NATIONAL ACADEMIES *Sciences Engineering Medicine*

Frontiers of Statistics in Science and Engineering: 2035 and Beyond

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Download the report and report resources:
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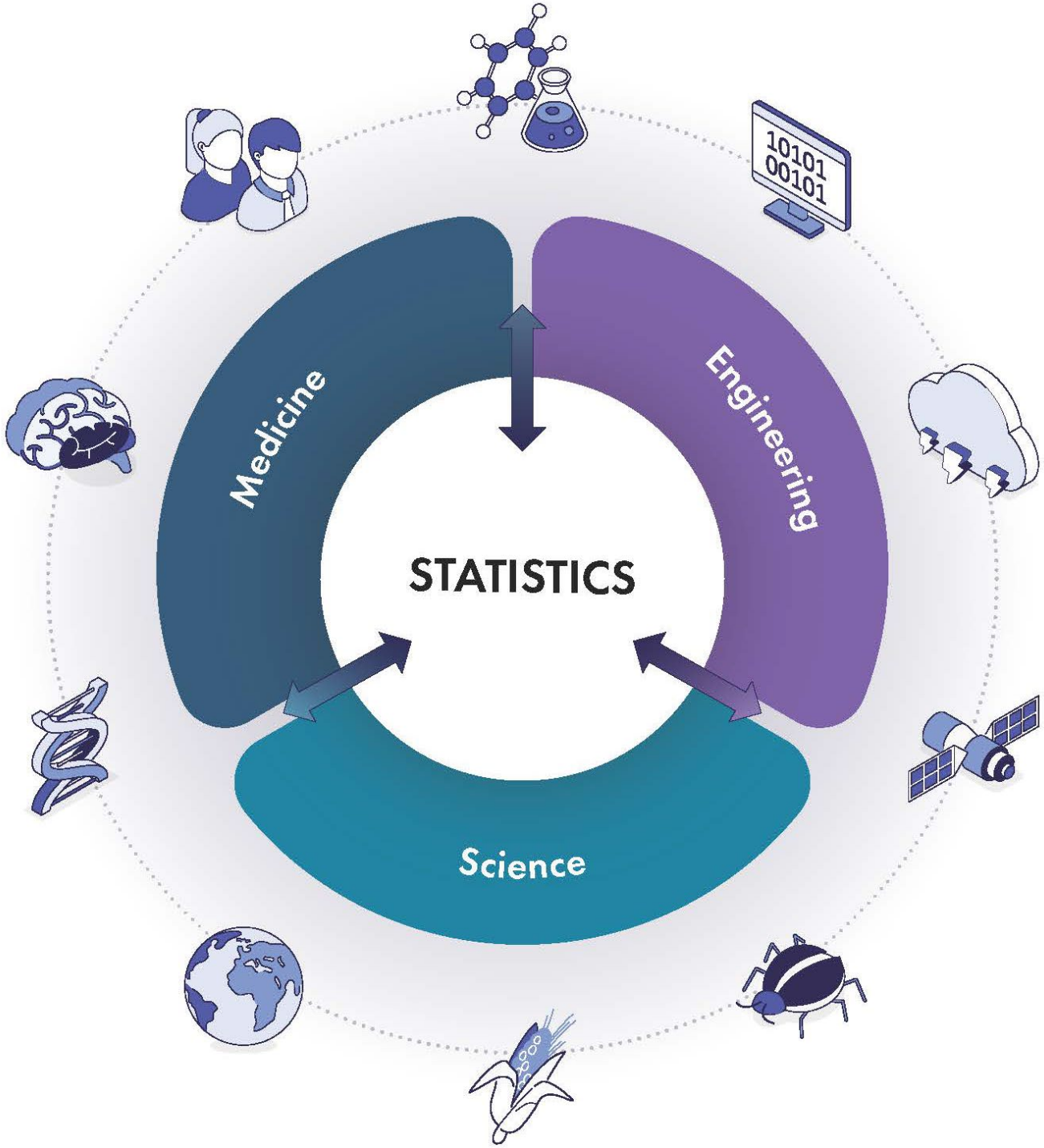

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Context: Statistics is not static, neither is science.

- *Statistics and Science: A Report of the London Workshop on the Future of the Statistical Sciences.* (“The London Report”)
  - International Statistical Institute, 2013
  - https://www.niss.org/sites/default/files/news_attachments/Report%20of%20the%20London%20Workshop%20on%20the%20Future%20of%20the%20Statistical%20Sciences.pdf
- *Statistics at a Crossroads: Who is for the Challenge?*
  - Report to NSF, 2019
  - https://arxiv.org/pdf/2503.22945
- *“Rebuilding Statistics in the Age of AI: A Town Hall Discussion on Culture, Infrastructure, and Training.*
  - January 2026, https://arxiv.org/html/2601.17510v1
- *“The Future Statistician”* from the Royal Statistical Society and Government Statistical Office (UK).

Study Statement of Task

A forward-looking assessment of the current state of the statistical sciences and emerging opportunities for 2035 and beyond that will assess:

- **Statistical research**.
- **Statistical research in allied fields**.
- **Statistical needs to support scientific and technological advances**.
- **Strength of interdisciplinary collaborations.**
- **Statistical education, training, and workforce development**.

Study Committee

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Rice University, *Chair*

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Study Process and Information Gathering

- 34 committee meetings
- Information gathering: Spoke with 49 experts from across disciplines, encompassing multiple perspectives
  - 10 public panels organized by the committee gathered information around statistical areas and applications including **privacy**, **blockchain**, **agriculture**, **education** and more
    - Panel at the workshop on Uncertainty Quantification for Material Science and Engineering held by UChicago's Institute for Mathematical and Statistical Innovation
  - Public Call for Perspectives
  - Joint briefing with NSF, NIH, NSA

About the Report – Key Takeaways

- Statistics has a long history of catalyzing and accelerating discovery and innovation.
- As the research and innovation landscape evolves rapidly, demands on statistics are growing; **U.S. competitiveness will depend on bolstering training, collaboration, and investment.**
- **This report recommends strategies to strengthen the statistical enterprise,** including approaches that build capacity, improve practice, and expand cross-sector partnerships.

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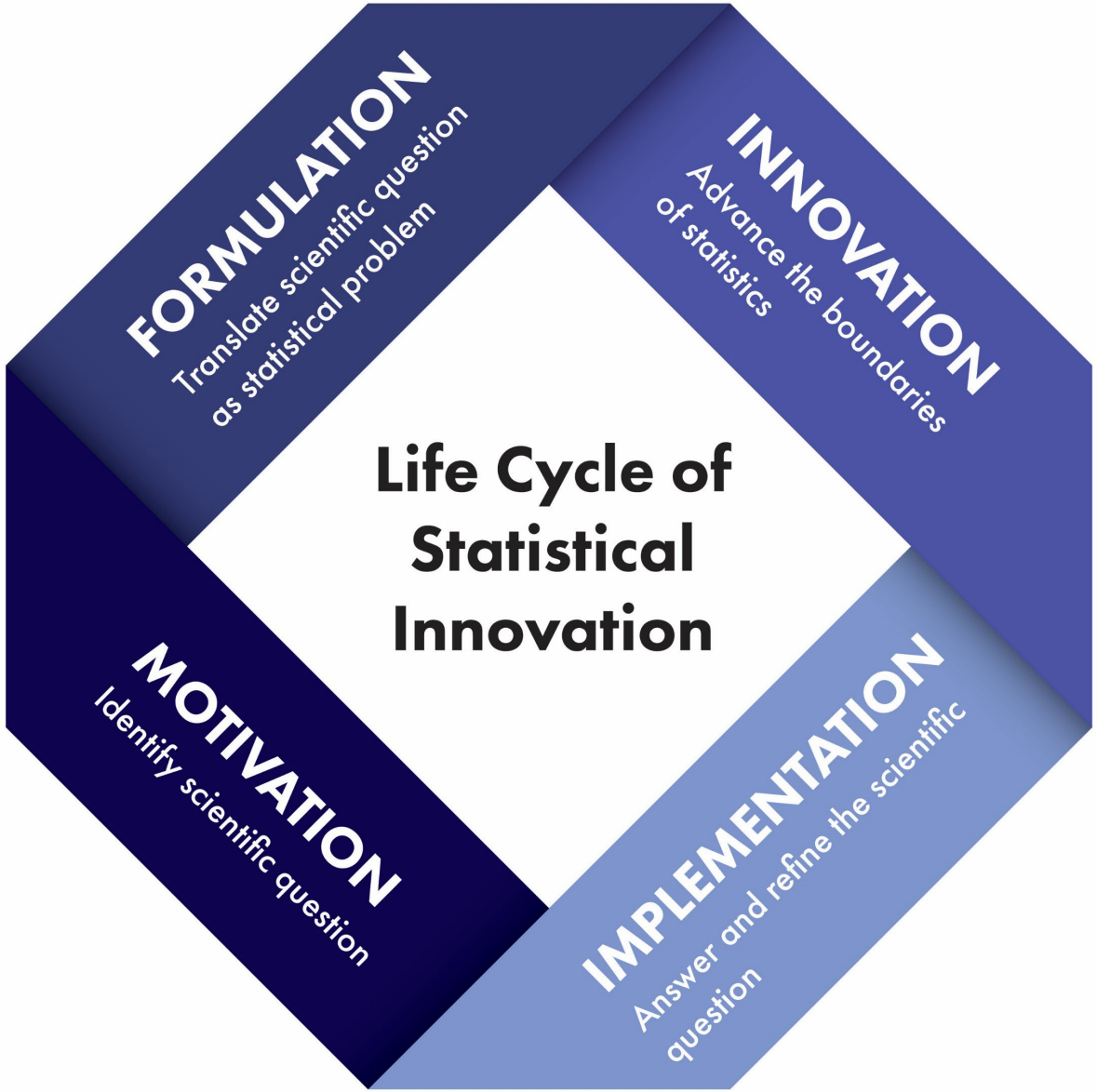
The Nature of Statistical Innovation

Conclusion: Statistical scientists drive the statistical innovation life cycle through the adoption and rigorous evaluation of emerging technologies and applications. **Sustaining the agility and impact of this innovation cycle requires increased funding** and prioritization of research contributions that are practice-informed and application-driven to advance both methodological and applied work across the discipline.



Statistics informs scientific development

Many of today's scientific developments have **deep roots in decades of theoretical statistics**, including advances in:

- biostatistics and genomics
- artificial intelligence
- characterizing high-dimensional systems
- social networks
- resilient infrastructure
- pricing financial derivatives
- predicting rare events

Scientific demands and developments that are **catalyzing the frontiers of statistics** include:

- artificial intelligence
- uncertainty quantification for streaming data and complex systems
- opportunistic and observational data collection and usage
- decentralized and distributed data
- characterizing rare events
- test-time optimization

Scientific developments inform statistics

In other words: There are many, many cool problems in Statistics, in Science, and in their intersection.

Statistics & Artificial Intelligence

The rapid advancement of AI calls for increasing contributions from the field of statistics.

Recommendation: Federal funding agencies should prioritize funding to expand and accelerate rigorous ongoing statistical thinking in AI research and education initiatives.

Successful initiatives should:

- Integrate statistical thinking into AI and AI-based research through centers of excellence or major collaborations;
- Incorporate explicit guidance for statistical rigor in data-driven and AI research proposals, as well as include reviewers with statistical expertise;
- Support a comprehensive survey of statistics representation in the AI institutes; and
- Include statistical thinking and rigor as a major pillar of AI education and training, as well as explicitly seek collaboration with the statistics community in AI-related training funding.

In other words: Statistics needs to be part of AI; AI needs to be part of Statistics.

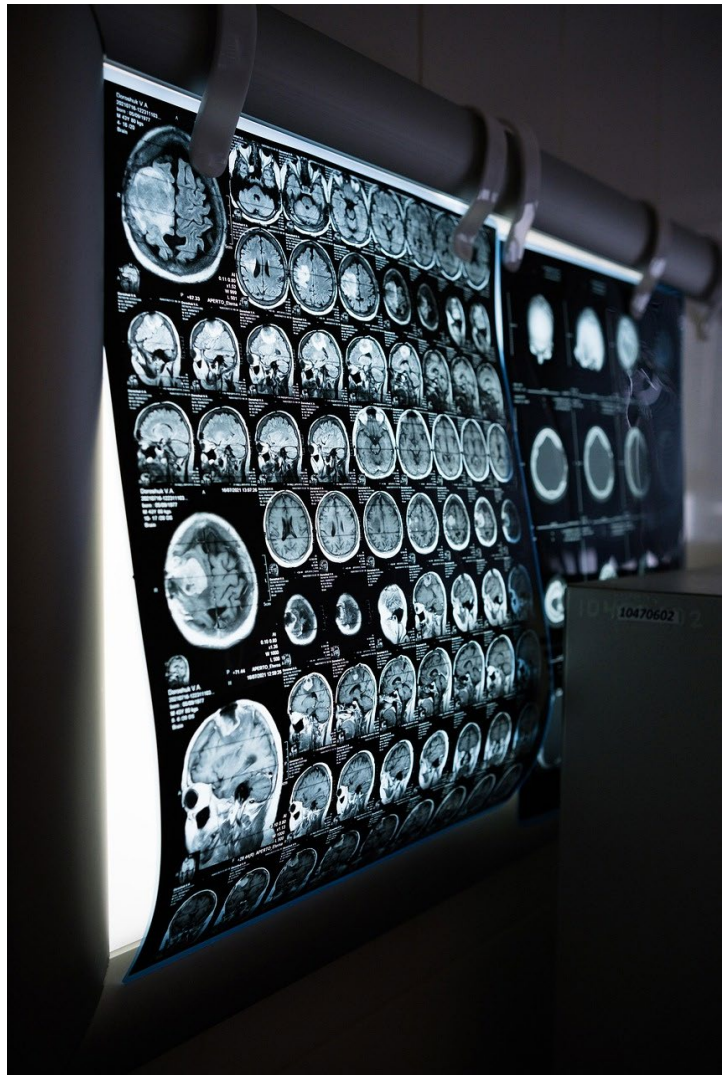
Making Meaning of Data

Conclusion: Statistical research enhances data utility and application. As new data types emerge and as complexity increases, statistics and analytic tools will need to evolve to keep pace with the changing landscape.

The field of statistics must contend with:

- Emerging types of data (images, blockchain, etc.)
- Fused data from heterogeneous sources
- Dynamic and new data storage and access paradigms
- Dual-use nature of data

Key Finding: As new data types emerge and evolve, statisticians will need new methods for structuring, sampling, modeling, and analyzing these data.



In other words: New types of data require new types of statistics and new types of statistical thinking.

Towards a Collaborative Ecosystem

Fostering collaboration

- Statisticians are integral to team science
- Ongoing interaction between researchers in science, engineering, and statistics is critical
- Training is best encountered through experiential learning and hands-on collaborations.

Infrastructure

- Enable scalability
- Encourage reproducibility
- Unified data ecosystems
- Model version control
- Audit trails
- Transparency measures

Financial Structures

Academia plays a foundational role in driving industry innovation. **NSF investments result in private sector successes** such as Google.

Both NSF and NIH should expand opportunities to advance science through the inclusion of statistics with current and emerging public–private partnerships.

Enhanced Investment is Paramount

The report recommends that **NSF and NIH bolster ongoing support for statistics, spanning methods, applications, training, and education.**

Successful efforts should highlight:

- Statisticians in co-leadership roles
- Analysis and inference in highly distributed environments
- Statistical research explicitly targeting decision making
- Methods that integrate quantum computing, including statistical algorithms to exploit quantum computing
- Statistical research to improve quality, scalability, and representativeness of novel data streams and types
- Privacy- and confidentiality-preserving methods
- Theory to understand geometric data structure
- Collaboration with other agencies to establish a coordinated program for ongoing evaluation and reform of graduate statistical education.

Equipping the Statistics Workforce

- Statistics curricula need continual modernization to keep pace with the evolution of the field.
- Statistical thinking plays an important role in AI-focused programs.
- Large-scale computational training is vital.
- An AI-savvy workforce will understand the strengths and limitations of AI, thoughtfully evaluate model outputs, recognize potential biases, and incorporate awareness of uncertainty into its decision making.
- **Recommendation: NSF, NIH, and NSA should invest in undergraduate and graduate training in statistics, biostatistics, and data science. Mechanisms include graduate fellowships, research experiences for undergraduates, and innovative programs that vertically and cross-sectionally integrate students, postdoctoral graduates, faculty, and industry researchers in statistics.**

Transforming statistics education is necessary for U.S. competitiveness.

In other words: How best to train statistical problem-solvers?

Bringing together the “in other words”:

- There are many, many cool problems in Statistics, in Science, and in their intersection.
- Statistics needs to be part of AI; AI needs to be part of Statistics.
- New types of data require new types of statistics and new types of statistical thinking.
- How best to train statistical problem-solvers?

Summary for discussion

- Statistics is dynamic.
- The nature of data is dynamic.
  - Challenge: How to train today for needed skills of tomorrow?
- Statistics does not live in a vacuum.
  - Statistics involves collaboration and theory.
  - Teams solve problems.
  - Teams need a range of people with different skillsets.
- The statistical workforce is collaborative, ever evolving, and needs problem solvers.

A Roadmap for Recommendation Implementation

1. Recommendation 7-3 (artificial intelligence [AI]) National Science Foundation (NSF) and all agencies
2. Recommendation 7-1 (statistical foundations and innovation) NSF
3. Recommendation 7-2 (statistical foundations and innovation) National Institutes of Health (NIH)
4. Recommendation 7-7 (public–private partnerships) NSF, NIH, and all agencies
5. Recommendation 7-8 (academic reform) Academic departments and journals
6. Recommendation 7-4 (hybrid models) All agencies
7. Recommendation 7-5 (adaptive design) NSF, NIH, and all agencies
8. Recommendation 7-6 (Research Training Group) NSF and NIH

The field of statistics underpins a wealth of scientific and engineering advancement. Breakthroughs today stem from decades of investments in foundational research within statistics. **Investment in the statistical sciences is essential for U.S. competitiveness.**

Thank You

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Information Gathering Sessions

January 13, 2025: Causal Inference: Frontiers and Opportunities

- Moderator: Xihong Lin, Committee Member (Harvard)
- Panelists: Hongzhe Li (UPenn), Peng Ding (Berkeley), Michael Kosorok (UNC), Betsy Ogburn (JHU)

February 4: Journal Editors' Perspectives on Trends in Statistical Sciences

- Moderator: Daniela Witten, Committee Member (U of Washington)
- Panelists: Hani Doss (U of Florida), Lexin Li (UC Berkeley), Annie Qu (UC Irvine), Dylan Small (UPenn), Michael Stein (Rutgers), Lan Wang (U of Miami)

February 20: Statistics at the National Labs

- Moderators: Amy Braverman, Committee Member (NASA Jet Propulsion Lab), Stephan R. Sain, Committee Member (Jupiter Intelligence)
- Panelists: Carlo Graziani (Argonne National Lab), David Schimel (NASA Jet Propulsion Lab), Lyndsay Shand (Sandia National Labs), Scott Vander Wiel (Los Alamos National Lab)

Information Gathering Sessions

March 4: Statistical Privacy Panel

- Moderator: Rina Barber, Committee Member (UChicago)
- Panelists: Bonnie Berger (MIT), John Duchi (Stanford), Weijie Su (UPenn)

April 1: Statistics in Industry

- Moderator: Lorin Crawford, Committee Member (Microsoft Research)
- Panelists: Sivan Aldor-Noiman (Banff Advisors), Bonnie Ghosh-Dastidar (RAND), Amarjot Kaur (Merck), Lester Mackey (Microsoft Research), Vijay Nair (Wells Fargo)

April 15: Statistics in Sustainable and Renewable Agriculture

- Moderator: Kathy Ensor, Committee Chair (Rice University)
- Panelists: Trevor Hefley (Kansas State University), Eunchun Park (University of Arkansas), Frederi Viens (Rice University), Linda Young (USDA National Agricultural Statistics Service)

Information Gathering Sessions

April 23: Panel on the Frontiers of Statistics at the UChicago Institute for Mathematical and Statistical Innovation Workshop on Uncertainty Quantification for Material Science and Engineering

- Moderator: Kathy Ensor, Committee Chair (Rice University)
- Panelists: Peter Chien (University of Wisconsin–Madison), Ralph Smith (North Carolina State University), Wei Chen (Northwestern University), Roshan Joseph (Georgia Institute of Technology), Anh Tran (Sandia National Laboratories)

July 10: Panel with the ASA's Caucus of Academic Representatives

- Moderator: Kathy Ensor, Committee Chair (Rice University)
- Panelists: Veera Baladandayuthapani (University of Michigan), Catherine Calder (University of Texas at Austin), Nicole Alana Lazar (Pennsylvania State University), Shari Messinger (University of Miami), Jeffrey Morris (University of Pennsylvania), Dan Nettleton (Iowa State University), Robert Perera (Virginia Commonwealth University), Abel Rodriguez (University of Washington), Christopher Saunders (South Dakota State University), Ming Tony Tan (Georgetown University)

Information Gathering Sessions

September 9: Blockchain discussion with Yulia Gel (Virginia Tech University) and Ricky Rambharat (Northrop Grumman)

September 9: Statistics Education discussion with Donna LaLonde (ASA), Dave Hunter (Penn State), Beth Chance (Cal Poly), Monnie McGee (Southern Methodist University), Mark Ward (Purdue), Jan Dasgupta (Washington State)

Recommendation: Statistical Foundations and Innovation

Recommendation 7-1: Prioritized investment in the field's foundations is essential to accelerate trustworthy, data-driven scientific discovery; keep pace with the modern technological evolution; and maximize positive societal impact by enabling future breakthroughs at the frontiers of statistics. The National Science Foundation (NSF) should bolster its ongoing support for statistics, spanning methods, applications, theory, training, and education, and embed statistical science across the agency.

A successful program (or suite of programs) would advance statistical foundations, methods, applications, and training across NSF's scientific and engineering portfolio and include the following:

- **Foundational Statistical Methods and Applications.** Targeted cross-agency funding opportunities should highlight the importance of these translational contributions and the leadership by statisticians.
- **Foundational Statistical Research.** Some practice-informed needs for investment in theoretical research include the following:
- **Foundational Statistical Education.** Collaboration with other agencies to establish a nationally coordinated program supporting ongoing evaluation and reform of graduate statistical education, particularly in light of the rapid pace of technological evolution. The coordinated effort should develop strategies to strengthen the domestic pipeline for graduate students in statistics.

Recommendation: Statistical Foundations and Innovation

Recommendation 7-2: The National Institutes of Health (NIH) should expand its support for the foundations of statistics in health science across the biomedical sciences, spanning methods, applications, theory, training, and education.

- Continue strengthening **NIH support for cutting-edge statistical methodological research and applications**, which are essential for accelerating discovery from existing and emerging biomedical data.
- Evaluate and ensure that NIH study sections explicitly recognize statistical methodological research as a priority by **assigning proposals to panels with appropriate statistical expertise and by applying review criteria that reflect the nature and impact of methodological contributions**.
- Evaluate and ensure that training (T, F) and career development (K) award programs are structured and reviewed in ways that **prioritize training of future biostatisticians**, apply evaluation criteria appropriate to methodological and interdisciplinary preparation, and involve reviewers with relevant statistical expertise.

Recommendation: Artificial Intelligence

Recommendation 7-3: Federal funding agencies should prioritize funding to **expand and accelerate rigorous ongoing statistical thinking in artificial intelligence (AI) research and education initiatives**. Successful initiatives would embed statistics into AI programs in the following ways:

- **AI-Based Research**. Specifically, federal funding agencies such as the National Science Foundation (NSF), National Institutes of Health (NIH), Department of Defense, Department of Energy, National Aeronautics and Space Administration, and National Security Agency should do the following:
  - Support the identification of crosscutting opportunities to **integrate statistical thinking into AI and AI-based research** through centers of excellence or major collaborations that build on the success of the National AI Research Institutes and broaden statistical research to ensure the accurate, reliable, and reproducible use of AI for improved research results.
  - Elevate the role of statistical rigor in data-driven and AI research by incorporating explicit guidance in calls for proposals and proposal review criteria and including reviewers with statistical expertise. Language should include **guidance regarding statistical validity of inference and accuracy of uncertainty quantification**.
  - Support a **comprehensive survey that identifies the footprint of the field of statistics**, the statisticians involved, and the foci of their research, throughout the network of National AI Research Institutes.
- **AI Education**. Future NSF, NIH, and other federal agencies' AI-related training funding, such as to accelerate AI education programs, should **include statistical thinking and rigor as a major pillar**. Calls should explicitly seek collaboration with the statistics community.

Recommendation: Hybrid Models

Recommendation 7-4: Funding agencies should collaboratively **identify crosscutting, translational issues to inform future programs supporting the emergence of hybrid statistical–scientific models**. Such programs should foster collaborative advances in statistical, scientific, and engineering theory, analytic methods, and applications.

Recommendation: Adaptive Design

Recommendation 7-5: In the near term, the National Institutes of Health (NIH) and National Science Foundation (NSF) should **establish an interdisciplinary and translational cross-agency initiative incorporating innovative adaptive and autonomous statistical design**, in which statisticians play a critical role in funded teams. Although NIH and NSF may serve as the leaders of this cross-agency initiative, the National Security Agency, Department of Energy, National Aeronautics and Space Administration, national laboratories, U.S. Department of Agriculture, and other federal research agencies are also in a position to benefit directly from U.S. leadership in the space of adaptive and autonomous statistical design.

Recommendation: Research Training Group

Recommendation 7-6: The National Science Foundation, National Institutes of Health, and National Security Agency should **invest in undergraduate and graduate training in statistics, biostatistics, and data science**. Mechanisms include graduate fellowships, research experiences for undergraduates, and innovative programs that vertically and cross-sectionally integrate students, postdoctoral graduates, faculty, and industry researchers in statistics. Strategic priorities for such support should focus on cross-disciplinary, application-driven training; interuniversity collaboration; partnerships with industry and government; and computational training for the next generation of statisticians capable of leveraging the advanced large-scale computing infrastructure developed in industry today.

Recommendation: Public-Private Partnerships

Recommendation 7-7: Both the National Science Foundation and National Institutes of Health, as well as other funding agencies, should **expand opportunities to advance science through the inclusion of statistics with current and emerging public–private partnerships**. Such historical investments have led to breakthroughs in medicine, health care, agriculture, energy, the discovery of new materials, the financial sector, insurance, weather prediction, and resilient infrastructure and communities, and will lead to significant advancements in the future, ensuring sustained U.S. competitiveness.

Recommendation: Academic Reform

Recommendation 7-8: Universities should strengthen support for and champion the contributions of statistical departments, and statistical departments should **prioritize hiring, tenure, and promotion practices that reward innovation, deep and ongoing collaboration, and high-impact contributions, including contributions in statistical software, analytic pipelines, and curated data sets**. Journals should create environments that encourage and reward high-risk, high-reward research and education initiatives, including novel methodological advances, interdisciplinary applications, and collaborations. Funding agencies and industrial partners should create opportunities for statisticians to serve not only as collaborators but also as leaders in interdisciplinary research teams and education efforts, reinforcing a culture that values their central role in scientific progress.