Why Public Access to Data is So Important
(and why getting the policy right is even more so)

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Open Data Crucial to Science Today

- not a new concept, rooted in *skepticism*
- Transactions of the Royal Society 1660's
- Transparency, knowledge transfer -> goal to perfect the *scholarly record*. Nothing else.
- Technology has changed the nature of experimentation, data, and communication.

Computation is Becoming Central to Scientific Research

1. enormous, and increasing, amounts of data collection:
   - CMS project at LHC: 300 "events" per second, 5.2M seconds of runtime per year, .5MB per event = 780TB/yr => several PB when data processed,
   - Sloan Digital Sky Survey: 9th data release (SDSS-III 2012), 60TB,
   - quantitative revolution in social science due to abundance of social network data (Lazier et al, *Science*, 2009)
   - *Science* survey of peer reviewers: 340 researchers regularly work with datasets >100GB; 119 regularly work with datasets >1TB (N=1700, Feb 11, 2011, p. 692)
2. massive simulations of the complete evolution of a physical system, systematically varying parameters,
3. deep intellectual contributions now encoded in software.

Credibility Crisis

One study (Ioannidis (2011)): 9% of authors studied made data available

JASA June	Computational Articles	Code Publicly Available
1996	9 of 20	0%
2006	33 of 35	9%
2009	32 of 32	16%
2011	29 of 29	21%

Generally, data and code not made available at the time of publication, insufficient information in the publication for verification, replication of results. ***A Credibility Crisis***

Scientific Perspective

- "Really Reproducible Research" inspired by Stanford Professor Jon Claerbout:

  "The idea is: An article about computational science in a scientific publication is *not* the scholarship itself, it is merely *advertising* of the scholarship. The actual scholarship is the complete ... set of instructions [and data] which generated the figures." David Donoho, 1998.

Updating the Scientific Method

Argument: computation presents only a *potential* third branch of the scientific method (Stodden et al 2009):

- Branch 1 (deductive): mathematics, formal logic,
- Branch 2 (empirical): statistical analysis of controlled experiments,
- Branch 3,4? (computational): large scale simulations / data driven computational science.

The Ubiquity of Error

- The central motivation for the scientific method is to root out error:
  - Deductive branch: the well-defined concept of the proof,
  - Empirical branch: the machinery of hypothesis testing, structured communication of methods and protocols.
- Computational science as practiced today does not generate reliable knowledge. "breezy demos"
- See e.g. Ioannidis, "Why Most Published Research Findings are False," PLoS Med, 2005.

Openness in Science

- Science Policy must support scientific ends: Reliability and accuracy of the scientific record.
- Facilitate Reproducibility - the ability to regenerate published results (data and code availability, alongside results).
- Need infrastructure to facilitate (1):
    1. deposit/curation of data and code,
    2. link to published article,
    3. permanence of link.

Science Policy

- "Open Data" is not well-defined. Scope: Share data and code that permit others in the field to replicate published results. (traditionally done by the publication alone).
- Data and code availability at the time of publication.
- Public access. "With many eyeball, all bugs are shallow." Recall: primary goal of the scientific method to root out error.
- Need infrastructure/software tools to facilitate (2):

    1. data/code suitable for sharing, created *during the research process*.

Scientific Research Varies Widely

- Different research questions call for different tools, solutions, and implementations to reach "really reproducible research."
- Questions can be solely data-driven research to empirical research contained entirely in software (simulations).
- "Data" has very different meanings depending on the question behind the research.
- Overspecification of how to reach goals will not work, for either infrastructure or tools. Empower communities to reach clearly specified goals that support science, with funds, deadlines, and enforcement (and community engagement in the process).

Sharing: Funding Agency Policy

- NSF grant guidelines: "NSF ... expects investigators to share with other researchers, at no more than incremental cost and within a reasonable time, the data, samples, physical collections and other supporting materials created or gathered in the course of the work. It also encourages grantees to share software and inventions or otherwise act to make the innovations they embody widely useful and usable." (2005 and earlier)
- NSF peer-reviewed Data Management Plan (DMP), January 2011.
- NIH (2003): "The NIH endorses the sharing of final research data to serve these and other important scientific goals. The NIH expects and supports the timely release and sharing of final research data from NIH-supported studies for use by other researchers." (>$500,000, include data sharing plan)

NSF Data Management Plan

"Proposals submitted or due on or after January 18, 2011, must include a supplementary document of no more than two pages labeled 'Data Management Plan.' This supplementary document should describe how the proposal will conform to NSF policy on the dissemination and sharing of research results." (http://www.nsf.gov/bfa/dias/policy/dmp.jsp)

Software management plans appearing.. (BigData joint NSF/NIH solicitation)

Congress: America COMPETES

- America COMPETES Re-authorization (2011):
  - § 103: Interagency Public Access Committee:

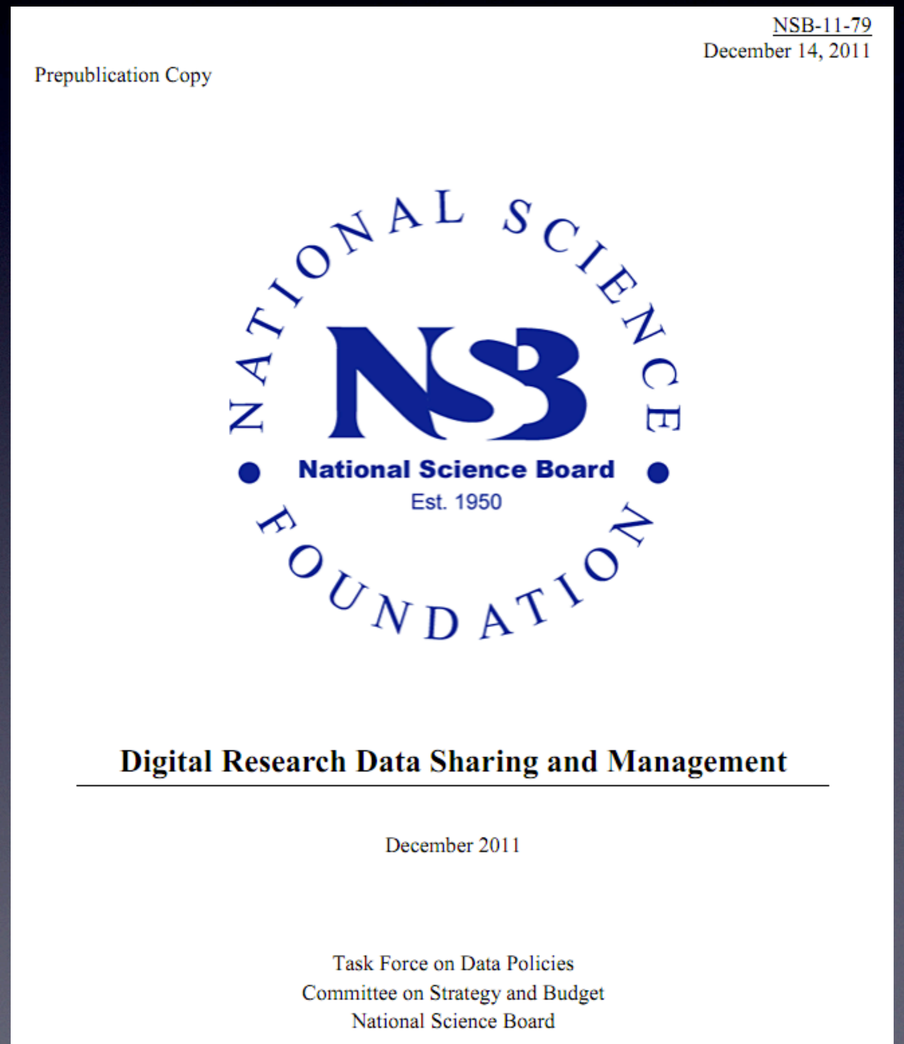
    "coordinate Federal science agency research and policies related to the dissemination and long-term stewardship of the results of unclassified research, *including digital data* and peer-reviewed scholarly publications, supported wholly, or in part, by funding from the Federal science agencies." (emphasis added)

  - § 104: Federal Scientific Collections: OSTP "shall develop policies for the management and use of Federal scientific collections to improve the quality, organization, *access, including online access*, and long-term preservation of such collections for the benefit of the scientific enterprise." (emphasis added)

Science Policy in Congress

- America COMPETES due to be reauthorized, drafting underway,
- Hearing on Research Integrity and Transparency by the House Science, Space, and Technology Committee (March 5).
- Reproducibility cannot be an unfunded mandate.

National Science Board Report



NSB-11-79
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NATIONAL SCIENCE FOUNDATION

National Science Board
Est. 1950

Digital Research Data Sharing and Management

December 2011

Task Force on Data Policies
Committee on Strategy and Budget
National Science Board

"Digital Research Data Sharing and Management," December 2011.

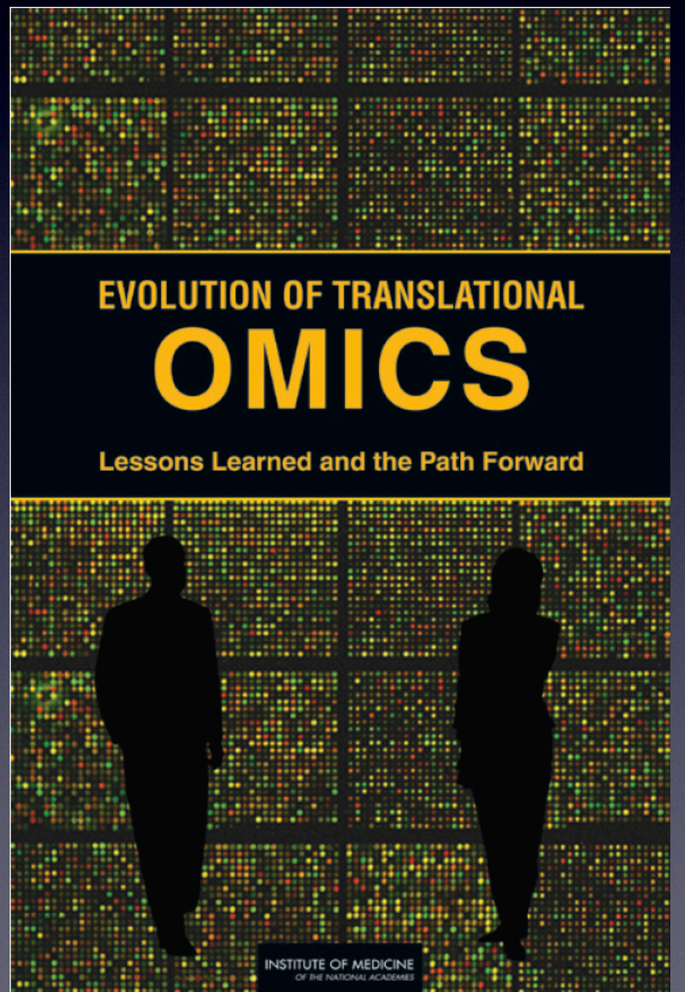
http://www.nsf.gov/nsb/publications/2011/nsb1124.pdf

NAS Data Sharing Report

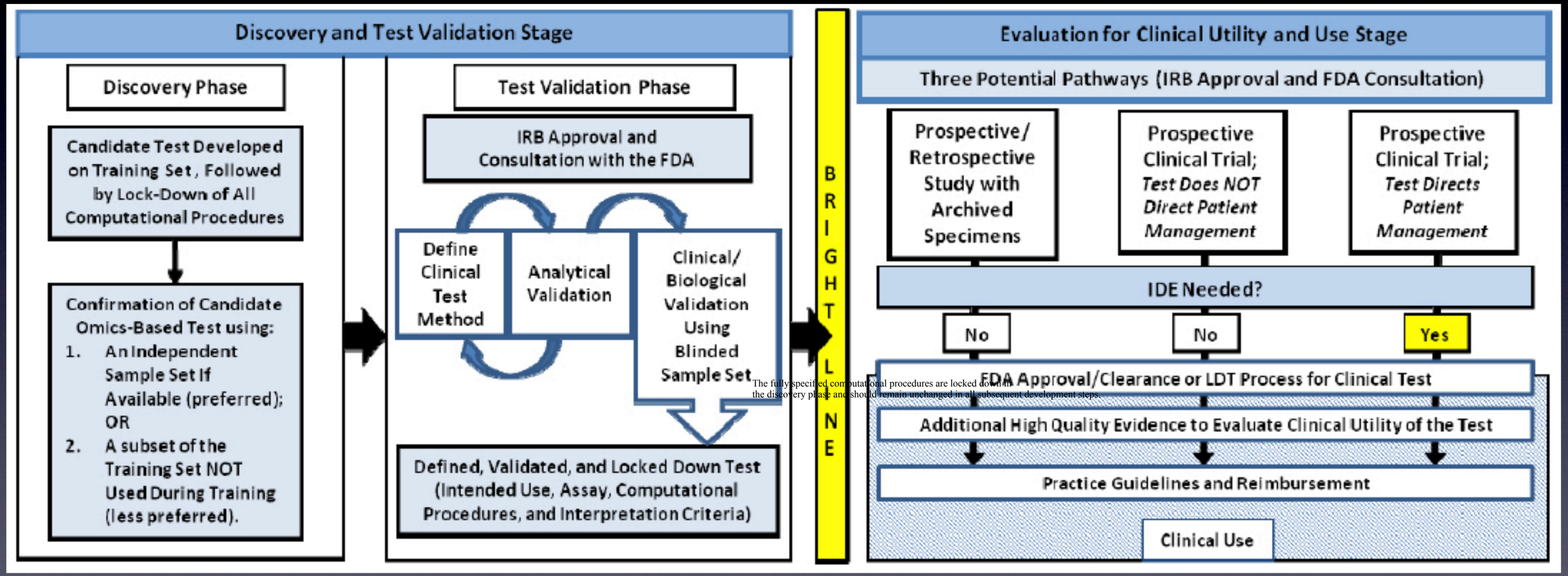
- Sharing Publication-Related Data and Materials: Responsibilities of Authorship in the Life Sciences, (2003)
- "Principle 1. Authors should include in their publications the data, algorithms, or other information that is central or integral to the publication—that is, whatever is necessary to support the major claims of the paper and would enable one skilled in the art to verify or replicate the claims."

IOM "Evolution of Translational Omics: Lessons Learned and the Path Forward"

- March 23 2012, IOM releases report,
- Recommends new standards for omics-based tests, including a fixed version of the software, expressly for verification purposes.



IOM Report: Figure S-1



"The fully specified computational procedures are locked down in the discovery phase and should remain unchanged in all subsequent development steps."

Legal Barriers: Copyright

"To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." (U.S. Const. art. I, §8, cl. 8)

- Original expression of ideas falls under copyright *by default* (papers, code, figures, tables..)
- Copyright secures exclusive rights vested in the author to:
  - reproduce the work
  - prepare derivative works based upon the original

Exceptions and Limitations: Fair Use.

Response from Within the Sciences

The *Reproducible Research Standard* (*RRS*) (Stodden, 2009)

- A suite of license recommendations for computational science:
    - Release media components (text, figures) under CC BY,
    - Release code components under Modified BSD or similar,
    - Release data to public domain or attach attribution license.

➡ Remove copyright's barrier to reproducible research and,

➡ Realign the IP framework with longstanding scientific norms.

Winner of the Access to Knowledge Kaltura Award 2008

Copyright and Data

- Copyright adheres to raw facts in Europe.
- In the US raw facts are not copyrightable, but the original "selection and arrangement" of these facts is copyrightable. (Feist Publns Inc. v. Rural Tel. Serv. Co., 499 U.S. 340 (1991)).
- the possibility of a residual copyright in data (attribution licensing or public domain certification).
- Law doesn't match reality on the ground: What constitutes a "raw" fact anyway?

Sharing: Journal Policy

- Journal Policy snapshots June 2011 and June 2012:
- Select all journals from ISI classifications "Statistics & Probability," "Mathematical & Computational Biology," and "Multidisciplinary Sciences" (this includes Science and Nature).
- N = 170, after deleting journals that have ceased publication.

Data Sharing Policy

	2011	2012	Change
Required as condition of publication, barring exceptions	18	19	1
Required but may not affect editorial decisions	3	10	7
Explicitly encouraged/addressed, may be reviewed and/or hosted	35	30	-5
Implied	0	5	5
No mention	114	106	-8

Code Sharing Policy

	2011	2012	Change
Required as condition of publication, barring exceptions	6	6	0
Required but may not affect editorial decisions	6	6	0
Explicitly encouraged/addressed, may be reviewed and/or hosted	17	21	4
Implied	0	3	3
No mention	141	134	-7

Barriers to Journal Policy Making

- Standards for code and data sharing,
- Meta-data, archiving, re-use, documentation, sharing platforms, citation standards,
- Review, who checks replication, if anyone,
- Burdens on authors, especially less technical authors,
- Evolving, early research; affects decisions on when to publish,
- Business concerns, attracting the best papers.

Tools for Computational Science

- Dissemination Platforms:

  RunMyCode.org | IPOL | Madagascar
  MLOSS.org | thedatahub.org | nanoHUB.org
  Open Science Framework

- Workflow Tracking and Research Environments:

  VisTrails | Kepler | CDE
  Galaxy | GenePattern | Paper Mâché
  Sumatra | Taverna | Pegasus

- Embedded Publishing:

  Verifiable Computational Research | Sweave
  Collage Authoring Environment | SHARE

A Grassroots Movement

- AMP 2011 "Reproducible Research: Tools and Strategies for Scientific Computing"
- Open Science Framework / Reproducibility Project in Psychology
- AMP / ICIAM 2011 "Community Forum on Reproducible Research Policies"
- SIAM Geosciences 2011 "Reproducible and Open Source Software in the Geosciences"
- ENAR International Biometric Society 2011: Panel on Reproducible Research
- AAAS 2011: "The Digitization of Science: Reproducibility and Interdisciplinary Knowledge Transfer"
- SIAM CSE 2011: "Verifiable, Reproducible Computational Science"
- Yale 2009: Roundtable on Data and Code Sharing in the Computational Sciences
- ACM SIGMOD conferences
- NSF/OCI report on Grand Challenge Communities (Dec, 2010)
- IOM "Review of Omics-based Tests for Predicting Patient Outcomes in Clinical Trials"
- ...

References

- "The Scientific Method in Practice: Reproducibility in the Computational Sciences"
- "Open Science: Policy Implications for the Evolving Phenomenon of User-led Scientific Innovation"
- "Enabling Reproducible Research: Open Licensing for Scientific Innovation"
- Reproducible Research: Tools and Strategies for Scientific Computing, July 2011
- Reproducible Research in Computational Science: What, Why and How, Community Forum, July 2011

available at http://www.stodden.net