisconsin–Madison, offers a freely accessible library of mentoring compact templates and evidence-based training curricula for both mentors and mentees at all career stages.[4] See Box 2-1 for an example of team charters.

The COVID-19 vaccine trials of 2020 illustrate what might happen when collaborative design is improvised under extreme time pressure. The Oxford-AstraZeneca trial (Mahase, 2020; Voysey et al., 2020) joined academic researchers, a commercial manufacturer, and multiple national regulatory bodies in a collaboration whose terms were being negotiated even as the trial was running. Questions that a team charter would normally resolve at the outset—who controls the data, who has publication rights, how disagreements between partners will be resolved—surfaced mid-process, in some cases publicly and acrimoniously, at precisely the moment when public trust in the process was most critical. A highly publicized dosing discrepancy, traced partly to miscommunication between institutional partners with different assumptions about decision-making authority, created confusion about the trial's results that proved difficult to correct in the media.[5] The lesson is not that speed is incompatible with deliberate collaborative design. It is that the questions a team charter addresses become harder, not easier, to resolve once work is already underway, and that the cost of leaving them unresolved rises with the stakes.

In international collaborations, the lead institution often has de facto control over the research agenda and research resources, and without intention and forethought, this can often recapitulate disparate power structures. To forestall this possibility, projects

[4] See https://cimerproject.org/.

[5] For media coverage of the confusion, see Associated Press (2021) and Park (2020).

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BOX 2-1 Illustrative Example: Team Charters[1]

Dr. One is an assistant professor leading a new multidisciplinary research project on urban air quality and public health. The team includes an environmental engineer, a data scientist, a clinician, and two graduate students from different departments. The project is funded through a large collaborative grant that emphasizes integration across fields and rapid publication of results. At the outset, the team agrees informally to "figure things out as they go," which is fine by Dr. One, who doesn't want to overstep as a new professor running a large project for the first time.

There is enthusiasm and a shared sense of purpose, but no written agreement about authorship, decision making, or data management. Each member brings different disciplinary norms: the engineer expects first authorship to reflect the most significant contributions to the project while the data scientist assumes authorship will be alphabetical. The clinician is already considering publication in medical journals, while the engineer expects to prioritize conference proceedings for publication.

As the project progresses, tensions begin to surface. There is growing pressure to determine the mode of publication and the authorship structure to meet the funder's goal of rapid publication, but no consensus on how to do so. At the same time, the graduate students notice inconsistencies in how data are being processed across subteams. One student raises concerns that some preprocessing steps are not well documented and may not be reproducible. Dr. One encourages the team to "keep moving forward" to meet grant deadlines, suggesting that they can clean up documentation later.

The graduate students feel caught in the middle. They are unsure whose direction to follow, how to raise concerns about data verification, or whether questioning authorship decisions could affect their standing on the team. They do not feel like they are receiving the

[1] This example is hypothetical but based on the expert knowledge and experience of the authoring committee.

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mentorship they expected to receive and feel like they have a less clear understanding of professional norms compared to when they started.

Dr. One realizes that the lack of shared agreements is now affecting both the working relationships and the integrity of the research. Despite discomfort with "taking the lead," Dr. One calls a team meeting to focus on establishing a shared set of values and expectations on everything from authorship to data management to mentorship of the graduate students on the team. They write it down in an email that is sent to every team member to ensure that everyone has access to the decisions.

Reflective questions:

- At what point should teams establish explicit agreements about authorship, decision making, and data practices in collaborative projects?
- When during the life of a collaborative project should research teams revisit authorship agreements?
- How can a collaborating researcher who is not the project lead advocate for a project charter at the inception?

should be genuinely co-designed with international partners from the very beginning, from the research questions being asked, to a fair and just division of labor, to an equitable stake in the outcomes.

Defining Roles and Responsibilities

Clear role definition is foundational to everything else. When everyone on a team understands what they are responsible for, coordination becomes much easier. When roles are ambiguous, tasks might not be assigned or completed, people might duplicate or impinge on others' work, and resentment builds. The questions to answer at the start of a collaboration include: Who is responsible for which aspects of the research? Who has authority to make decisions

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in each domain? What does each person's contribution entitle them to in terms of credit, access to data, and say in how results are published? What is the process if someone would like a change to the plan?

Discussions about these questions are particularly helpful for determining authorship, which is at once a professional currency and a source of genuine ethical complexity. Authorship expectations vary across disciplines. In some fields the PI is routinely either the first or the last author on every paper from their laboratory, whereas other fields have alphabetical authorship lists. In biomedical research, the International Committee of Medical Journal Editors' criteria are the most widely applied standard, requiring that authorship be reserved for those who have made substantial intellectual contributions to conception or design, data acquisition or analysis, and who have also participated in drafting or critically revising the work, approved the final version, and agreed to be accountable for its integrity (ICMJE, 2023). As scientific work has become more collaborative and multi-institutional, proposals for more granular contributor-role taxonomies[6] have gained traction, with some journals now requiring authors to specify their individual contributions using structured frameworks designed to make the division of labor transparent and verifiable (McNutt et al., 2018). When people from different disciplinary cultures collaborate, what each of them assumes is obvious may be invisible to the other. Discussing authorship early and throughout the research process supports clarity and reduces conflict.

In addition to disciplinary differences, authorship norms vary across countries and cultures in ways that are not always evident. Understanding the practices of an international partner, as well as the values that underpin those practices, is an important step before disputes arise (Bird et al., 2023). Navigating to a mutually agreeable approach requires openness to the possibility that the right solution may differ from what either partner would assume by default, or to what either partner believes is the only acceptable result (Lin, 2025).

The 2015 National Academies' report, *Enhancing the Effectiveness of Team Science,* recommended that universities and disciplinary

[6] See the Contributor Role Taxonomy (CRediT) for an example: https://credit.niso.org/.

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associations develop and evaluate principles for allocating credit in team-based work. A decade later, that recommendation has been only partially implemented. In its absence, the responsibility falls on individual collaborators to negotiate these questions themselves.

Data: Ownership, Access, Preservation, and Stewardship

Who owns the data produced by a collaboration, who has the right to use it, and who is responsible for its integrity and long-term preservation? Who has the authority to decide the answers to these questions when there is conflict? These are not abstract questions. When a collaboration ends, whether amicably or under unforeseeably difficult circumstances, the data question becomes concrete and urgent. Researchers who have not agreed on how the data are to be used in advance may find themselves unable to publish because another party claims veto rights, or unable to reproduce findings because they no longer have access to the original data.

Good practice in collaborative data stewardship involves documenting, at the outset, what data will be collected, how and where they will be stored, who has access and under what conditions, what the plan is for sharing data, when data will be shared (upon collection, after an embargo period, or after publication), how data will be licensed, and what happens to the data if a team member leaves. These questions have become more pressing as funders and journals increasingly expect data to meet the FAIR (Findable, Accessible, Interoperable, and Reusable) principles, a framework now widely adopted as a benchmark for responsible data sharing across disciplines (Wilkinson et al., 2016). Other frameworks, such as the CARE (Collective benefit, Authority to control, Responsibility, and Ethics) principles, can often complement the FAIR principles (Carroll et al., 2020). Institutional policies and funder requirements will shape some of these decisions, but they rarely answer all of the questions that a specific collaboration needs to resolve.

In international collaborations, questions of ownership, access, preservation, and stewardship will be familiar from domestic experience, but other issues, such as intellectual property, patent, and commercialization rights, are often more complex to resolve.

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International collaborations also introduce issues that arise less frequently in domestic collaborations: export control regulations and research security concerns. It is important and necessary that researchers work with their institutional research administrators or the commercialization, research compliance, or legal offices early in the process, and with frequent ongoing communication, including with communities or other researchers who might have divergent concepts of property or ownership.

Communication and Coordination

Communication practices influence collaboration effectiveness. The 2025 *Team Science* report emphasizes that communication norms should be explicitly established and matched to the structure and goals of the team (NASEM, 2025). A small, collocated group working intensively together may function well with informal daily conversation. A large, geographically distributed team working across time zones needs more deliberate structure: regular synchronous meetings, clear protocols for asynchronous communication, and explicit norms about how quickly people are expected to respond.

Virtual and hybrid collaboration, now widespread, has introduced additional complexity. The tools for virtual collaboration are plentiful, but the 2025 *Team Science* report cautions that these tools must be intentionally deployed. Simply having access to video conferencing or shared document platforms does not produce effective collaboration; that requires deliberate choices about when and how to use the tools and ongoing attention to whether they are actually serving the team's needs.

These concerns can be magnified in international collaborations. The time zone differences may be significant, making regular synchronous meetings challenging; it is also important to recognize that in international collaborations, one might be dealing with an infrastructure that makes virtual collaboration approaches regularly unreliable. Both mediate what timely communication and coordination can reasonably look like. Awareness and cultural sensitivity around possible language barriers, unequal capacities and resources, variability in negotiation and/or communication

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styles, and differing expectations about process and outcomes are also considerations.

Conflict Resolution Pathways

Conflict can be a normal part of collaboration. The question is not always whether conflict will arise but whether the team has the structures to manage it if it does. Establishing processes for resolving disagreements supports team function. Who is the appropriate person to approach if two team members cannot resolve a scientific disagreement? What are the institutional mechanisms for escalation if a team member believes that they are being treated unfairly? What happens when someone wants to leave the collaboration, and what are their rights and obligations at that point?

Some of these questions can be uncomfortable to raise at the beginning of a collaboration, when everyone is optimistic and collegial. But raising them at the start is far better than discovering, in the middle of a crisis, that no one knows what the process is. External sources, such as conflict mediators, research ethics consults, ombuds, and channels for reporting, might offer support for raising these questions.

Conflict resolution in international collaborations shares the same basic challenges as any collaboration, but as noted throughout, the international context adds several layers of complexity (language, power asymmetries, cultural differences, here specifically in recognizing and managing conflict). As in domestic collaborations, negotiating the conflict resolution processes together and in advance of beginning the research is a crucial step.

DOING THE WORK TOGETHER: DYNAMICS, SAFETY, AND INCLUSION

Once a collaboration is underway, daily interactions shape outcomes. These are not soft or secondary concerns. Psychological safety, the ability to raise questions, concerns, or mistakes without negative consequences, supports effective and productive collaboration (NASEM, 2025).

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Psychological Safety and Belonging

Psychological safety refers to a shared belief that the team is a place where it is safe to speak up, to ask questions, to raise concerns, and to make mistakes without being ridiculed or punished. It does not mean that everyone always agrees or that standards are low; it means that the team culture is one where honest engagement is welcomed. Research on high-functioning teams, including in scientific settings, consistently finds that psychological safety is associated with greater innovation, more thorough error detection, and better collective learning.

The consequences of absent psychological safety are documented with particular clarity in NASA's investigation of the Space Shuttle *Columbia* disaster in 2003. The *Columbia* Accident Investigation Board found that engineers who had identified a potentially catastrophic foam-strike during the mission had raised their concerns and been effectively shut down. The organizational culture had created strong implicit pressure not to raise issues that might delay the mission or embarrass the program. That pressure was never policy; it was transmitted through the way concerns were received, questions dismissed, and dissenting voices excluded from decision making. The board concluded that the organizational causes of the accident were as significant as the physical ones, and that NASA's failure was not a failure of individual engineers but of the system in which they worked. In the aftermath, NASA undertook substantial reforms to its team communication structures, creating formal mechanisms for minority technical opinions to be heard and documented, and distributing responsibility for raising safety concerns across the team rather than leaving it to individuals (Vaughan, 2006). The parallel to research settings is direct. Amy Edmondson's (1999) foundational work on psychological safety in medical teams found that teams reporting the most errors were not the least competent; they were the most psychologically safe, and therefore the most honest about what was actually happening. A research team in which junior members are afraid to flag problems will not catch those problems until they are harder to remedy.

Creating psychological safety is influenced by leadership and team norms. When a PI routinely dismisses challenges to an analytical interpretation, when a senior collaborator makes it clear

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that junior members should not raise concerns about the research process, or when a laboratory culture treats self-promotion rather than honest inquiry as the path to recognition, psychological safety is absent. The costs are real: people do not flag problems they see, findings do not get checked as rigorously as they should, and the science is worse as a result. In some fields, physical safety can be compromised as well. For example, in remote research locations such as Antarctica, where researchers are often isolated, subject to extreme weather, and reliant on contractors for handling of equipment, harassment can contribute to workplace safety concerns (NSF, 2022).

For early-career researchers, the practical question is often not how to create psychological safety, which is largely the responsibility of those who lead teams, but how to preserve one's own intellectual integrity in environments where it is not guaranteed. This means cultivating relationships with trusted colleagues who are outside the immediate collaboration, maintaining records of contributions and decisions, and knowing what institutional resources are available if the need arises to raise a concern through formal channels.

Inclusion, Difference, and Reasonable Accommodation

A genuinely inclusive collaboration is one that is designed with an awareness of the different circumstances, needs, and perspectives that team members bring to it. This extends to differences among team members that may influence collaboration, including individual backgrounds or experiences, as well as to less visible ones such as caregiving responsibilities, financial constraints, neurodivergence, different cultural norms around hierarchy and communication, and different disciplinary assumptions about how science should be done.

The 2024 National Academies' publication *Disrupting Ableism* addresses the specific barriers that researchers with disabilities face in science, technology, engineering, and mathematics environments, and the 2024 report *Supporting Family Caregivers in STEMM: A Call to Action* documents how caregiving responsibilities, which are disproportionately borne by women and researchers from some cultural backgrounds, affect scientific careers (NASEM, 2024a,b). For some early-career researchers, parental leave can influence their

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career trajectories: a nationwide survey of postdoctoral researchers who became parents during their appointments found that more than 1 in 5 mothers and 1 in 10 fathers reported that their PI's response to their new parent status had a negative impact on the overall quality of their appointment, with postdoctoral scholars of color experiencing these effects at significantly higher rates (Lee et al., 2017).

A collaboration that takes inclusion seriously will consider, for example, whether meeting times are genuinely accessible to members in different time zones or with caregiving responsibilities, whether its communication practices work for members with sensory or cognitive differences, and whether its authorship practices recognize the contributions of researchers who cannot always be as visibly present as others.

Reasonable accommodation is a foundational principle of fairness. It is the recognition that people work best when the conditions of their work do not impose unnecessary obstacles, and that designing for inclusion both ensures access to the full talent pool of potential contributors and tends to improve the experience for everyone, not just those with the most obvious needs.

Harassment, Discrimination, Bullying, and Incivility

Research on the prevalence of harassment and discrimination in academic science is consistent and troubling, and as emerging technologies change how researchers interact with each other, digital harassment[7] may become more prevalent. Sexual harassment is widespread in academic science, engineering, and medicine, and it causes significant harm to individuals and to the scientific enterprise as a whole, including adverse career outcomes, loss of talent in the scientific workforce, and damage to research integrity (NASEM, 2018). Subsequent work by the National Academies' Action Collaborative on Preventing Sexual Harassment has built on this research by documenting the vulnerability of early-career researchers, the role of power differentials in enabling harassment, and the failure of many institutions to respond effectively. It has also

[7] A resource about online harassment is the Online Harassment Field Manual at https://onlineharassmentfieldmanual.pen.org/.

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documented many promising efforts to address these challenges across the research landscape.

Harassment in research settings does not always present as the archetypical case of a quid pro quo sexual advance from a supervisor. Much of what researchers experience is what the 2018 report calls "gender harassment," which can happen to people of any gender, and encompasses demeaning comments, exclusion from networks, undermining of credibility, and other forms of differential treatment that, individually, might seem minor but that cumulatively can cause serious harm. Sexual harassment in academia is also often intertwined with discrimination based on other protected characteristics, producing distinct and sometimes intersecting harms that have been unevenly studied and insufficiently addressed.

Moreover, the 2018 National Academies' report found that it was within environments of generalized disrespect that much sexual harassment occurs. A global survey of more than 2,000 individuals in academic science institutions found that 84 percent of respondents reported experiencing abusive supervision and 59 percent reported witnessing it, with graduate students and postdoctoral scholars constituting the majority of targets and perpetrators overwhelmingly drawn from positions of greater hierarchical power (Moss and Mahmoudi, 2021).

The National Academies' issue paper *Preventing Sexual Harassment and Reducing Harm by Addressing Abuses of Power in Higher Education Institutions* explores the ways in which harassment in academic settings is inseparable from the structure of power in those settings (Kleinman and Thomas, 2023). Organizations with large power differentials are more likely to have high rates of sexual harassment (NASEM, 2018); when harassment occurs in the context of a power differential, the harm is greater; and the same structural features that enable harassment also make it harder for those who experience it to report it or seek redress (Kleinman and Thomas, 2023).

For researchers who experience harassment or discrimination within a collaboration, the decisions about how to report and address it are rarely simple. Formal complaint processes exist at the institutional level, and often exist at the funder level as well, with federal agencies recently seeking more transparency about the

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adverse behavior of PIs (NASA, 2020; NSF, 2021; Serio et al., 2023) Many institutions have a wide swathe of resources, but evidence shows that only a small minority of those experiencing harassment report it for reasons that are often complex (NASEM, 2018). The National Academies' issue paper (Kleinman and Thomas, 2023) documents that retaliation against those who report harassment, those who support complainants, and witnesses is common, and that efforts from institutions to proactively prevent retaliation from happening exist, but are limited (Boyd et al., 2023). The 2022 National Academies' issue paper Applying Procedural Justice to Sexual Harassment Policies, Processes, and Practice suggests that institutions could reduce the harm of harassment by making their processes more transparent, more consistent, and more clearly oriented toward fairness; this requires deliberate institutional commitment, not just the existence of formal policies (Umphress and Thomas, 2022). See Box 2-2 for an example on navigating boundaries and addressing harassment.

The Role of Bystanders

One of the most significant shifts in thinking about harassment prevention in recent years is the growing emphasis on bystander intervention—on the role that individual witnesses to harassment or discrimination can play in interrupting it. The 2023 National Academies' issue paper *Strategies for Developing, Implementing, and Sustaining Sexual Harassment Bystander Intervention Programs for Faculty, Staff, and Graduate Students* reviews existing bystander programs and identifies both their promise and their limitations, particularly in the context of early-career researchers (Kuhn et al., 2023).

Bystander intervention training typically offers participants a framework for recognizing situations that call for response, and a repertoire of options that do not require confrontation: the "four Ds" of direct intervention, distraction, delegation (engaging someone with more authority), and delay (checking in with the affected person afterward). The research suggests that training can increase people's willingness and ability to intervene. Many also emphasize that research into bystander intervention effectiveness is limited, particularly in the long term. Although it may offer participants

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BOX 2-2 Illustrative Example: Navigating Boundaries and Addressing Harassment[1]

Dr. Postdoc is an international postdoctoral scholar who has just arrived in the United States to begin a fellowship in molecular biology. New to the country, she does not yet have a driver's license, is unfamiliar with local laws and policies, and has not formed a social network. Most of her time is spent in the laboratory or alone in her apartment.

Her laboratory director, Dr. Director, is a widely respected researcher who is well published and well liked. He has been welcoming and attentive as Dr. Postdoc adjusts, often checking in and staying late while she works. She is appreciative of the support, as Dr. Director is her only mentor and there are no other postdoctoral scholars to talk to. Two graduate students also work in the laboratory, but their schedules and research differ significantly from hers, limiting interaction.

One evening, after Dr. Postdoc misses the last shuttle, Dr. Director offers to drive her home. Grateful and with limited alternatives, she accepts. When they arrive, Dr. Postdoc—still thinking about an unresolved issue in her data—invites him inside to continue discussing her work. The conversation shifts to personal topics, like previous relationships. Then Dr. Director asks her out. Dr. Postdoc is surprised at the suggestion and politely declines, saying that she would prefer not to date anyone at work.

The next day, Dr. Director is acting differently—largely ignoring Dr. Postdoc and not providing the support he promised on her data issues. Later, a graduate student tells Dr. Postdoc that Dr. Director had questioned Dr. Postdoc's technical abilities earlier that day—feedback that contrasts with the consistently positive evaluations he had given her directly. One month later, Dr. Director asks her out again, and she declines a second time. Although his advances were not sexually explicit, Dr. Postoc feels pressured and uncomfortable with these repeated requests from her supervisor.

[1] This example is hypothetical but based on the expert knowledge and experience of the authoring committee.

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The change in climate in the laboratory, coupled with new criticism made Dr. Postdoc concerned that Dr. Director was retaliating against her for declining his requests for a date. As her sole supervisor, Dr. Director controls her evaluation, research progress, and future recommendations. If he terminates her employment, she would become out of compliance with her J-1 visa and may have to leave the United States entirely. This, in turn, may dramatically impact her career, as there are very few similar laboratory positions in her country of origin.

She becomes increasingly anxious at work, worried that any minor delay or mistake will result in the termination of her employment. She is uncertain if anyone at the university could work with her to prevent retaliation for rejecting Dr. Director, as her employee handbook indicates that any concerns should be reported to her supervisor. She considers leaving the field of research entirely, unsure how she can develop her career without a strong recommendation from Dr. Director.

Reflective questions:

- What institutional resources (formal or informal) would you need to feel confident seeking advice or reporting concerns in a situation like this?
- As a bystander, what signs might indicate that a colleague is experiencing pressure, harassment, discomfort, or potential retaliation, even if they have not said so directly?

short-term insights into how to intervene, the research on whether they actually do intervene is still nascent (Bush et al., 2019; Kettrey et al., 2019; Lam et al., 2023); however, bystander intervention is one

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option for addressing sexual harassment that is often well within the control of individual early-career researchers.

For early-career researchers who witness harassment or discrimination in their teams or broader research environment, the most important first step is often to check in privately with the person affected and ask what, if anything, would be helpful. Navigating specific instances of bias or mistreatment in real time is one of the most difficult challenges researchers face, and targeted training on how to respond in the moment can make a meaningful difference; the Stanford Salles laboratory has developed scenario-based approaches to help researchers recognize and respond to bias as it occurs,[8] while Mello and Jagsi (2020) offer a practical companion resource with concrete language researchers can draw on when confronting discrimination and harassment across a range of specific situations.

NAVIGATING DIFFICULTY: CONFLICT, TRUST, AND THE DECISION TO EXIT

Not all conflict in a collaboration is a sign that something has gone wrong. Disagreement about scientific interpretations, debates about methods, differing judgments about risk—these are normal features of scientific work, and working through them honestly is part of how science gets better. The kind of conflict that causes lasting damage is conflict that is not acknowledged, not addressed, or not handled with basic respect for everyone involved.

When conflict arises, a general first step is to attempt to address it directly with the person involved, at the lowest level of formality that seems appropriate. Many conflicts that feel serious are the product of misunderstanding, different expectations about what was agreed, or different cultural norms about how disagreements are expressed. A straightforward conversation, approached with curiosity rather than accusation, often resolves them. One promising structural approach developed in healthcare settings shifts the burden of addressing unprofessional behavior away from targets and onto the institution: Vanderbilt University Medical Center's Co-worker

[8] See Ending Sexual Harassment: Teaching of Principal Investigators (E-STOP) at https://salleslab.stanford.edu/E-STOP; see also Southall (2024).

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Observation Reporting System, paired with the Patient Advocacy Reporting System, uses a peer-based reporting model in which a trained colleague delivers feedback through an informal "cup of coffee" conversation, and data show that the majority of individuals who receive this kind of early, low-stakes intervention do not repeat the behavior (Webb et al., 2016).

When direct conversation does not work, or when the conflict involves a power differential that makes direct conversation difficult, the next step is to involve someone who can help mediate—a trusted colleague, a department ombudsperson, or another formal institutional resource. As an example of a formal resource, the National Institutes of Health instituted the CIVIL program[9] as an alternative avenue for staff to address unprofessional behavior outside of more formal routes. One key to the program is the ability to report untoward behavior anonymously, reducing the fear of retaliation. A caseworker then investigates and any findings are reviewed with the supervisor of the staff member who had displayed inappropriate behavior. With input from institutional leadership and the human resources department, the caseworker and supervisor decide on the appropriate adjudication.

Escalation to formal institutional processes is appropriate, even expected, when a conflict involves what is reasonably believed to be a violation of research integrity, harassment or discrimination, or a serious breach of the agreements that govern the collaboration. However, this kind of reporting can be fraught, and those who fear loss of confidentiality might not be willing to come forward. The 2022 issue paper *Applying Procedural Justice to Sexual Harassment Policies, Processes, and Practice* offers a useful framework for evaluating what fair institutional processes look like—one that researchers can use both to assess the processes at their own institutions and to advocate for improvements (Umphress and Thomas, 2022). For behaviors that contribute to toxic training environments but fall short of clear legal or policy violations, the Association of American Medical Colleges' Appropriate Treatment of Research Trainees (AToRT) framework offers institutions a tiered, scalable approach to addressing everything from microaggressions

[9] https://hr.nih.gov/staff-resources/civil-program

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and infringements on trainee autonomy to more egregious misconduct, with response levels calibrated to the nature and severity of the offense (AAMC GREAT, 2021). The institutional landscape for these processes is complex—different offices handle different kinds of complaints, timelines vary, and the experience of going through a formal process can be difficult and uncertain. Understanding the institution's requirements and resources before they are needed, so that when a situation arises a solution can be found as quickly as possible, is time well spent.

Repairing Trust

Collaborations can survive conflict, even serious conflict, if the parties involved are willing to engage in the work of repair. What repair requires varies with the situation—sometimes it is an acknowledgment that a mistake was made, sometimes a renegotiation of the terms of collaboration, sometimes structural changes to how the team works. What it always requires is some degree of honesty about what went wrong and some genuine commitment to doing things differently.

Consider a scenario that recurs with some regularity in collaborative science. Two researchers have co-led a multiyear project, and as a major paper nears submission, a dispute arises over authorship order. Each believes, with genuine basis, that their contributions warrant first authorship. Neither had discussed the question explicitly at the outset—each had assumed the answer was obvious. What follows, in the worst cases, is a breakdown: the paper delayed, the collaboration poisoned, sometimes a formal complaint filed. But in cases in which repair is possible, what makes it so is almost always the same set of moves: a direct conversation in which both parties articulate not just their position but their reasoning; a willingness to surface the assumptions each had been carrying without the other's knowledge; and a negotiated—sometimes creative, such as co-first authorship with an explanatory footnote—that both can accept. The collaboration often continues, sometimes stronger for having worked through the conflict explicitly. What makes repair possible in such cases is exactly what makes it uncommon: the willingness to have a genuinely honest conversation about something both parties would prefer to avoid.

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Trust, once damaged, takes time to rebuild and might never fully recover. Because of this, it is important to treat relationships within a collaboration as worth tending, because they can be difficult to repair or replace.

Knowing When and How to Exit

There are collaborations that cannot be repaired and should be ended. Recognizing this—and knowing how to exit responsibly—is one of the least-discussed and most important aspects of collaborative science.

A responsible exit means, as much as can reasonably be expected, honoring the commitments an individual has made, giving appropriate notice, documenting contributions clearly, and preserving the integrity of the shared data and materials. Exiting responsibly also means avoiding disappearing abruptly, cutting off communication, or taking data or materials without explicit agreement; but it does not mean staying indefinitely in a situation that is harmful to individuals or to the quality of the science.

The decision about when to exit, and how to do so, is often complicated by real costs: potential damage to professional relationships, loss of access to resources or data, and the professional precarity that makes it hard for anyone, especially early-career researchers, to walk away from something that is not working. These are real constraints, and they do not have easy solutions. What can help is having honest conversations with trusted people outside the collaboration, knowing what institutional resources are available, and knowing and being clear about boundaries.

CONCLUDING COLLABORATIONS

Every collaboration, regardless of how successful it has been, eventually comes to an end. When it is over, researchers who were a part of it need to fulfill whatever responsibilities remain. They also have the opportunity to look back and take lessons. Taking that opportunity seriously is part of what it means to develop as a scientist and as a collaborator.

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Offboarding: People, Data, and Materials

When someone leaves a collaboration, the offboarding process matters. Questions that need to be answered include: What data and materials will the departing person be able to take or access? What are their ongoing obligations to the project—for example, to review and respond to questions about work they have already done? What will they be acknowledged for, and in what form? How will previous commitments to authorship be honored? What are the confidentiality obligations that persist after they leave? Ideally, these questions should have been addressed in the original collaboration agreement. When they have not been, they need to be resolved explicitly to avoid assumptions or misunderstandings. Poorly managed offboarding can leave people feeling that their contributions were not fairly recognized, can create disputes over credit and publication, and can compromise the long-term integrity of the research record.

Carrying Lessons Forward

Collaboration offers knowledge about how a particular kind of work gets done, relationships (however complicated) to connect to a broader community, and experience of what works, what does not, and to do differently next time.

Researchers who become genuinely skilled collaborators tend to be the ones who have paid attention to those experiences—who have been willing to reflect honestly on their own patterns and habits, who have sought feedback from people they trust, and who have treated each collaboration not just as a means to a product but as a practice. That practice extends beyond the work itself. As the Introduction to this guide observed, scientists bear responsibility not only for the knowledge they produce but for the environments in which they produce it. Building a laboratory culture characterized by fairness, respect, and professionalism is not separate from conducting good science; it is a condition for it. The evidence is clear that diverse teams produce more innovative research, and that the structural barriers keeping talented people out of science are real and addressable (Handelsman et al., 2005). Effective mentorship is one of the most direct levers available to individual scientists, and research on what makes mentoring relationships work has moved

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well beyond intuition into something that can be defined, taught, and assessed (Pfund et al., 2016).

Science depends on people working together across differences of training, perspective, cultural norms and practices, and power. Getting better at that is not incidental to the scientific enterprise. It is part of what science asks of us. Box 2-3 provides a list of questions for consideration over the duration of a collaboration. These questions are provided as a resource for discussion at the beginning of collaboration so teams can agree on the answers.

BOX 2-3 Questions for Collaboration Planning

Data: What data will be shared internally? Externally? When will the data be shared internally and externally? How will the data be shared across collaborators? How will data be shared to external audiences? Who has the decision-making authority for sharing the data? Will any part of the data be copyrighted or licensed, and if so, who will own the copyright or license?

Code: What code will be shared internally? Externally? When will the code be shared internally and externally? How will code be shared across collaborators? How will code be shared to external audiences? Who has the decision-making authority for sharing the code? Will the code be open source? Will any part of the code be copyrighted or licensed, and if so, who will own the copyright or license?

Analysis and Results: What results will be shared internally? Externally? When will results be shared internally and externally? How will results be shared across collaborators? How will results be shared to external audiences? Who has the decision-making authority for sharing the results? Will any part of the methods, analysis, or results be copyrighted or licensed, and if so, who will own the copyright or license?

Other Questions to Consider:

- What information is noted in the grant/contract language (if applicable)?

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- What information does each collaborator have? What expertise does each collaborator bring, and when should they be consulted on processes?
- When should the research institution be consulted?
- When should the funding organization (if different than the research organization) be consulted?
- If one or more collaborators are working as part of their dissertation research, what parts of the entire work will be shared in dissertation(s), and when, as opposed to other publications?

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3

Earning and Maintaining Trust

Trust facilitates many processes of the research endeavor. Members of a research team need to trust one another to do their collaborative work, and science needs society to have trust in the scientific process and in research institutions. Without trust, research findings go unheeded, public support erodes, and the scientific enterprise loses its capacity to contribute to human welfare. Trust in the scientific record facilitates all research endeavors, and it is the responsibility of researchers at all career stages to maintain that record. This trust is built through behaviors at the individual, team, and institutional levels as well as through interactions both among researchers and between researchers and the public. Trust develops over time through consistent demonstrations of expertise, benevolence (i.e., care), integrity, and openness (Besley et al., 2021a; Hendriks et al., 2015; Reif et al., 2025). But scientists can lose trust quickly, through data fabrication, selective reporting of results, failure to acknowledge funding sources or prior work, failure to protect society from harmful research practices, and other irresponsible behaviors. Scientific institutions can similarly lose

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credibility when they cover up misconduct by individual scientists. Both situations lead to the public perception that scientists cannot be relied upon to tell the truth about what they know and how they know it or to show concern for public good.

The responsibility for earning and maintaining trust operates across multiple levels and that strengthening research integrity requires addressing both individual conduct and institutional structures. Researchers rely on each other to report findings accurately, to give credit where it is due, and to correct errors when identified. Funders rely on researchers to use resources responsibly. Research participants rely on ethical conduct of scientists and proper handling of contributions. Academic institutions rely on faculty and staff to uphold standards of conduct to protect both science as a reliable knowledge production process and society, and industry, government laboratories, and other research organizations rely on researchers to uphold those standards. Individual researchers rely on institutions to support them in their search for truth and public benefit. The public relies on scientific findings to represent the best available evidence, acknowledge uncertainties, and not overstate what is known in order to advance personal or political agendas.

Public trust influences decisions in health, policy, and technology and affects participation in research and support for funding. Society is less likely to accept recommendations made by scientists when trust in scientists and research institutions declines. Scientific research depends on financial support, a substantial portion of which comes from taxpayers through federal agencies. When trust erodes, support for scientific research becomes harder to maintain (Besley, 2018; Ho et al., 2010). Science-based policy decisions in domains such as public health, environmental protection, technology regulation, and others depend on policymakers and citizens believing that scientific evidence is trustworthy (Algan et al., 2021). These forms of trust are not automatic. Scientists are expected to earn and maintain such trust (NASEM, 2017).

This chapter focuses on the behaviors and responsibilities that build and sustain trust across different contexts. The content is organized around four major themes:

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1. Trustworthiness of individual researchers, in the daily practices and professional commitments that establish trustworthiness;
2. Institutional structures that support trustworthy science, such as the policies, cultures, and accountability mechanisms that organizations ought to provide;
3. Trustworthy communication with the public, or how scientists can share their work honestly and openly while navigating media and policy environments; and
4. Trust in community-engaged research, including the special obligations that arise when working directly with communities in research.

Together, these themes add up to the collective responsibility that scientists and institutions bear for maintaining the social contract between science and society.

Responsibility for maintaining trust is shared across individuals, teams, institutions, funders, and publishers. Research teams within a laboratory or across disciplines and institutions play critical roles in creating environments where ethical conduct and active engagement with societal needs and concerns are expected, supported, and enforced. Institutions are responsible for ensuring that researchers employed and supported by them act in ways that strengthen rather than weaken trust. Funding agencies shape expectations through their requirements and oversight. Professional societies establish standards and provide forums for discussing ethical challenges. Journals and publishers act as gatekeepers and determine what gets disseminated (see Box 5-5 for more information on publications). Collectively, academic communities set norms about the degree to which scientists are expected to engage meaningfully with other societal actors (Jamieson et al., 2019). All of these actors contribute to the ecosystem in which trust can flourish or erode. Early-career researchers benefit from understanding both individual responsibilities and the broader systems that support trustworthy research, and how they can participate in and even contribute to building structures that enable demonstrations of trustworthiness as they advance in their careers.

As with other chapters, this one is a framework rather than an exhaustive treatment. The landscape of trust in science is constantly

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evolving, shaped by new technologies, changing social expectations, and emerging ethical challenges. What remains constant is the centrality of trust to the entire enterprise. The goal here is to help researchers recognize the considerations that shape trust, to provide guidance on navigating them responsibly, and to reinforce that maintaining public trust is not just a professional obligation but a prerequisite for science to fulfill its potential as a force for good in the world.

TRUSTWORTHINESS FOR RESEARCHERS

Researchers occupy a distinctive position in society. Many have substantial autonomy to pursue questions that interest them and access to resources that make investigation possible. They also are seen as experts in their field, which gives them a measure of authority in shaping public discourse. With this position come responsibilities. Scientists are expected to work with integrity and contribute to collective knowledge in ways that build fairly on others' work and upon which others can fairly build. Their responsibilities, however, go beyond avoiding misconduct. To build trust, scientists should consider and act upon how their research choices and findings might affect the people and communities their research touches. Meeting basic honesty standards is necessary, but trustworthy researchers also engage thoughtfully with critique (Altenmüller et al., 2021), acknowledge uncertainty (Gustafson and Rice, 2020), and consider the public interest when making decisions about what to study, which methods to use, and how to communicate (Druckman et al., 2025).

The social contract between science and society rests on the premise that scientific inquiry always serves the common good. This perspective does not mean that all research has immediate, practical application, but it does mean that researchers have an obligation to consider how their work could impact society. In fields involving emerging technologies, such as artificial intelligence (AI), gene editing, synthetic biology, or nanotechnology, these implications can be profound. Anticipating ethical and social issues that could arise from a line of research inquiry (in some instances, by engaging with stakeholders who might be affected) and contributing to the development of responsible guidelines are all part of what it

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means to be a trustworthy researcher in these domains (Murdock et al., 2005). Values matter here. When scientific values such as the pursuit of knowledge for its own sake come into tension with social values, such as protecting privacy or preventing harm, researchers are expected to navigate these tensions thoughtfully rather than assuming that the values of scientific inquiry always take priority. Additionally, attention must be paid to the distribution of the societal goods of research, so that, for example, new medical treatments do not benefit only the wealthiest members of society.

Trust is earned and maintained through behaviors both large and small. At its foundation, trustworthiness requires meeting basic expertise and honesty standards: reporting data accurately, citing sources properly, disclosing conflicts of interest, correcting errors when identified, and so forth. But trust requires more than just avoiding misconduct. Epistemic humility, defined as acknowledging what is not known, recognizing the limits of expertise, avoiding overconfident claims, and not substituting one's own values for matters of public choice (Koetke et al., 2025), matters. So does responsible engagement with the scientific community: responding constructively to criticism, raising substantive critiques of others' work, and participating in the debates and discussions that advance understanding. A clear consideration of public interest and public good is also essential, which includes recognizing that the public funds a substantial part of the research enterprise and has a legitimate stake in how that work is conducted, communicated, and moved into application or action.

People trust scientists based on three key perceptions: that scientists have relevant expertise, that they have pro-social motives (i.e., that they are motivated by concern for the collective good rather than narrow self-interest), and that they possess deep integrity and moral values. Threats to any of these dimensions undermine trust, while demonstrations of these dimensions can build trust (Besley et al., 2026). For example, researchers might foster perceptions of integrity by being open about uncertainty and limits, and they can harm trustworthiness when they overstate the certainty of findings, whether to secure funding, seek media attention, or unduly influence public policy. They can demonstrate their concern for public goods by engaging with communities to

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ensure that their research addresses real societal needs and can harm trustworthiness when they create the impression that they care more about getting published than having a positive impact (Benson-Greenwald et al., 2023). Eagerly engaging public concerns about the societal and ethical implications of their research can signal a desire to help others, while dismissing such concerns may signal a lack of humility and a disregard for the common good and societal values. Reducing unwarranted hype, for example, by resisting institutional and personal pressures to exaggerate the significance or immediate applications of findings, is essential to maintaining trustworthiness (Jamieson et al., 2019). These are not hypothetical examples. They happen, and when they do, they can either enhance or damage not just individual reputations but the trustworthiness of science more broadly. See Box 3-1 for a historical example of trust for the Havasupai Tribe.

Minimizing and managing mistakes is another aspect of demonstrating trustworthiness. Everyone makes occasional errors in data entry, analysis, or interpretation. While scientists are expected to have processes to avoid such errors, once they have occurred, what matters is how those errors are handled. A researcher who discovers a mistake in a published paper has a responsibility to correct the record, even if doing so is professionally and personally uncomfortable. Institutions and journals have effective procedures for corrections and retractions, and using those procedures demonstrates integrity rather than weakness. Transparency about research misconduct follows the same logic. When misconduct occurs, responding to it with honesty rather than defensiveness is essential to maintaining trust. Academic institutions should have a research integrity office, and industrial corporations should have an ethics and compliance office. These offices respond to concerns about research integrity and handle allegations of research misconduct. Whistleblowers who report concerns about fabrication, falsification, or plagiarism often face retaliation, but protecting whistleblowers who have made allegations in good faith and with a reasonable basis for the allegations and taking their concerns seriously is a marker of institutional integrity and a desire to benefit society rather than narrow interests.

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BOX 3-1 Historical Example: The Havasupai Case

In 1989, members of the Havasupai Tribe—a small Native American community living at the base of the Grand Canyon—approached Arizona State University (ASU) researchers with a pressing concern: rates of type 2 diabetes among their people were alarmingly high. They consented to provide blood samples for a study aimed at identifying genetic factors behind that disease. What researchers did not describe, and thus did not seek tribal members' consent for, was that they would use the samples provided to investigate schizophrenia, population migration patterns, and questions of inbreeding—topics that were both scientifically separate from diabetes research but also a repudiation of Havasupai cultural beliefs. For example, the tribe holds that their people originated in the canyon and tribal members did not consent to using their blood samples to research migration patterns, so research results suggesting their ancestors migrated from Asia directly contradicted that belief.

By the time a tribal member stumbled upon a dissertation defense in 2003 and realized what had been done with the blood, researchers had published over 20 papers using Havasupai samples, most of which of which had nothing to do with diabetes.[1,2] The written consent form that participants had signed said only that the research would "study the causes of behavioral/medical disorders"—broad language that researchers later argued covered their subsequent work, and that tribal members reasonably understood to mean something far more limited.[3]

Despite researchers claiming that the broad language covered their subsequent work, tribal members felt that they had been deceived. The lessons for early-career researchers are of the danger of ambiguity in consent procedures and that legally defensible consent

[1] Zawilak, T. 2025. Havasupai Tribe v. the Arizona Board of Regents (2008). https://embryo.asu.edu/pages/havasupai-tribe-v-arizona-board-regents-2008.

[2] Sterling, R. L. 2011. Genetic research among the Havasupai: A cautionary tale. AMA Journal of Ethics 13(2): 113–117. https://doi.org/10.1001/virtualmentor.2011.13.2.hlaw1-1102.

[3] Garrison, N. A. 2013. Genomic justice for Native Americans: Impact of the Havasupai case on genetic research. Science, Technology, & Human Values 38(2): 201–223. https://doi.org/10.1177/0162243912470009.

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and genuinely informed consent are not the same thing. When a more senior colleague is moving ahead with uses of data or biological material that feel like they push past what participants understood they were agreeing to, the appropriate response is to raise the question—with the senior researcher directly, with the institutional review board (IRB), or with a research integrity officer. Complicating this case are the unique aspects of working with Tribal Nations, which are sovereign governments with authority over their citizens and lands.

Bringing community members themselves into the process of designing and reviewing consent forms, rather than treating consent as a legal formality to be cleared before work begins, is not just ethically preferable; it is practically essential for studies involving communities with historical reasons for skepticism about outside researchers. Work by De Sutter et al. (2022)[4] on co-creating electronic informed consent with research participants, and by Skinner et al. (2015)[5] applying community-based participatory research principles to genomic consent documents, offers concrete guidance on how to do this well. The Havasupai case is sometimes invoked as an example of what happened before modern ethical standards were fully in place, but the blood was collected in 1990 and IRB approval existed. The problem was not the absence of rules; it was the absence of genuine respect for the people whose trust made the research possible.

The lawsuit the tribe filed against Arizona State University's Board of Regents eventually settled in 2010 for $700,000, with the university also agreeing to return all blood samples and provide scholarships and assistance with a health clinic. In a quiet ceremony, tribal members who had traveled to the ASU campus in Tempe carried the samples home. Thirty-two of the individuals who had donated blood samples for diabetes research had died while the legal battle dragged on.

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[4] De Sutter, E., D. Geerts, P. Borry, et al. 2022. Co-creation with research participants to inform the design of electronic informed consent. Digital Health 8: 20552076221109068. https://doi.org/10.1177/20552076221109068.

[5] Skinner, H. G., L. Calancie, M. B. Vu, et al. 2015. Using community-based participatory research principles to develop more understandable recruitment and informed consent documents in genomic research. PLoS ONE 10(5): e0125466. https://doi.org/10.1371/journal.pone.0125466.

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The case never produced a formal legal precedent because it settled before any court could rule on it, but it had several effects on community research in other contexts. Tribes across the country grew more reluctant to participate in genetic research, even though there was a clear vision for how the studies would benefit them.[3] Because the institution did not fully disclose the research to be performed on the blood samples, including research that conflicted with cultural values of the Havasupai, the damage to trust was great. And publicity surrounding the behavior of the researchers and institution meant that the damaged trust was not confined to one institution or one study but spread through entire communities that already had good historical reasons to be cautious about what researchers actually do with the access they are granted. However, multiple Indigenous data rights assertions, advocacy groups, and even the establishment of new Indigenous review groups were outcomes of this case and others similar to it. For example, the Navajo Nation Human Research Review Board was established in 1996.[6,7,8]

[6] Begay, R. L., N. A, Garrison, F, Sage, et al. 2020. Weaving the strands of life (Iiná Bitł'ool): History of genetic research involving Navajo people. Human Biology 91(3):189–208. https://doi.org/10.13110/humanbiology.91.3.04.

[7] Brugge, D., and M. Missaghian. 2006. Protecting the Navajo people through tribal regulation of research. Science and Engineering Ethics 12: 491–507. https://doi.org/10.1007/s11948-006-0047-2.

[8] Drabiak-Syed, K. 2010. Lessons from Havasupai Tribe v. Arizona State University Board of Regents: Recognizing group, cultural, and dignitary harms as legitimate risks warranting integration into research practice. Journal of Health and Biomedical Law 6: 175–225. https://doi.org/10.13016/dhke-perq.

Researchers are expected to be open about data, limitations, and uncertainty, and also to recognize that scientific facts often inform complex societal decisions without dictating them. Acknowledging a gap between what the evidence shows and what policies should follow is critical. Scientists can and should contribute to policy discussions, but they should clearly explain limitations and

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uncertainties when they are presenting evidence or discussing particular courses of action.

Recognizing prior breaches of trust and working to remedy them is another important way to demonstrate trustworthiness. When communities or groups have been harmed by bad behaviors that have included exploitation, deception, and failure to share benefits, researchers currently working in those contexts have an obligation to acknowledge this history and demonstrate through their actions that they will not repeat those patterns (Christopher et al., 2008; Jagosh et al., 2015). This approach requires humility, transparency about how current work differs from past practices, and sustained engagement that allows trust to be rebuilt over time.

Finally, trustworthiness requires being a responsible steward of public funds. Research is expensive. Through federal and state budgets, taxpayers provide a significant amount of the support received by research in the United States. Foundations, corporations, and other funders contribute as well (and many of them receive public benefits such as tax considerations for committing funds to research). These resources come with expectations: that they will be used efficiently, that results will be reported widely and honestly, and that the work will be conducted ethically. Researchers who treat grant funding as a public commitment can build trust. Those who see it as an entitlement rather than a responsibility and who fail to deliver on promised work erode trust not just with their immediate funders but with the broader public that underwrites the enterprise. Being a responsible researcher means taking these obligations seriously.

A particular challenge and opportunity for trustworthiness arises when researchers engage with policy processes. Scientists play multiple roles in policy contexts: observers who bring newly identified phenomena to the public agenda, analysts who evaluate evidence and identify options, advisors who help policymakers understand technical issues, and sometimes advocates for particular policy outcomes. These roles can depend on the field of expertise and the circumstance in which their advice is being sought. Analysis aims to expand the range of policy options by clarifying what is known and what trade-offs different choices entail. Advocacy aims to narrow that range by arguing for specific actions. Both are legitimate

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activities, but they demand different forms of transparency. When serving as analysts or advisors, researchers have an obligation to present evidence fairly and to acknowledge uncertainties and alternative interpretations. When supporting particular policies in public forums or through direct engagement with policymakers, researchers should be clear about that role and should not present advocacy positions as if they were neutral scientific assessments. Even as advocates, those who identify as scientists should be expected to uphold norms of integrity. The line between these roles can blur, and researchers should be thoughtful about when they are crossing it and how they communicate that transition to their audiences (Kotcher et al., 2017).

INSTITUTIONAL SUPPORT STRUCTURES FOR TRUSTWORTHY SCIENCE

Individual researchers cannot build and maintain trust alone. Universities, research institutes, public and private funding agencies, and professional organizations all play essential roles in building trust in the scientific community (Scott et al., 2024). Institutional policies and decisions made by institutional leaders can go a long way to creating an environment that fosters ethical conduct and robust societal engagement (Besley et al., 2021b). Similarly, gaps in policy or ineffective leadership can leave gaps that allow misconduct to flourish. The training, oversight, and accountability mechanisms they provide shape how research gets done and shared. Researchers are expected to understand these structures not just because they are subject to them, but also because they will help shape and sustain them.

Responsibility in science is distributed. When something goes wrong, determining who bears responsibility and who should be held accountable requires understanding this distribution. Individual researchers are responsible for the integrity of their own work, but principal investigators are responsible for the conduct of their teams. Institutions are responsible for creating environments in which ethical behavior is enabled and expected, and misconduct or irresponsible practice is addressed. Funders are responsible for setting clear expectations; institutions where researchers work are responsible for ensuring that the funds provided for research are

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used appropriately. Professional bodies such as societies, journals, or accrediting organizations bear responsibility for promoting and enforcing standards within their fields, although the responsibility of enforcing those standards also lies with institutions. A graduate student who fabricates data is ultimately responsible for that fabrication, but the advisor who failed to provide adequate supervision also bears some responsibility. An institution that investigates credible allegations of misconduct rather than ignoring them demonstrates its own integrity as well as that of the broader system.

Transparency about funding is another institutional responsibility. Who is paying for research, and what expectations come with that funding? Answers to these questions are often inadequately disclosed (ISC, 2025) despite public concerns about funding. Institutions should make research funding visible by showing what grant money is coming in, from what sources, and to whom it is being awarded. Journals would do well to require that authors disclose their funding sources for the work on which their submission is based. Similarly, conference organizers would be serving the cause of transparency by requiring that presenters be transparent about who funded the work. Conflicts of interest, whether financial or otherwise, need to be identified and managed. None of this eliminates the possibility that funding sources might influence research or public trust in research, but it allows others to assess that possibility and to interpret findings with appropriate skepticism when necessary.

Institutional interests do not always align with scientific or public interests. Universities depend on research funding, and that dependence can create pressure to overlook conduct violations if the researcher involved brings in substantial grant money. Corporations that sponsor research may have financial stakes in particular outcomes, creating incentives to suppress or selectively report findings. Government agencies may face political pressure to reach conclusions that support particular policies. These conflicts are not easily resolved, but they should be acknowledged, and research and its integrity should be insulated from inappropriate pressures. Institutions that prioritize their own financial or reputational interests over scientific integrity erode trust, both internally and

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externally. Trustworthy institutions recognize these tensions and put policies in place to ensure that scientific standards are not compromised by competing interests.

Good practices for investigating allegations of research misconduct are essential to maintaining trust. Institutions are required by federal regulations to have procedures for handling misconduct inquiries and investigations, but the quality of those procedures varies. Effective investigations are conducted by individuals with relevant expertise, free from conflicts of interest, and with access to necessary evidence. They are completed in a timely manner, because delays undermine confidence in the process and can allow misconduct to continue. They protect both the rights of the accused and the integrity of the process. They result in findings that are based on evidence rather than institutional convenience. And they lead to appropriate consequences, including sanctions against those found responsible, exoneration of those who are not responsible, and corrective measures to prevent similar problems in the future. Critically, institutions should publicly share the results of misconduct investigations, even if the person involved has left the institution. Transparency about how misconduct is handled is essential to demonstrating that the institution takes integrity seriously. When institutions fail to investigate misconduct promptly and thoroughly, or when they retaliate against those who raise concerns, they signal that integrity is not a priority. See Box 3-2 for an illustrative example of ambiguity in disclosure expectations and institutional guidance.

Creating a culture that promotes transparency, ethical conduct, and attention to positive societal impact is perhaps the most important institutional function. Formal policies and training are necessary, but they are not sufficient. Culture is shaped by the daily behaviors of faculty, administrators, and senior researchers. It is shaped by what gets rewarded and what gets punished, by whose concerns are taken seriously and whose are dismissed, by whether people feel safe raising questions about practices they find troubling or feel undermined when they do raise questions. Institutions that want to build trustworthy cultures should think carefully about these dynamics, protect whistleblowers rather than retaliating against them, and support junior researchers who are

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BOX 3-2 Illustrative Example: Ambiguity in Disclosure Expectations and Institutional Guidance[1]

A researcher was removed from a federal grant and subjected to institutional and public scrutiny due to concerns about undisclosed foreign ties and potential conflicts of interest. The scrutiny was, in part, influenced by broader national attention to foreign government interference in research and heightened sensitivity to collaborations involving specific countries. Over time, it became clear that the concerns centered on interpretation of disclosure requirements and institutional expectations, rather than clear evidence of espionage or illicit transfer of research. The researcher maintained that all relevant information had been disclosed through appropriate channels or that differences in interpretation accounted for perceived gaps. Although the case did not ultimately result in criminal conviction, the professional consequences were significant, including reputational damage, loss of research opportunities, and disruption to ongoing projects. For early-career researchers, this case illustrates how ambiguity in disclosure rules can intersect with heightened geopolitical concerns to create risk, particularly for individuals with international backgrounds or collaborations. Additionally, it highlights the importance of institutions providing clear, consistent guidance and due process when evaluating potential research security issues or other instances of misconduct. That is, researchers facing scrutiny are entitled to understand the specific allegations made against them, have access to institutional support, and have their disclosures evaluated against the policies and practices that were in effect at the time they were accused of wrongdoing. The key teaching point is that research security must be implemented in a way that protects both national interests and the foundational principles of fairness and inclusion in science. Researchers should be diligent in documenting all affiliations and support, but they should also understand that the system is evolving and that transparency, communication,

[1] This example is hypothetical but based on the expert knowledge and experience of the authoring committee.

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and institutional support are essential safeguards against both undercompliance and overreach.

navigating difficult situations rather than leaving them to figure things out alone. Stewardship of institutional resources includes stewardship of people. This requires creating environments where everyone, regardless of rank and status, is treated with respect and held to consistent standards. While most institutions articulate such principles, they may not be put into practice across the entire organization.

The impact of emerging technologies such as AI on the broader scientific enterprise is something with which institutions are only beginning to grapple. AI tools are changing how research is conducted, how data are analyzed, and communication related to findings. AI and other tools likely to be developed may offer efficiencies, but they are also likely to introduce risks—risks of bias, of error, of overreliance on systems that are not fully understood, and communication processes that outpace reflection. Institutions have a responsibility to develop thoughtful guidelines about how these tools should and should not be used, and to ensure that researchers understand both the capabilities and the limitations of the technologies they employ. These questions are not just technical ones; they are ethical ones. The decisions that institutions make about emerging technologies will shape the trustworthiness of the research conducted within them.

Consider, for example, the use of large language models in research writing, data analysis, or literature review. These tools can accelerate certain tasks, but they can also introduce errors, reproduce biases present in their training data, or generate plausible-sounding text that is factually incorrect, conceptually inaccurate, or hallucinates the existence of sources. Researchers who use these tools are responsible for the accuracy of what they

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produce, but institutions also have a role in setting expectations and providing training. Similarly, as machine learning techniques become more central to data analysis across fields, institutions are expected to ensure that researchers understand when these methods are appropriate, how to validate their outputs, and when human judgment remains essential. Allowing technologies to be adopted without institutional guidance may create conditions in which errors can propagate unchecked and trust can erode not because of individual misconduct but because of systemic failures to recognize and manage new risks.[1]

TRUSTWORTHY SCIENCE COMMUNICATION AS PUBLIC ENGAGEMENT

The degree to which scientists seek to engage people outside their field and the broader public matters as much for trust as how they conduct that work in the first place. Most people and groups in society lack direct access to the research process. What they typically see are the claims that scientists make, the way uncertainties are presented, and whether scientists seem genuinely interested in helping people managing complex issues or whether they seem more interested in advancing their own agendas. Trustworthy science communication is not about simplifying findings to the point of distortion or about presenting a unified front that conceals legitimate disagreement. It is about sharing evidence honestly while providing appropriate context for the research, including underlying motives and what was done to ensure the work's integrity (e.g., avoiding conflicts of interest, using validation processes such as expert review). It may often involve acknowledging what is uncertain versus what is well established, helping audiences distinguish between what is accepted and what remains contested within the scientific community.

Scientific debates should be visible in science communication. When there are key evidential disputes, disagreements over interpretation, or methodological disagreements within a field, the public deserves to know about them. Claiming artificial unanimity is dishonest and, when such certainty inevitably dissipates because of

[1] See Box 1-2-and "Humans Teaming Up with Systems and Technology" in chapter 2.

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new evidence, people may lose trust. When any claims of consensus are presented to the public, there should be transparency about the nature of agreement that exists within the field and what any substantive dissenting views are, even if they are held by a minority. Consensus is only trustworthy if it is properly formed (Oreskes, 2019). Scientists' ability to claim consensus can emerge only from robust debate, after multiple perspectives have been considered, and after evidence has been evaluated rigorously. Scientific communication should help the public assess when such consensus exists and when it does not. This claim means being honest about the state of knowledge and about where legitimate uncertainty and disagreement remain. At the same time, those critiquing research need to recognize that providing uptake and response to critique is a requirement for all, including those leveling critique. Merely raising criticisms without considering how the researchers addressed previous criticism undermines the value of critique and the integrity of the scientific endeavor (Chinn and Hart, 2022).

Communicating uncertainty is one of the hardest aspects of science communication, but it is essential to maintaining trust. Science makes claims that are provisional, and thus open to revision as more evidence, more refined data, or new interpretations become available. Of course, scientists should speak in probabilities when appropriate, although it is not always appropriate, as some facts are established beyond reasonable doubt (the Earth is not flat, vaccines do not cause autism). But for many questions, especially those at the frontiers of knowledge, probability language is essential. The public and the media, however, often seem to demand clear answers even when a clear answer is not available. The solution is not to pretend that science offers more certainty than it does. Rather, the solution is to remind others that science is an iterative process in which conclusions are updated based on new data. This revisiting of and reflection on claims is a defining feature of science, not a flaw. Researchers who communicate uncertainty effectively help audiences understand that changing one's mind in light of evidence is a strength, not a weakness.

Avoiding hype and misrepresentation is another key component of trustworthy communication (Intemann, 2022). Researchers face strong incentives to overstate the significance of their findings in

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order to secure funding, to attract media attention, to advance their careers, and to satisfy their institutions' desires for the same. But hype damages trust. When preliminary findings are presented as breakthroughs, when limitations are downplayed, or when potential applications are exaggerated, audiences come to doubt whether scientists are reliable narrators of their own work. The problem is compounded when institutions and funders amplify hype in their press releases and promotional materials. Trustworthy communication requires discipline: describing findings accurately, situating them within the broader state of knowledge, discussing potential downsides along with potential upsides of application, and resisting the temptation to claim more than the evidence supports.

Navigating traditional media, social media platforms, and policy contexts requires different skills than conducting research. Journalists operate under tight deadlines and often lack deep expertise in the topics they cover. Social media platforms may seem to reward sensational claims and punish nuance, at least in the short term. Policy contexts involve competing interests and political pressures that can distort how evidence is interpreted. Researchers engaging in these spaces should understand these dynamics and think carefully about how their contributions might be received and used. This warning should not mean avoiding public engagement but approaching it thoughtfully, with attention to how communication can build or erode trust.

Accountability is another dimension of trustworthy communication. Scientists are expected to be willing to admit errors publicly, to retract flawed studies with humility, and to correct misstatements when they occur. These practices are hard, especially when they run up against institutional self-interest. Admitting error feels like failure, and in a competitive research environment, it can seem like professional suicide. But audiences understand that mistakes happen. What they do not understand or forgive is defensiveness, evasiveness, or refusal to acknowledge problems that have been clearly identified. A researcher who publicly corrects an error demonstrates integrity (Altenmüller et al., 2021). A researcher who doubles down on a flawed claim demonstrates the opposite.

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Good practices for science communication extend beyond talking to journalists and posting on social media. Researchers, particularly early-career researchers, may not realize the opportunities available to them to engage with local communities at all stages of the research process. Rotary Clubs, Kiwanis, library programs, and similar organizations are often looking for speakers who can share scientific insights in accessible ways. These are not high-profile venues, but they can be valuable ones. They allow researchers to connect with people who might never attend an academic lecture or read a scientific journal, and they help build trust at the grassroots level. Creating derivative products from peer-reviewed research, such as policy briefs, synthesis reports, op-eds, and accessible explainers, is another form of engagement. These products serve audiences who want to engage with scientific information but do not have the time or expertise to read the primary literature. These audiences may include scientists from other disciplines. Producing these products well requires thought and effort, but the investment pays off in broader understanding and stronger trust. See Box 3-3 for an illustrative example about communicating via social media.

Importantly, science communication should involve two-way exchange, and not just dissemination. This type of communication is often discussed as public engagement because of the focus on engaging more deeply with other actors. Seeking out the needs and concerns of local community groups, policymakers, and other societal actors, and trying to understand how such groups view scientific questions and interpret scientific findings, can help scientists make better research and communication choices. When engagement is genuinely reciprocal and scientists learn from the public as well as informing them, the result is research that is more relevant, communication that is more effective, and trust that is more durable.

TRUST WHEN WORKING WITH COMMUNITIES

Working with communities demands a different kind of trust than working with participants recruited to participate in a particular study (Pandya et al., 2025). For example, potential partner communities might be residents of a neighborhood where environmental sampling is taking place, patients with a particular

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BOX 3-3 Illustrative Example: Communicating via Social Media[1]

Maya is a second-year doctoral student in nutritional sciences at a research university. Passionate and articulate, she begins posting short-form videos on social media under a handle that prominently features her university affiliation and department. Her content is engaging and her following grows quickly. Over several months, Maya's posts increasingly promote a protein-only dietary approach, eliminating carbohydrates and most fats entirely, as a solution for metabolic health. The content is confident, accessible, and positioned as cutting-edge. It is also directly contradicted by the published evidence base and overlaps substantially with the active research program of a senior faculty member in her department whose work documents the harms of extreme macronutrient restriction.

A senior faculty member in the department is the leading scholar in macronutrient composition for metabolic health. He has approached Maya to ask her to take care when posting on this topic. Maya believes it is her personal freedom of expression to post whatever she wants and disregards his comments. In fact, she has started to tell other students that this faculty member is trying to silence her. A *New York Times* health reporter, drawn by Maya's following, publishes a feature spotlighting her views, identifying her university and department by name throughout. Within 48 hours, dozens of researchers and clinicians from around the world respond publicly, many directing their criticism not just at Maya but at the institution. The faculty member whose work is implicated feels that the attention is lowering the intellectual reputation of the department and worries that it will be hard to overcome. The university's communications office is fielding press inquiries.

Maya is surprised. She believed she was sharing her personal views, not speaking for the university.

Questions: At what point, if any, does a student's personal social media activity become a professional or institutional matter? What

[1] This example is hypothetical but based on the expert knowledge and experience of the authoring committee.

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factors shift that line: platform size, institutional affiliation in the biography, media coverage?

Maya says she was sharing personal views, not institutional positions. Is that distinction meaningful once the university is named in a national publication? Does intent change the consequence?

What obligations does a student have to engage with the evidence base before posting publicly in their field of study?

Maya's posts attracted a large audience partly *because* of her institutional affiliation. Does benefiting from an institution's credibility create any corresponding responsibilities?

Where does academic freedom end and professional accountability begin for a student? Is the answer different for a faculty member?

What responsibility did the department have before this happened: in graduate training, mentorship, or social media guidance? Is the institution partly implicated in the gap?

The faculty member whose research is contradicted feels undermined but had no prior conversation with Maya about her posts. Who should have initiated that conversation, and when?

What are the competing obligations (student privacy, institutional reputation, scientific integrity, public trust)?

Science communication on social media can democratize expertise and reach people who would never read a journal article. How do we support students in building public voices without producing the conditions for this case? What structures, training, or norms would help?

disease who are being recruited for collaboration in research, or Indigenous communities whose traditional knowledge is relevant to ecological research. In fact, there are unique issues surrounding the conduct of research with Tribal Nations (see Box 3-1). A resource

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for researchers is the NIH Community Engagement Alliance effort,[2] which has a presence across the United States and was instrumental in ensuring that COVID vaccine trials were conducted with a mix of volunteers that reflected national demographics.

Obtaining informed consent and protecting confidentiality are often not enough with potentially vulnerable groups. When research draws from communities and affects people's lives, their environments, or their access to resources, it requires richer and more complex relationships of trust. These relationships take time to build and reflect past experiences, whether good or bad. A single consultation or well-crafted consent form will not establish that relationship. What is needed is engagement built around ongoing communication, mutual respect, and genuine willingness to incorporate community perspectives into research design and interpretation.

Scientists should approach community engagement differently from general public outreach. Public outreach often aims to inform broad audiences about scientific findings. High-quality community engagement, in contrast, involves working with specific groups of people who have a direct stake in the research being conducted. In each case, the community is not just a source of data but a partner whose interests and concerns shape the research itself. Trustworthy engagement requires recognizing this distinction and acting accordingly.

Some key principles that allow community engagement to build trust include mutual respect, inclusion, responsiveness, and co-design. Mutual respect, in this context, means treating community members as partners in the research process, not simply as subjects to be studied or obstacles to be managed. Inclusion means ensuring that the people most affected by the research have a voice in how it is conducted. Responsiveness means listening to community concerns and adapting the research when those concerns are legitimate. Co-design means involving community members in shaping research questions, methods, and dissemination strategies from the outset, rather than presenting

[2] See About Community-Engaged Research and CEAL, https://nihceal.org/about-community-engaged-research-and-ceal.

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them with a finished plan and asking for approval, or simply going ahead with the research without any consultation. These principles are easy to state but often hard to implement, particularly in academic research environments that work on different timetables than communities do and are often weak on project management skills and capacities that keep engagement going.

Knowing when and how to involve communities demands judgment that depends on the nature of the research. Not every project requires community engagement, but many do (Garlick and Fallon, 2023). If researchers choose to do engaged research with a community, they are expected to recognize the power they wield in that position and work with communities to ensure that the community agrees with both the direction and use of the research. If the research draws on community knowledge or resources, the community should be involved in decisions about how that knowledge or those resources are used. If the findings are likely to be applied in ways that affect the community, community members should have input into how those applications are developed and implemented. These are not bureaucratic requirements; they are ethical obligations, and research institutions who want to build trust in science should do more to recognize the values of, and provide specific support for, this kind of work.

Adopting good community engagement practices begins with identifying who, individually and collectively, might find the research relevant to their interests. Identifying these individuals and groups is not always easy. Such groups may not be geographically defined. They may not be formally organized. They may include people whose interests conflict with one another. Once such groups are identified, the next step is treating them with respect, which sounds simple but requires sustained effort. Respect means eliciting their perspectives and taking their hopes and concerns seriously even when they are inconvenient, providing information in accessible formats, holding meetings at times and places that work for community members rather than for researchers, and following through on commitments. It means recognizing that community members have expertise that researchers do not possess, and that research is likely to be better when that expertise is incorporated.

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It is important to acknowledge that good community engagement is hard work. It takes time, requires skills for which many researchers have not been trained, and often involves navigating complex social and political dynamics. Institutions may or may not have appropriate support structures to help researchers do this work well. Some have community engagement offices or partnerships with community organizations, while others offer little infrastructure. Researchers should always ask what resources their institution can provide, but they should also recognize that institutional support is not always available or adequate. Even with the best intentions and strongest institutional backing, good outcomes are not guaranteed for all participants. Community members may have different goals, and what constitutes success for one group may not align with what others value. Navigating these complexities requires humility, flexibility, and a willingness to accept that perfection is not achievable even when the effort is sincere. As with all research, the desired outcome is not determined by good intent or planning.

Community-engaged research builds trust through sustained efforts to nurture relationships. One-time consultations are not enough. Communities involved in prior research—particularly marginalized communities that have experienced exploitation or harm (e.g., the Havasupai tribe described in Box 3-1)—may be skeptical of new research initiatives, and rightly so. Building trust in these contexts requires being able to demonstrate value, patience, transparency, and a commitment to acting in the community's interest. It requires acknowledging past harms and showing, through actions rather than words, that this research will be different. It requires ensuring that benefits accrue to the community, not just to the researchers, and that findings are shared in ways that communities can use. These commitments cannot be taken lightly. Researchers who engage communities superficially, or who fail to follow through on promises, can do more damage to trust than if they had never engaged at all.

Concrete practices can help translate these principles into action. Before beginning research, spend time in the community without immediately launching into data collection. Attend community meetings, talk with local leaders and residents, and listen to

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what matters to them. When developing research questions, ask community members what they want to know, not just what researchers find interesting. When designing methods, consider whether the planned approaches will work in community contexts or whether they can be adapted. When interpreting findings, bring preliminary results back to community members and ask whether the interpretations make sense given their lived experience. When disseminating results, materials in formats the community can use beyond academic papers, such as summary reports, presentations at community venues, or training materials that community organizations can employ, can be useful.

Community-based participatory research (Balazs and Morello-Frosch, 2013) offers one model for this kind of engagement, though it is demanding and not appropriate for every study. In this approach, community members are involved as partners throughout the research process, from formulating questions to collecting data to analyzing findings. Power is shared, and community priorities shape the direction of the work. This approach requires researchers to relinquish some control and to accept that the research may take longer or go in directions they did not initially anticipate. But the payoff, when done well, is research that is more relevant, more trustworthy, and more likely to lead to meaningful change. Even when full participatory approaches are not feasible, the underlying principles of respect, inclusion, responsiveness, and shared benefit can and should guide community-engaged research of all kinds.

SUMMARY

The social contract for science is shifting but continues to be based on trust. Earning and maintaining public trust is central to the scientific enterprise. Without trust, research findings get ignored, funding evaporates, and science loses its capacity to contribute to human welfare. Trust builds through iterative behaviors of how individual researchers conduct their work, the cultures that teams and institutions create, the ways that science is performed and communicated with the public. Trust builds slowly. It can be lost quickly. Thus, constant attention to trustworthiness is required, not as a burden but as a responsibility that comes with the privilege of doing science.

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Individual researchers bear responsibility for conducting their work with integrity, for being honest about what they know and what they do not know, and for thoughtfully engaging with the communities who might be positively or negatively affected by their research. But individual efforts are not sufficient. Institutions are expected to foster environments that support ethical conduct and that respond effectively when misconduct occurs. Institutions should also seek more opportunities to contribute to the public good through research while being transparent about their sources of funding, about conflicts of interest, and about the processes by which research is overseen. They are expected to be supportive toward people who raise concerns rather than retaliating against them. Finally, institutions should recognize that building trustworthy cultures is an ongoing process, not a one-time achievement.

The public should expect the research enterprise to operate with expertise, integrity, and in the public interest. Fulfilling this expectation does not mean that every study has immediate practical application or that researchers should avoid controversial topics. It means treating research participants and community partners with respect and ensuring that the benefits of research are shared broadly. It means that scientists should present evidence fairly, acknowledge uncertainty, and resist pressures to overstate what is known. And it means recognizing that trust is not something that can be demanded but rather earned, maintained, and renewed through consistent demonstration of the values that science aspires to uphold.

Early-career researchers are entering the profession at a time when public trust in science faces significant challenges. Misinformation is common and spreads rapidly. Polarization colors how some scientific research is supported and how some scientific findings are received. Institutional failures, when they occur, receive intense scrutiny. In this environment, individual researchers are expected to be intentional about fostering trustworthiness and avoid being paralyzed by the weight of these challenges. Trust is built through small, consistent actions as much as through large ones. Doing good work, listening, treating others with respect, admitting mistakes, and engaging thoughtfully with critique—these are things every researcher can do, regardless of career stage

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or institutional setting. Collectively, they form the foundation of a trustworthy scientific enterprise that can sustain itself across generations and continue to serve the common good.

The path forward requires both individual commitment and systemic change. Researchers hold themselves to high standards, but they also expect their institutions to provide an environment that supports those standards. When institutions fail to support whistleblowers, when they tolerate misconduct, when they prioritize revenue over integrity, individual researchers have an obligation to speak up. Such actions are not easy, particularly for those without job security or institutional power. But change happens when enough people refuse to accept behaviors and actions that are incompatible with high standards. Professional societies, funding agencies, and journals all have roles to play in rewarding researchers who demonstrate exceptional trustworthiness and in creating stronger accountability structures. Building and maintaining trust is a collective responsibility.

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4

Openness and Security

Research advances through the open exchange of ideas, data, and methods. This is not simply a professional norm—it is the mechanism by which claims get tested, errors get corrected, and knowledge accumulates across generations of researchers. Openness flows from the core scientific values of honesty and objectivity. If a finding is reported, then the evidence supporting that finding is expected to be available for evaluation by others. In practice, this includes sharing published conclusions along with the methods, data, and analytical decisions that support research conclusions. For broader audiences, openness may also include access to relevant datasets, code or algorithms, and methodological detail sufficient to support understanding and replication.

At the same time, science operates within institutional, economic, and geopolitical contexts. Research is conducted within institutions, funded by the institutions themselves as well as governments, philanthropies, and corporations, and connected to technologies that have real-world consequences. Intellectual property considerations, competitive pressures, obligations to

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protect sensitive personal information, and national security concerns can place legitimate limits on what can be shared, with whom, when, and how. These constraints are especially common in industry-sponsored research, in work supported by defense or intelligence agencies, in research with human participants, and in work that could have national security[1] implications. Early-career researchers moving among academic, governmental, and corporate settings often encounter these limits for the first time without much preparation. This chapter is designed, in part, to help with that.

Research security refers to practices and policies intended to protect research from misuse, theft, or unintended harm. Research security and openness are not opposites; they function together and require consideration of context. They are complementary and exist in productive tension, and navigating that tension thoughtfully is part of what it means to be a responsible scientist today. The global research environment has grown significantly more complex in recent years. International collaborations that were once routine now require greater attention to questions of malign foreign influence, interference, and information control. Federal agencies have developed new disclosure requirements, and in response, institutions have developed new processes and requirements to help ensure lawful, administrative, and personal compliance with these evolving federal standards. (ODNI, n.d.). These changes do not undermine the value of open science; disclosures are very much a part of open-science practices and principles of transparency and they change the landscape within which it happens.

This chapter addresses both openness and research security as mutually reinforcing topics that are relevant across the entire arc of a research project—from the earliest stages of conceiving a study, through data collection and analysis, to publication and public communication. The relevant considerations shift at different points in this arc. A researcher's obligations regarding unpublished data differ from their obligations once findings are submitted for peer review, which differ again once work is published and the underlying materials become part of the scholarly record. In general,

[1] Defined as the manner in which specific activities, technologies, policies, investments, or capabilities could harm a nation's strategic interests either directly or indirectly.

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data should not be shared before a manuscript is submitted for peer review but should be shared after the manuscript is published. Understanding the steps in that process and what "responsible" conduct looks like at each stage is a practical skill that takes time to develop.

Responsibility in this domain is also shared. Individual researchers make choices every day about what to share, when, with whom, and how. But research teams set norms and disciplines differ in their data-sharing practices (e.g., high-energy physics, climate science, and genomics data are shared early and widely in those disciplinary communities, while other fields do not have the same expectations). In addition, institutions and governments establish and enforce policies, and the broader research enterprise depends on all of these actors doing their part. This chapter addresses what those different responsibilities look like in practice, so that early-career researchers have a clear sense of what to expect from their institutions and what will be expected of them. The default presumption for fundamental research should always favor sharing and accessibility—the burden of justification falls on restriction, not on openness.

No single chapter or resource can fully capture the range of situations that researchers encounter as norms, laws, and geopolitical realities continue to evolve. What follows is a way of thinking about these issues rather than an exhaustive guide. The goal is to help researchers recognize the relevant considerations when they arise, ask the right questions, and know where to look for authoritative guidance. Fortunately, most universities and private companies have developed resources to assist researchers in making decisions that facilitate research while ensuring compliance with research security requirements. Likewise, the federal government has developed resources, such as the National Science Foundation's Safeguarding the Entire Community in the U.S. Research Ecosystem (SECURE) Center,[2] which are available freely to all to help make risk-informed decisions.

[2] https://www.secure-center.org/

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OPENNESS, SHARING, AND ACCESS AS A DEFAULT IN SCIENCE

Scientific openness refers to sharing, where appropriate, the methods and outputs of research, including data, models, protocols, and code. It is not an ancillary feature of research but one of its defining characteristics. As well as the above, this commitment encompasses hypotheses, materials, results, theories, and the computer code used in processing and analyzing data and images (Hardies, 2025). The qualifier "as appropriate" recognizes that not all information can be shared in all contexts, but general expectation is that openness is the default, and restrictions require justification. Science is cumulative. Findings build on prior work, and future research depends on access to current methods and results. Without sufficient access to underlying evidence, the evaluation, replication, and extension of findings are limited. Replication becomes impossible. Errors go undetected. Progress slows.

Although openness and sharing are different now than over history, some examples illustrate how openness contributes to progress. The scientific revolution of the seventeenth century did not simply introduce new methods of investigation; it established new social practices around the communication of knowledge. Natural philosophers began publishing their methods and findings not in private correspondence but in journals and proceedings accessible to other scholars. Robert Boyle's detailed accounts of his air pump experiments, for instance, were not merely descriptions of results but invitations to others to build similar apparatuses and test his claims. The Royal Society's motto, "Nullius in verba," or take nobody's word for it, encapsulated a commitment to evidence that could be examined by others. Isaac Newton's publication of *Principia Mathematica* in 1687 set a standard for mathematical transparency, laying out derivations in painstaking detail so that others could follow his reasoning step by step. These were not just acts of individual generosity but deliberate efforts to build a collective system of knowledge that did not depend on trust in authority.

The benefits of this approach have proven to be both profound and unpredictable. Fundamental research conducted openly, whether driven by curiosity or application, has repeatedly led to innovations that no one anticipated at the outset. The development of magnetic resonance imaging, now a routine

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diagnostic tool, emerged from basic research in nuclear magnetic resonance that physicists undertook in the 1940s with no medical application in mind. The laser, invented in 1960, was famously called "a solution looking for a problem"; today it is foundational to telecommunications, surgery, manufacturing, and data storage. Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) gene-editing technology traces its origins to basic research by different teams across several decades and countries (Lander, 2016). In 2006, Jill Banfield, a geomicrobiologist, noticed that her sequencing of microbes from acid minefields contained expressed clustered interspersed short palindromic repeats and engaged the help of a colleague in chemistry and molecular cell biology, Jennifer Doudna, in analyzing their origin and function. Doudna's curiosity about Banfield's results led her to begin researching CRISPR (UC Berkeley, 2026). The World Wide Web was created by a particle physicist, Tim Berners-Lee, to help scientists share information, and by making the underlying code freely available he enabled its explosive growth. The Global Positioning System relies on corrections for relativistic effects that were calculated by physicists studying the fundamental nature of space and time. None of these innovations were planned. They emerged because the knowledge on which they rested was openly available to people working on different problems. Restricting access to fundamental research does not simply slow the pace of discovery within a given field; it cuts off the pathways by which knowledge in one domain becomes useful in another. Such examples demonstrate how openness can increase impact of science.

Research is conducted within institutions and can be internally funded or externally funded by a variety of sources, including public agencies, industry, and philanthropy. Much research is conducted in the national interest, whether to advance public health, strengthen economic competitiveness, or address challenges such as climate change and energy security. Funding often comes with expectations about the relevance and impact of the work being supported as well as the return on public investment of tax dollars. These realities do not, however, change the fundamental character of scientific knowledge itself. Knowledge is not a commodity that can be owned in the way that land or equipment can be owned. It is, by its nature,

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nonrivalrous: one person's use of an idea does not always diminish its availability to others. When knowledge is made openly available, it benefits not only the present generation but all future generations who will build on it. This is not an idealistic aspiration; it is a practical feature of how science actually works.

The principle that knowledge belongs to everyone, including and especially to those who come after us, places a moral dimension on decisions about sharing. To restrict access to findings or methods that have been produced with public funding, or to limit the circulation of fundamental research in ways that serve narrow institutional or commercial interests, is to constrain the potential uses of that knowledge by people we will never meet and whose needs we cannot predict. This does not mean that restrictions are never justified—intellectual property protections can incentivize the development of useful technologies, and some information must be safeguarded for legitimate security or proprietary reasons. But these justifications are weighed against the broader obligation to contribute to the collective body of knowledge that sustains scientific progress. Decisions about sharing involve balancing incentives for innovation with broader benefits of accessibility, and the default presumption should always favor openness, with the burden of proof falling on those who would limit it.

Open Science

Open science involves transparency and accessibility in how research is conducted and shared.[3] There are a wide range of open-science practices, including study planning, preregistration (e.g., specifying the research plan and submitting it to a registry) to mitigate publication bias and set a public date for beginning work,[4] material and code sharing, leveraging open-source software and hardware, and open peer review, among others.

Preprints, manuscripts posted before peer review, provide rapid access to findings but may lack formal peer review. Physics has used arXiv for decades with few incidents (Service, 2022); biomedicine

[3] For an illustration of the wide range of practices that are part of open science, see Figure2-1 of NASEM, 2018, at https://www.nationalacademies.org/read/25116/chapter/4#25.

[4] Center for Open Science, What is preregistration? https://www.cos.io/initiatives/prereg.

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adopted preprints more cautiously, with COVID-19 demonstrating both the benefits of rapid sharing and the risks of premature findings influencing policy. Researchers posting preprints are expected to ensure that shared findings are sufficiently robust and clearly communicated. Peer review, despite its limitations, remains essential for identifying errors and strengthening arguments before publication.

Data-sharing practices include frameworks such as FAIR (Findable, Accessible, Interoperable, Reusable; Wilkinson et al., 2016). However, not all data can be shared openly, particularly where privacy or safety concerns exist. Specific individuals can be identified from the disclosure of a few demographic attributes. Indigenous communities may assert data sovereignty. Endangered species locations must be protected. Open data also requires costly infrastructure and curation that fall unevenly across institutions. Risk mitigation strategies include aggregating data for privacy, using controlled-access repositories, posting preprints with clear disclaimers about peer-review status, and making deliberate decisions about what to share, when, with whom, and how.

HOW IS RESEARCH SECURITY DEVELOPED AND MAINTAINED?

Research security can be understood as a set of practices that protect research processes, participants, and outcomes from misuse or harm. Secure research is research conducted with appropriate attention to risks: to individual privacy, to institutional interests, to the safety of vulnerable populations, and to national security when relevant. The goal is not to wall off knowledge but to ensure that the pursuit of knowledge does not create harms that could have been anticipated and prevented. In that regard, research security policies actually empower researchers to perform their work in an increasingly complex world.

Security considerations vary depending on context. At the most immediate level, research security protects researchers' professional interests. Early-career scientists working on novel findings need assurance that their work will not be appropriated before publication. Intellectual property protections—patents, licensing agreements, material transfer agreements—serve to incentivize innovation by ensuring that those who invest time and

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resources in developing new technologies can benefit from that investment. Proprietary information held by corporate sponsors is often safeguarded to maintain competitive advantage and honor contractual obligations, which stifles collaboration. These are not abstract concerns. A postdoctoral researcher whose preliminary data are shared prematurely with a competitor may lose the opportunity to publish first. A university that fails to protect commercially valuable discoveries may forfeit licensing revenue that supports future research.

Research on human participants introduces additional obligations to protect privacy and confidentiality. Personal data pertaining to research participants—medical records, genetic information, behavioral data—must be protected not only to comply with regulations such as the Health Insurance Portability and Accountability Act (HIPAA; CDC, 2024) and the Common Rule (DHHS, n.d.) but to honor the trust that participants place in researchers when they agree to contribute to a study. Beyond individual privacy, some research has implications for entire communities or populations. Studies involving Indigenous knowledge, for instance, may require consultation with tribal authorities and adherence to data sovereignty principles. Research on endangered species may need to restrict location data to prevent poaching. And some research, such as projects in advanced computing, synthetic biology, or dual-use technologies, raises national security concerns that require coordination with federal agencies to prevent exploitation by foreign adversaries. Each of these considerations reflects a legitimate reason to limit access, at least temporarily or selectively, to certain kinds of information.

Historically, research security practices have been implemented effectively, but not without consequences. The Manhattan Project demonstrated that large-scale scientific collaboration could be conducted under strict secrecy when national security required it, but it also raised enduring questions about scientists' ethical responsibilities when their work has catastrophic potential. Cold War–era restrictions on scientific communication, including limits on conference attendance and publication by researchers from certain countries, succeeded in protecting some sensitive information but also hampered international collaboration and bred mistrust.

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More recently, concerns about foreign interference have led to new disclosure requirements and heightened scrutiny of international partnerships. Some of these measures are necessary; some have been poorly designed. The challenge is distinguishing between legitimate security concerns and policies that accomplish little beyond creating administrative burden and chilling legitimate collaboration.

Research security done wrong damages people and institutions. Researchers with familial, cultural, or professional ties to countries whose governments are subjects of heightened scrutiny can find themselves navigating systems that treat them with unwarranted suspicion (Mervis, 2023). For example, a Chinese American scientist working on federally funded research may face questions about loyalties. Researchers investigating nascent or politically unpopular ideas may find their work subjected to additional review not because it poses genuine risks but because it touches on sensitive topics. These disparities are not hypothetical. They have real consequences for career trajectories, mental health, and the diversity of the scientific workforce. Security done wrong can also strain international relationships. When policies are perceived as targeting scientists from specific countries rather than addressing specific risks, they undermine the goodwill on which cross-border research depends. The result is not just damaged collaborations but a global research environment in which scientists feel less safe sharing ideas.

Thoughtful implementation of security measures supports both protection and collaboration. Clear agreements about data sharing, intellectual property, and publication rights that are negotiated in advance and understood by all parties can reduce uncertainty and conflict. Export control compliance, when implemented thoughtfully, ensures that sensitive technologies are protected without preventing legitimate research. Institutions that invest in training researchers to recognize and report security risks create environments in which people feel supported rather than surveilled. International partnerships built on transparent communication about what information can be shared, and with whom, tend to be more durable than those where expectations are left implicit. The key is proportionality: security measures should be calibrated to

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actual risks, not applied as blanket restrictions that assume the worst of everyone involved.

Data Governance

Data governance, the policies and infrastructure that determine how research data are collected, stored, shared, and preserved, sits at the intersection of openness and security (Kaiser and Brainard, 2023). Done well, it ensures that data are accessible to those who need them while being protected from misuse. Done poorly, it becomes a source of frustration and inequity. The costs of data governance are significant and unevenly distributed. Universities and federal agencies are expected to invest in secure storage systems, data management personnel, and compliance infrastructure (Holdren, 2013; Nelson, 2022). Someone has to create the metadata that makes datasets findable and usable by others, and that work often falls to researchers themselves, who may lack the time or training to do it well, and in some cases a research grant expires before the metadata are created so there is a disincentive to work on the datasets for a project that is no longer supported. Multi-institutional and international collaborations raise questions of ownership: when a dataset is produced by researchers from five countries working under different legal and institutional frameworks, who controls access to the original data? Who decides when and how they can be shared? These are not merely logistical questions; they go to the heart of who gets credit, who bears risk, and whose interests are prioritized. The answers matter.

PRODUCTIVE COEXISTENCE OF OPENNESS AND RESEARCH SECURITY

The relationship between openness and security involves balancing competing priorities. Historically, scientific norms emphasized accessibility and sharing. These norms worked well in an era when most fundamental research was conducted in universities and government laboratories within relatively stable geopolitical contexts. However, changes in the research environment, such as globalization, technological advances, and national security concerns, have introduced additional considerations. Research is increasingly international, with collaborations spanning dozens

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of institutions across multiple continents and tools (e.g., genetic sequencing, the Internet, artificial intelligence foundational models) shared and ubiquitous. It is also increasingly consequential, as advances in fields such as artificial intelligence, biotechnology, and quantum computing raise new questions about potential and adversarial exploitation of dual-use research of concern. Security challenges have emerged not because scientists have become less trustworthy but because the context in which they operate has grown more complex. The task now is to reconcile longstanding commitments to openness with emerging obligations to protect sensitive work, human participants, and national interests.

One productive reframing is to treat due diligence not as a barrier to collaboration but as a tool for enabling it. When researchers take time to understand who their collaborators are, what institutional policies govern their work, and what legal frameworks apply to data sharing and intellectual property, they create a foundation for partnerships that can withstand scrutiny. This is especially important in international collaborations, where differences in legal systems, data protection standards, and export control regulations can create unintended violations if left unexamined. Security measures can support collaboration by clarifying expectations and reducing risks. A research team that establishes clear agreements about authorship, data ownership, and publication timelines and cost at the outset is far less likely to encounter disputes later. A university that conducts background checks on potential collaborators is not signaling suspicion; it is ensuring that all parties can proceed with confidence that institutional requirements are being met. Indeed, such examples are common in our daily lives, such as applying for a loan. It all boils down to knowing with whom one is creating a relationship. Responsible openness means being transparent about what can be shared, and under what conditions, rather than assuming that all information should be available to everyone at all times. Openness can therefore increase security through practices such as disclosing conflicts of interest, as well as through infrastructures, such as persistent identifiers and metadata, that link researchers to the outputs they produce, their institutional affiliations, funding sources, and collaborators.

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Competing interests may arise. Academic freedom—the principle that researchers should be free to pursue questions without political or institutional interference—exists in tension with compliance obligations imposed by funders, regulators, and university administrators. Ethical obligations to research participants may conflict with pressures to publish findings quickly. Institutional policies designed to protect intellectual property can delay or prevent the kind of open data sharing that funders now increasingly require. These are not conflicts between good and bad actors; they are structural features of a research ecosystem in which different stakeholders have legitimate but incompatible priorities. Responsibilities are distributed across individuals and institutions, and clear policies and accessible guidance support researchers in navigating these issues. This is easier at well-resourced research-intensive universities with dedicated research compliance offices than at smaller institutions where faculty may be expected to navigate export control, conflicts of interest, and human participant regulations with minimal support. The question of who is responsible when something goes wrong—when a collaboration violates export control rules, or when proprietary data are inadvertently shared—depends in part on whether the institution provided adequate guidance in the first place (Monastersky, 2008).

Balancing openness and security requires sustained attention to context. Norms vary across disciplines, institutions, and cultural contexts. Physicists accustomed to posting preprints on arXiv may find themselves at odds with biomedical collaborators who may have experienced prior embargo periods. A national laboratory operating under Department of Energy security protocols will have different expectations than a liberal arts college. Researchers trained in the United States may take for granted a level of informal communication that colleagues from countries with stricter data protection laws find inappropriate. Norms also shift over time. What was considered acceptable 5 years ago may no longer be acceptable, as funding agencies adopt new data management requirements or as geopolitical tensions alter the risk calculus for certain kinds of international partnerships. Awareness of these shifting norms within one's unit, institution, profession, and legal system is foundational

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to responsible research conduct. Decisions that make sense in one context may be inappropriate in another.

Industry partnerships may include confidentiality requirements, intellectual property constraints, and limits on publication timing. Companies operate under competitive pressures and short timelines that academic researchers typically do not face. Proprietary data cannot be shared openly without jeopardizing market position. Confidentiality agreements are standard. Publication may be delayed or require company approval. None of this is inherently problematic, but it does require researchers to think carefully about what commitments they are making and whether those commitments align with their professional obligations. A graduate student working on an industry-sponsored project needs to understand whether the terms of that sponsorship will allow them to publish their thesis or dissertation. A junior faculty member negotiating a consulting agreement should know whether it restricts their ability to collaborate with other companies or to share findings at conferences.

Team science and international collaborations, both of which are essential to progress in research, amplify both opportunities and risks. A multinational research consortium can pool expertise, share costly infrastructure, and address questions that no single institution could tackle alone. But such collaborations also require due diligence. Who are the collaborators? What is their institutional affiliation? Are they subject to foreign government interference in ways that could compromise the independence of the research? These questions are not about presuming bad faith; they are about understanding the context in which partners operate. Security, approached this way, becomes an enabler of sustainable collaboration. When all parties know what is expected of them, when data-sharing protocols are clearly documented, when intellectual property agreements are negotiated in advance, partnerships are more likely to endure. Cultural norms matter here as well. What counts as appropriate acknowledgment of contribution? How are disagreements about authorship resolved? What communication styles are considered professional? Understanding these conditions in advance supports informed participation. Responsible openness, in this context, means being explicit about expectations and

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attentive to differences in how research and relationships are practiced across borders.

RECOGNIZING AND MITIGATING RISKS

Recognizing risk begins with developing a realistic sense of what can go wrong and what steps can reduce the likelihood or severity of harm. The risks that researchers face vary widely depending on their field, their institutional setting, and the nature of their collaborations. Interference efforts by governments or entities to inappropriately influence, exploit, or redirect research for strategic advantage have received considerable attention in recent years, particularly in fields with national security implications. Export controls, which restrict the transfer of certain technologies and technical data to foreign nationals or countries, apply to some research and some countries, and violations can carry serious legal consequences. Intellectual property theft, whether by competitors or foreign actors, threatens both individual researchers and institutions. Idea theft, though harder to define and prosecute, can occur when preliminary findings shared informally are appropriated by others. Security risks are not evenly distributed and are expected to be addressed proportionately. See Box 4-1 for an illustrative example about export-controlled technical data violations.

Cybersecurity practices that support protection of research materials, such as secure data storage, authentication, and controlled access, are also forms of open-science practices. Openness exists on a spectrum, from controlled access to fully open. Controlled access and secure data storage solutions still enable sharing of data, if only to those with the required authorization. A compromised email account can expose confidential communications with research participants. Weak password practices or failure to use multifactor authentication or terminating access to computers after a person leaves an institution can allow unauthorized access to data repositories. Physical security and data governance practices are also important. An unlocked laboratory, an unattended laptop, or improperly disposed notes can compromise sensitive materials just as easily as a digital breach.

Dual-use research of concern, which has both beneficial applications and potential for harm, requires careful consideration

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BOX 4-1 Illustrative Example: Export-Controlled Technical Data Violations[1]

A faculty member working on a defense-related research contract was convicted and sentenced for conspiring to unlawfully export restricted military technical data. The significance of this case for early-career researchers lies in the concept of the "deemed export," which is often poorly understood in academic settings. Many early-career scientists assume that export violations occur only when physical equipment is shipped overseas. In reality, export-controlled information can be exported by emailing technical data, carrying it on a laptop while traveling, disclosing it to a foreign national without authorization, or otherwise making controlled technical information available in ways prohibited by law. In this case, the controlled information was tied to advanced aerospace-related technology, and the prosecution made clear that the legal problem arose from the transfer of restricted technical data itself, not just from a piece of hardware crossing a border. The teaching value of the case is substantial because it shows that excellent science, patriotic intent, or academic reputation do not excuse noncompliance. Even unintentionally disclosing information can lead to severe penalties. Thus, if a project has publication restrictions, defense applications, International Traffic in Arms Regulations (ITAR), or Export Administration Regulations (EAR) implications,[2] access limitations, or sponsor language about foreign nationals, early-career researchers must stop assuming that the work is covered by the ordinary culture of open science. Most institutions have offices of research security or international affairs to which researchers can turn for advice, specifically about what can be shared, with whom, by what method, and under what travel conditions before any disclosure occurs.

[1] This example is hypothetical but based on the expert knowledge and experience of the authoring committee.

[2] ITAR governs defense-specific items (e.g., munitions) with strict rules that usually prohibit foreign national access. EAR governs "dual-use" work, that is, that which has both commercial and military uses, allowing greater flexibility. ITAR is stricter, while EAR covers a broader scope.

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of how findings might be misused. The same synthetic biology techniques that enable vaccine development could, in principle, be used to engineer pathogens. The same machine learning algorithms that improve medical diagnostics could be repurposed for surveillance. Emerging technologies often outpace regulatory frameworks, leaving researchers to make judgment calls about what risks are acceptable and what safeguards are necessary, and researchers have a responsibility to lend their experiences to developing best practices for responsible use of these emerging technologies. Data governance, stewardship, and privacy protections are not peripheral concerns but central to maintaining public trust and protecting research participants.

Developing a culture of security involves integrating risk awareness into routine research practices. Laboratories should have clear protocols for who has access to what equipment and data. Research groups should discuss, at the outset of projects, what information is sensitive and how it will be protected. Institutions should provide ongoing training that is practical and relevant, not merely a compliance exercise to be clicked through. The goal is to make security considerations part of routine research planning rather than an afterthought or an emergency response. This is easier said than done, particularly when administrative burden is already high and researchers and institutions feel overwhelmed by compliance requirements that seem disconnected from the actual work they do. The challenge is to implement safeguards that are proportionate to actual risks and designed with the realities of research practice in mind.

Due diligence in collaboration includes clarifying several questions. Who will have access to data? Under what legal and institutional frameworks will the work be conducted? Are there export control restrictions that apply? What are the publication expectations, and are there any restrictions on sharing findings? These questions are not interrogations; they are the groundwork for partnerships that function smoothly. For international collaborations, due diligence might include checking whether potential collaborators are affiliated with foreign government entities that could exert undue influence, or whether they have access to resources that raise questions about funding sources. For

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industry partnerships, it might mean clarifying intellectual property ownership and ensuring that confidentiality agreements do not prevent researchers from fulfilling their academic obligations. The purpose is not to identify reasons to avoid collaboration but to raise potential issues early, when they can be addressed, rather than discovering them later when they have become crises.

Compliance requirements, including disclosure of funding and affiliations, support identification of potential risks. Conflicts of interest (COI) arise when a researcher has significant financial or personal relationships that could influence the research design, bias the data analysis, or affect the reporting of results. Conflicts of commitment (COC) arise when researchers have obligations among or between multiple institutions (employers or others).[5, 6]

Disclosure obligations to report foreign financial interests, outside consulting arrangements, or collaborations with institutions on government watch lists are designed to identify potential conflicts of interest or security risks before they become problematic. Although some researchers may view these requirements as unnecessary bureaucratic intrusions, ignoring them is not an option. Failure to disclose can result in loss of funding, institutional sanctions, or, in extreme cases, criminal prosecution. Researchers are also expected to report all funding sources when that information is relevant to assessing potential biases that might influence the integrity of the work (NASEM, 2017). For example, if the funding came from a Malign Foreign Talent Recruitment Program (Prabhakar, 2024), that information is important for assessing research security. Training, when done well, helps researchers understand not just what they are required to do but why those requirements exist, how to integrate them into their workflow, and how to model them for those in their charge. Institutions are responsible for making training accessible, relevant, and nonredundant and researchers are responsible for taking it seriously.

Risk identification is ongoing as technologies and contexts evolve. The landscape changes. Technologies evolve. Geopolitical tensions

[5] For definitions of COI, COC, and other research-related terms, see NSF (2023).

[6] See also chapter 5 and Box 5-2.

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shift. Funding agency policies are updated. What was considered low risk 5 years ago may require closer scrutiny today. Researchers are expected to remain informed about relevant policies and seek guidance when needed. This does not mean constant anxiety or second-guessing every collaboration. It means maintaining a baseline awareness of the risks relevant to one's work and knowing when to seek guidance from research compliance offices, export control specialists, or institutional review boards. Most institutions have people whose job is to help navigate these issues. Using those resources is a sign of professionalism.

COMMUNICATING RESULTS AND COMMUNITY ENGAGEMENT

Different audiences require different forms of communication. Scientific audiences expect detailed methods and evidence, while broader audiences require clarity and context. Both matter. Both carry obligations.

Two-way community engagement is an ethical obligation when research involves or affects communities. Effective engagement recognizes that communities contribute expertise and perspectives, and community engagement is essential for building and maintaining public trust in science, and in turn, for building support for public funding. Good practices include early consultation, involving community members in study design, sharing findings accessibly, and ensuring that benefits accrue to participants. This matters especially for historically marginalized populations subjected to exploitative research. Trust builds through sustained relationships, not one-time consultations. Democratizing knowledge means not just making information available but ensuring that people can understand and use it, recognizing that communities hold expertise that researchers need. Open science, done well, creates conditions for knowledge to be produced, shared, and applied in ways that benefit everyone.[7] .

SUMMARY

Science progresses through openness, including sharing of ideas, methods, and data. Collaboration across institutions, disciplines, and

[7] See additional discussion of community engagement in Chapters 1 and 3.

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borders supports innovation. The default presumption in science should always favor accessibility and sharing.

Research security supports protection of research processes, participants, and outcomes. Security measures, implemented thoughtfully, protect the integrity of the research process and the trust on which scientific collaboration depends. They safeguard the interests of researchers, research participants, and the institutions that support inquiry. They ensure that knowledge generated with public resources serves the public good rather than being exploited for purposes that undermine it. Openness and security operate together and require context-specific judgment and a willingness to weigh competing considerations rather than defaulting to rigid rules.

Early-career researchers will navigate these issues throughout their careers, in contexts that will continue to evolve. Technologies will change. Geopolitical relationships will shift. Institutional policies will be updated. What remains constant is the obligation to approach these questions with integrity, to seek guidance when uncertain, and to recognize that responsible research conduct is not just about following rules but about making thoughtful decisions in service of knowledge and the communities that depend on it. The goal is not perfection but ongoing attention to the values that make science both trustworthy and transformative.

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5

Responsible Conduct and Stewardship of the Research Process

Scientific research is a privilege that carries profound responsibilities. Those who engage in research are responsible for public resources, the well-being of research participants, the integrity of the scientific record, and ultimately, society's trust in science itself. This trust is neither automatic nor permanent—it is earned and maintained through conscientious stewardship at every stage of the research process.

Stewardship in research can be defined as the responsible, ethical, and effective management of people, resources, data, and public trust in the research enterprise with the goal of advancing knowledge while safeguarding integrity, accountability, and societal benefit. This definition encompasses far more than simply following rules or checking compliance boxes. As introduced in the opening chapter of this guide, stewardship emphasizes responsibility for the integrity, credibility, and sustainability of research. It extends beyond adherence to laws, rules, and regulations to include the exercise of professional judgment, commitment to transparency and honesty in reporting, and genuine care for people, resources, and

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the scientific record. Whether designing an experiment, analyzing data, or communicating findings, stewardship requires thoughtful consideration of choices affecting not only a researcher's immediate work but also the broader research enterprise and society.

This chapter provides a framework for understanding stewardship responsibilities as they arise throughout the research life cycle. While certain concepts undergird stewardship responsibilities at all stages of research, science is inherently iterative rather than strictly linear. This chapter discusses stewardship in the four key stages of research activity: conceptualizing, designing, conducting, and finally conveying research. At each stage, researchers commit to following the norms of responsible conduct, including the judicious use of resources, appropriate oversight and protections for research participants and subjects, prevention of mistakes and negligence, and adherence to norms of ethics and integrity that govern scientific practice, including global standards (Resnik and Shamoo, 2011).

An essential aspect of research stewardship is understanding that responsibility operates at multiple levels. Individuals, research teams, and institutions each play distinct yet interconnected roles in ensuring research integrity. Throughout this chapter, we clarify what these different responsibilities entail so that, in particular, early-career researchers know what to expect from themselves, their collaborators, and their institutions. Some aspects of stewardship rest entirely within the individual's control, such as maintaining accurate notes or properly attributing ideas. Others are primarily institutional responsibilities, such as providing adequate research infrastructure, establishing clear policies for data management (NIH, 2026), or providing tools, training, or support for researchers. Still others are shared among team members, requiring clear communication and mutual accountability.

The reality is more complex still: there are gray areas where the locus of responsibility is not always clear-cut. When data-sharing policies differ across countries, institutions, or agencies, how are differences navigated? When a research team spans multiple institutions, who ensures that data-sharing practices align across different organizational policies or across differential application or interpretation of those policies? When collaborators bring

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different disciplinary norms to a project, whose standards should prevail? These ambiguities underscore the importance of proactive communication and the establishment of systems that enable effective collaboration (NASEM, 2018). This chapter addresses individual and institutional responsibilities, their existing interdependence, and the collaborative frameworks necessary to bridge them.

Research takes many forms across diverse contexts. The guidance presented here is broadly applicable across different research settings—from bench science and computational research to clinical trials and field studies—and different institutional contexts, including academic institutions, industry laboratories, government agencies, and independent research organizations. At the same time, we recognize that different disciplines may face distinct stewardship challenges. For example, disciplines differ in their experimental design and what counts as evidence, with some fields focused on observable, measurable, or agreed-upon variables, whereas others focus on theoretical constructs (NASEM, 2025). Understanding these differences, and how these are defined in different scientific fields, is essential for valid and credible science. Data citation practices differ across disciplines (Gregory et al., 2023). Further, data-sharing norms vary and, in some fields, ethical concerns about data sharing exist. For example, in health fields sharing data about human research participants and communities that participate in community-engaged research raises issues of consent and deidentification, among other issues (Sabatello et al., 2022).

Finally, there are inherent limitations of any single chapter or guide, which cannot address every possible stewardship scenario that individuals may encounter in a research career. Instead, the goal is to provide a framework for thinking through stewardship questions as they arise, to highlight key principles that should guide decisions, and to encourage the habit of asking the right questions—even when the answers are not immediately obvious. Stewardship is ultimately about cultivating judgment, not just following instructions. This foundation will better equip early-career researchers to navigate the complex landscape of research responsibilities and contribute to a research culture worthy of public trust.

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CONCEPTUALIZING CURIOSITY: THE RESPONSIBLE DESIGN OF SCIENTIFIC INQUIRY

The initial spark of scientific curiosity—that moment when a researcher identifies a question worth pursuing—carries profound implications that extend far beyond the laboratory. The design phase of research, when scientists conceptualize their inquiries and chart their investigative paths, represents a critical juncture where intellectual freedom intersects with ethical responsibility. This is where the stewardship of science begins, not with data collection or publication, but with the fundamental choices about what to study and why.

The Value of Basic Science and Its Translation

Discussions of research impact often impose a false binary between basic and applied science, as if research must be either purely curiosity-driven or directly translational. This dichotomy misrepresents how science actually works, including but not limited to discovery science, mechanistic research, exploratory research, and use-inspired basic research. Today's basic research provides tomorrow's applications in unpredictable ways (Ahmadpoor and Jones, 2017). The laser emerged from investigations into fundamental quantum mechanics; CRISPR gene editing arose from studies of bacterial immunity; glucagon-like peptide-1 drugs were developed from research that included examining the venom of Gila monsters (Page, 2014). In addition, basic research in materials led to the transistor that enables miniaturization of components, and to lithium-ion batteries that power them (Ghose, 2025; Xie and Lu, 2020). Basic physics research led to geolocation (Tuhin, 2025). Guided research between Corning and Apple on break-resistant glass contributed to touch-screen displays (NIST, 2018).

Basic research represents an essential investment in expanding the foundation upon which many future applications will rest (Tovey, 2017). Its value lies in building the conceptual infrastructure and methodological tools that make future breakthroughs possible. Research demands both intellectual courage and ethical humility—courage to pursue difficult questions and humility to recognize that curiosity, while necessary, is not sufficient justification for all inquiry.

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Choosing the Right Question

Not all scientifically interesting questions are equally worth pursuing. The selection of research questions demands careful consideration of multiple factors: feasibility given available resources and expertise, ethical implications of the work itself, the realistic risk of failed research (e.g., not being able to start or finish a research project), the impact and importance of the question, and the potential for misuse of findings. A technically fascinating question about enhancing pathogen transmissibility, for instance, might be scientifically tractable yet ethically problematic given the risks of accidental release or intentional misuse. Similarly, randomized studies of the health effects of human behavior, such as taking up smoking, or environmental toxins, such as pesticide use on crops, could be informative to public health policies but cannot be conducted due to the ethical concerns inherent in human subject research. Finally, researchers are expected to conduct a thorough literature review[1] to determine whether the research question merits further examination or whether prior results have fairly consistently pointed to an answer.[2]

Feasibility considerations extend beyond technical capability to encompass temporal and resource constraints. A graduate student with limited funding and a 5-year timeline faces different constraints than an established laboratory with sustained institutional support. Responsible question selection acknowledges these realities without abandoning ambitious inquiry—it means designing projects that can yield meaningful results within realistic parameters while maintaining scientific rigor.

The risk of negative results that fail to confirm a hypothesis deserves particular attention in an academic culture that often privileges positive results. Questions with high risk of null results may still merit pursuit if the potential payoff is substantial, but whether the probabilistic return justifies the investment of finite resources remains an important consideration and, importantly,

[1] Although generative artificial intelligence (AI) can help with literature searches, researchers should examine the results carefully to ensure that they are accurate. See, for example, Ruben (2026) https://www.science.org/content/article/cite-unseen-when-ai-hallucinates-scientific-articles.

[2] It is important to note that, even when prior results indicate a consistent answer, in social science research, a different population or a new social context might warrant a replication study.

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whether trainees working on such projects will be able to build viable careers even if the research does not yield the hoped-for outcomes. Valuing and disseminating null findings encourages ethical and transparent research practices, reduces publication bias, and contributes to a more accurate scientific record. Evidence showing no association can be as informative and relevant as evidence demonstrating an association; thus, null results can be highly influential and move fields forward. One example of this is a study showing that treatment of periodontitis in pregnant women safely improves periodontal disease without significantly altering rates of preterm birth, low birthweight, or fetal growth restriction (Michalowicz et al., 2006).

When Curiosity Becomes Irresponsible: Anticipating Impact, Risk, and Benefit

The pursuit of knowledge for its own sake stands as a foundational value in science, yet curiosity alone cannot justify all research endeavors. In some cases the research question is irresponsible because it causes unacceptable harm to either the population being studied or to the broader community (Resnik and Elliott, 2016). Responsible research requires researchers to think seriously about the answers they might find and their consequences. The question "If answered, who does my research help, hurt, or exclude?" should inform project conception, not merely appear in grant applications as an afterthought. Researchers are also expected to consider whether their questions are important or impactful to society as well as whether they are novel. This forward-thinking approach means considering not only intended applications but also potential misapplications and unintended consequences.

Research design may become irresponsible when its foreseeable harms outweigh its benefits (e.g., studying the impact of cortisol on decision making by inducing significant stress reactions in study participants), when it exploits vulnerable populations (e.g., running an expensive and risky cancer drug trial in low-income patient populations), or when it serves primarily to advance individual careers at the expense of broader scientific or social goods (e.g., creating a high-profile AI system to predict people's future locations based on large-scale Global Positioning System data). Equally

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important is considering who might be excluded from research studies and, thus, research benefits. Studies conducted exclusively in well-resourced settings or on nonrepresentative populations may generate findings that do not translate to other contexts or groups, potentially widening rather than narrowing existing disparities. For example, participants with severe obesity (body mass index ≥ 40) are often disqualified for participation in research studies as part of exclusion criteria, yet this population faces the most severe burden of disease. As a result, study findings are not typically generalizable to this population, which could hamper access to much needed therapies or potentially mask adverse outcomes that disproportionately impact the excluded populations. In publishing research, it is critical to discuss the limitations of the research as well as the generalizability of the results to the broader population.

Some research findings could be weaponized, used to reinforce discrimination, or deployed to manipulate vulnerable populations. Although scientists cannot predict all future uses of their work, positive or negative, they can identify obvious risks and consider whether and how to mitigate them—through careful communication about limitations, engagement with affected communities, or in some cases, choosing not to pursue certain lines of inquiry (NASEM, 2017a).

Additionally, funding structures play a crucial role in shaping what research is pursued, sometimes leading to beneficial research on topics such as gerontology or addiction, but at other times incentivizing detrimental research practices. The sources of funding and the requirements for receiving such funding have changed significantly over the last two decades (Pece and Anderson, 2024). Today's early-career researchers are tasked with navigating a much more complex map of funding sources and incentives than did those of the mid-twentieth century (Ganz and Vincent, 2023; Tian et al., 2024). When funding priorities emphasize fashionable topics or promise unrealistic timelines for translational impact, they can incentivize scientifically questionable work. Funders who demand preliminary data for "innovative" proposals create paradoxical pressures that may discourage genuinely novel inquiry. Moreover, funding mechanisms that disproportionately support research with immediate commercial applications can starve the foundational

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work upon which future breakthroughs depend (Gomi, 2026; Trang, 2025).

Career incentives, although not entirely within the control of the individual researcher, sometimes diminish the informativeness of research. The pressure to publish frequently in high-impact journals can encourage researchers to fragment their work into "least publishable units" or to chase sensational topics rather than pursuing important but less widely publicized questions. In some cases, researchers will experience pressure to oversell the implications of their findings. When scientists design research primarily to generate attention-grabbing results rather than to advance understanding, they compromise their role as stewards of knowledge. Although institutions are responsible for developing and implementing policies for promotion and tenure for team science, early-career researchers can ask themselves and their mentors critical questions about misalignments between research and career incentives.

Although there are many important, impactful, and novel research questions to consider, when harmful questions get asked, responsibility is distributed across investigators, institutions, funders, and governance structures that shape what questions get asked and why. See Box 5-1 for questions that may help an early-career researcher navigate their own responsibility and choices in this phase of the research process.

DESIGNING RESEARCH: STEWARDSHIP AT THE PLANNING STAGE

The design phase of research is where aspirations meet reality, where curiosity transforms into a concrete plan of inquiry. It is also where many of the most consequential stewardship decisions are made. Long before data are collected or analyzed, researchers make choices about methods, resources, protections, and collaborations that will fundamentally shape not only what can be discovered but also how that discovery unfolds and who it affects. Thoughtful stewardship at the design stage requires researchers to balance scientific ambition with practical constraints, methodological rigor

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BOX 5-1 Questions for Conceptualizing Curiosity

The following questions may help an early-career research make informed choices about lines of inquiry:

Feasibility and scope: Given my current resources, timeline, and expertise, is this research question realistically achievable—and can it produce meaningful results within those constraints?

Consequences: Could pursuing this question create risks (e.g., harm, misuse, or unintended consequences), and have I seriously weighed those against its potential benefits?

Return on effort: If this project yields null or inconclusive results, will it still contribute value—to the field and to my own development—and is that outcome acceptable given the time and effort required?

Downstream use: Could my findings be misused, misinterpreted, or weaponized, and have I taken reasonable steps to anticipate and mitigate those risks?

Incentives and integrity: Am I pursuing this question because it meaningfully advances knowledge, or because it is likely to generate attention, funding, or publications?

with ethical obligations, and individual expertise with collective needs.[3]

Responsible Use of Resources in Research Design

Research is resource-intensive, drawing on funding from public and private sources, institutional infrastructure (e.g., libraries, communications support, heating and air-conditioning), equipment, and the time and expertise of research personnel. Stewardship of these resources begins with honest assessment and transparent planning. Researchers align their research aims, methods, and scope with the resources and expertise actually available to them.

[3] See also chapters 2 and 4.

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This alignment requires careful consideration of feasibility. Can the proposed study be completed within the available time frame? Does the research team possess the necessary technical skills, or will additional training or collaboration be required? Is the budget sufficient not only for data collection but also for proper analysis, storage, and dissemination? Transparency in feasibility assessment and budgeting is not merely an administrative task—it is a form of stewardship that protects against wasted resources, incomplete studies, and disappointed expectations.

Stewardship of resources also means recognizing that every research dollar or hour spent on one project is unavailable for another. This reality underscores the importance of designing studies that are likely to yield meaningful results and advance knowledge efficiently. It does not mean avoiding ambitious or risky research, but it does mean being honest about those risks and ensuring that the potential scientific value justifies the investment.

Adhering to Expectations of Rigor and Quality

At the heart of research design is a fundamental principle: the method must match the question. Yet this principle is often compromised when researchers select methods based on their popularity, ease of implementation, or innovative appeal rather than their appropriateness for addressing the research question at hand. For example, convenience sampling, in which a researcher draws research participants from the most accessible source rather than using random sampling of a larger population of interest, can lead to research that might be methodologically sound but is not generalizable to any other individual (Andrade, 2020). Responsible stewardship involves methodological choices that are driven by the nature of the inquiry, not by what is trendy or convenient. In addition, discipline-specific training, mentoring, and peer review can help researchers choose the most appropriate methods for their research question. The research reproduction system itself is a product of an incentive environment that rewards methodological performance over methodological judgment. It is important to recognize how these incentives impact judgment and think critically about the rigor and fitness of the approach and methods relative to the research question.

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Every research field defines for itself what counts as rigorous research and then teaches that rigor to new researchers and uses it as the basis for peer review, publication, and dissemination. This discipline-specific definition of rigor also serves as the foundation for both reproducibility—the ability of other researchers to obtain consistent results using the same data and methods—and replicability—the ability to achieve consistent results across different studies addressing the same scientific question (NASEM, 2019). These concepts are not abstract ideals but practical necessities that allow scientific knowledge to be verified, built upon, and trusted. Replication is a scientific norm in most disciplines and is required for regulatory agencies and other mechanisms. Designing for rigor means anticipating how others might attempt to replicate the work and ensuring that methods and documentation enable such efforts.[4]

An essential aspect of rigorous research is framing neutral questions and remaining genuinely open to both informative and uninformative findings (Importance of no evidence, 2019). Science is iterative, and researchers learn from every well-designed experiment regardless of the outcome. The scientific edifice rests on the building blocks laid by those who came before, and knowledge evolves over time through the accumulation of both positive and negative results. Designing studies that can provide evidence for the absence of a meaningful effect, within a certain margin of error, is just as important as studies providing evidence for its presence.

It is also crucial to distinguish between evidence and consensus in research design. A single study provides evidence, but scientific understanding emerges from the broader consensus built across multiple studies, methods, and research groups. In interpreting research results, researchers should avoid overstating the implications of individual findings and instead situate their work within the larger scientific conversation. In health research, the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach provides a way to assess certainty and strength of any recommendations based on the study design, risk of bias in the design or conduct of the research, inconsistency across

[4] For an example of how changing research paradigms led to lack of replication of early studies, see Siontis et al. (2010).

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different studies, how the evidence addresses a clinical question, the degree of uncertainty in effect sizes, and publication bias (Prasad, 2024).

The emergence of AI as a tool in research design introduces new stewardship considerations. AI can assist in literature review, hypothesis generation, study design optimization, and more. However, researchers must thoughtfully consider how its use impacts their work and the broader scientific enterprise. AI should be used as a tool that requires human review and verification rather than substituting for human judgment and expertise. Understanding this distinction, and questioning the outputs of any work generated by AI or other emerging technology, is critical for maintaining the integrity and accountability that stewardship demands.

Ethical and Regulatory Considerations in Research Design

Research design must follow ethical and regulatory requirements from the outset and consider the ethics trade-offs inherent in many design questions, not as afterthoughts. Oversight mechanisms such as Institutional Review Boards (IRBs), Institutional Animal Care and Use Committees (IACUCs), and Environmental Health and Safety offices exist to protect research participants, animals, communities, and environments from unnecessary harm. While the later section on "Human, Animal, and Environmental Protections in Practice" goes into more detail about some of the specific practices that regulatory bodies govern, it is also discussed here to emphasize that ethical treatment of study participants and subjects, laboratories, and the environment are as much as part of the planning process and the practice of research.

Stewardship requires designing studies that minimize risk and burden to all affected parties. This means considering not only immediate harms but also longer-term implications. How will data be stored and protected? Who might gain access to it in the future? What are the potential downstream uses—and misuses—of the data generated? Anticipating data-sharing and reuse scenarios during the design phase allows researchers to build in appropriate protections and obtain informed consent that accurately reflects how data may be utilized.

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Preventing Mistakes and Negligence Through Thoughtful Design

Poor design introduces risks that can undermine an entire research project. Weak study design, ambiguous protocols, or inadequate planning can lead to unusable data, irreproducible results, or findings that cannot support the conclusions drawn from them. These are not merely technical failures—they represent failures of stewardship that waste resources and erode trust in the research enterprise.

Documentation, analytic planning, and clarity in research protocols serve as bulwarks against such failures. Protocols should be detailed enough that another trained researcher could implement them. Analytic plans should be developed before data collection begins, specifying how data will be processed, what statistical approaches will be used, and how potential complications will be addressed. This level of planning helps prevent the selective reporting of results and reduces opportunities for bias—whether intentional or unconscious—to influence findings. Preregistration can also help minimize problems with research.[5]

Importantly, identifying design vulnerabilities is not solely an individual responsibility. Mentoring and team discussion play crucial roles in catching potential problems early. Presenting proposed designs to colleagues, seeking feedback from those with different perspectives or expertise, and engaging in constructive criticism are all part of good stewardship practice.

Conflicts of Interest and Commitment

The design phase is the stage at which competing interests and potential biases are confronted and managed. As noted in the Openness and Security chapter, COI arise when a researcher has significant financial or personal relationships that could influence the research design, bias the data analysis, or affect the reporting of results. Financial COI arise when a researcher (or any immediate family members) expects to gain financially from the results of research and conduct the research in an unethical or irresponsible

[5] See also chapter 4.

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way in order to maximize the potential financial gain.[6] Researchers must consider any potential for financial gain from their work and disclose it to their institutions. Other COI arise independent of financial considerations and arise from personal and institutional relationships. For example, in the review of grant proposals, a reviewer who supervised the dissertation of a proposal's principal investigator has an individual COI, and a reviewer who holds an unpaid emeritus appointment at the university submitting a proposal has an institutional COI.

COI are distinct from COC (ORI, n.d.). COC arise when researchers have obligations among or between multiple institutions (employers or others). Researchers, particularly students, face difficult decisions about how to divide their time between research and other responsibilities, how to serve their scientific disciplines, how to respect their employer's interests, mission, and values, and how to represent science to the broader society. Conflicts between these commitments can be a source of considerable strain and can cause problems in a researcher's career. Managing these responsibilities is challenging but different from managing COI, which are primarily financial in nature. See Box 5-2 for more discussion of COC.

VALUES AND BELIEFS OF RESEARCHERS

Beyond conflicts of interest and commitment are issues related to the values and beliefs that researchers hold. Researchers can have strongly held convictions—for example, a desire to eliminate a particular disease, reduce environmental pollution, or demonstrate the biological underpinnings of human behavior. Or someone might have strong philosophical, religious, cultural, or political beliefs that could influence scientific judgments. Researchers are expected to be introspective to understand their own beliefs, to identify potential conflicts between their values and the research, and to make sure that they do not inappropriately bias their work. Early-career researchers should discuss any potential conflicts with their mentors.

Despite cautionary historical episodes where values distorted research—such as the ideological rejection of Mendelian genetics in the Soviet Union or the misuse of science in eugenics—science

[6] https://ori.hhs.gov/content/Chapter-5-Conflicts-of-Interest-Financial-conflicts.

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BOX 5-2 Conflicts of Commitment

All individuals have interests other than work, and researchers are no exception. Researchers are allowed to join activities both outside of and within their work institution. For example, a researcher at a government or industry laboratory might perform consulting work for a local company or teach at a local college, or a faculty member might consult with companies or join several departmental or institutional committees. Another example occurs when individuals whose salaries are paid mostly or entirely from research grants (i.e., they have protected research time) agree to teach some classes or work in a clinic. However, when those interests start consuming the time and attention required by one's institution, advisor, funder, and own training, the competing interests become a problem. Researchers who say "yes" too often to outside activities end up overcommitting their time, and because institutions have legitimate interest in how their employees spend their time, researchers are expected to learn the relevant policies that govern professional activities, consulting, and other activities outside of the work institution. Violations might have significant impact on one's reputation or may result in misconduct accusations or legal issues.

Resources for early-career researchers include mentors, advisors, department chair, and institutional or agency policy. Researchers are expected to know their primary role and commitments and how much time is committed to them, disclose early and ask before making commitments, be realistic in assessing time demands of potential commitments and account for all hours before taking on anything new, and understand what the institution and funder allow. Early-career researchers can ask their senior mentor for advice when faced with these types of requests for their time.

is not a valueless endeavor. The desire to do good work is a human value, as is the conviction that standards of honesty and objectivity

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must be maintained. However, values that compromise objectivity and introduce bias must be recognized and minimized. Researchers must remain open to new ideas and continually test their own and others' ideas against new information. Research is ideally designed so that findings are not predetermined, but instead emerge from the evidence through an open-minded approach.

Respectful engagement with collaborators and communities is another dimension of ethical research design.[7] When research involves or affects specific communities—whether defined geographically, demographically, or by shared experience—those communities should have meaningful input into how research is designed and conducted. This engagement honors both the dignity of those affected and the quality of the research itself, as community knowledge often reveals considerations that external researchers might miss. Similarly, as the research enterprise becomes more interdisciplinary and team based, designing studies in which all collaborators have meaningful input from the start will yield more rigorous results. For example, involving statisticians early in the research process can strengthen survey methodology before data collection begins, rather than bringing them in only after the data are ready for cleaning and analysis. Similarly, involving ethicists early can improve the acceptability of the design, reduce study harms, and improve the informed consent process[8] for study participants.

Relatedly, adopting open science and community engagement practices early in the design process reflects a commitment to transparency and collaboration that strengthens both individual studies and the broader research enterprise. Whether through preregistration of study designs, sharing of protocols, or plans for data and code availability, these practices make research more robust, collaborative, and trustworthy, which are the ultimate goals of stewardship in science. In laboratory-based research, these commitments also extend to detailed documentation of experimental conditions, materials, and protocols, as well as the sharing of reagents, cell lines, or instrumentation details that are

[7] See chapters 1, 2, and 3.

[8] Informed consent for research on human participants is described at https://www.hhs.gov/ohrp/regulations-and-policy/guidance/faq/informed-consent/index.html.

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essential for replication. Early attention to standardization and recordkeeping can improve the reproducibility and replicability of experimental findings across laboratories.

Finally, understanding the norms for conducting research in a specific discipline is foundational, but researchers must also be aware of crosscutting ethical guidelines that transcend disciplinary boundaries. Different disciplines may have distinct traditions regarding authorship, data sharing, or conflicts of interest, but certain principles, such as honesty, respect for persons, and commitment to societal benefit, apply universally. See Box 5-3 for questions that may help an early-career researcher navigate their own responsibility and choices in this phase of the research process.

RESPONSIBLE USE OF RESOURCES DURING RESEARCH CONDUCT

The conduct of research activity is where plans meet reality, where hypotheses encounter evidence, and where the daily choices of researchers shape the integrity of scientific findings and knowledge. While research design establishes intentions, research conduct determines outcomes. This stage demands constant vigilance, ethical awareness, and practical wisdom as researchers navigate the complexities and unpredictability of generating reliable knowledge while upholding their obligations to participants, colleagues, institutions, and society.

Part of these obligations flow through research resources. In this way, research resources—funds, equipment, data, and personnel time—are not merely tools but trustworthiness made tangible. The appropriate use of these resources during research conduct reflects respect for the sources that provided them and for the alternative uses they might have served. In general, researchers must use funds for purposes approved in their statement of work, maintain equipment properly to extend its useful life, manage data with care to preserve its value and integrity, and treat personnel time as the precious commodity it is.

Transparency is a bedrock of public trust in research and must be considered in various aspects of the research process from recordkeeping to publication. When researchers are transparent about their methods, their use of resources, their challenges, and

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BOX 5-3 Questions for Designing Research

The following questions may help an early-career researcher make informed choices about research planning and design:

Alignment and availability of resources: Do my research aims, methods, and scope realistically match the time, funding, equipment, and expertise available to me and my team?

Alignment of rigor: Are the methods I've chosen truly the best way to answer my research question, or am I being influenced by convenience, trends, or familiarity? What are the limitations of my methods?

Replicability and reproducibility: Have I designed this study in a way that others could reproduce and replicate it, with sufficient clarity, transparency, and methodological soundness?

Compliance: Have I fully considered the ethical and regulatory requirements relevant to this study from the beginning, and do I understand how oversight bodies apply to my work?

Consideration of project lifespan: Have I fully accounted for all stages of the project—including data collection, analysis, storage, and dissemination—and identified any gaps in skills or resources?

Openness to outcomes: Am I genuinely prepared for all possible results, including null or inconclusive findings, and have I designed the study to detect both the presence and absence of an effect? What aspects of my background, beliefs, or experiences might bias my interpretations of the results, including null findings?

Collaboration and feedback: Have I sought input from mentors, colleagues, and/or community members (as appropriate) to identify vulnerabilities in my design, and am I open to revising my approach based on that feedback? Is their collaboration meaningful or perfunctory?

Risk: Does my study design minimize potential harms and burdens, not only in the short term, but also in terms of longer-term impacts on participants, communities, or environments?

Data stewardship and future use: How will the data be stored, protected, and potentially shared, and have I anticipated possible

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future uses or misuses in a way that informs responsible consent and safeguards?

Disciplinary norms: Am I aligning my design with both disciplinary norms and broader research principles, such as openness, honesty, and respect?

their limitations, they invite scrutiny that strengthens both individual studies and the broader scientific enterprise. Transparency means documenting resource use accurately, reporting progress honestly, and acknowledging when plans need revision or when resources prove insufficient. In practice, transparency practices can include maintaining clear, contemporaneous records of decisions, protocols, data-handling procedures, and deviations from original plans. Well-organized laboratory notebooks (whether traditional paper or electronic, which strengthens data integrity and audit or tracking efforts, enables more secure sharing of data with collaborators, and provides the ability to readily search the entire record), version-controlled code, audit trails for data processing, and documented rationales for methodological choices make it possible for others—and for the researchers themselves—to trace how findings were produced. Researchers should consider how their practices support accountability by ensuring that work can be reviewed, verified, and, if necessary, corrected, early in the process and should create specific, concrete plans for acting transparently in their work.

The emergence of AI and other rapidly evolving technologies introduces new dimensions to resource stewardship. Researchers must use these tools appropriately, transparently, and responsibly. They should understand not only what these technologies can do but also their limitations, biases, and potential impacts. Are

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computational resources being used efficiently? Are AI tools being deployed with appropriate human oversight? Is the use of these technologies documented sufficiently for others to understand and evaluate the work? Is it clear what happens to data that are fed into AI-enabled systems? Moreover, because understanding of such new technologies can rapidly evolve as use becomes more widespread and refined, researchers should seek to continuously question their own usage and understanding of the tools over the full lifespan of the project.

Supervision, training, and fair treatment of research team members constitute another critical dimension of resource stewardship. Team members are not merely resources to be deployed but individuals deserving of mentorship, professional development, and fair and respectful treatment. The chapter on "Collaborating Responsibly" explores these concepts in more depth, but collaboration should not be considered separately from the practice of research itself. Research leaders bear responsibility for creating environments where team members can learn, contribute meaningfully, and develop their own capacities as researchers. Specific training requirements from agencies such as the National Institutes of Health and the National Science Foundation and from nongovernmental institutions are detailed on those institutional websites, but the underlying principle is clear: investing in people is investing in research quality and integrity.

Laboratory safety practices and environmental stewardship extend researchers' obligations beyond the immediate research team to the broader community and environment. Proper handling of hazardous materials, safe disposal practices, and adherence to environmental regulations protect laboratory personnel, surrounding communities, and natural systems. These are not bureaucratic inconveniences but essential practices that reflect research's relationship to the world in which it occurs.

Understanding and adhering to proper reporting procedures—for finances, project progress, research findings, as well as for mistakes, misconduct, or other ethical issues—closes the loop of accountability. Funding agencies, institutions, and the public have legitimate interests in knowing how resources are used, what progress is made, what findings emerge, and what problems arise.

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Transparent, timely, and accurate reporting honors these interests and maintains the trust that makes research possible.

Human, Animal, and Environmental Protections in Practice

Research involving human participants raises profound ethical responsibilities. Any scientist who conducts such research must protect participants' interests by complying with federal, state, and local regulations and with relevant codes established by professional groups. These provisions ensure that risks to participants are minimized, that risks are reasonable given expected benefits, that research treats participants and communities fairly, that participants or their authorized representatives provide informed consent (or waivers are granted), that investigators inform participants of key elements of the study protocol, and that privacy and confidentiality are maintained.

U.S. federal regulations known as the Common Rule lay out requirements for research involving human participants, specifying which research falls under its jurisdiction, provisions for obtaining informed consent, procedures for gaining project approval, and training requirements. IRBs review and approve federally funded research involving human participants, conduct regular reviews, approve proposed changes, monitor consent procedures, gather information on adverse events, and examine COI.

Hand-in-hand with following regulations, researchers must consider the ethics challenges or tensions in their work with care and thoughtfulness. The involvement of human participants can raise difficult questions. Should people be asked to participate in studies involving some risk with no prospect of personal benefits? Should studies be done with underserved populations when it is not clear when relevant benefits will accrue to them in the future? How should consent provisions be modified for children, prisoners, those with mental health or cognitive challenges, those with less education, or others requiring special scrutiny in research? What levels of understanding should be required, and how should this be assessed? Should the same provisions apply to all research everywhere, or should standards reflect local conditions and traditions? At minimum, anyone engaging in research with humans

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must be aware of all relevant regulations and have appropriate training.

Similarly, the use of animals in research is subject to regulations and professional codes. The federal Animal Welfare Act[9] and the U.S. Public Health Service's Policy on the Humane Care and Use of Laboratory Animals (DHHS and NIH, 2015) establish requirements for animal care and treatment. The policy requires adherence to both the Animal Welfare Act and the Guide for the Care and Use of Laboratory Animals (NRC, 2011). Researchers should carefully consider the "three R's" of animal testing alternatives: reduction in numbers used, refinement of techniques to reduce pain and distress, and replacement of conscious living animals with insentient material. IACUCs review proposals, oversee animal care programs, and respond to concerns. Non-animal-based methods to study disease and biological function, called novel alternative methods (NAMs) are new and also governed by emerging policies.[10] The choice for researchers is not necessarily to employ either animals or NAMs; the adoption of either, or both, should be based on which is the best approach to answering the research question under study.

Ethical awareness must extend beyond initial approval. Throughout the conduct of their research, researchers must monitor adherence to protocols continuously and respond to unanticipated issues as they arise. Research rarely proceeds exactly as planned, and maintaining ethical standards requires ongoing attention, not just checkbox compliance at the outset. Respect for participant autonomy and welfare and commitments to fairness must pervade the entire research process.

Handling of sensitive materials extends beyond personally identifiable information and protected health information to include human remains, qualitative data about traumatic experiences, and other materials requiring special care. Understanding what makes materials sensitive and how to handle them appropriately is essential for conducting research with dignity and respect.

[9] See https://www.nal.usda.gov/animal-health-and-welfare/animal-welfare-act.

[10] See policies at NIH (Bertagnolli, 2024) and at the Food and Drug Administration (FDA, 2026).

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Responsible Treatment of Data

To conduct research responsibly, researchers are expected to collect and treat data correctly and ethically (ASA, 2022; Clinical Tools, Inc., n.d.; NASEM, 2017b). Standard practices for ethical data collection differ across disciplines, but all disciplines find ways to balance considerations related to transparency, integrity, reproducibility, privacy, national security, respect for human dignity, and intellectual property. Researchers have a responsibility to know and follow the norms of their field and to understand the standards of other fields to which their collaborators belong. They are also obligated to continuously reflect on whether the norms of their fields successfully balance such considerations, particularly in an era of quickly evolving technological tools.

Researchers draw conclusions based on data from measurements and observations. If data are altered to present a case stronger than the data warrant, researchers fail to fulfill their obligations. They mislead colleagues and potentially impede progress in their field. They undermine their own authority and trustworthiness. And they introduce information into the scientific record that could cause harm to the broader society. Researchers who manipulate their data in ways that deceive others, even if the manipulation seems insignificant at the time, are violating both the basic values and widely accepted professional standards of science.

Responsible use of data is particularly important in an age in which the Internet allows almost uncontrollably fast and extensive spread of information to an increasingly broad audience. Misleading or inaccurate data can have far-reaching and unpredictable consequences of a magnitude not known before modern communication technologies.

The best methods will count for little if data are recorded inaccurately or haphazardly. Requirements for data collection differ among disciplines and research groups, but researchers have a fundamental obligation to create and maintain an accurate, accessible, and permanent record of what they have done in sufficient detail for others to check and replicate their work. Strategies for recording data with integrity will vary with the field. This may require entering data into bound notebooks with sequentially numbered pages using permanent ink, using computer

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applications with secure data-entry fields, identifying when and where work was done, developing detailed data dictionaries and code books, and retaining data for specified lengths of time. The chapter on "Openness and Security" delves into the tension between transparent data practices and privacy concerns in more detail.[11]

Unfortunately, beginning researchers often receive little or no formal training in recording, analyzing, storing, or sharing data. Regularly scheduled meetings to discuss data issues and policies maintained by research groups and institutions can establish clear expectations and responsibilities. Some fields, such as the social sciences, may also be handling sensitive or potentially identifying information about study participants and should consider data stewardship standards related to deidentification and privacy. New researchers should ask questions about their team's or laboratory's standard operating procedures, such as: What is our laboratory notebook standard and who reviews entries? Who else needs to review code for data analysis before it is used for a manuscript? What is the protocol for field notes? Where do we store consent forms separately from human participant data to maintain anonymity? What are the archival retrieval and deposit practices? What do I do with my records when I leave the laboratory or institution? Who owns the data, the researcher or the institution?

Not only does the recording of data have integrity standards; so, too, does reporting of scientific findings. Conclusions that are drawn must be warranted by the data collected and not reach beyond what the data reveal. Further, when a scientific paper or book is published, other researchers must have access to the data and research materials needed to support stated conclusions if they are to verify and build on that research. Many research institutions, funding agencies, and scientific journals have policies requiring the sharing of data and unique research materials. Given the expectation that data will be accessible, researchers who refuse to share the evidentiary basis behind their conclusions, or the materials needed to replicate published experiments, fail to maintain the standards of science.

[11] See chapter 4.

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Responsible data-cleaning practices include version control, accurate descriptions of cleaning procedures, and avoidance of cherry-picking the data. Every decision to include, exclude, or transform data should be documented and justifiable according to preestablished criteria or transparent reasoning.

Minimizing Errors, Negligence, and Misconduct

All scientific research is susceptible to human error. At the frontiers of knowledge, experimental techniques often are pushed to the limit, the signal can be difficult to separate from noise, and even the question to be answered may not be well defined. In such uncertain and fluid situations, identifying reliable data in a mass of confusing and sometimes contradictory observations can be extremely difficult.

Furthermore, researchers sometimes have to take risks to explore innovative ideas or observations. They may have to rely on theoretical or experimental techniques not fully developed or extend conjectures into new realms. Such risk-taking does not excuse sloppy research, but it should not be condemned as misguided.

Finally, all researchers are human. They do not have limitless working time or access to unlimited resources. Even the most responsible researcher can make an honest mistake in the design of an experiment, calibration of instruments, recording of data, interpretation of results, or other aspects of research.

Despite these difficulties, researchers have an obligation to the public, to their profession, and to themselves to be as accurate and careful as possible. Scientific disciplines have developed methods and practices designed to minimize the possibility of mistakes, and failing to observe these methods violates the standards of science. Fields and disciplines within the scientific enterprise have the responsibility to ensure that the methods and practices to promote integrity, reduce error, and report both findings and errors transparently and accurately are well communicated to junior researchers and trainees.

Beyond honest errors are mistakes caused by negligence. Haste, carelessness, inattention, and simple administrative or typographical errors—any of these can lead to work that is inaccurate or does not meet scientific standards or the practices of a discipline. Researchers who are negligent are placing their

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reputation, the work of their colleagues, and the public's confidence in science at risk. Though science is built on the idea that peers will replicate results, actual replication is selective. It is not practical or necessary to reconstruct all observations and theoretical constructs made by others. To make progress, researchers must trust that previous investigators performed work in accordance with accepted standards.

Some research behaviors are so at odds with the core principles of science that they are treated very harshly by the scientific community and by institutions that oversee research. Anyone who engages in these behaviors is risking their scientific career and threatening the overall reputation of science and the health and welfare of the intended beneficiaries of research.

Collectively these actions have come to be known as scientific misconduct. The U.S. Department of Health and Human Services Office of Research Integrity defines misconduct as "fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results." Fabrication is "making up data or results." Falsification is "manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record." Plagiarism is "the appropriation of another person's ideas, processes, results, or words without giving appropriate credit."[12] However, there are many forms of detrimental research practices or adverse behavior that may be included in more recent professional standards, such as harassment, discrimination, and bullying (AGU, 2023; APS, 2024). These ethical standards are often living documents that grow and change with further understanding of the roles, responsibilities, and expectations of researchers.

Although some cases of misconduct have arisen from sloppy work or honest mistakes, when researchers intentionally deceive colleagues by falsifying information, fabricating research results, or using others' words and ideas without giving credit, they are violating fundamental research standards and basic societal values.

[12] https://ori.hhs.gov/definition-research-misconduct.

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These actions are seen as the worst violations of scientific standards because they undermine the trust on which science is based.[13]

Practices that reduce risk include thorough documentation, version control, and internal checks. When concerns arise, researchers have responsibilities regarding confidentiality and must understand that nonretaliation protections exist for those who report problems in good faith.[14]

Ethical Decision Making in Day-to-Day Research Activities

Daily research practice requires navigating complex ethical terrain, an experience for which some decision-making guides exist.[15] Power dynamics within research teams affect credit allocation, authorship expectations, and whose voices are heard in decision making. Researchers must be aware of these dynamics and work to ensure that credit is distributed fairly and that all team members can contribute their perspectives.

Managing bias, pressure, and incentives during data collection and analysis requires constant vigilance. The pressure to publish, to secure funding, to achieve positive results—all of these can subtly or overtly influence how data are collected, analyzed, and interpreted. Researchers must develop practices and cultivate awareness that help them resist these pressures and maintain objectivity.

Ethical considerations in the use of emerging technologies, including AI tools, extend beyond technical competence to questions of appropriate application, transparency about limitations, and responsibility for outcomes. As these technologies become more integrated into research workflows, researchers must remain thoughtful about when and how to use them, always maintaining human judgment and accountability at the center of the research process.

[13] For the requirements for findings of research misconduct, see the Code of Federal Regulations, 93 CFR § 93.103, https://www.ecfr.gov/current/title-42/chapter-I/subchapter-H/part-93/subpart-A/section-93.103.

[14] See chapter 3.

[15] Some frameworks for ethical decision-making can be found at https://www.scu.edu/ethics/ethics-resources/ethical-decision-making/.

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See Box 5-4 for questions that may help an early-career researcher navigate their own responsibility and choices in this phase of the research process.

CONVEYING RESEARCH: STEWARDSHIP IN COMMUNICATION AND DISSEMINATION

The communication of research findings represents the culmination of the research process and the beginning of knowledge's journey into the broader world. How researchers share their work—with scholarly communities, research participants, funders, and the public—determines whether their efforts contribute positively to the collective enterprise of science or become isolated fragments of information or misinformation (NASEM, 2025; West and Bergstrom, 2020). Stewardship in post-research communication requires researchers to be as thoughtful about how they convey findings as they were about generating them, recognizing that incomplete, inaccurate, or misleading communication can undermine public trust, waste resources, and impede scientific progress.

The traditional way to communicate research findings over time is by archival publications that describe what was discovered, the prior research and experience on which it was based, and the methods that were used. To ensure high quality, publications are normally subjected to peer review prior to publication and published reviews afterwards (together with confirmational studies).

Literature Reviews and Citations

The foundation of responsible communication begins with how researchers engage with existing scholarship. Researchers are expected to read in full any paper they cite and not rely only on the article's abstract, which sometimes does not reflect the actual research. Citations serve multiple essential functions: they acknowledge intellectual debts, allow readers to locate original sources, provide context for new work, and enable verification of claims. Yet citation practices are often executed carelessly (or not at all), with consequential effects (Greenberg, 2009; Robinson and Goodman, 2011).

When analyzed carefully, many citation lists in published papers contain numerous errors (Rivkin, 2020). Beyond incorrect spellings,

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BOX 5-4 Questions for Doing Research

The following questions may help an early-career researcher make informed choices about the practice of research:

Use of resources: Am I using the resources entrusted to me (funds, data, equipment, and people's time) in ways that are consistent with their intended purpose and respectful of their value?

Documentation: Would someone else be able to clearly understand, evaluate, and reproduce my work based on how I document my methods, decisions, and use of tools (including AI)?

Safety and fairness: Am I creating and contributing to a research environment that prioritizes accountability, transparency, safety, and the fair treatment and professional development of all team members?

Thoroughness and oversight: Have I taken all reasonable steps to ensure that my work is careful, accurate, and consistent with the accepted methods and standards of my field, even under uncertainty or time constraints? Would my research practice withstand scrutiny from peers?

Continual monitoring: Am I actively monitoring my research as it unfolds and am I prepared to respond appropriately to unexpected ethical issues, rather than relying solely on initial approvals or compliance requirements?

Responsibility: If an error or concern arises, am I responding transparently and responsibly?

Openness: Am I sharing (or preparing to share) my data, methods, and materials in accordance with disciplinary norms and policies, while still protecting privacy, confidentiality, and intellectual property where appropriate?

Awareness of incentives: How might pressures (e.g., to publish, secure funding, or produce positive results) be influencing my decisions, and what steps am I taking to maintain objectivity in my work?

Awareness of novelty: Am I using emerging technologies, including AI tools, in ways that are appropriate, transparent, and accountable, with a clear understanding of their limitations and impacts?

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titles, years, and page numbers, citations may not be relevant to the current work or may not support the points made in the paper. Authors may try to inflate the importance of a new paper by including references to previously published work but failing to clearly discuss the connection between their new results and those reported in the previous study. Extreme self-citation (Van Noorden and Chawla. 2019) along with purposeful omission of work published by others are both forms of intellectual dishonesty, and those practices along with reading or using AI to summarize increasingly only review articles and not the primary literature, skews fields of research to conform to views of the largest, most widely published, research groups.

Researchers have a responsibility to search the literature thoroughly and to cite prior work accurately. Implied in this responsibility is that authors should read and cite the original paper rather than, or in addition to, textbooks, a more recent paper, or a review article. This practice of backtracing to original research sources ensures that claims are properly attributed and that the evolution and use of ideas are accurately represented. It also prevents the propagation of errors that can occur when researchers cite secondary sources without verifying the primary evidence.

Proper citation is essential to the value of references and to the integrity of the scientific record. It may be tempting to adopt a useful idea from an article, manuscript, or even a casual conversation without giving credit to the originator. But researchers have an obligation to be scrupulously honest with themselves and with others regarding the use of others' ideas. This allows readers to locate the original source the author has used to justify a conclusion and to find more detailed information about how earlier work was done and how the current work differs.

Responsible Sharing of Research Results

In the seventeenth century, many scientists kept new findings secret so others could not claim results as their own. The solution to this problem was worked out by Henry Oldenburg, secretary of the Royal Society of London, who guaranteed both rapid publication in the society's *Philosophical Transactions* and official support if an author's priority was questioned. Oldenburg also pioneered sending

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submitted manuscripts to experts who could judge their quality. Out of these arrangements emerged both the modern scientific journal and the practice of peer review.

Publication in a peer-reviewed journal remains an important way of disseminating a complete set of research results (NASEM, 2018). The importance of publication accounts for a perception that the first to publish a view or finding rather than the first to discover it will get most credit for the discovery, although that is not always the case. Once results are published, they can be freely used by other researchers to extend knowledge, but until results are so widely known that they have become common knowledge, people who use them are obliged to recognize the discoverer through citations.

Of course, publishing has changed significantly over the years, and the word "journal" in a broad sense refers to traditional print journals, modern digital journals, and other peer-reviewed outlets for publication as appropriate.[16] While much of the research community relies on journals for peer review, some disciplines have distinct traditions. For example, computer science relies heavily on conference proceedings, and preprints are growing ever more popular in many swiftly moving fields. Additionally, not all publishing outlets are appropriate venues for peer review. The past couple of decades have seen a rise in predatory journals (Beall, 2012; Chandra and Dasgupta, 2024), which are publication outlets that prioritize profit over research integrity and scholarly quality (Castellana, 2024; COPE Council, 2019). Early-career researchers should explore what outlets are considered standard in their field of study and perform due diligence about the nature of the specific publishing outlet they want to use. See Box 5-5 for an illustrative example of an early-career researcher considering outlets for research results.

Accuracy, completeness, and transparency in reporting findings are paramount. This means conveying nuance and uncertainty rather than overstating conclusions, maintaining clarity and precision in language, and adapting communication appropriately for different audiences without sacrificing accuracy. When communicating with fellow specialists, researchers can assume shared knowledge and use technical terminology; when addressing

[16] See chapter 4.

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BOX 5-5 Illustrative Example: Choosing Publication Outlets[1]

Dr. A is an early-career researcher at a research-intensive university, working on a series of incremental but carefully executed studies in a competitive field. Dr. A has completed several peer-reviewed conference proceedings and also has posted one manuscript as a preprint prior to peer review, although Dr. A is aware that researchers carry a responsibility to ultimately submit all preprint manuscripts for peer review.

Facing an upcoming tenure review, Dr. A feels increasing pressure to demonstrate productivity through publications. Several manuscripts have been submitted to reputable journals but remain under review or have been rejected after lengthy delays.

During this period, Dr. A receives multiple email solicitations from journals. In one case, a journal editor suggested in the email that if results supporting a specific conclusion were provided, the manuscript would be accepted for publication, but Dr. A knows that editorial practice is not ethical or responsible and does not respond to that editor. Other journal editors send emails that promise rapid peer review and publication within days, often for a publication fee. Dr. A has heard that many legitimate open-access journals charge author fees to defray the cost of publication, but has not yet learned that some journals, called predatory journals, charge fees but do not offer serious peer review The journals who email Dr. A have professional-sounding titles and editorial boards that appear, at first glance, to include recognized scholars. One such journal invites Dr. A to submit a manuscript and offers a "discounted" article processing charge if submitted within a week.

After briefly reviewing the journal's website—without closely scrutinizing its peer-review practices, indexing status, or editorial legitimacy—Dr. A submits a manuscript. Within 5 days, the paper is accepted with minimal comments. The article is published shortly thereafter.

[1] This example is hypothetical but based on the expert knowledge and experience of the authoring committee.

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Dr. A cites this publication as part of the promotion package and submits a grant proposal citing this paper as supporting data. An inquiry revealed the journal is not indexed in the database it claimed, several editorial board members denied involvement, and the article was not peer reviewed.

Months later, a colleague questions the credibility of the journal, noting that it is not indexed in major databases. The journal's website does not describe their peer review process, and in the published article, the dates Received, Revised, and Accepted are not listed.

Questions for consideration:

- What research should Dr. A have to done to avoid the lost cost, time, and credibility from publishing in a predatory journal?
- Given the pressure to publish positive findings and the misalignment between research and career incentives,[2] what questions should Dr. A reflect on and ask of peers and mentors? For example, would more preprint publications help alleviate pressure and allow Dr. A to maintain productivity without using a predatory journal?

[2] See "Choosing the Right Question in Conceptualizing Curiosity" above.

policymakers or the public, the same findings must be translated without being oversimplified or distorted.

Similarly, selecting which results to present or feature in communications about the work is a form of interpretation of the results. Researchers may consider the robustness and reliability of findings in their efforts to publish (Lee and Wang, 2020). Reporting null, unexpected, or mixed results presents particular challenges. The pressure to publish positive findings can tempt researchers to emphasize supportive results while downplaying or omitting contradictory evidence. Yet null and unexpected results are often as valuable as positive findings, revealing the boundaries of theories,

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identifying flawed assumptions, or pointing toward new questions. Stewardship requires honest reporting of all results, not selective presentation of those that fit desired narratives.

Similarly, publication practices are susceptible to abuse. Researchers may be tempted to publish virtually the same results in two different places, though most journals and professional societies explicitly prohibit the practice of duplicate publications.[17] They also may publish results in "least publishable units"—papers just detailed enough to be published but that do not give the full story of the research project. These practices waste resources and time of editors, reviewers, and readers and impose costs on the scientific enterprise. They also can be counterproductive if a researcher gains a reputation for publishing shoddy or incomplete work.

Stewardship of the scientific record and public trust extends beyond individual publications to encompass researchers' broader communication practices. When researchers publicize preliminary results that are later shown to be inaccurate or incorrect, considerable effort by other researchers can be wasted and public trust in the scientific community can be undermined. If research results are made available before publication in a journal (such as in a preprint), researchers need to use some kind of peer review process that may compensate for the lack of formal journal review. Moreover, researchers should be cautious about posting material such as raw data or figures to publicly accessible websites if they plan to publish in a peer-reviewed journal, as some journals consider this "prior publication," or may consider it as a threat to a double-blind review process.[18] As with other research practices, early-career researchers can consult their mentors if they question how they should be publishing their results.

Financial stewardship and public trust intersect in how researchers communicate about funding and resource use.

[17] Duplicate or dual publications are prohibited because they waste resources at both research organizations and the journals themselves. In addition, incentives for promotion and tenure at research universities rely on a faculty members' number of publications, so publishing the same article twice would artificially increase that publication number. See the DHHS Office of Research integrity website at https://ori.hhs.gov/duplicate-dual-publications for more information on duplicate publications.

[18] For more information on previously published material, see COPE Council (2024).

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Transparency about funding sources, acknowledgment of potential conflicts of interest, and honest accounting of how resources were used all contribute to maintaining public confidence in research.

The importance of sharing results extends beyond scholarly publication to include participants, communities, and taxpayers or donors who made the research possible. Research participants who contributed their time, information, or biological samples deserve to learn what was discovered through their contributions. Communities affected by research have legitimate interests in understanding findings that concern them. Funders, whether public agencies spending taxpayer dollars or private donors, deserve to know what their support accomplished. These communications (e.g., press releases, social media posts) require different approaches than scholarly publication but are equally important to responsible stewardship (NASEM, 2017a).

In sum, in addition to consulting existing collaboration or research plans as well as any funding grant or contract, early-career researchers may consider the following operational steps for publication in journal and broader communication outlets:

1. Identify the kind of publication outlet that is most appropriate to the discipline of the project.
2. Identify the specific journal, conference, or other outlet that you would like to publish in and review the timelines and requirements for submission. Solicit feedback from peers and mentors about the appropriateness of the outlet to avoid predatory journals.
3. Decide what elements of the project (data, code, methods, materials, etc.) will be shared and to what degree. Create a dissemination plan that includes consideration of openness and security.
4. Ensure that the data and documentation are ready to be shared. Solicit informal feedback from the research team prior to publication.
5. Ensure that the report, article, presentation, etc. is complete, accurate, and accessible to the audience. This includes proper attribution and credit to the contributors, and clarity on the scope and limitations of the work.

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6. Submit the publication and engage in the review process with an open mind.
7. Engage with the public in nonscholarly outlets as appropriate.
8. Correct the scientific record when needed, including retractions if necessary.

Authorship, Credit, and Attribution

Authorship represents a public claim of responsibility for and contribution to published work (Holcombe, 2021; ICMJE, 2026). However, norms for authorship, acknowledgment, and citation vary across disciplines, creating common sources of disputes and misunderstandings. Some fields list authors alphabetically, whereas others order them by contribution level. Some disciplines include everyone who contributed materially, whereas others reserve authorship for those who can defend the entire work.

Despite these variations, certain principles transcend disciplinary boundaries. Authorship should reflect genuine intellectual contribution to the work. For the most part, those who provided only technical assistance, funding, or general supervision without substantive intellectual input should be acknowledged but not listed as authors. Conversely, those who made significant intellectual contributions should not be relegated to acknowledgments to limit the number of authors.[19]

Intellectual honesty in representing contributions requires researchers to discuss authorship expectations early in collaborative projects, to revisit these conversations as projects evolve, and to resolve disputes through transparent discussion rather than assumption or avoidance. The question is not merely who deserves credit but who bears responsibility for the work's integrity and conclusions.[20]

[19] See also chapter 2.

[20] See the Contributor Role Taxonomy (CRediT) for descriptions about contributor roles and how to give credit: https://credit.niso.org/.

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Peer Review and Confidentiality

Peer review represents a privilege and a responsibility. Reviewers are entrusted with unpublished work and must treat this information as confidential. The ethical responsibilities of both authors and reviewers include managing conflicts of interest, protecting privileged information, and conducting the review process with fairness and rigor.

Reviewers should not use information from manuscripts or grant proposals under review to advance their own research, should not share manuscripts with others (including uploading them to AI) without permission, and should decline to review when conflicts of interest exist. Quality peer- review is time-consuming and is often not incentivized by employers or supervisors. Early-career researchers may wonder whether reviewing is a good use of their time. In addition to being a responsibility of membership in the research community, reviewing can be a valuable learning experience. Identifying the flaws in the presentation and even the substance of a submitted manuscript can strengthen one's own skills. Even while holding submitted work in confidence, it can stimulate new research ideas that the reviewer can pursue.

Reviewing grant proposals will help early-career researchers learn about and better understand practices for writing successful grant proposals, although it can be a very time-consuming activity. Reviewing manuscripts and grant proposals is both justified as a contribution to the scientific community and expected as part of professional responsibility, but is not rewarded in the same way as publications and grants. Thus, early-career researchers should discuss all invitations to review with their mentors and research supervisors to determine if the added workload would be beneficial.

Authors similarly bear responsibilities: to present work honestly, to disclose conflicts, to respond constructively to criticism, and to recognize that peer review, while imperfect, serves the essential function of quality control and improvement in science.

Raw data, computational models, instrument outputs, simulation tools, records of deliberations, and draft papers all can be posted

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online and accessed before peer review.[21] To the extent that these methods speed and broaden dissemination and verification of results, they strengthen research. However, if these new ways bypass traditional quality control mechanisms, they risk weakening conventions that have served science well.

Corrections, Retractions, and Ongoing Accountability

Discovery of errors after publication tests a researcher's commitment to stewardship. The responsible path is clear but not always easy: errors should be corrected promptly and transparently. This means distinguishing honest mistakes from misconduct, communicating with journals about necessary corrections or retractions, informing collaborators who may have relied on the erroneous work, and notifying the broader community when appropriate.

Corrections maintain the integrity of the scientific record while acknowledging the reality that all researchers are fallible. Retractions become necessary when errors are so fundamental that the work's conclusions cannot stand. In either case, the goal is not to assign blame but to ensure that the scientific record accurately reflects our current understanding.

Ongoing accountability means recognizing that publication is not the end of researchers' relationship to their work. As understanding evolves and new evidence emerges, researchers may need to revisit, reinterpret, or revise earlier conclusions. This iterative process, conducted with transparency and integrity, exemplifies stewardship at its best—commitment not to being right but to getting it right.

See Box 5-6 for questions that may help an early-career researcher navigate their own responsibility and choices in this phase of the research process.

SUMMARY: STEWARDSHIP AS AN ONGOING COMMITMENT

Stewardship in research requires continuous commitment to responsibility, integrity, and care that spans the entire research life cycle. From the moment curiosity crystallizes into a research

[21] More information on peer review is at https://authors.wiley.com/Reviewers/journal-reviewers/what-is-peer-review/index.html.

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BOX 5-6 Questions for Conveying Research

The following questions may help an early-career researcher make informed choices about communicating about their projects:

Citations: Do my citations genuinely support the claims I am making, and have I clearly explained how prior work relates to and informs my own research?

Completeness: Am I communicating my findings with full accuracy, transparency, and completeness—including uncertainty, limitations, and null or conflicting results—rather than selectively emphasizing favorable outcomes?

Outlet selection: Have I selected an appropriate and credible outlet for my work, and done due diligence to ensure that it aligns with disciplinary standards and avoids predatory practices?

Contributions and authorship: Have we discussed and agreed upon authorship roles, order of authorship, and expectations early in the project and revisited them as contributions evolved?

Peer review: Am I upholding confidentiality, fairness, and integrity in the peer review process (whether as a reviewer or an author) including managing conflicts of interest appropriately?

Correcting the record: If an error is discovered in my work, am I prepared to address it promptly and transparently by taking appropriate steps such as corrections or retractions to maintain the integrity of the scientific record?

question through the long journey to publication and dissemination, researchers bear obligations that extend far beyond their immediate professional interests.

In designing research, stewardship means aligning ambitions with resources, matching methods to questions, anticipating ethical implications, and building in safeguards against bias and error before the work begins. It means recognizing that thoughtful

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planning is not merely preparation but an act of responsibility toward all who will be affected by the research.

In conducting research, stewardship becomes a concrete and daily endeavor. It appears in how researchers treat data, manage resources, protect participants, maintain laboratory safety, and navigate the inevitable tensions between competing pressures and ethical obligations. It requires vigilance, documentation, transparency, and the courage to acknowledge mistakes and seek guidance when uncertainty arises. The doing phase tests whether researchers' commitments to integrity can withstand the pressures of real-world constraints and the temptations of convenience.

In conveying research, stewardship demands careful attention to how knowledge is shared. Proper citation, accurate reporting of results and limitations, responsible authorship, and prompt correction of errors all reflect recognition that communication is not the end of research but its contribution to an ongoing collective enterprise.

What unifies these stages is the recognition that stewardship operates at multiple levels. Individual researchers must cultivate personal integrity and professional judgment. Research teams must establish clear expectations and mutual accountability. Institutions must provide infrastructure and cultures that promote responsible conduct. These levels are interdependent—individual virtue cannot compensate for broken systems, and perfect policies cannot substitute for personal commitment.

The framework presented here cannot address every dilemma that may be encountered. Research is too diverse and too dynamic for any guide to be comprehensive. This chapter provides a foundation for thinking through stewardship questions as they arise: an understanding of core principles, an awareness of key responsibilities, and an appreciation for why these matters deserve sustained attention even as research practices change over time.

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APPENDIX A

Statements of Task

All projects, including this consensus activity, carried out by expert committees convened by the National Academies are guided by a statement of task, which defines the scope of the work and guides both the writing and the peer review of the final report. Committees are instructed to respond to the statement of task and not go beyond it. Reviewers are asked to assess whether the committee's report has responded to the statement of task in an evidence-based way and has not gone beyond it. In this project, the Overarching Committee and the four panels were each guided by their own Statement of Task.

- Box A-1 presents the Statement of Task for the Overarching Committee.
- Box A-2 presents the Statement of Task for the Panel on Collaborating Responsibly.
- Box A-3 presents the Statement of Task for the Panel on Earning and Maintaining Trust.
- Box A-4 presents the Statement of Task for the Panel on Openness and Security.
- Box A-5 presents the Statement of Task for the Panel on Responsible Conduct and Stewardship of the Research Process.

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BOX A-1 Overarching Committee Statement of Task

An ad hoc committee of the National Academies of Sciences, Engineering, and Medicine will produce a revised, expanded, and online version of *On Being a Scientist: A Guide to the Responsible and Ethical Conduct of Research*. This new version will update and expand on the 2009 edition to reflect changes in the current national and international research enterprise relevant to the conduct of research and to address professional conduct that limits or harms research talent and research advancement.

The guide will be revised in three ways. First, the guide's existing text and example scenarios, which describe key topics, issues, and questions to consider on responsible and ethical conduct in research, will be updated overall to ensure it reflects current best practices and experiences in research (such as for the topics of conflicts of interest, intellectual property, sharing and treatment of data, the researcher in society, and human subjects research) and to remove any text that may appear outdated for today's students. Second, and a greater focus of the project, will be to add, expand, and/or significantly revise text on the following topics:

- Preventing, addressing, and mitigating sexual harassment,
- Following good practices for advising and mentoring,
- Facilitating and strengthening reproducibility and replicability,
- Adopting open science and good community engagement practices,
- Fostering and advancing a more inclusive and collaborative culture in research that broadens participation and supports the full engagement of all individuals,
- Recognizing and mitigating potential risks and promoting a culture of research security,
- Supporting good practices for team science and international collaboration, and
- Addressing the ethical issues with emerging technologies and their impact on the practices and norms of research.

On topics, such as research security, that are actively evolving in terms of how scientists should handle the issues, the content will be developed with special attention to facilitating additional details being added in the future as consensus is reached.

Third, the guide will be revised and reorganized to be published as an online-first, user-friendly resource containing a series of modules that address

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key topics in a concise, easy-to-read format. The structure will enable individual modules to be added or revised independently in the future, as new research and information warrant. Such revisions and additional modules will build on findings and recommendations from relevant National Academies reports and other relevant sources.

The process of developing the updated guide will include consultations with anticipated user groups and members of target audiences (such as responsible conduct of research educators and early-career researchers) to understand how On Being a Scientist is currently used, can be of greatest value to the research community, and can best complement existing research ethics training resources.

The ad hoc committee will lead the overall revision by:

- updating the introductory materials,
- reorganizing the topics and content from the existing edition into broader topic areas that allow for greater emphasis and coverage of the topics identified above,
- updating sections of the existing report needing only minimal revisions,
- identifying topics/sections to be revised or expanded by separate panels and developing a scope of work for each panel, and
- developing the organization and design for the online guide.

Ad hoc panels will be appointed to author or revise each module or section of a module as identified by the committee and to ensure the topics identified above are included in the updated guide. The modules authored by the panels will not require approval by the committee.

The committee and the panels will not provide recommendations; rather they will provide: introductory information about key topics and issues that are part of responsible conduct in research, example scenarios to help readers understand the issues, and key questions for researchers to consider as they pursue science in a responsible manner.

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BOX A-2 Panel on Collaborating Responsibly Statement of Task

The National Academies are currently undertaking the consensus study *On Being a Scientist: An Updated and Online Guide to the Responsible and Ethical Conduct of Research*. The current study committee is tasked with producing a revised, expanded, and online version of the guide, which will update and expand on the 2009 edition to reflect changes in the current national and international research enterprise relevant to the conduct of research and to address professional conduct that limits or harms research talent and research advancement. To support this work, and building on the study's Statement of Task, an ad hoc panel will be appointed to author the portion of the guide focusing on collaborating responsibly. The panel will cover the following topics with a focus on professional and responsible conduct in interpersonal and institutional relationships:

- Supporting good practices for team science, international collaboration, and collaboration across institutions, disciplines, and sectors,
- Following good practices for advising and mentoring,
- Fostering and advancing a more collaborative culture in research that broadens participation and supports the full engagement of all individuals,
- Preventing, addressing, and mitigating sexual harassment, and
- Understanding the organizational and cultural systems that shape how investigators lead, collaborate, and manage teams within the research enterprise.

The panel will make use of existing content from the third edition of *On Being a Scientist* (2009), update it where appropriate, and incorporate new information from existing literature and research. The panel will prepare the content for the online-first and modular format that the new edition of *On Being a Scientist* will use and will ensure the text is concise and easy -to read.

The text authored by the panel will not require approval by the committee for the *On Being a Scientist* consensus study; however, the panel will include one or two people who are also on the committee, and the rest of the committee will have opportunities to provide feedback and suggestions to the panel. The panel will provide: introductory information about the key topics and issues described above that are part of responsible conduct in research, example scenarios to help readers understand the issues, and key questions for researchers to consider as they pursue science in a responsible manner.

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BOX A-3 Panel on Earning and Maintaining Trust Statement of Task

The National Academies of Sciences, Engineering, and Medicine are currently undertaking the consensus study *On Being a Scientist: An Updated and Online Guide to the Responsible and Ethical Conduct of Research*. The study committee will produce a revised, expanded, and online version of the guide, which will update and expand on the 2009 edition to reflect changes in the current national and international research enterprise relevant to the conduct of research and to address professional conduct that limits or harms research talent and research advancement. To support this work, ad hoc panels will be appointed to develop specific sections of the guide.

The Panel on Earning and Maintaining Trust will produce content covering the following topics, with a focus on trust within the research community and with the public, and trust in research findings and in researchers:

- Examining the role and responsibilities of the researcher in society (including the concept of a social compact and the values of science);
- Adopting good community engagement practices;
- Following good practices related to public engagement;
- Practicing responsible and effective science communication;
- Addressing the ethical issues with emerging technologies and their impact on the practices and norms of research;
- Responding to and transparency about research misconduct, conduct violations, and mistakes and negligence;
- Understanding the roles of and relationships between the investigator, institutions, organizations, and the broader scientific enterprise; and
- Being a responsible steward of public funds.

The panel will make use of existing content from the third edition of *On Being a Scientist* (2009), update it where appropriate, and incorporate new information from existing literature and research. It will prepare the content for the online-first and modular format that the new edition of *On Being a Scientist* will use and will ensure the text is concise and easy to read.

The content produced by the Panel on Earning and Maintaining Trust will include: introductory information about the key topics and issues described above that are part of responsible conduct in research, sample scenarios to help readers understand the issues, and key questions for researchers to consider as they pursue science in a responsible manner. The panel's product

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will be a guide for students and early-career researchers and will not contain any recommendations.

The material authored by the panel will not require approval by the full study committee; however, the panel will include one or two members who are also on the committee, and the rest of the committee will have opportunities to provide feedback and suggestions to the panel.

The final product will be subject to institutional review prior to online publication.

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BOX A-4 Panel on Openness and Security Statement of Task

The National Academies of Sciences, Engineering, and Medicine are currently undertaking the consensus study *On Being a Scientist: An Updated and Online Guide to the Responsible and Ethical Conduct of Research*. The study committee will produce a revised, expanded, and online version of the guide, which will update and expand on the 2009 edition to reflect changes in the current national and international research enterprise relevant to the conduct of research and to address professional conduct that limits or harms research talent and research advancement. To support this work, ad hoc panels will be appointed to develop specific sections of the guide.

The Panel on Openness and Security will produce content covering the following topics, with a focus on how they relate to and are affected by openness and security:

- Recognizing the potential impact of competing interests, commitments, and values;
- Recognizing and mitigating potential risks and promoting a culture of research security;
- Adopting open science and good community engagement practices;
- Supporting good practices for team science and international collaboration;
- Addressing intellectual property considerations (including patents, copyrights, trade secrets, fair use, international laws, and emerging technologies);
- Following required disclosures and policies related to research security and integrity compliance (including honest errors, negligence, corrections, consequences of failure to adhere to law and policy);
- Adopting physical- and cyber-security practices (including training, responsibilities, and consequences);
- Following ethical standards related to sharing research results before publication (including the use of preprints, peer review, authorship, citations, dissemination, new technologies, and communications);
- Following responsible practices for data governance, data stewardship, and data privacy (including the treatment of personally identifiable information and protected health information);

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- Understanding the role of industry in research security and differences in requirements and approaches between industry and other research performers;
- Addressing the ethical issues with dual-use research of concern (especially when fundamental research becomes a security issue); and
- Addressing the ethical issues with emerging technologies and their impact on the practices and norms of research.

The panel will make use of existing content from the third edition of *On Being a Scientist* (2009), update it where appropriate, and incorporate new information from existing literature and research. It will prepare the content for the online-first and modular format that the new edition of *On Being a Scientist* will use and will ensure the text is concise and easy-to-read.

The content produced by the Panel on Openness and Security will include: introductory information about the key topics and issues described above that are part of responsible conduct in research, sample scenarios to help readers understand the issues, and key questions for researchers to consider as they pursue science in a responsible manner. The panel's product will be a guide for students and early-career researchers and will not contain any recommendations.

The material authored by the panel will not require approval by the full study committee; however, the panel will include one or two members who are also on the committee, and the rest of the committee will have opportunities to provide feedback and suggestions to the panel.

The final product will be subject to institutional review prior to online publication.

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BOX A-5 Panel on Responsible Conduct and Stewardship of the Research Process Statement of Task

The National Academies of Sciences, Engineering, and Medicine are currently undertaking the consensus study *On Being a Scientist: An Updated and Online Guide to the Responsible and Ethical Conduct of Research*. The study committee will produce a revised, expanded, and online version of the guide, which will update and expand on the 2009 edition to reflect changes in the current national and international research enterprise relevant to the conduct of research and to address professional conduct that limits or harms research talent and research advancement. To support this work, ad hoc panels will be appointed to develop specific sections of the guide.

The Panel on Responsible Conduct and Stewardship of the Research Process will produce content that includes both compliance with laws and regulations and responsible conduct and other considerations beyond formal compliance. It will cover the following topics with a focus on the research process (designing, doing, and conveying research):

- Facilitating and strengthening reproducibility and replicability;
- Adopting open science and good community engagement practices;
- Understanding, preventing, and responding to research misconduct (including fabrication, falsification, plagiarism, abuse of confidentiality, failure to allocate credit, failure to report misconduct, retaliation);
- Preventing mistakes and negligence (including honest errors, replication issues, and corrections);
- Identifying, mitigating, and disclosing competing interests and bias;
- Conducting research with human participants and animal subjects;
- Following lab safety techniques and standards, and responsible environmental practices;
- Practicing responsible treatment of data;
- Being a responsible steward of research funds, intellectual property, and institutional resources;
- Addressing the ethical issues with emerging technologies and their impact on the practices and norms of research; and
- Sharing of research results (including the peer-review process, authorship, publication, citations, dissemination, new technology and emerging communications practices).

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The panel will make use of existing content from the third edition of *On Being a Scientist* (2009), update it where appropriate, and incorporate new information from existing literature and research. It will prepare the content for the online-first and modular format that the new edition of *On Being a Scientist* will use and will ensure the text is concise and easy to read.

The content produced by the Panel on Responsible Conduct and Stewardship of the Research Process will include: introductory information about the key topics and issues described above that are part of responsible conduct in research, sample scenarios to help readers understand the issues, and key questions for researchers to consider as they pursue science in a responsible manner. The panel's product will be a guide for students and early-career researchers and will not contain any recommendations.

The material authored by the panel will not require approval by the full study committee; however, the panel will include one or two members who are also on the committee, and the rest of the committee will have opportunities to provide feedback and suggestions to the panel.

The final product will be subject to institutional review prior to online publication.

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APPENDIX B

Resources for Further Reading

The chapters in this guide include several citations, many of which are past reports from the National Academies of Sciences, Engineering, and Medicine that are linked in the text. Here we provide a list of resources for further reading, listed alphabetically.

Contessa, G. 2023. It takes a village to trust science: Towards a (thoroughly) social approach to public trust in science. Erkenntnis 88: 2941–2966. https://doi.org/10.1007/s10670-021-00485-8.

Droegemeier, K. K. 2023. *Demystifying the Academic Research Enterprise: Becoming a Successful Scholar in a Complex and Competitive Environment*. Cambridge, MA: MIT Press. https://direct.mit.edu/books/oa-monograph/5708/Demystifying-the-Academic-Research.

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Goodstein, D. 2010. *On Fact and Fraud: Cautionary Tales from the Front Lines of Science*, Student edition. Princeton University Press. http://www.jstor.org/stable/j.ctt7s7j4.

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Labs That Work for Everyone, an interactive, asynchronous program designed to build the skills to work effectively in laboratory groups and research teams. Available at https://ncpre.csl.illinois.edu/pilot-our-programs/ltw.

Macrina, F. L. 2014. *Scientific Integrity: Text and Cases in Responsible Conduct of Research*, 4th edition. Washington: American Society for Microbiology.

Mayer, R. C., J. H. Davis, and F. D. Schoorman. 1995. An integrative model of organizational trust. *Academy of Management Review* 20: 709–734. https://doi.org/10.2307/258792.

McCroskey, J. C., and J. J. Teven, 1999. Goodwill: A reexamination of the construct and its measurement. *Communication Monographs* 66, 90–103. https://doi.org/10.1080/03637759909376464.

Metzen, H. 2024. Objectivity, shared values, and trust. *Synthese* 203: 60. https://doi.org/10.1007/s11229-024-04493-3.

National Center for Principled Leadership and Research Ethics offers several resources for researchers and institutional leaders: https://ncpre.csl.illinois.edu/research/resources.

Nature collection on Reliable research in the social and behavioural and sciences https://www.nature.com/collections/idajfifcfg.

NetEthics: Building Tools & Training to Advance Responsible Conduct in Complex Research Networks Pioneering Novel Technologies. Several resources available at https://consortium.umn.edu/grant/netethics-building-tools-training-advance-responsible-conduct-complex-research-networks.

Pew Research Center Trust in Science Publications, https://www.pewresearch.org/topic/science/trust-in-science/.

Rolin, K. H. 2024. Earning epistemic trustworthiness: An impact assessment model. *Synthese* 203: 39. https://doi.org/10.1007/s11229-023-04472-0.

Schuster, C., and A. M. Scheu. 2026. How communication of scientific uncertainty affects trust in science—A systematic review. *Risk Analysis* 46(5): e70233. https://doi.org/10.1111/risa.70233.

Shamoo, A. E., and D. B. Resnik. 2015. *Responsible Conduct of Research*, 3rd edition. New York: Oxford University Press.

Skloot, R. 2010. *The Immortal Life of Henrietta Lacks*. Crown Publishing.

U.S. Department of Health and Human Services Office of Research Integrity https://ori.hhs.gov/.

Validated tools to assess working climates in groups, departments, colleges, and entire institutions. Available at: https://ncpreassessment.web.illinois.edu/.

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APPENDIX C

Committee Biographies

ALAN I. LESHNER (*Co-Chair, Overarching Committee*) is the chief executive officer emeritus of the American Association for the Advancement of Science (AAAS) and former executive publisher of the journal *Science*. Before joining AAAS, Leshner was director of the National Institute on Drug Abuse at the National Institutes of Health. He also served as deputy director and acting director of the National Institute of Mental Health, and in several roles at the National Science Foundation. Previously, Leshner was professor of psychology at Bucknell University. Leshner is an elected fellow of AAAS, the American Academy of Arts & Sciences, and many others. He was a member and served as vice cchair of the governing Council of the National Academy of Medicine (formerly the Institute of Medicine) of the National Academies of Sciences, Engineering, and Medicine. He served two terms on the National Science Board, appointed first by President Bush and then reappointed by President Obama. Leshner received M.S. and Ph.D. degrees in physiological psychology from Rutgers University and an A.B. in psychology from Franklin and Marshall College. Leshner has received many honors and awards, including the Walsh McDermott Medal from the National Academy of Medicine and seven honorary Doctor of Science degrees.

MICHELE MASUCCI (*Co-Chair, Overarching Committee; Chair, Earning and Maintaining Trust Panel*) serves as the vice chancellor for research and economic development for the University System of Maryland. In this role, she leads efforts to align the University System of Maryland's expertise, programs, and resources in research and

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economic development to enhance the strength of the system's research enterprise and to advance the translation of research outcomes into practical applications through technology commercialization, innovation initiatives, university–industry partnerships, and related activities. Masucci also holds an academic appointment as professor of geography and environmental systems at the University of Maryland, Baltimore County and is an affiliated professor at the University of Maryland Center for Environmental Science. Masucci's research examines how the geographies of information and communication technologies impact community efficacies associated with education, health, and environmental quality both in the United States and internationally. She has also worked to develop university partnerships with nonprofit organizations to support this work, supported by funding from federal, state, local, and foundation sponsors. Masucci previously served as the vice president for research at Temple University, director of the Information Technology and Society Research Group, and professor and chair of the Department of Geography and Urban Studies. She also served as the co-chair of the Federal Demonstration Partnership and president of the Federal Demonstration Partnership Foundation during the past 7 years. She is a member of the board of directors for Oak Ridge Associated Universities and the University City Science Center.

KIANA ARAN (*Openness and Security Panel*) is an associate professor of bioengineering and medicine at the University of California (UC), San Diego, pioneering bioelectronics for multi-omics studies for precision medicine and aging research. Aran is also a founder of multiple startups in biotechnology with one successful exit. She is also the co-director of the Center for Technologies for Healthy Aging at UC San Diego and is a member of the New Voices program of the National Academies of Sciences, Engineering, and Medicine. Her contributions have earned numerous prestigious awards. In 2025, she won the inaugural Sony and Nature Award for Top Women in Technology, recognizing her among three global leaders. In 2024, she was named a Senior Member of the National Academy of Inventors and Distinguished Engineer of the Year by the San Diego Society of Engineers. Other honors include New Voices in Sciences, Engineering, and Medicine (2023), Inc. USA's Top 200 Female Founders (2023), and Distinguished Engineer by the Society of Women Engineers (2023). Past accolades include the Nature Research Award for Inspiring Women in Science (2021), the NSF CAREER Award, The Scientist's Top 10 Innovations Award, and the Athena Pinnacle Award (2020). Her research was featured in *Nature Biomedical Engineering*'s Most Read Papers and *Nature*'s Behind the Paper Top 10 List (2019). She also received the CONNECT Most Innovative Product Award and San Diego Venture Group's Coolest Companies Award (2019). With over 33 issued or pending patents, Aran continues to drive groundbreaking innovations in biotechnology.

SZCZEPAN BARAN (*Responsible Conduct and Stewardship of the Research Process Panel*) sits at the crossroads of veterinary medicine, artificial intelligence (AI), and ethical innovation, pioneering how scientific evidence is generated and validated. He founded Baran Café, an innovation consultancy modernizing evidence generation,

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and Tech4Pets, an AI company advancing behavioral and health analytics for companion animals. As a research associate at KU Leuven's Division of Animal and Human Health Engineering, he integrates new approach methodologies (NAMs), digital biomarkers, and AI modeling to connect preclinical discovery with clinical and regulatory relevance. He co-leads the National Institutes of Health's (NIH's) Complement-ARIE Validation and Qualification Network (VQN) as industry co-chair of the Foundation for the NIH, defining validation frameworks for NAMs and digital models. In Europe, he contributes to the Innovative Health Initiative NHPig project, developing predictive micro- and mini-pig models to replace nonhuman primates in safety testing. A contributor to multiple National Academies of Sciences reports, he helped shape the NIH's $486 million investment in next-generation research infrastructure. Formerly head of emerging technologies at Novartis and chief scientific officer at VeriSIM Life, Baran now advances ROI (return on investment) frameworks uniting digital, NAM, and in vivo technologies—bridging ethical modernization with scientific and economic value. Educated in Poland and shaped by global experience, he views translation as both a technical and moral pursuit.

CYNTHIA BEALL (*Openness and Security Panel*) is S. Idell Professor and Distinguished University Professor of Anthropology Emerita at Case Western Reserve University. Beall is a biological anthropologist whose research focuses on human evolution and adaptation to high-altitude hypoxia, particularly the different patterns of adaptation exhibited by Andean, Tibetan and East African highlanders. Honors include a Guggenheim Fellowship, and receipt of the Raymond Pearl Award and the Franz Boas Distinguished Achievement Award from the Human Biology Society. Beall is a member of the U.S. National Academy of Sciences, the American Philosophical Society, and the American Academy of Arts & Sciences. She received her BA in biology from the University of Pennsylvania, her M.A. and Ph.D. in anthropology from Pennsylvania State University.

JOHN C. BESLEY (*Earning and Maintaining Trust Panel*) is the Ellis N. Brandt Professor of Public Relations at Michigan State University (MSU). He studies public opinion about science and scientists' opinions about the public. His goal is to help the scientific community make evidence-based and strategic communication choices. He also does research aimed at understanding how views about decision makers and decision-making processes (i.e., trustworthiness and fairness beliefs) affect perceptions of science and technology. Besley has published more than 120 peer-reviewed journal articles and book chapters. This work has appeared in high-ranking journals including *Risk Analysis, Science Communication,* and *Public Understanding of Science.* MSU awarded Besley its William J. Beal Outstanding Faculty Award in 2021, and the American Association for the Advancement of Science honored him as a fellow in 2018. In 2013, the Association for Education in Journalism and Mass Communication awarded him the Hillier-Krieghbaum Under 40 Award. Besley earned his Ph.D. in communication from Cornell University in 2006 and both master's (public administration, 2000), and bachelor's (journalism, 1998) degrees from Carleton

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ERIN KAI-LING CHIOU (*Collaborating Responsibly Panel*) is an associate professor of human systems engineering at The Polytechnic School, part of the Ira A. Fulton Schools of Engineering at Arizona State University. Her research focuses on human–automation interaction, trust in sociotechnical systems, and addressing human–system integration challenges in complex work domains such as education, healthcare, security, and defense. She has over a decade of experience leading and contributing to multidisciplinary and interdisciplinary research teams. Chiou received her Ph.D. and M.S. in industrial and systems engineering (human factors and ergonomics) from the University of Wisconsin–Madison; and her B.S. in psychology and philosophy from the University of Illinois Urbana–Champaign. She has served as a report reviewer and committee member for several National Academies' efforts since 2019, including the 2021 consensus study on "Human–AI Teaming: State-of-the-Art and Research Needs," and the 2025 consensus study on "The Science and Practice of Team Science."

ROGER CONE (*Overarching Committee and Collaborating Responsibly Panel*) joined the University of Michigan in 2016 as the director of the Life Sciences Institute, and was appointed vice provost for the biosciences in 2017. Cone was chairman of the Department of Molecular Physiology and Biophysics at Vanderbilt University from 2008 to 2016, and a faculty member of the Vollum Institute, Oregon Health Sciences University from 1990 to 2008. Cone is credited with the discovery of multiple fundamental biological roles for the melanocortin system in energy homeostasis. These findings resulted from studies cloning and characterizing the five receptors for the melanocortin peptides, and analyzing the pharmacological and physiological functions of these receptors. Cone's group demonstrated the melanocortin-4 receptor as a critical regulator of energy homeostasis, leading to the discovery of mutations in the MC4R gene as the leading cause of syndromic obesity, and development of the first drug for syndromic obesity, Imcivree. Cone received his B.A. in biochemistry from Princeton, and Ph.D. in biology from Massachusetts Institute of Technology. Cone was elected to the National Academy of Sciences (2010), and the National Academy of Medicine (2016), and received the Berson Award, Berthold Memorial Award, Ipsen Prize, and the Rolf Luft Prize. Cone served two terms on the National Research Council Board on Life Sciences.

STEPHANIE DIEM (*Collaborating Responsibly Panel*) is an assistant professor in the Department of Nuclear Engineering and Engineering Physics at the University of Wisconsin–Madison. She was formerly a staff scientist at Oak Ridge National Laboratory in the Fusion Energy Division and was on long-term assignment at the DIII-D National Fusion Facility. Her research expertise is in experimental plasma physics and fusion energy technology. She is the principal investigator of the Pegasus-III Experiment that develops innovative plasma initiation technology to reduce the cost and complexity of future fusion energy devices. She leads an

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interdisciplinary group investigating the societal, environmental, economic, and technological impacts of fusion energy systems. She was selected by the National Academies as a member of 2021 and 2024 cohorts of the New Voices in Science, Engineering, and Medicine, a 2025 Kavli Fellow, and a U.S. Science Envoy for the U.S. Department of State and received the 2023 Excellence in Fusion Engineering Award from the Fusion Power Associates.

HEATHER DOUGLAS (*Overarching Committee and Earning and Maintaining Trust Panel*) is a professor in the Department of Philosophy at Michigan State University. She held previous tenure-line faculty positions at the University of Puget Sound, the University of Tennessee, and the University of Waterloo prior to moving to Michigan State in 2018. She is a philosopher of science who works on the relationships among science, values, and democratic publics, including the moral responsibilities of science and historical shifts in the understanding of those responsibilities. In 2016, she was named an American Association for the Advancement of Science fellow, and she was Senior Visiting Fellow at the Center for Philosophy of Science at the University of Pittsburgh in 2021–2022. She was named to the International Science Council's Committee for Freedom and Responsibility in Science in 2025. She is the author of *Science, Policy, and the Value-Free Ideal* (2009), *The Rightful Place of Science: Science, Values, and Democracy* (2021), and the editor of the book series *Science, Values, and the Public* for University of Pittsburgh Press. Douglas received a Ph.D. from the History and Philosophy of Science Department at the University of Pittsburgh in 1998. In 2026, she received an honorary doctorate from Université Catholique de Louvain in Belgium.

KELVIN K. DROEGEMEIER (*Overarching Committee and Co-Chair, Openness and Security Panel*) is professor of climate, meteorology, and atmospheric sciences and special advisor to the chancellor for science and policy at the University of Illinois Urbana–Champaign. He previously spent 38 years on the faculty at the University of Oklahoma, where he served for nearly a decade as vice president for research. He co-founded and directed one of the first 11 National Science Foundation (NSF) Science and Technology Centers and co-founded an NSF Engineering Research Center. Droegemeier served as Oklahoma cabinet secretary for science and technology and served two terms on the National Science Board for the last 4 years as vice chairman. Most recently, he served as director of the White House Office of Science and Technology Policy, science advisor to the President, and acting director of NSF. He is a fellow of the American Meteorological Society and of the American Association for the Advancement of Science and has served on and chaired numerous boards, including as chair of the University Corporation for Atmospheric Research and the Southeastern Universities Research Association boards of trustees, and presently serves on the Board on Research Data and Information, and the Committee on Science, Engineering and Public Policy, of the National Academies of Sciences, Engineering, and Medicine. In 2023, Droegemeier authored a book titled *Demystifying the Academic Research Enterprise*. Droegemeier's expertise is in thunderstorm dynamics, computational fluid dynamics, data assimilation, numerical weather prediction, and aviation weather.

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MONICA DUS (*Openness and Security Panel*) is a molecular biologist whose work bridges research, science strategy, and national capacity building. She is the assistant vice president for natural sciences and engineering and a professor at the University of Michigan, where she leads the Laboratory of Molecular Nutrition and teaches genetics to hundreds of undergraduate students. Her laboratory integrates molecular and systems approaches to study precision nutrition, neurometabolism, and nutrigenomics. She was a 2023 White House Fellow and Guggenheim Fellow, and her work has been supported by the National Institutes of Health, the National Science Foundation, and Sloan, Klingenstein-Simons, and Rita Allen foundations. As director of the Office of National Laboratories in the University of Michigan's Office of the Vice President for Research, Dus leads initiatives that align academic science and workforce development with national science and technology priorities. She collaborates closely with national and service laboratories, defense agencies, and interagency partners across critical and emerging technologies. She served as special assistant to the 78th Secretary of the Navy, supporting and leading projects on national science and technology strategy, workforce development, and force resilience with other executive agencies. She serves on the National Academies' New Voices in Sciences, Engineering, and Medicine Cohort 3, the American Association for the Advancement of Science (AAAS) Task Force on the Vision for American Science & Technology, and the AAAS Leadership Development Committee.

ELENA FUENTES-AFFLICK (*Earning and Maintaining Trust Panel*) is the Association of American Medical Colleges' chief scientific officer and leads the association's programs that support medical research and the training of physician-scientists and researchers in academic medicine. She provides leadership and vision for addressing research and science policy and other related critical issues facing academic medicine, medical schools, teaching health systems, and teaching hospitals. An elected member of the National Academy of Medicine and the American Academy of Arts & Sciences, Fuentes-Afflick's scholarly work has focused on Latino health, acculturation, immigrant health, health disparities, and faculty misconduct in academic medicine. Fuentes-Afflick has served in national leadership roles for the Society for Pediatric Research, the American Pediatric Society, and the National Academy of Medicine. She has received the Joseph W. St. Geme, Jr. Leadership Award from the Federation of Pediatric Organizations for sustained, impactful contributions to child health and the Elizabeth Blackwell Career Achievement Award from the American Medical Women's Association. Fuentes-Afflick earned her undergraduate and medical degrees at the University of Michigan and a master's degree in public health from the University of California (UC), Berkeley. She completed her pediatric residency and chief residency at UC San Francisco (SF), followed by a research fellowship at the UCSF Philip R. Lee Institute for Health Policy Studies. She has served as an ex officio member of the National Academies' Committee on Women in Science, Engineering, and Medicine and currently serves on the advisory committee for the Action Collaborative on Education and Workforce Trajectories in Tech.

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KEVIN GAMACHE (*Openness and Security Panel*) is associate vice chancellor and chief research security officer for the Texas A&M University System. He ensures compliance with federal requirements for protecting sensitive information across A&M System universities. Gamache is the principal investigator and director of the National Science Foundation's Safeguarding the Entire Community in the U.S. Research Ecosystem (SECURE) Analytics cooperative agreement. He also founded and leads the Academic Security & Counter Exploitation Program, a national consortium dedicated to enhancing security awareness in academia. A retired U.S. Air Force Colonel with 24 years of service, he holds a Ph.D. from Texas A&M University and an M.S. from the Industrial College of the Armed Forces.

STEVEN GOODMAN (*Responsible Conduct and Stewardship of the Research Process Panel*) is a professor of epidemiology, medicine, and health policy (by courtesy), Stanford University School of Medicine, and associate dean for clinical and translational research. He is affiliated faculty in the Stanford Center for Biomedical Ethics. He has led training and degree programs for graduate students, faculty, and staff for over three decades, many in the realm of professional development and ethics. His main research and implementation focus is on the rigor and reproducibility of biomedical research. He has also published extensively on the foundations of scientific inference and other aspects of scientific and statistical methodology. He founded and directs the Stanford Program on Research Rigor and Reproducibility and co-founded METRICS (the Meta-research Innovation Center at Stanford). Honors include election to the National Academy of Medicine, the Spinoza Chair in Medicine (University of Amsterdam) for his work in inference, the Lilienfeld Award (American College of Epidemiology) for lifetime achievement in epidemiological research and teaching, and election to the Johns Hopkins Society of Fellows. He is currently a member of the National Academies' Council on Scientific Integrity and Trust.

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LAURA GREENE (*Responsible Conduct and Stewardship of the Research Process Panel*) is chief scientist at the National High Magnetic Field Laboratory and the Marie Krafft Professor of Physics at Florida State University. Her research is on quantum materials, focusing on fundamental studies of novel materials, their synthesis, and the mechanisms of unconventional superconductivity. In 2021, Greene was appointed to serve as a member of the President's Council of Advisors for Science and Technology. She was the 2017 president of the American Physical Society (APS), served on the board of directors for the American Association for the Advancement of Science (AAAS), and is vice president for ethics and outreach of the International Union of Pure and Applied Physics. She was a member of the U.S. Department of State–supported COACh team. She is a member of the National Academy of Sciences and the American Academy of Arts & Sciences, is a fellow of the Institute of Physics (United Kingdom), the AAAS, and the APS. She received the American Association of Physics Teachers' Oersted Medal, Tallahassee Scientific Society Gold Medal, American Physical Society Five Sigma Physicist Award for Advocacy in Science Policy, E.O. Lawrence Award for Materials Research, APS Maria Goeppert-Mayer Award, and the Bellcore Award of Excellence; and has been a Guggenheim Fellow.

DAVID H. GUSTON (*Earning and Maintaining Trust Panel*) is Foundation Professor in Arizona State University's (ASU's) School for the Future of Innovation in Society, where he was founding director (2015–2021). He is also associate vice provost for discovery,

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engagement, and outcomes in ASU's Julie Ann Wrigley Global Futures Laboratory. At ASU, he was principal investigator and director of the National Science Foundation–funded Center for Nanotechnology in Society (2005–2016) and co-director of the Consortium for Science, Policy and Outcomes (2008–2020). Guston's work has focused on the relationship between science and democratic politics, and his research has been instrumental in the conception and implementation of ideas about boundary organizations, responsible innovation, and anticipatory governance. His book, *Between Politics and Science,* won the Don K. Price prize from the American Political Science Association, and he is an elected fellow of the American Association for the Advancement of Science. He holds an A.B. from Yale and a Ph.D. in political science from Massachusetts Institute of Technology, and he held a postdoctoral fellowship at Harvard's Kennedy School of Government, Belfer Center for Science and International Affairs. Guston served on the National Academy of Engineering committee chaired by Norm Augustine, whose recommendations led to the creation of the Center for Engineering, Ethics, and Society.

RESHMA JAGSI (*Overarching Committee and Chair, Collaborating Responsibly Panel*) is chair of the Department of Radiation Oncology and senior faculty fellow in ethics at Emory University. A physician-bioethicist, her research includes empirical and normative work on professionalism, social scientific studies of harassment in academic medicine, and translational clinical research in breast cancer. Elected to the National Academy of Medicine, Association of American Physicians, and American Society for Clinical Investigation, she has authored or co-authored over 500 publications and is principal investigator on multiple grants from the National Institutes of Health (NIH) and philanthropic foundations. After undergraduate and medical education at Harvard and a doctorate in social policy at Oxford as a British Marshall Scholar, she joined the faculty of the University of Michigan, where she served as director of its Center for Bioethics and Social Sciences in Medicine. She serves on the National Academies' Committee on Women in Science, Engineering, and Medicine, the NIH's Board of Scientific Counselors, and the Greenwall Foundation's Faculty Scholars Program Committee. Frequently asked to advise on professionalism and ethics, she was appointed to the University of Michigan President's Commission on Values and asked to draft the professionalism policy for Emory's School of Medicine. She is a fellow of the American Association for the Advancement of Science, American Society of Clinical Oncology, American Society for Radiation Oncology, and the Hastings Center.

CHARLES JOHNSON-BEY (*Openness and Security Panel*) is a nationally recognized engineering executive on a mission to use technology to demonstrate the human genius. A member of the National Academy of Engineering, he is known for translating emerging technologies into real-world impact across defense, academia, and industry. With expertise spanning artificial intelligence, cyber, quantum, and advanced manufacturing areas, he brings a unique ability to distill complex innovations into clear, accessible insights for both technical and public audiences. A passionate advocate for future-forward innovation, he co-leads the National Science

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Foundation–sponsored Engineering Research Visioning Alliance, helping to shape national engineering research agendas. Johnson-Bey is a former partner and senior vice president at Booz Allen Hamilton, where he led engineering and advanced technology strategy as well as a ~$500M defense portfolio. Prior to Booz Allen, he had a distinguished career at Lockheed Martin Corporation in advanced technology and strategy. As the Open Innovation Program manager, he led the multimillion-dollar technology portfolio that supported nine of Lockheed's Focus programs with a projected $20B in total addressable market. He received a B.S. in electrical and computer engineering from Johns Hopkins University and received a Ph.D. in electrical engineering from the University of Delaware. In March 2025, he completed a year-long, 400+-hour curriculum for a chief technology officer professional certificate from Massachusetts Institute of Technology.

NANCY KASS (*Overarching Committee and Responsible Conduct and Stewardship of the Research Process Panel*) is Phoebe R. Berman Professor of Bioethics and Public Health at Johns Hopkins University (JHU), where she is also deputy director for public health in the Berman Institute of Bioethics and professor of health policy and management in the Johns Hopkins Bloomberg School of Public Health (JHSPH). Kass conducts empirical work in bioethics and health policy. Her publications are on U.S. and global research ethics, public health ethics, infectious diseases and ethics policy, and ethics and the learning healthcare system. Kass developed the first course on research ethics and integrity at JHSPH and taught it for 15 years; she has taught research ethics in short courses at JHU and in several other countries. She received two Dean's awards for mentoring. She developed guidance on mentoring for Ph.D. students across Johns Hopkins University (while serving as vice-provost) and for mentoring junior faculty in her academic department. In fall 2024, Kass was a visiting scholar at the Stanford Center for Biomedical Ethics. From June 2023 to June 2024, she served as ethics advisor, Office of the Commissioner, U.S. Food and Drug Administration through an Intergovernmental Personnel Act (IPA) arrangement. From 2017 to 2023, Kass served as vice-provost for graduate education at JHU. In 2009–2010, Kass was based in Geneva, Switzerland, working with the World Health Organization (WHO) Ethics Review Committee Secretariat. Kass is an elected member of the National Academy of Medicine and a fellow of the Hastings Center.

LISA M. LEE (*Collaborating Responsibly Panel*) is senior associate vice president for research and innovation, director of scholarly integrity and research compliance, and research professor of public health at Virginia Tech. Previously she served in the Obama administration where she was appointed executive director of the Presidential Bioethics Commission. She also served as the inaugural chief of bioethics at Walter Reed Army Institute of Research where her role included institutional review board (IRB) chair, research integrity officer, and chair of the Bioethics Consultation Service. She has authored numerous publications in both public health science and ethics and serves as associate editor for the *Public Health Reports* and *Journal of Bioethical Inquiry.* The focus of Lee's current work is research ethics, scientific integrity, and public health ethics. Lee served as chair of the executive board of the Association

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for Practical and Professional Ethics from 2021 to 2023 and served as the inaugural chair of the Ethics Section of the American Public Health Association. As an infectious disease epidemiologist and bioethicist, Lee has worked in public health at the state, federal, and global levels, including 14 years at the U.S. Centers for Disease Control and Prevention where she served as the agency's assistant science officer, director of the Office of Scientific Integrity, and chief science officer in the Office of Surveillance and Epidemiology. She has served on public health and ethics working groups for the World Health Organization, the Wellcome Trust, and Chatham House. In 2014 she was honored with the Pellegrino Medal for excellence in bioethics. Lee holds a Ph.D. in public health from Johns Hopkins University, and an M.A. in educational psychology and M.S. in bioethics.

MITUL LUHAR (*Overarching Committee and Earning and Maintaining Trust Panel*) is Associate Professor of Aerospace and Mechanical Engineering and Civil and Environmental Engineering at the University of Southern California, where he holds the Henry Salvatori Early Career Chair in Engineering. His primary research expertise is in fluid dynamics. His work addresses aerodynamic and hydrodynamic design, the restoration and management of river systems, and the evaluation of nature-based solutions to coastal hazards. Dr. Luhar has received the NSF CAREER Award and the AFOSR Young Investigator Program Award. Before joining USC, he was a Postdoctoral Scholar at Caltech. He earned his PhD from MIT, where he was awarded a Presidential Fellowship, and his BA and M.Eng. degrees from the University of Cambridge. He is an alum of the National Academy of Engineering's Frontiers of Engineering program and co-chaired the third cohort of the National Academies' New Voices program from 2024–2026.

BRUCE MANDT (*Collaborating Responsibly Panel*) is associate dean in the Graduate School and director of the Postdoctoral Office at the University of Colorado Anschutz Medical Campus (CU Anschutz). He also holds appointments as assistant professor in the Department of Pharmacology and director of the Mentoring^3 program within the Colorado Clinical and Translational Sciences Institute. His work at CU Anschutz is primarily focused on fostering supportive research training environments. Previously, Mandt was assistant research professor in the Psychology Department at the University of Colorado Denver (CU Denver), where he conducted drug abuse research, mentored students, and taught undergraduate courses, including research ethics. Nationally, he has served as co-chair of the Association of American Medical Colleges (AAMC) Group on Research, Education, and Training (GREAT) and as chair of its Postdoctoral Training Section. Mandt is a co-author of the AAMC GREAT Appropriate Treatment of Research Trainees (AToRT) guide and continues to serve as co-chair of the AToRT working group. Related to his administrative work, he received the Council of Graduate Schools Assistant/Associate Dean's Leadership Award in 2024. Mandt earned his Ph.D. in pharmacology from CU Anschutz and a B.A. in psychology from the University of Wisconsin–Madison.

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BARBARA MEANS (*Overarching Committee*) is principal learning sciences researcher at the nonprofit organization Digital Promise. Prior to joining Digital Promise in 2017, she was at SRI International, where she founded SRI's Center for Technology in Learning in 1994. Means studies the implementation and effectiveness of innovative education approaches supported by digital technology. Currently, she leads large-scale implementation and efficacy studies of digital courseware and teaching practices in the domains of college statistics and chemistry. Another thread of her research has examined opportunity structures for preparing students to enter and succeed in postsecondary science, technology, engineering, and mathematics programs. Drawing on her expertise in both education and learning technologies, Means has advised the U.S. Department of Education on national educational technology plans for both K-12 and postsecondary education. She has authored or edited a half dozen books related to learning and technology research. A fellow of the American Educational Research Association, she earned her undergraduate degree in psychology from Stanford University and her Ph.D. in educational psychology from the University of California, Berkeley. Means has served on many National Academies' study panels related to science education, including the panels that produced How People Learn I and How People Learn II.

PAUL NDEBELE (*Overarching Committee*) serves as an assistant director in the Office of Research Excellence in the Milken Institute School of Public Health. He also serves as a professorial lecturer in the Department of Global Health, where he teaches courses on responsible conduct of research, ethical and cultural issues in global research and programming, ethical issues in public health policy and practice, and ethics in domestic and international research. Ndebele also serves as a member of the George Washington University institutional review board. He holds a Ph.D. in research ethics obtained from University of KwaZulu Natal (UKZN) in South Africa. He has prior appointments as director at the Medical Research Council Zimbabwe, bioethicist contractor at the Division of AIDS, U.S. National Institutes of Health; assistant director of research ethics at University of Botswana; deputy director for Centre of Bioethics at College of Medicine, University of Malawi; and assistant visiting professor at Michigan State University. He has served as a scholar in four bioethics training programs including the Fogarty African Bioethics Training Program at Johns Hopkins University; SARETI at UKZN in South Africa; Erasmus Mundus Bioethics Program at Padova University (Italy); and Ethox Centre at Oxford University.

JODI M. NUNNARI (*Earning and Maintaining Trust Panel*) is a cell biologist and pioneer in the field of mitochondrial biology. She is the institute director at the Institutes of Science of Altos Laboratories and a distinguished professor emerita and former chair of the Department of Molecular and Cellular Biology at the University of California, Davis, while also serving as the editor-in-chief of *The Journal of Cell Biology*. As a postdoctoral fellow with Peter Walter at the University of California, San Francisco, Nunnari pioneered the use of green fluorescent protein to visualize mitochondria in budding yeast, helping to establish the field of mitochondrial dynamics. In 2017, Nunnari was elected as a member of the National Academy of Sciences. In 2020, she

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was elected to the European Molecular Biology Organization. In 2021, she was elected to the American Academy of Arts & Sciences. She studied chemistry at the College of Wooster before obtaining a Ph.D. in pharmacology from Vanderbilt University, working with Lee Limbird.

EMILY PENTZER (*Overarching Committee*) is professor of chemistry and senior associate dean for research in the College of Arts and Sciences at Texas A&M University in College Station. Her research program focuses on combining synthesis and processing to prepare polymer-based composites and understanding structure–property-–application relationships in carbon capture, thermal energy management, and electrochemical energy storage. Pentzer regularly participates in events aimed at the professional development of students and postdoctoral scholars and facilitating their transition to vibrant science, technology, engineering, and mathematics careers. She has received several awards including the National Science Foundation CAREER award (2016), Case Western Reserve University Faculty Diversity Excellence Award (2019), and the American Chemical Society Women's Chemist Committee Rising Star Award (2021), and she was named a Texas A&M Presidential Impact Fellow (2021) and finalist for the Blavatnik Award in physical sciences and engineering (2022). She currently serves as the inaugural editor in chief of *RSC* Applied Polymers (2023–present) and was a member of the third cohort of the New Voices program of the National Academies of Science, Engineering, and Medicine (2024–2026).

DENA PLEMMONS (*Overarching Committee and Collaborating Responsibly Panel*) is the founding director of the Research Ethics Education Program, and an adjunct associate professor in the Graduate Division at the University of California, Riverside. She serves as chair of the Executive Board of the Association for Practical and Professional Ethics (APPE) and has recently retired as the editor in chief of the SpringerNature journal *Science and Engineering Ethics*. She is an expert consultant to the National Center for Principled Leadership and Research Ethics, and in that capacity works on STEM-focused professional development programs. She is a member of American Association for the Advancement of Science (AAAS), and an elected AAAS fellow, as well as a member of Sigma Xi and APPE. Plemmons was trained as an anthropologist, but made a mid-career shift to the study of integrity in research with specific interests in research on research integrity and curriculum development for integrity and leadership. She has consistently been funded, as principal investigator (PI) and co-PI, through the National Institutes of Health, the National Science Foundation, and Office of Research Integrity of the Department of Health and Human Services for her research and curriculum development in research ethics, and investigations into common and best practices in areas of scientific practice, both nationally and internationally.

KEIVAN G. STASSUN (*Collaborating Responsibly Panel*) holds the Stevenson Chair in Astrophysics and holds secondary appointments in computer science and in management, at Vanderbilt University, where he has received a National Science Foundation (NSF) CAREER award, a Cottrell Scholar Award from the Research

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Corporation for Science Advancement, an HHMI Professor Award from the Howard Hughes Medical Institute, and a Ford Foundation Fellowship from the National Academy of Sciences. Stassun is a member of the leadership team for NASA's Ultraviolet Explorer and served as a co-investigator for NASA's Transiting Exoplanet Survey Satellite mission, chairs the executive committee of the Sloan Digital Sky Survey, serves on the National Academy of Sciences Space Studies Board, and served on the National Academy of Sciences Decadal Steering Committee for Astronomy and Astrophysics. An elected fellow of the American Physical Society, the American Astronomical Society, the American Association for the Advancement of Science, and Sigma Xi, and an elected member of the American Academy of Arts & Sciences, his research on stars and exoplanets has appeared in more than 600 peer-reviewed journal articles, with an emphasis on understanding the fundamental physical properties of stars and extrasolar planets. Having trained more than 50 Ph.D. students and postdoctoral scholars from all backgrounds, Stassun is a leader, advocate, and exemplar for training the next generation of American talent in science, technology, engineering, and mathematics fields: From 2004 to 2016, he served as founding director of the Fisk-Vanderbilt Masters-to-PhD Bridge Program, and since 2017, he serves as founding director of the Frist Center for Autism & Innovation in Vanderbilt's School of Engineering. He has served on National Science Foundation's Committee for Equal Opportunity in Science and Engineering, is a recipient of the American Physical Society's Nicholson Medal for Outreach, has been named Mentor of the Year by the American Association for the Advancement of Science, and has been honored with a Presidential Award for Excellence in Science Mathematics and Engineering Mentoring. In 2023, Stassun was appointed to a 6-year term on the National Science Board, in 2024 was named a MacArthur Fellow, and in 2025 received the National Medal of Science.

ELHAM TABASSI (*Earning and Maintaining Trust Panel*) is director of the Artificial Intelligence and Emerging Technology Initiative and a senior fellow in the Global Economy and Development Program at the Brookings Institution. A widely recognized leader in artificial intelligence (AI) governance, she previously served as chief AI advisor at the National Institute of Standards and Technology, where she guided development of the landmark AI Risk Management Framework. Named to the TIME100 list of most influential people in AI, she continues to shape national and international conversations on trustworthy, human-centered AI. Tabassi holds a master of science in electrical and electronics engineering from Santa Clara University and a bachelor's degree in electrical engineering from Sharif University of Technology.

CHRISTOPHER VIGGIANI (*Openness and Security Panel*) is the associate vice president for research integrity at Oregon State University (OSU). Viggiani leads the Office of Research Integrity, integrating high ethical and professional standards into OSU's research and innovation enterprise. He oversees programs on human research protections, animal welfare, research security, export controls and international compliance, responsible research practices and misconduct, conflicts of interest, biosafety, and more. Previously, he oversaw university policies and standards at OSU,

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MO WANG (*Responsible Conduct and Stewardship of the Research Process Panel*) is a University Distinguished Professor and the Lanzillotti-McKethan Eminent Scholar Chair and the associate dean for Research and Strategic Initiatives at the Warrington College of Business at University of Florida. He is also the chair of the Management Department and the director of the Human Resource Research Center at University of Florida. He specializes in research areas of organizational behavior and human resource management, especially on team science. He has received numerous research awards for his research in these areas, including Academy of Management (AOM) HR Division Scholarly Achievement Award; Careers Division Best Paper Award; European Union's Erasmus Mundus Scholarship Award for Work, Organizational and Personnel Psychology; Emerald Group's Outstanding Author Contribution Awards; Society for Industrial-Organizational Psychology's (SIOP) William A. Owens Scholarly Achievement Award; and Journal of Management Scholarly Impact Award. He also received a number of Early/Mid-Career Contribution Awards from AOM, American Psychological Association (APA), SIOP, and Society for Occupational Health Psychology. He is an elected foreign member of Academia Europaea (M.A.E) and a fellow of AOM, APA, APS, and SIOP.

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BILLY M. WILLIAMS (*Responsible Conduct and Stewardship of the Research Process Panel*) is the executive vice president for ethics and organizational advancement at the American Geophysical Union (AGU). Prior to joining AGU as science director in 2012, Williams served as a senior program officer at the National Academy of Sciences and as a global R&D director at the Dow Chemical Company. Williams was a member of the 2017–2018 National Academy of Sciences' Committee on Impact of Sexual Harassment in Academic Science Engineering and Medicine. He also served on the 2023 National Dialogue on the State of Research Integrity Education Committee, sponsored by the Association of Practical and Professional Ethics. Williams has served as principal investigator on research grants from multiple governmental and philanthropic funding organizations. In 2018, he co-led the founding of the Societies Consortium for Ending Harassment in STEMM—an organization now with more than 100 scientific societies' members. In addition to other leadership responsibilities at AGU, Williams leads the AGU Ethics Office, responsible for scientific research integrity standards and education, plus other AGU global ethical standard initiatives—such as the ethical framework for climate intervention research. Williams received his B.S. degree in chemistry from University of North Carolina at Chapel Hill and an M.S. in organic chemistry from Central Michigan University.

KEITH R. YAMAMOTO (*Openness and Security Panel*) is special advisor to the chancellor for science policy and strategy, vice chancellor for research emeritus, and professor of cellular and molecular pharmacology emeritus at University of California, San Francisco. He has led or served on national committees focused on human genome editing; U.S.–China science interactions; equity in biomedical technology research and development; public and science policy; public understanding and support of scientific research; science education and the biomedical workforce; research funding; peer review; open science; responsible conduct; and diversity, equity, and inclusion and anti-racism. He sits on the boards of directors of the Public Library of Science, the Engineering Biology Research Consortium, Research!America, and Rapid Science; the Board of Trustees of the Morgridge Institute for Research; the Governing Board of the California Institute for Regenerative Medicine; the Board of Counselors for the Radiation Effects Research Foundation; and the Advisory Board for Lawrence Berkeley National Laboratory. He was elected to the National Academy of Sciences, National Academy of Medicine, the American Academy of Arts & Sciences, the American Academy of Microbiology, and is a fellow of American Association for the Advancement of Science. Yamamoto earned a Ph.D. in biochemical sciences from Princeton University. He has participated in numerous National Academies' activities and currently serves as a member of the Board on Higher Education and Workforce as well as the Reenvisioning the Future of STEM Research at Emerging Research Institutions summit. He formerly served as co-chair of the Roundtable on Aligning Incentives for Open Science.

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