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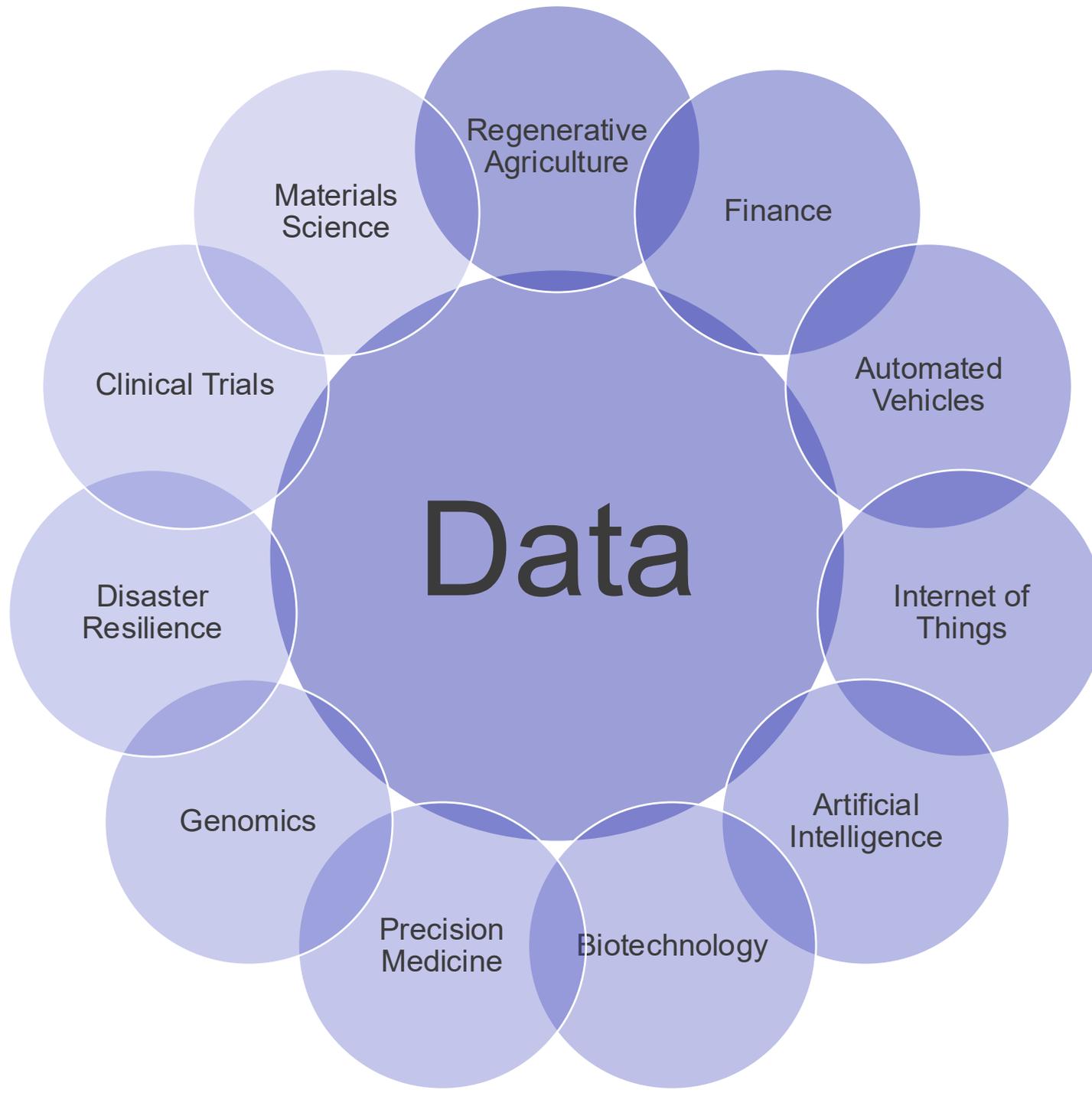# Frontiers of Statistics in Science and Engineering: 2035 and Beyond

*Kathy Ensor (chair), Lance Waller (vice chair), Amy Braverman, Lorin Crawford, Brian Reich, Daniela Witten, Tian Zheng*
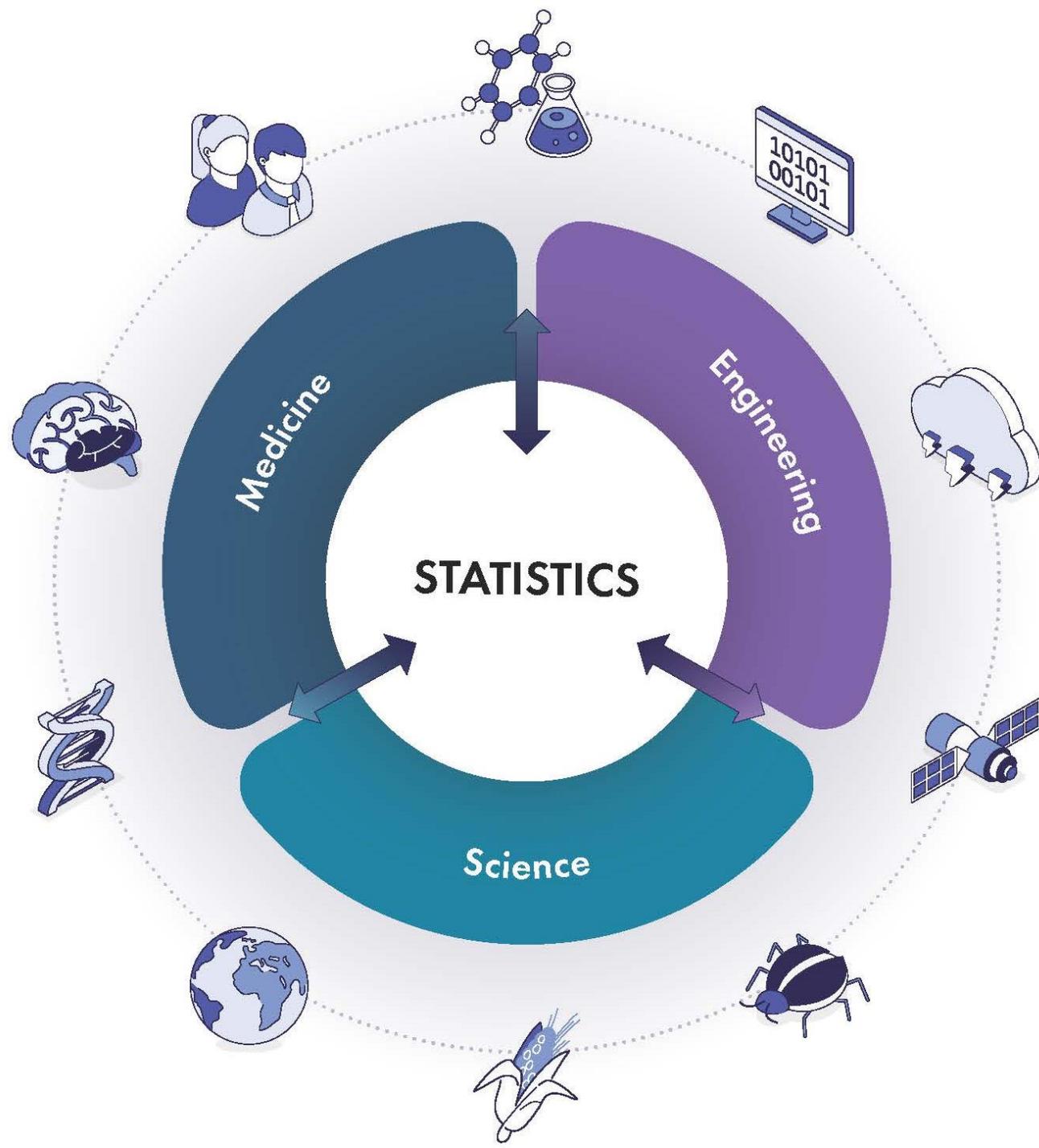
*February 26, 2026*

Download the report and report resources:
**nationalacademies.org/frontiers-of-statistics**

#FoS on slido.com

# Statistics is the science through which data become wisdom.

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# 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**. The state of research in the statistical sciences.

- **Statistical research in allied fields**. Interactions between statistics and related fields, as well as the statistical foundations that underpin machine learning, AI, and data science.

- **Statistical needs to support scientific and technological advances**. Urgent needs for statistical innovation in areas such as verification, validation, and uncertainty quantification; privacy and security; and working with heterogeneous and complex data.

- **Strength of interdisciplinary collaborations.** The role of statistical sciences in key research domains for American competitiveness.

- **Statistical education, training, and workforce development**. Approaches towards statistics education and training both within statistics and in fields that incorporate statistical thinking.

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# Study Committee

**Katherine Ensor**
Rice University, *Chair*

**Lance Waller**
Emory University, *Vice Chair*

**Rina Barber (NAS)**
University of Chicago

**Amy Braverman**
Jet Propulsion Laboratory,
California Institute of Technology

**Lorin Crawford**
Microsoft Research

**David Dunson**
Duke University

**Omar Ghattas**
The University of Texas at Austin

**Frauke Kreuter**
University of Maryland, College
Park

**Xihong Lin (NAS/NAM)**
Harvard University

**Brian Reich**
North Carolina State University

**Steve Sain**
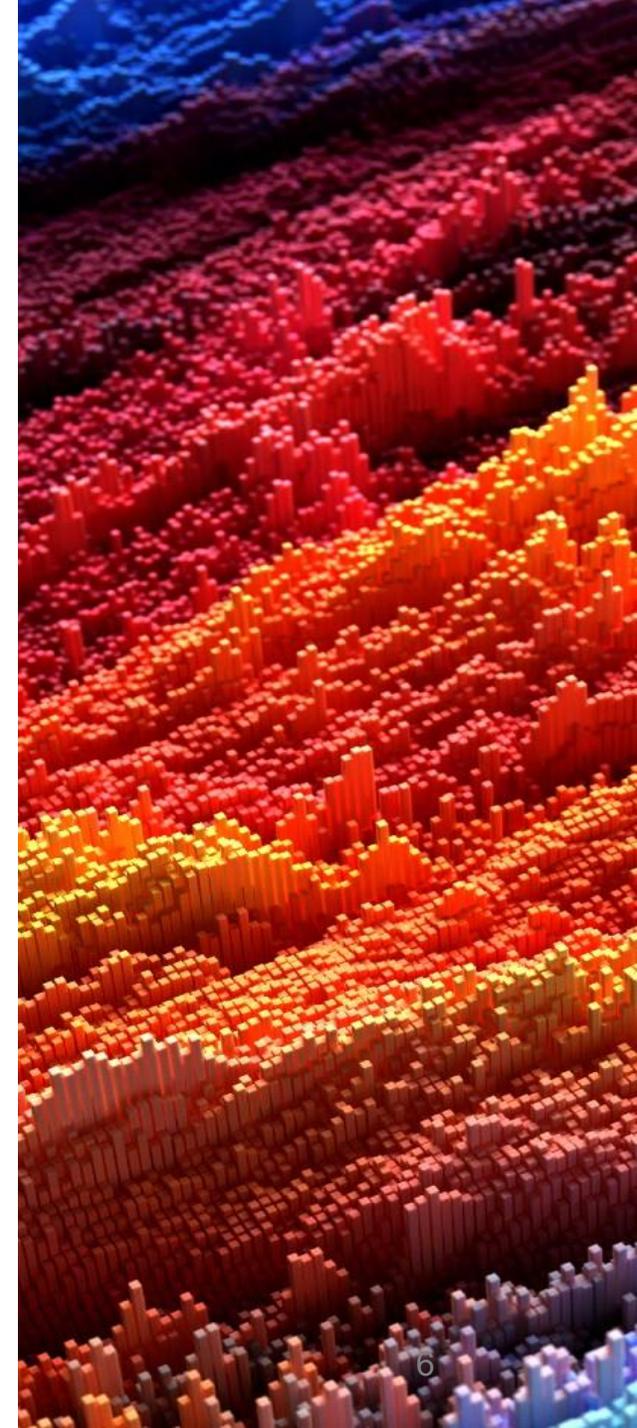Jupiter Intelligence

**Aarti Singh**
Carnegie Mellon University

**Daniela Witten**
University of Washington
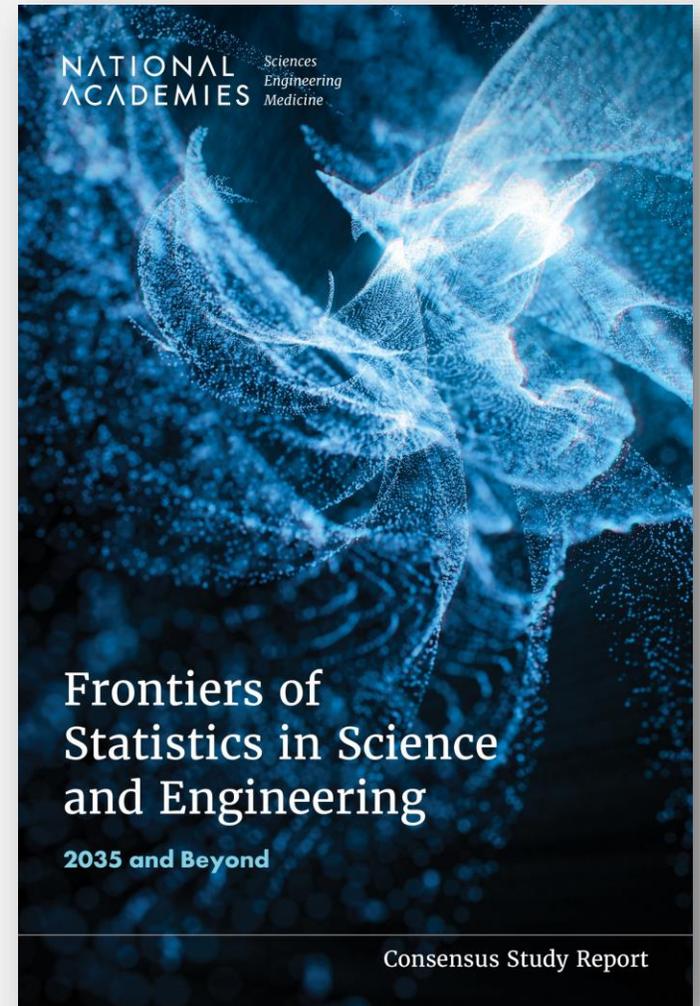
**Tian Zheng**
Columbia University

# 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

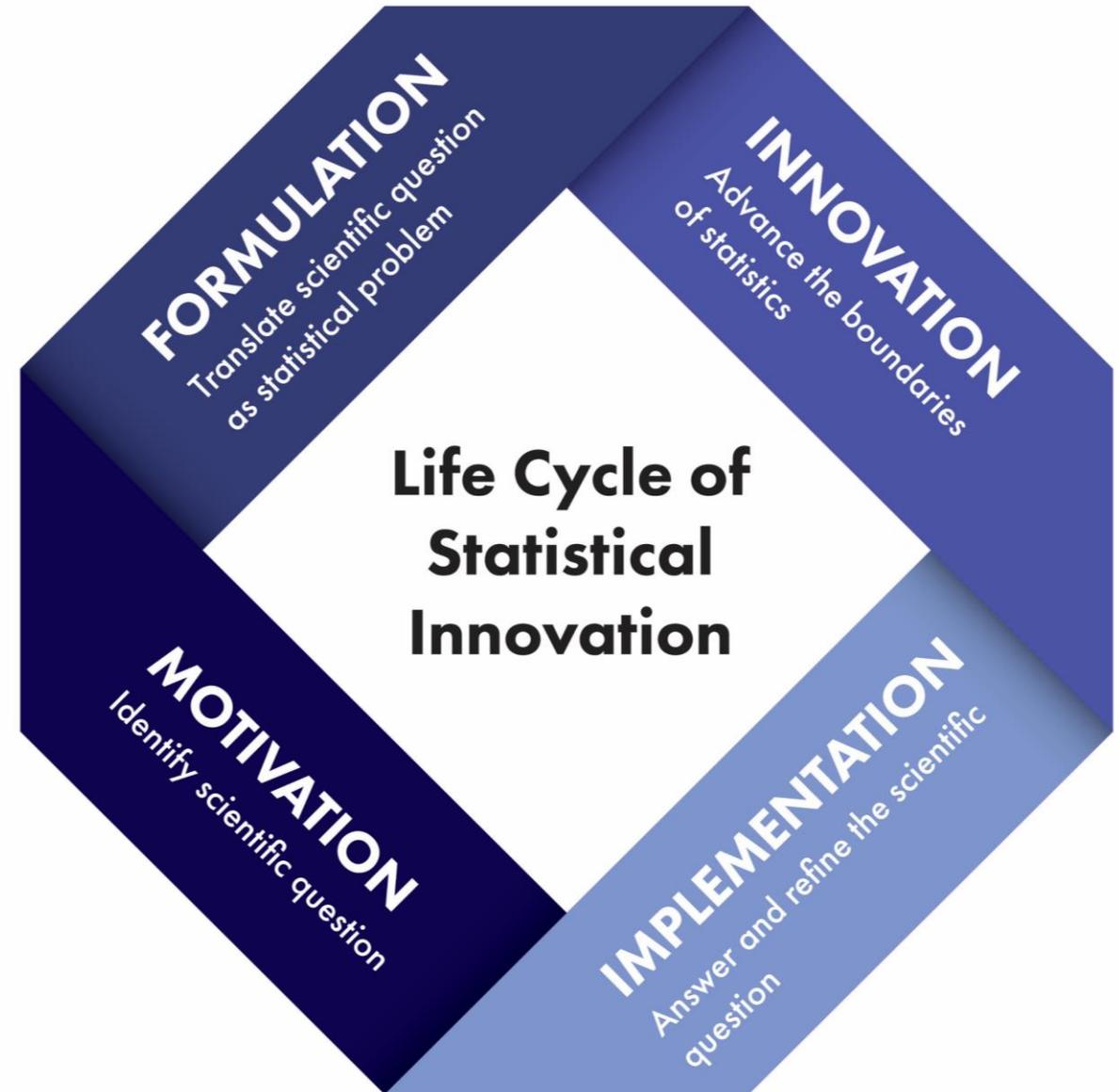NATIONAL ACADEMIES  *Sciences Engineering Medicine*

# About the Report – Key Takeaways

- Statistics has a long history of catalyzing and accelerating discovery and innovation by **transforming data into wisdom** across science, engineering, and medicine.

- 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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Frontiers of Statistics in Science and Engineering
2035 and Beyond

Consensus Study Report

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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.



FORMULATION
Translate scientific question as statistical problem

INNOVATION
Advance the boundaries of statistics

Life Cycle of Statistical Innovation

MOTIVATION
Identify scientific question

IMPLEMENTATION
Answer and refine the scientific question

## 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

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# 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.

# 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.
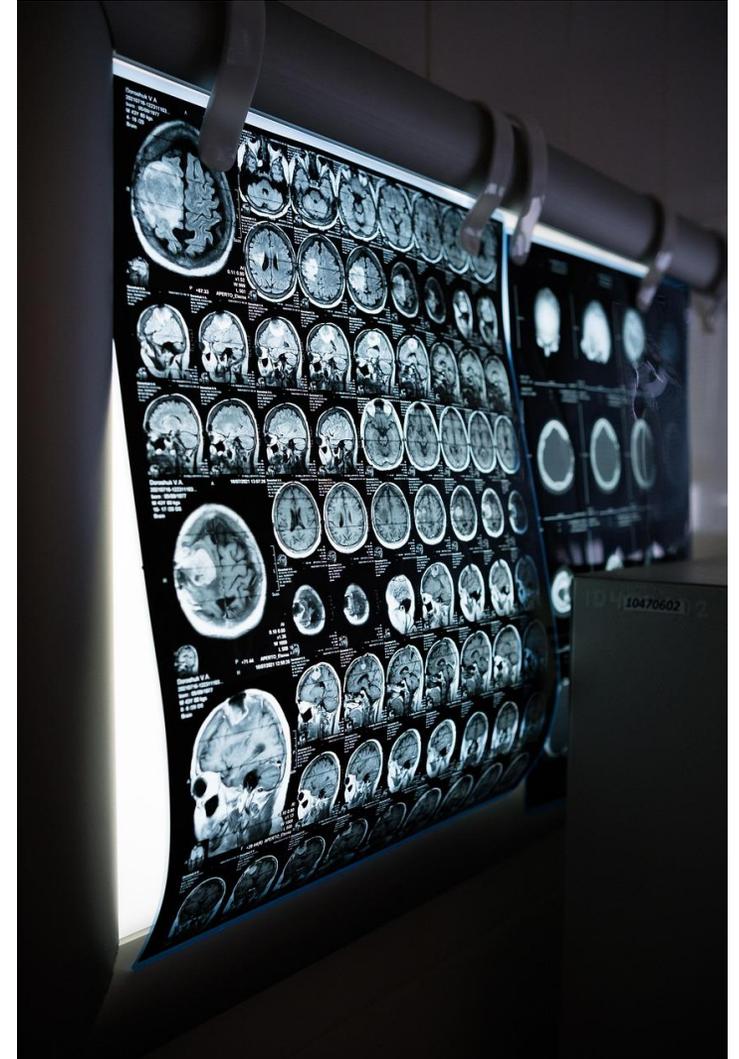
# The Imperative of Collaboration

**Most research areas in science and engineering are data-driven, requiring creative statistical thinking and advanced methodology.** Successful collaborations with the field of statistics include:

- GenCast

- Higgs boson

- Advances in imaging and neuroscience

- Materials Genome Initiative

- Simulation-Based Inference

- GARCH models to study financial market volatility

**Opportunities that necessitate collaboration** from the field of statistics include:

- Large-scale and real-time statistical methods

- Quantum computing

- Constrained resources and environmental impacts of computing

- Edge computing and decentralized inference

- Novel data architectures

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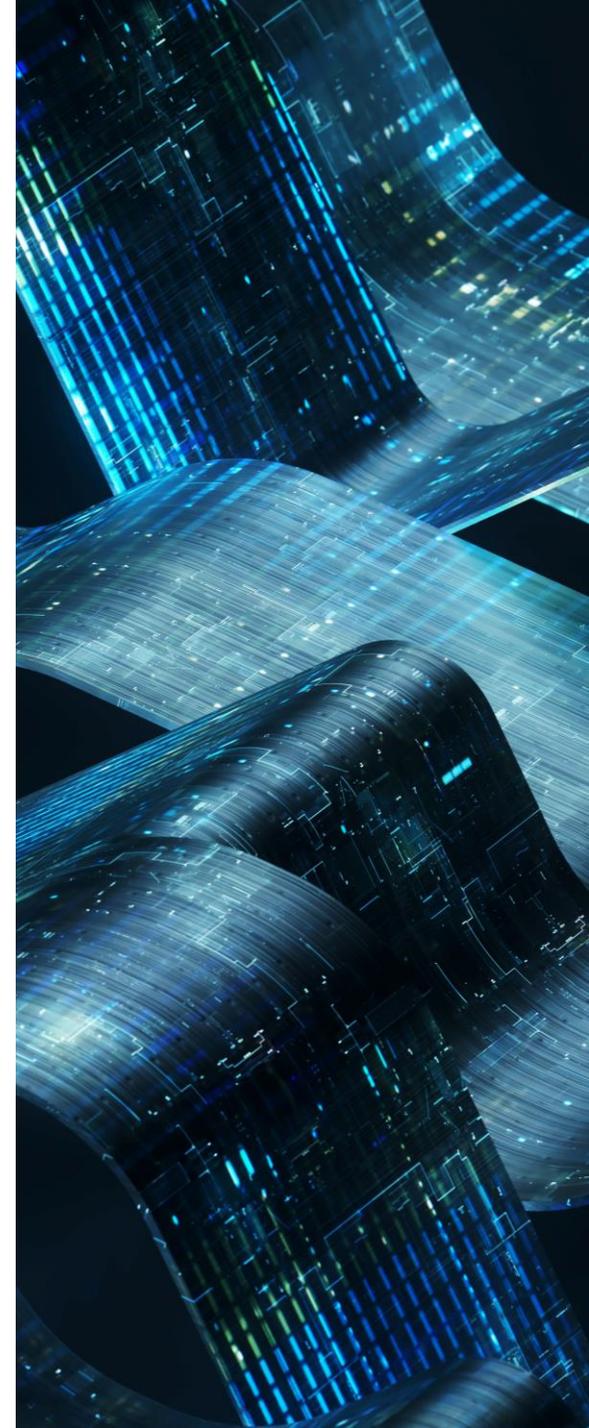
# Towards a Collaborative Ecosystem

## 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
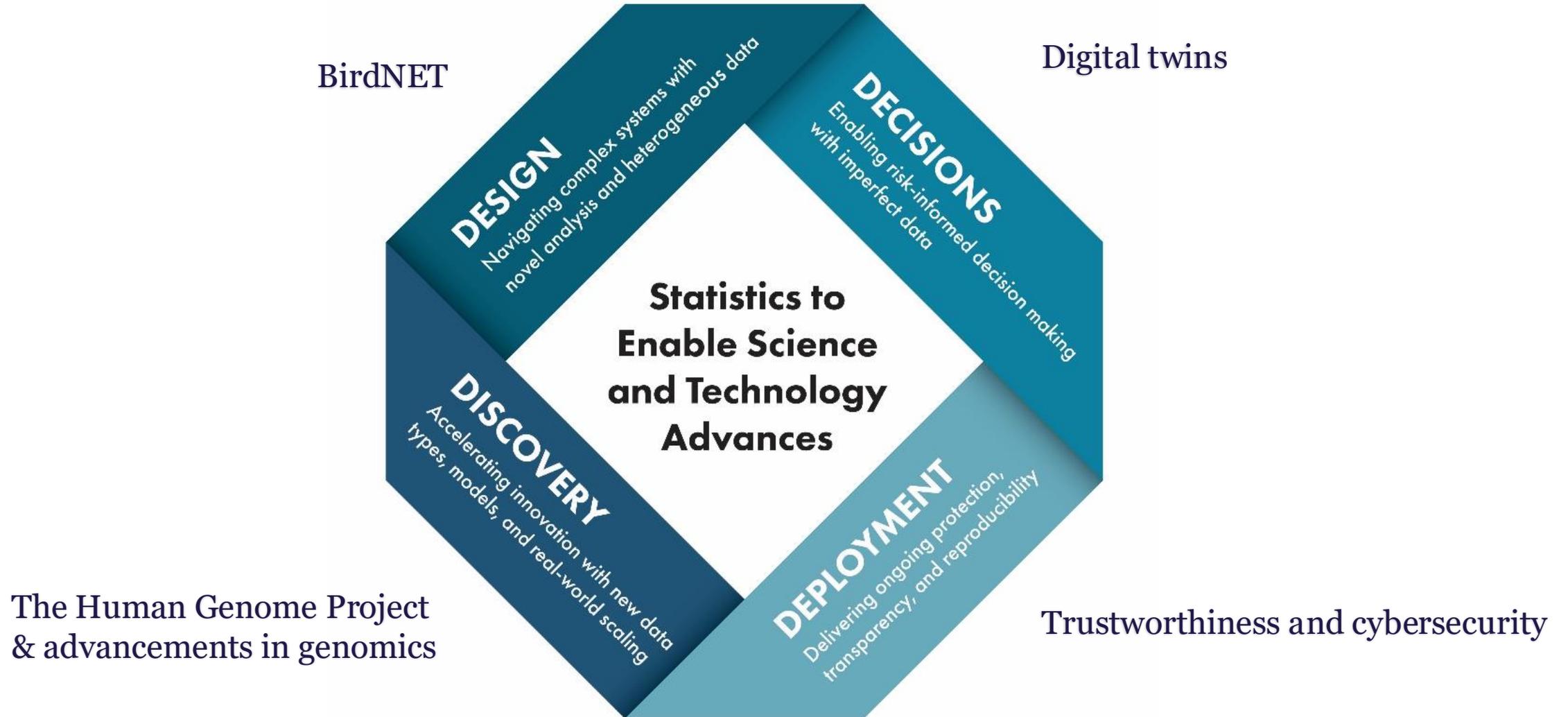
- Audit trails

- 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.**

# Statistics to Enable Scientific and Technological Advances



BirdNET

Digital twins

DESIGN
Navigating complex systems with novel analysis and heterogeneous data

DECISIONS
Enabling risk-informed decision making with imperfect data

Statistics to Enable Science and Technology Advances

DISCOVERY
Accelerating innovation with new data types, models, and real-world scaling

DEPLOYMENT
Delivering ongoing protection, transparency, and reproducibility

The Human Genome Project & advancements in genomics

Trustworthiness and cybersecurity

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# 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.

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# 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.*
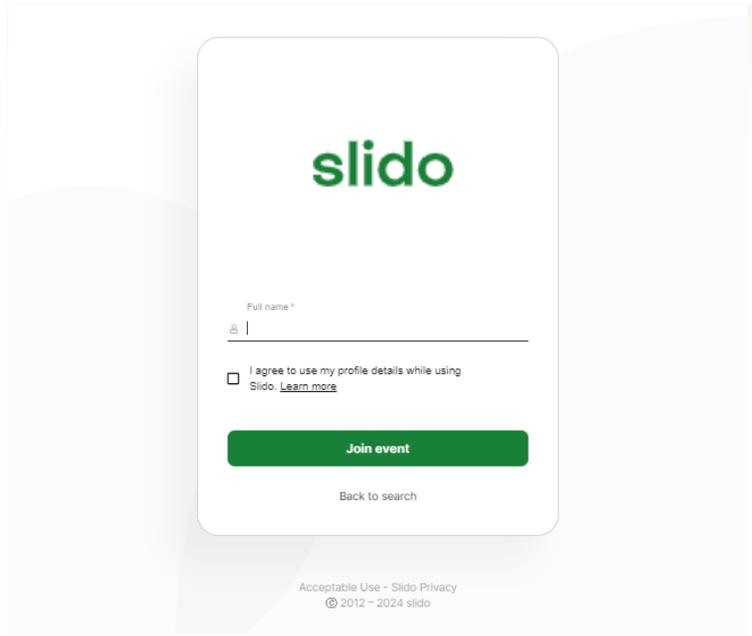
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# A Roadmap for Recommendation Implementation

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

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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

*Please submit questions using the slido window.*

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