# Enhancing Scientific Reproducibility in Biomedical Research Through Transparent Reporting

Sharing knowledge is what drives scientific progress—each new advance in biomedical research builds on previous observations. However, for experimental findings to be broadly accepted as credible by the scientific community, they must be verified by other researchers. An essential step is for researchers to report their findings in a clear and understandable manner so that others in the scientific community are able to validate the original results and build upon them.

In recent years, concern has been growing over a number of studies that have failed to replicate previous results and evidence from larger meta-analyses, which have pointed to the lack of reproducibility in biomedical research. **Funders, publishers, and other key stakeholders have recognized the need to encourage and enhance transparent reporting of preclinical research findings across the biomedical research life cycle.**

On September 25 and 26, 2019, the National Academies of Science, Engineering, and Medicine hosted a public workshop in Washington, DC, to discuss the current state of transparency in the reporting of preclinical biomedical research and to explore opportunities for harmonizing reporting guidelines across journals and funding agencies. This workshop built on recent consensus reports by the National Academies, including *Reproducibility and Replicability in Science*, *Open Science by Design: Realizing a Vision for 21st Century Research*, and *Fostering Integrity in Research*.

## The Need for Reproducibility and Replicability in Science

To establish a foundation for the workshop discussions, Harvey Fineberg, president of the Gordon and Betty Moore Foundation and workshop chair, elaborated on the findings and recommendations of the recently published National Academies report, *Reproducibility and Replicability in Science*.



*Reproducibility and replicability are critically important, but are not currently easy to attain.*

Harvey Fineberg, President, Gordon and Betty Moore Foundation

***"This is not one entity's problem alone to solve."** Stakeholders should consider working collectively to identify and address the cultural barriers to rigor, transparency, and replicability.*

Carrie Wolinetz, Acting Chief of Staff and Associate Director for Science Policy, Office of the Director, National Institutes of Health (NIH)

*Three qualities that foster trust in the scientific enterprise are **"competence, integrity, and benevolence."***

*The scientific community should take action to send **"consistent and meaningful signals"** regarding which studies reflect scientific norms.*

Marcia McNutt, President, National Academy of Sciences

## Public Trust in Science

Marcia McNutt, president of the National Academy of Sciences and former editor-in-chief of *Science*, delivered a keynote address on the importance of fostering a sense of trust within the scientific community and with the public.

## Transparent Reporting in Biomedical Research

Researchers from across the biomedical ecosystem shared their perspectives on the incentives, disincentives, challenges, and opportunities associated with transparent reporting and replicability in science.

*Most scientists today want to do rigorous good science, and the problem is they are caught in a system in which they are not judged by [the rigor of their processes].*

Arturo Casadevall, professor, Johns Hopkins University and Editor-in-Chief, *mBio*

*Education on transparent reporting of biomedical research should be targeted for early career faculty, postdoctoral fellows, graduate students, and undergraduates to raise awareness about the need for transparent reporting of biomedical research.*

Yarimar Carrasquillo, investigator, NIH National Center for Complementary and Integrative Health

***"Explicit measures of success"** are needed to assess the impact of interventions in the biomedical research ecosystem, including information on workload, cost, and replicability.*

Richard Nakamura, retired director, NIH Center for Scientific Review

*Rewards and incentives can inspire behavior, but enforcement is also needed. Journal editors can play a key role in the adoption of policies requiring adherence to reporting guidelines or transparency principles.*

Brian Nosek, cofounder, Center for Open Science; and An-Wen Chan, associate professor, University of Toronto

*Strategic partners can help build platforms that accelerate rigorous, reproducible, and translatable preclinical science that influences and enables reproducibility.*

Magali Haas, CEO and president, Cohen Veterans Bioscience

## Lessons Learned and Best Practices

Workshop participants discussed how the barriers to transparent reporting are rooted in the current culture of science and incentive structures. Several participants emphasized the importance of coordination across all stakeholders in fostering a culture of transparency.

## Checklists and Guidelines

Workshop participants delved further into the practical application and effectiveness of guidelines and checklists for enhancing transparent reporting of biomedical research.

*Journals are **"at the end of the process."** Achieving a broad shift in research practice will require initiatives targeting the beginning, within laboratories and academic institutions.*

Sowmya Swaminathan, Head of Editorial Policy & Research Integrity, Nature Research

*Checklists can improve transparent reporting and potentially shift research practice, but endorsement by journals is insufficient; checklists should be mandatory and compliance should be monitored, even though this approach adds burden.*

Sowmya Swaminathan and Malcolm Macleod, Professor, University of Edinburgh

*Checklist items should be prioritized and pilot tested to determine whether they are meaningful for the end users. **"Less is more"** when promoting checklist compliance.*

Steven Goodman, Professor and Co-director of METRICS, Stanford University; Veronique Kiermer, executive editor, *PLOS*; and Shai Silberberg, director of research quality, NINDS

***"[Increased] transparency will be the legacy of this rigor, reproducibility, transparency movement."** Moving toward better experimental design in the long term is important, but reporting guidelines can be implemented to improve transparency now.*

Benedict Kolber, Associate Professor of Biological Sciences, Duquesne University

*Publishers and funders can help **"bookend the process"** of promoting transparent reporting through a number of activities, like aligning reporting requirements with transparent reporting practices so expectations are clear for researchers throughout the research life cycle.*

Veronique Kiermer and Valda Vinson, Editor, Research Education at *Science*

*Improving research practices must be driven by scientists reforming their own fields with the help of experts in rigor and reproducibility, impelled by institutional leadership, manifest by structures and metrics.*

Steven Goodman

## Toward Minimal Standards for Improving Reproducibility of Biomedical Research

Workshop participants discussed potential stakeholder actions to harmonize guidelines and support uptake of minimal reporting standards for improving reproducibility of biomedical research

## Opportunities for Promoting Transparent Reporting

Participants broke into small groups to consider the roles and responsibilities of researchers, publishers, institutions, and funders in improving transparent reporting of biomedical research.

*Separating reviewers for different sections (e.g., statistics, methods) could be an approach to share the burden of peer review.*

Benedict Kolber and Shai Silberberg

*A commonality of successful guidelines is that they facilitate team science, which brings together investigators, collaborators, and research support staff to share the workload.*

Franklin Sayre, STEM librarian, Thompson Rivers University

*The research community and publishers should work collaboratively toward culture change.*

Valda Vinson

*If you want [to make] science better, make better science easier.*

Leslie McIntosh, cofounder and chief executive officer of Ripeta

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