NSF Perspective on the Data Deluge

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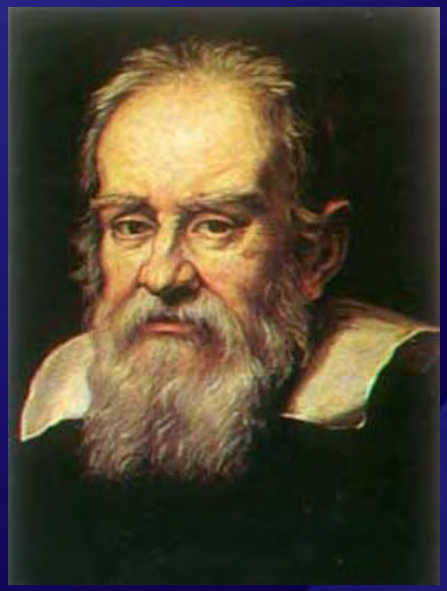
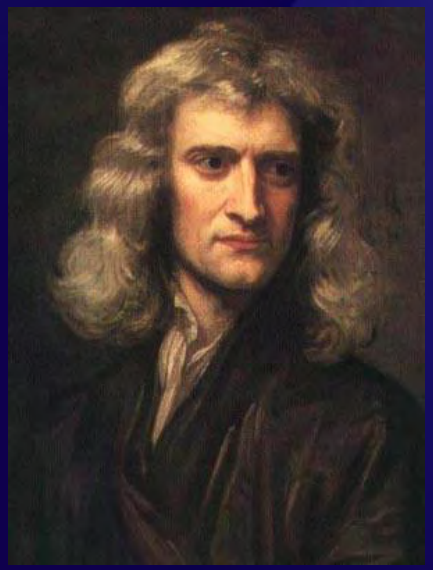
Profound Transformation of Science
Gravitational Physics



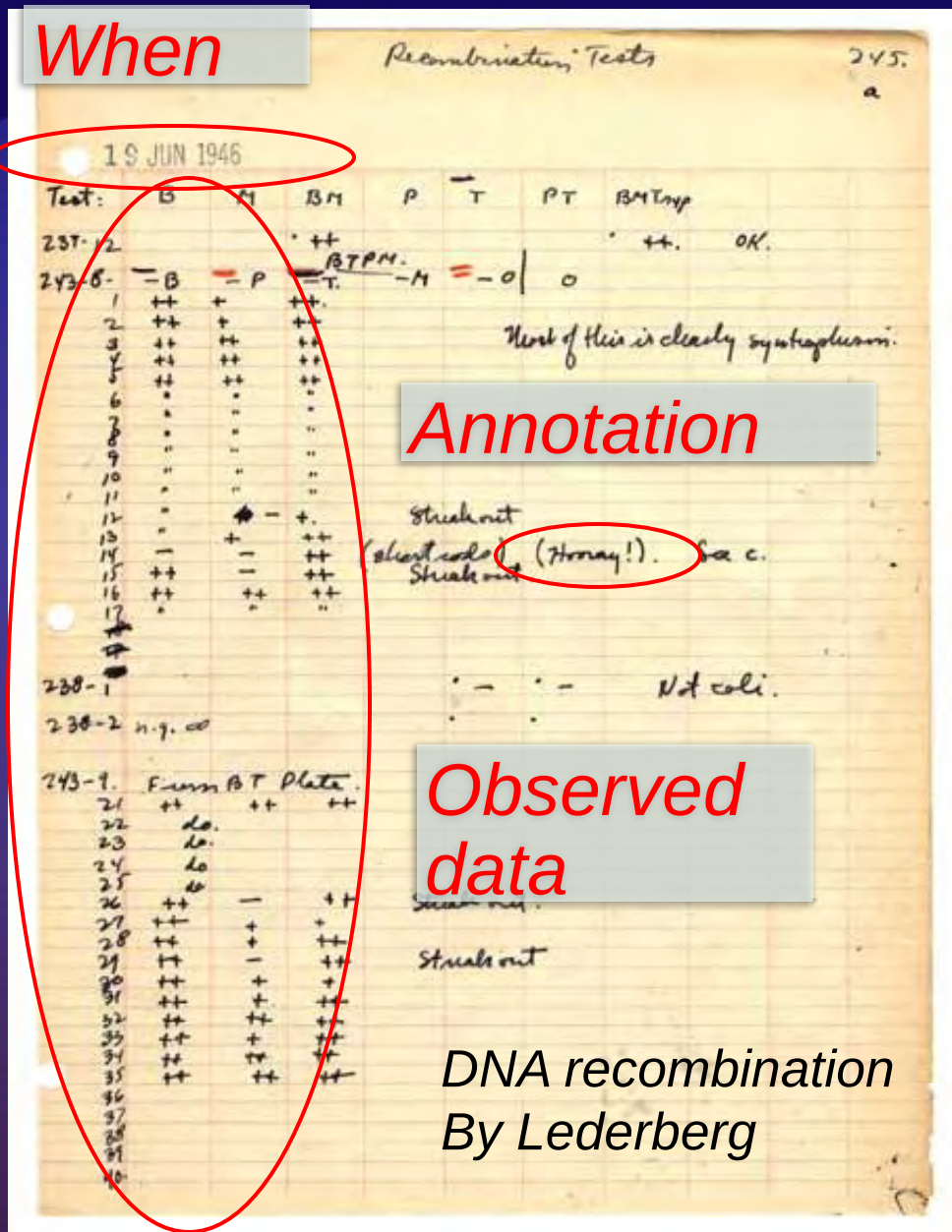


- Galileo, Newton usher in birth of modern science: c. 1600
- Problem: single "particle" (apple) in gravitational field (General 2 body-problem already too hard)
- Methods
  - Data: notebooks (Kbytes)
  - Theory: driven by data
  - Computation: calculus by hand (1 Flop/s)
- Collaboration
  - 1 brilliant scientist, 1-2 student

Source: Juliana Freire, U of Utah

Provenance in Science

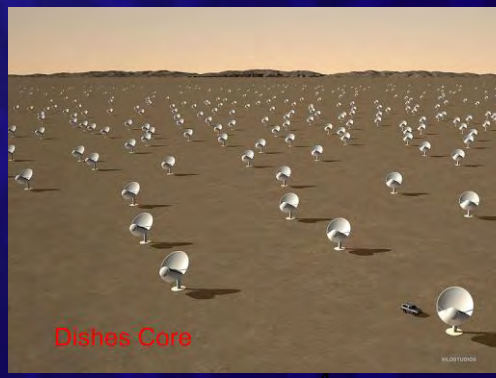
- *Provenance is as important as the result*
- Not a new issue
- Lab notebooks have been used for a long time
- What is new?
  - Large volumes of data
  - Complex analyses—computational processes
- Writing notes is no longer an option...
- *GC Communities require open, sharable data, standards, metadata*



Explosive Trends in Data Growth

- Comparative Metagenomics
  - DNA sequencing of entire families of organisms
  - Already hundreds of TB, thousands of users
- HD Collaborations and Optiportals
  - Multichannel HD, gigapixel visualizations
- Petascale-Exascale simulation
  - They generate peta-exabytes per simulation!
- Square Kilometer Array
  - 3000 radio receivers, 1 km^2 area!
  - 19 countries! Possibly beginning in 201X, operational 202X
  - Data: exabyte per week! Analysis: Exaflops!

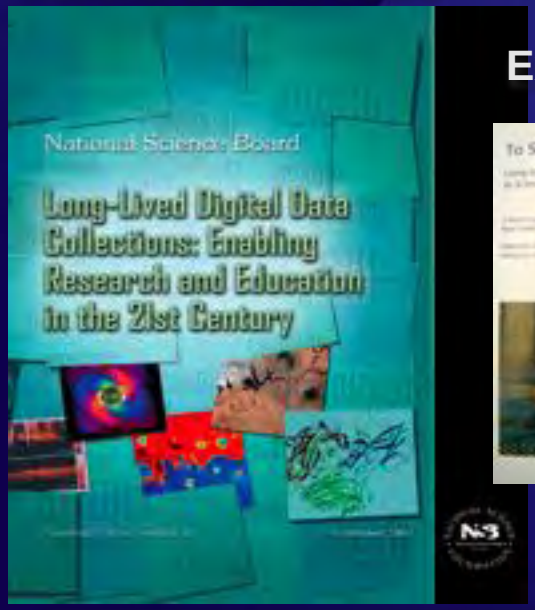
camera
Marine Microbial Ecology



Data Crisis: Information Big Bang

PCAST Digital Data

National Science Board



Expert Study

Industry

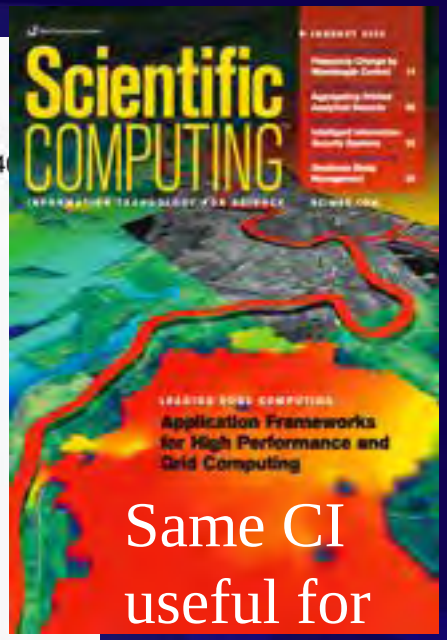
Storage Networking Industry Association (SNIA) *100 Year Archive Requirements Survey Report*

"there is a pending crisis in archiving… we have to create long-term methods for preserving information, for making it available for analysis in the future." 80% respondents: >50 yrs; 68% > 100 yrs

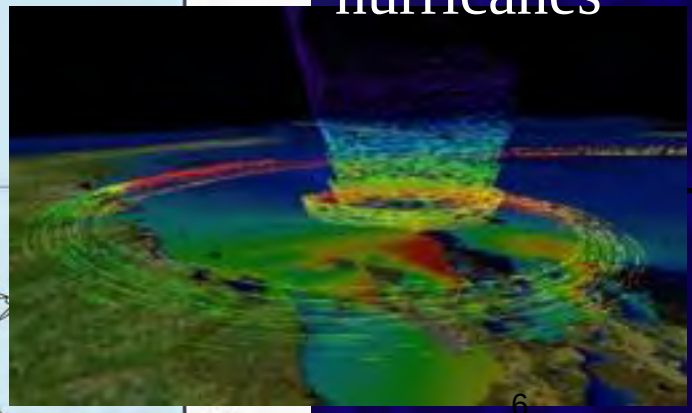
Wired, Nature

Grand Challenge Communities Combine it All...

Where is it going to go?



Same CI useful for black holes, hurricanes



The Shift Towards Data
Implications

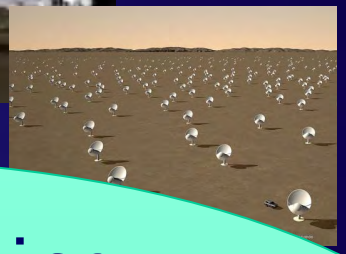
- All science is becoming data-dominated
  - Experiment, computation, theory
- Totally new methodologies
  - Algorithms, mathematics
  - All disciplines from science and engineering to arts and humanities
- End-to-end networking becomes critical part of the ecosystem
- How do we train "data-intensive" scientists?
- Data policy becomes critical!

NSF Vision & National Cyberinfrastructure Blueprint

Education Crisis: I need all of this to start to solve my problem!

neon
National Ecological Observatory Network, Inc.

Nets



DataNet

DataNet

Track 2

Science is becoming unreproducible in this environment. Validation?Provenance? Reproducibility?

Campus

Campus

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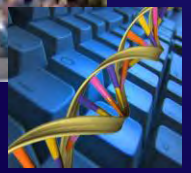

"Data Deluge" Drives Change at NSF

- Data Issues resonate the mo
- DataNet – $100M inves
  Access Partners – dev
  network of interactiv
  grand challenges, in
- INTEROP – Communit
  interdisciplinary, commu
  re-use data in ways not e
- Data-intensive computin SDSC Gordon facility
- NSF Data Policy – The "Data Working Group" (NSF-wide group of Program Directors) working to assure that data are shared within and across disciplines

There is a major shift in science towards data-intensive methods. NSF is responding...

Recent NSF Activities on Data Policy and Implementation

Changes Coming for Data!

- Long-standing NSF Policy on Data (Proposal & Award Policies & Procedures Guide)
  - "*Investigators are expected to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data... created or gathered in the course of work under NSF grants*"
- NSF will soon require a Data Management Plan (DMP), subject to peer review; criterion for award
  - The DMP will be in the form of a 2-page supplementary document to the proposal
  - It will not be possible to submit proposals without such a document
  - Customization by discipline, program necessary

Upcoming Implementation of NSF Data Policy

- Directorate-Specific Issues & Peer Review
- Many details are implemented/enforced via peer review and Program Officer discretion, including things like embargo period, standards, etc.
- The challenge at NSF is that "no one size fits all" so each Directorate will be responsible for its own recommendations for DMP content, appropriate institutional repositories, etc.
- This does not address Open Access as applied to publications

Fundamental poi
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Where is it placed? Author web site? Library? NSF sites?

Who pays? The NSF? The Institution? What is the cost model? What is reasonable?

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What data must be made available? Raw
ta? Peer reviewed?

How long is it made
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There is great variability in requirements across science communities: peer review can help guide this process.

Closing Remarks

This is Step 1

National Science Board has a newly formed Task Force on Data Policy

Discussions within NSF acknowledge that no one-size fits all, focus on incentives, consider software and publications (knowledge)