Science as an Open Enterprise

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Open Aire – Feb 2013

Report:

Report: www.royalsociety.org

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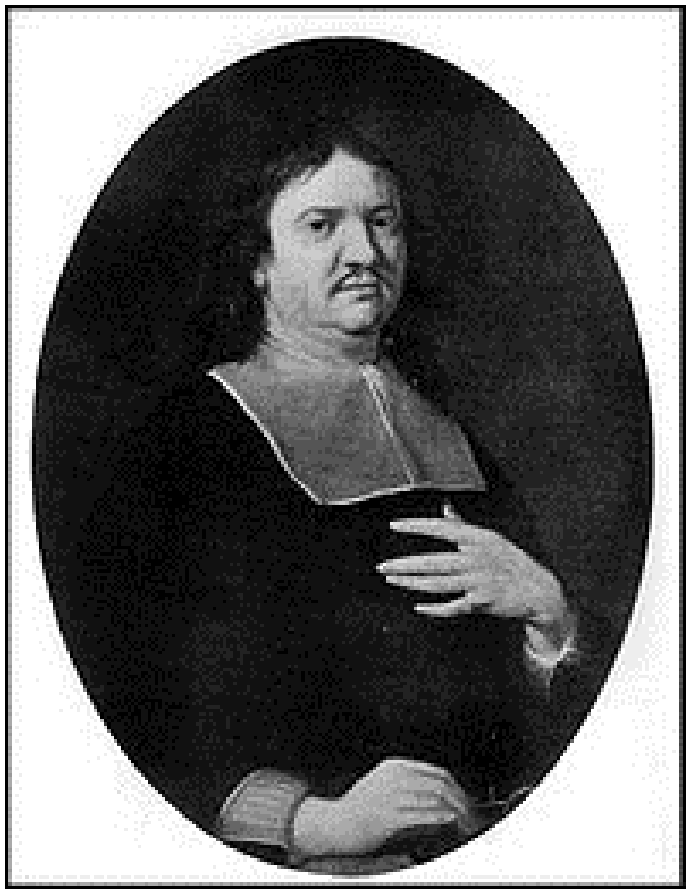
Open communication of data: the source of a scientific revolution and of scientific progress



Henry Oldenburg

PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.

Vol I.
For *Anno* 1665, and 1666.

In the *SAVOY*,
Printed by *T. N.* for *John Martyn* at the Bell, a little without *Temple-Bar*, and *James Allestry* in *Duck-Lane*,
Printers to the *Royal Society*.

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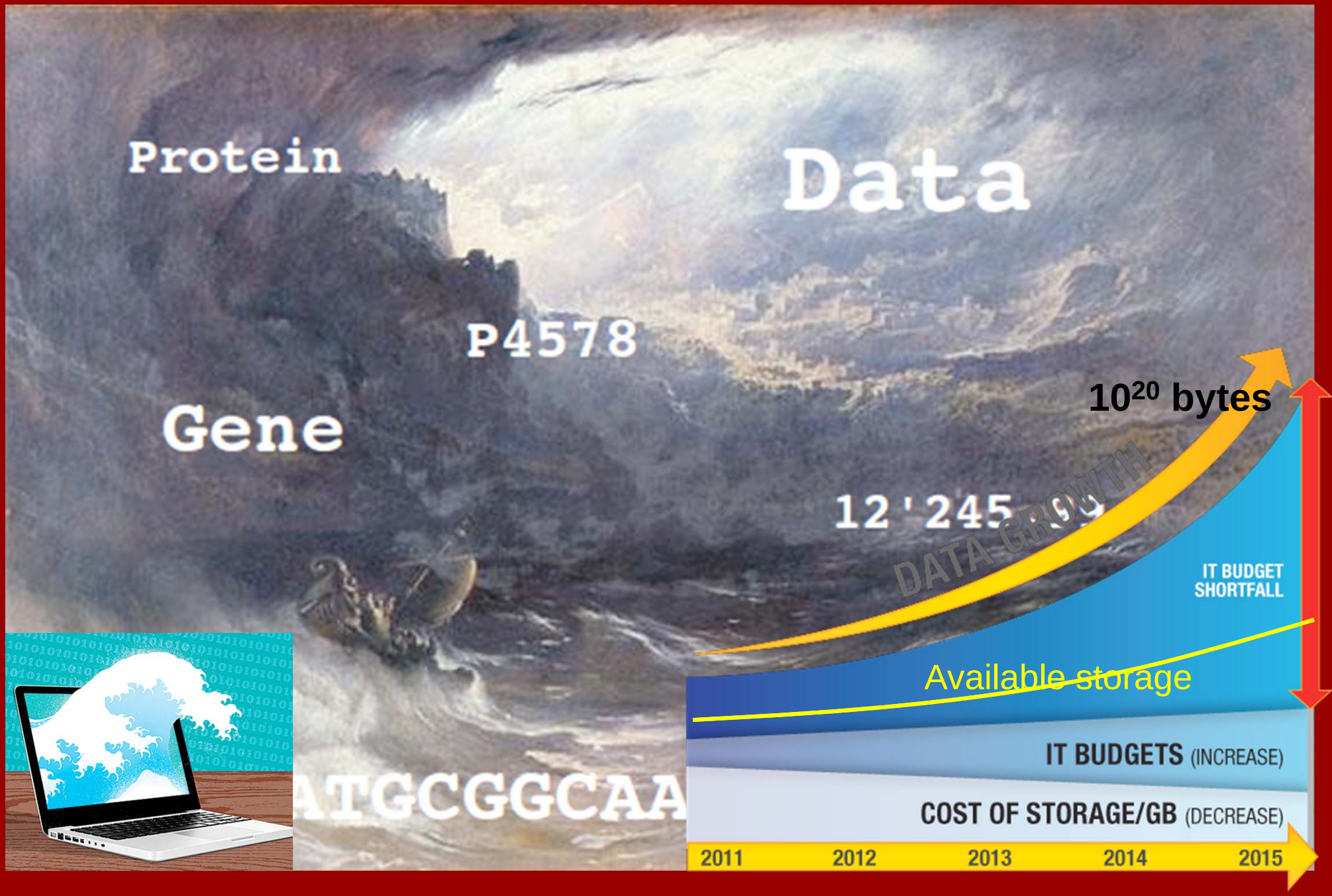
"It is therefore thought fit ***to employ the [printing] press****, as the most proper way to gratify those [who] . . . delight in the advancement of Learning and profitable Discoveries [and who are] invited and encouraged to search, try,* ***and find out new things, impart their knowledge to one another, and contribute what they can to the Grand Design of improving Natural Knowledge*** *. . . for the Glory of God . . .* ***and the Universal Good of Mankind****."*

…. how do we achieve these ends in the post-Gutenberg era, when massive digital acquisition and cyber space have replaced the printing press?

Problems & opportunities in the data deluge



The challenges & opportunities?

- **Closing the concept-data gap – maintaining scientific self-correction & credibility**
- Exploiting the data deluge & computational potential
- Combating fraud
- Addressing planetary challenges
- Supporting citizen science
- Responding to citizens' demands for evidence
- Restraining the "Database State"

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A crisis of replicability …… and of the credibility of science?

NATURE | VOL 483 | 29 MARCH 2012

REPRODUCIBILITY OF RESEARCH FINDINGS

Preclinical research generates many secondary publications, even when results cannot be reproduced.

Journal impact factor	Number of articles	Mean number of citations of non-reproduced articles*	Mean number of citations of reproduced articles
>20	21	248 (range 3–800)	231 (range 82–519)
5–19	32	169 (range 6–1,909)	13 (range 3–24)

Results from ten-year retrospective analysis of experiments performed prospectively. The term 'non-reproduced' was assigned on the basis of findings not being sufficiently robust to drive a drug-development programme.
*Source of citations: Google Scholar, May 2011.

The data providing the evidence for a published concept MUST be concurrently published, together with the metadata

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Challenges & opportunities?

- Closing the concept-data gap – maintaining scientific self-correction & credibility
- **Exploiting the data deluge & computational potential – data sharing**
- Combating fraud
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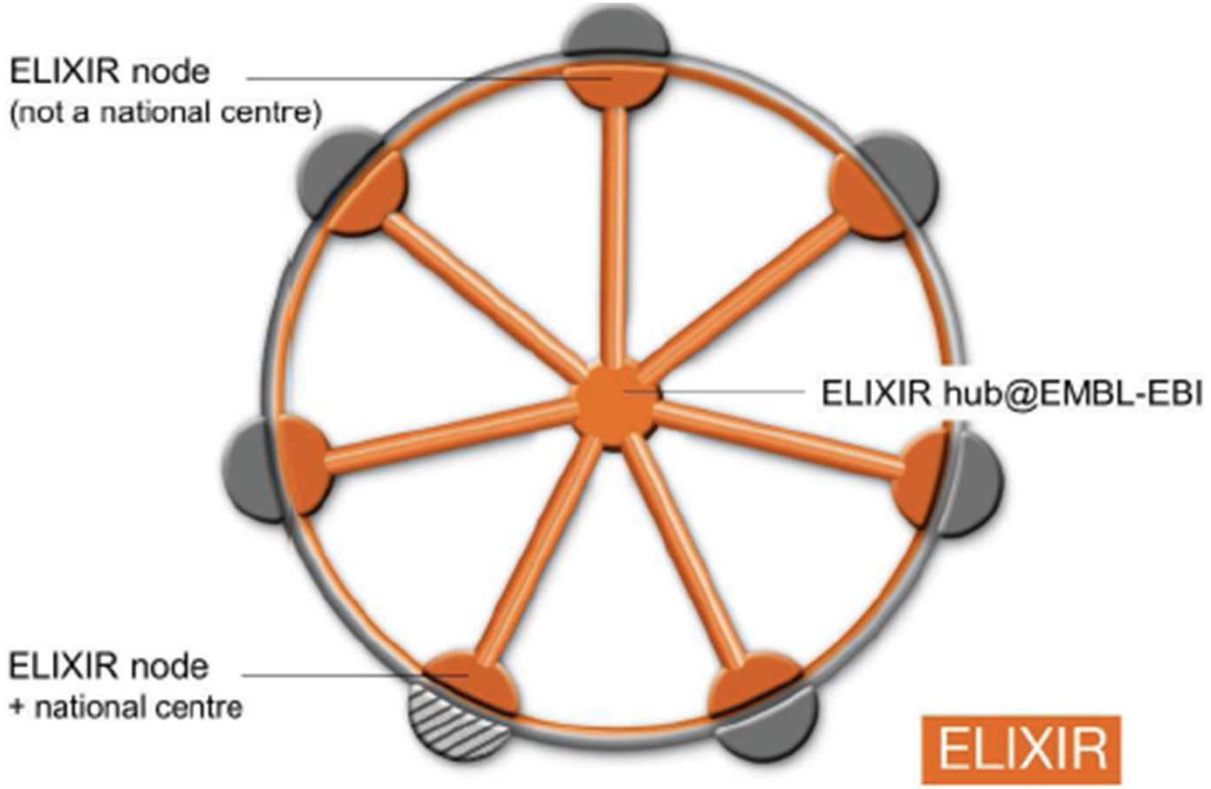
Proven benefit so that data sharing becomes embedded in ethos & practice – bio-informatics



ELIXIR Hub (European Bioinformatic Institute) and ELIXIR Nodes provide infrastructure for data, computing, tools, standards and training.

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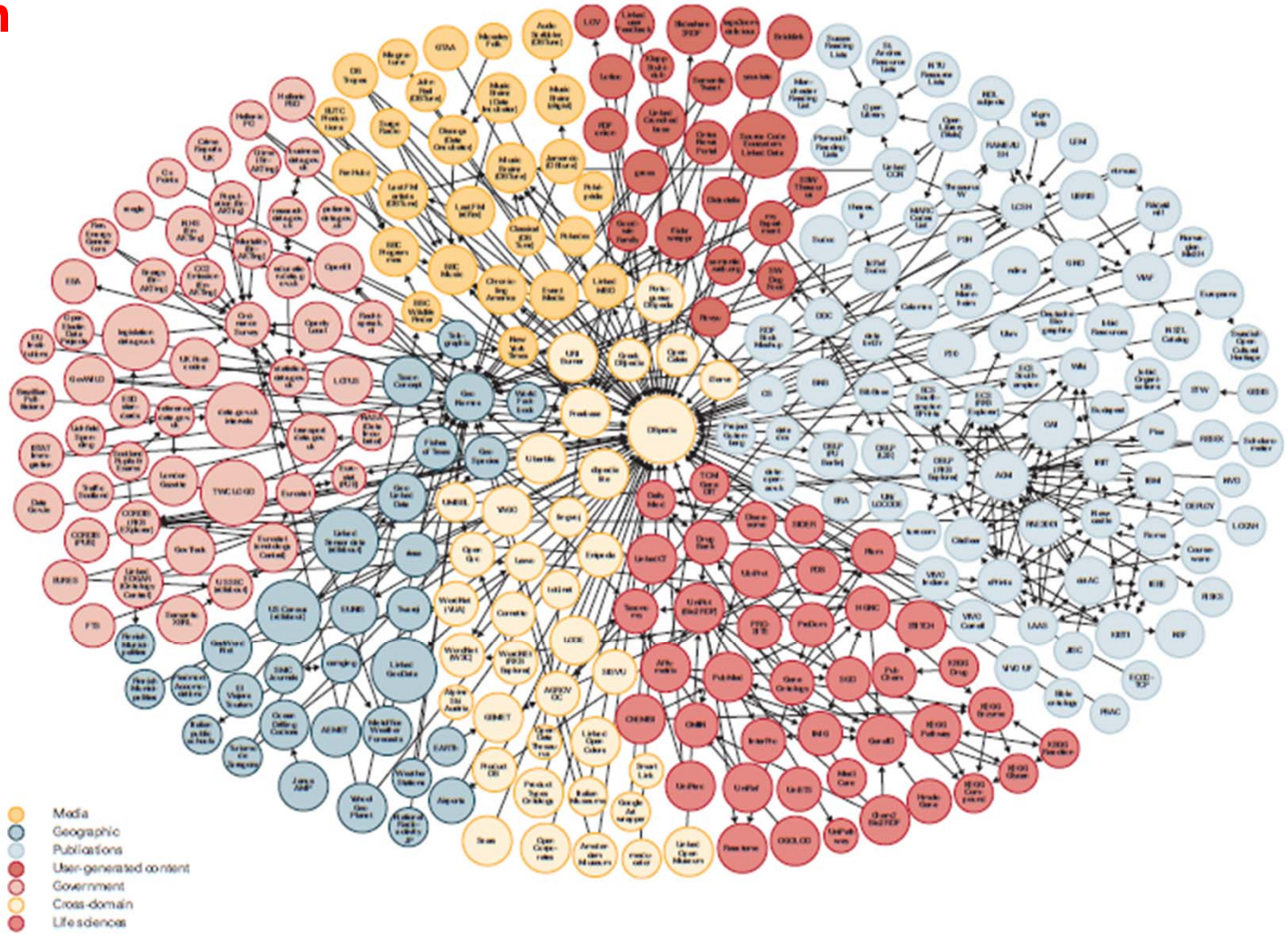
New scientific knowledge from data

E.g. the potential of linked data

- data integration
- dynamic data



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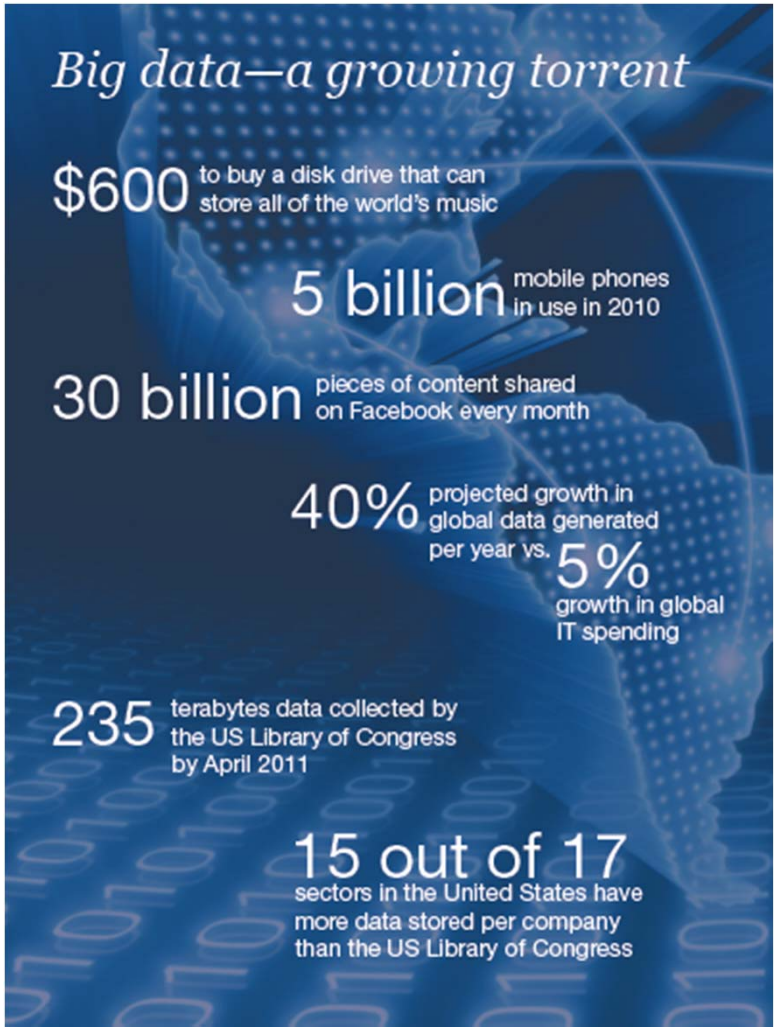
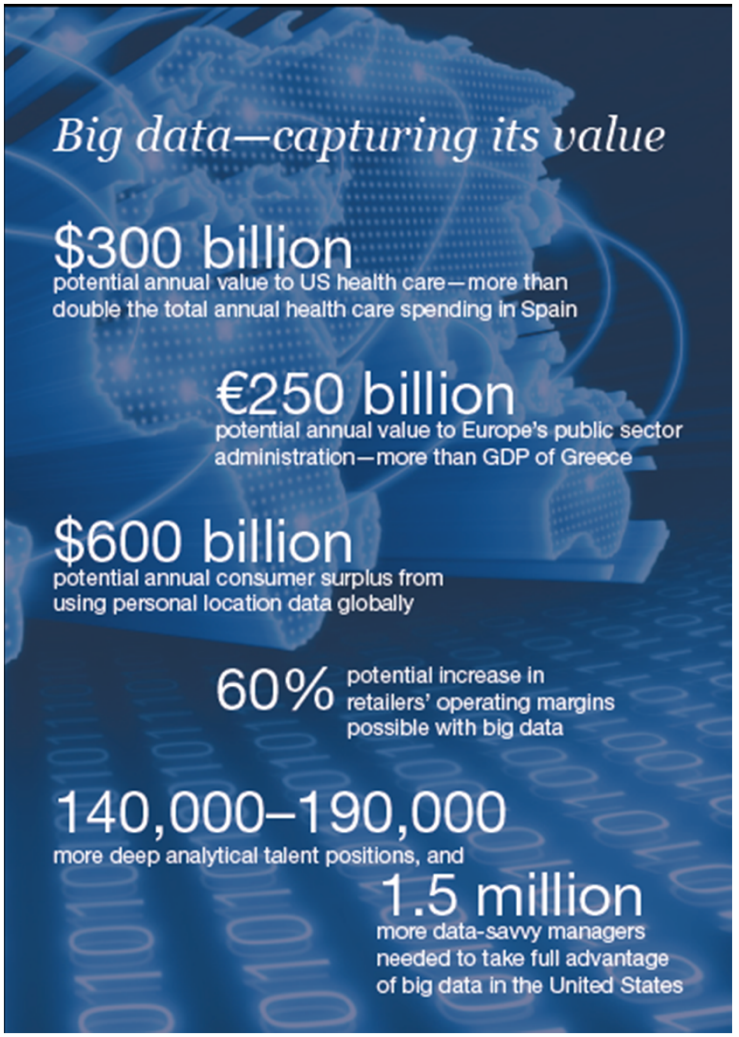
.... and the economic implications





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Its not just curation, retrieving and integrating data – its also what we do with it!

Jim Gray - "When you go and look at what scientists are doing, day in and day out, in terms of data analysis, it is truly dreadful. We are embarrassed by our data!"

- **Looking for inherent patterns – not just the expected / hoped for**
- **Partial reporting of data (cherry-picking) is scientific malpractice**
- **The role of Bayesian logic**

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- **Combating fraud**
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theguardian NOTES&THEORIES
DISPATCHES FROM THE SCIENCE DESK

"Scientific fraud is rife: it's time to stand up for good science"

"Science is broken"

Examples:

- psychology academics making up data,
- anaesthesiologist Yoshitaka Fujii with 172 faked articles
- *Nature* - rise in biomedical retraction rates overtakes rise in published papers

Cause:

Rewards and pressures promote extreme behaviours, and normalise malpractice (e.g. selective publication of positive novel findings)

Cures:

Open data for replication

Transparent peer review

Not just personal integrity – but system integrity

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Challenges & opportunities?

- Closing the concept-data gap – maintaining scientific self-correction & credibility
- Maintaining the credibility of science
- Exploiting the data deluge & computational potential
- Combating fraud
- **Addressing planetary challenges**
- Responding to citizens' demands for evidence
- Supporting citizen science
- Restraining the "Database State"

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Why is open data an urgent issue?

- Closing the concept-data gap
- Maintaining the credibility of science
- Exploiting the data deluge & computational potential
- Combating fraud
- Addressing planetary challenges
- **Responding to citizens' demands for evidence**
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- **Supporting citizen science – the 2030 question**
- Restraining the "Database State"

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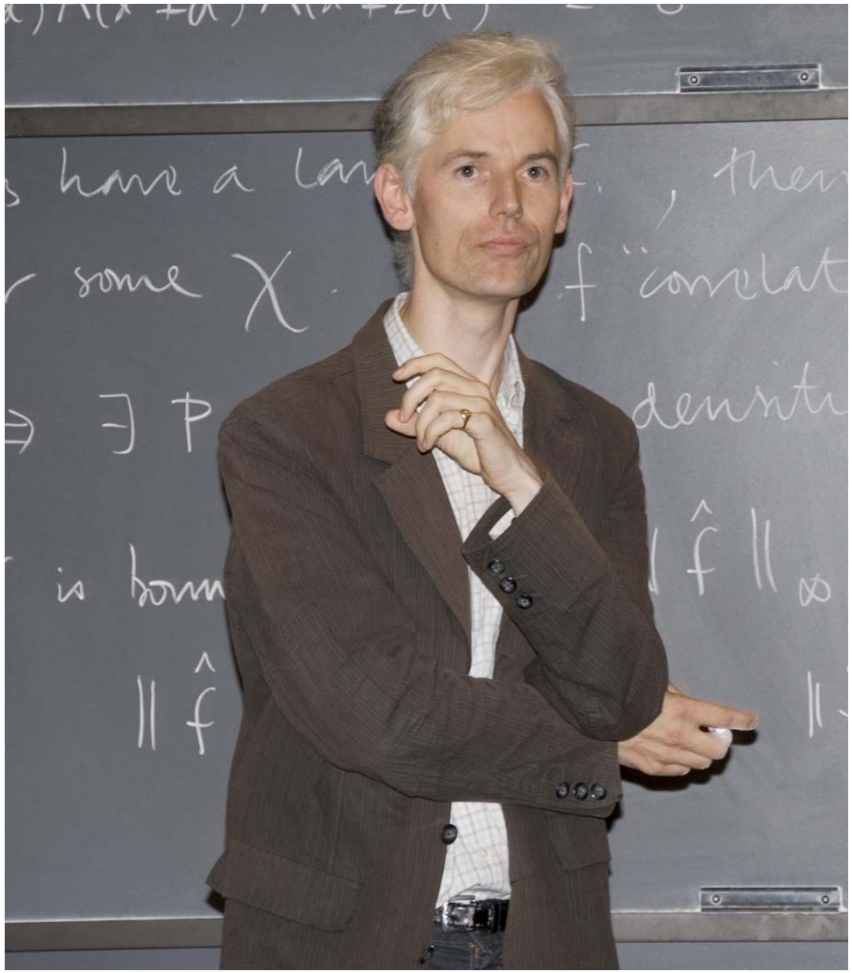
Opening-up science:
e.g. crowd-sourcing



Tim Gowers
- crowd-sourced mathematics

An unsolved problem posed on his blog.

32 days – 27 people – 800 substantive contributions

Emerging contributions rapidly developed or discarded

Problem solved!

"Its like driving a car whilst normal research is like pushing it"

What inhibits such processes?
- The criteria for credit and promotion.

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Openness of data *per se* has no value. Open science is more than disclosure

For effective communication, replication and re-purposing we need **intelligent openness**. Data and meta-data must be:

- **Accessible**
- **Intelligible**
- **Assessable**
- **Re-usable**

Only when these four criteria are fulfilled are data properly open

Metadata must be audience-sensitive

Scientific data rarely fits neatly into an EXCEL spreadsheet!

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Which publicly funded data for what purpose?

Data supporting the argument of a published paper?

- simultaneous deposition of citable data

Why should other data be open?

- greater benefit to science
- its not “our” data

Who should it be intelligently open to?

- other scientists
- citizen scientists
- the wider public

The dilemma of choice

Contradictory injunctions

Pressure to:

- commercialise, or
- share, collaborate., disseminate

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Boundaries of openness?

Openness should be the default position, with proportional exceptions for:

- **Legitimate commercial interests** (sectoral variation)
- **Privacy** (completely anonymised data is impossible)
- **Safety & security** (impacts contentious)

All these boundaries are fuzzy

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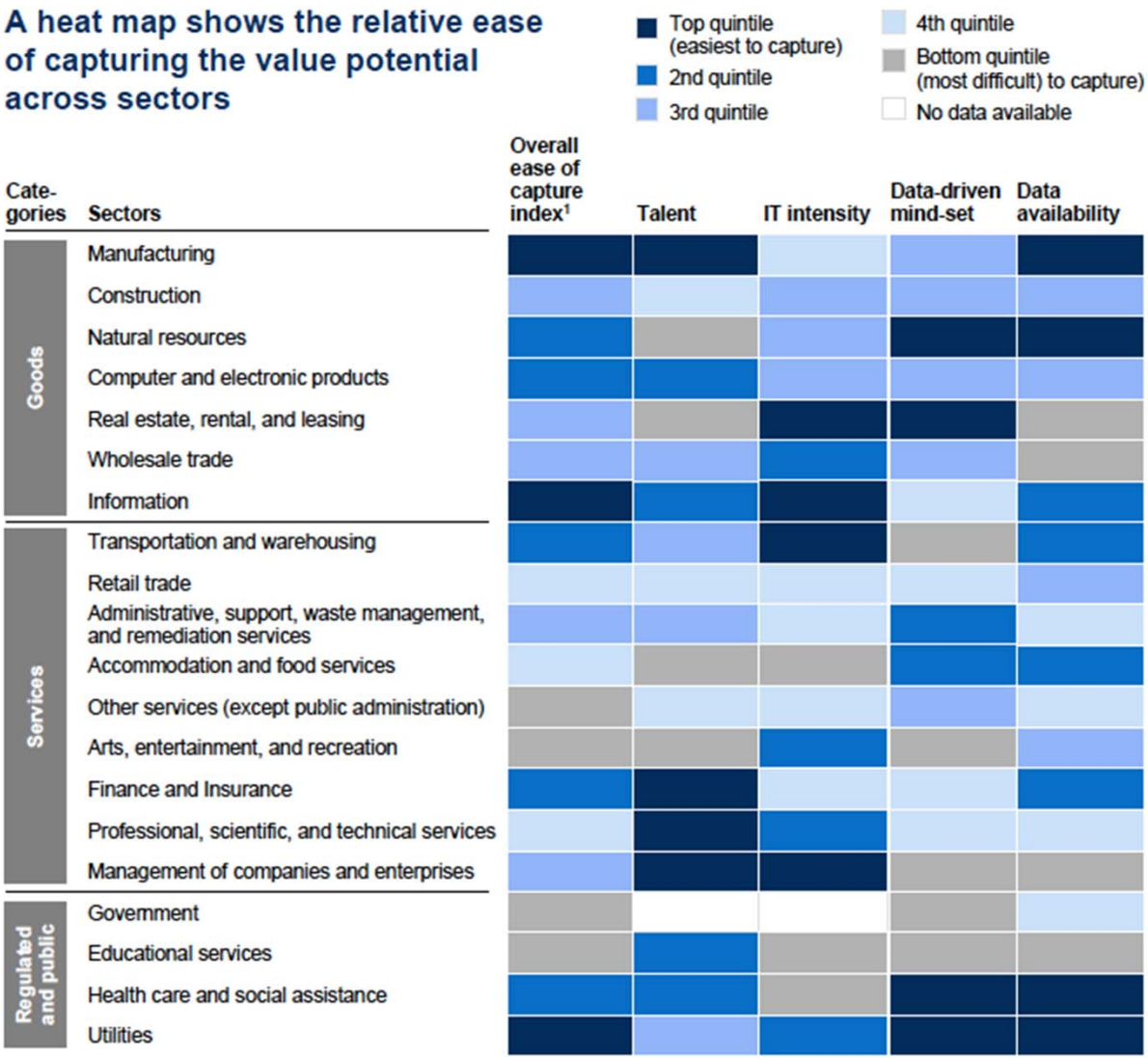
Commercial interests: potential by sector



1 See appendix for detailed definitions and metrics used for each of the criteria.

SOURCE: McKinsey Global Institute analysis

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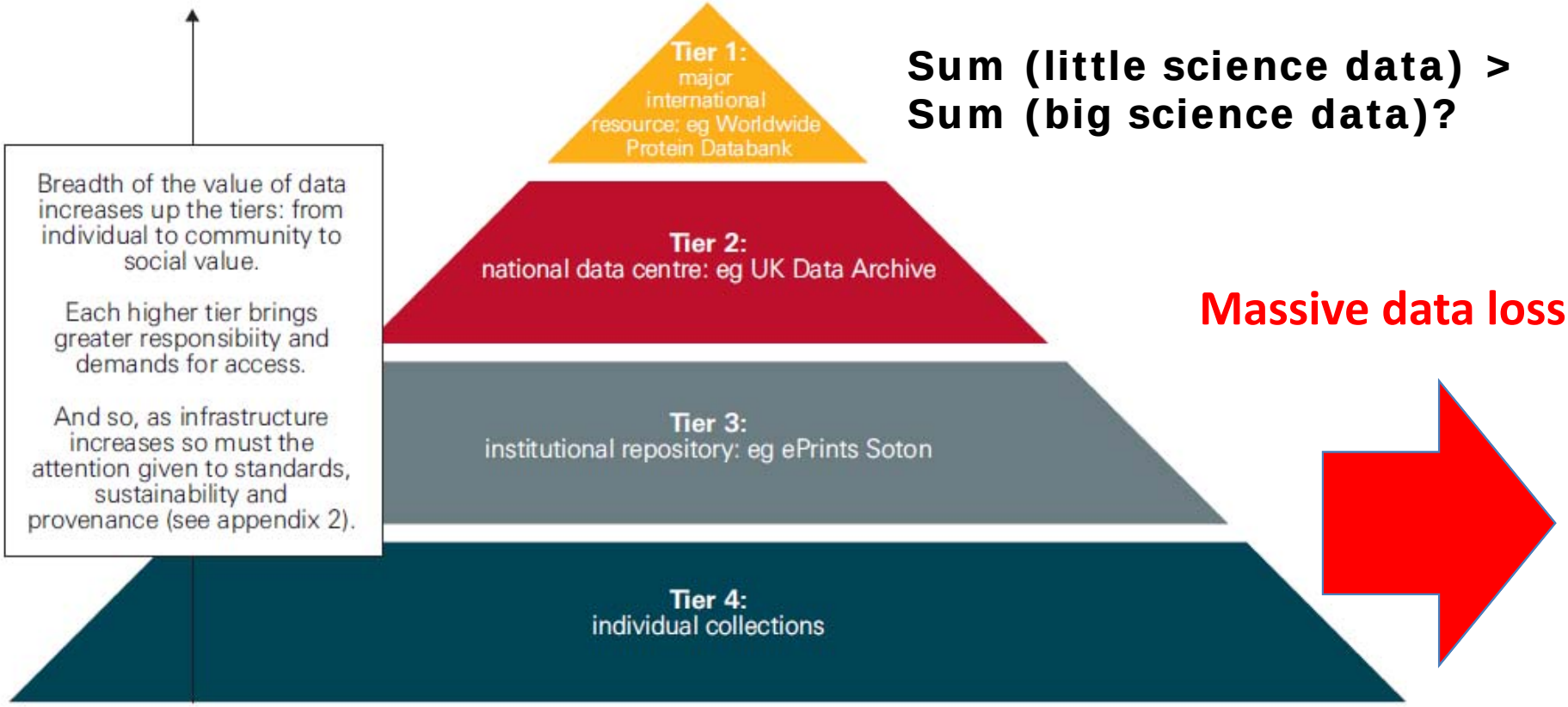
A data management ecology?

The role of the top-down and the bottom-up?

Sum (little science data) > Sum (big science data)?



Massive data loss

Views of young scientists

- **The generation gap: younger researchers typically produce more data; recognise data sharing as maximising value; have most potential to develop data sharing tools; and they are the future. We should listen to them!**

1. **a shift away from a research culture where data is viewed as a private preserve**
2. **the data evidence for a published argument MUST be intelligently open at the time of publication**
3. **data management should be embedded in the community producing and using the data**
4. **science data should be as easy to "remix" as music is to a DJ**
5. **replication is by far the best guarantee of preservation (e.g. LOCKSS)**
6. **give credit for useful data communication and novel ways of collaborating**
7. **common standards for communicating data (correct?)**
8. **the cost of intelligent openness is an integral part of the cost of doing science**
9. **Training and support**

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Essential enabling tools & processes:

key issues for research & implementation

- data integration
- supporting dynamic data
- providing provenance
- annotation
- metadata generation
- citation
- access to data scientists
- changing the library

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Scripts for the actors in open science

Scientists – changing cultural assumptions Employers (universities/institutes) – data responsibilities; crediting researchers; the role of libraries Funders of research - the cost of curation is a cost of research Learned societies – influencing their communities	Publishers of research – mandating open data; open up to data mining; be careful not to be obstacles to the progress of science Business – exploiting the opportunity; awareness & skills Government – efficiency of the science base; exploiting its data Governance processes for privacy, safety, security - proportionality

Challenges for universities

- Will they rise to the scientific challenge, or leave things to the information business?
- Will they be responsible for the knowledge they create?
- The university library; doing the wrong things through the wrong people?
- Adapting scientific education?
- Training data scientists?
- Supporting the data manipulation needs of their researchers?
- Supporting intelligent openness
- Open data and commercial imperatives

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The levels of influence

National

E.g. UK: Government "Transparency Boards" (Research, Business, Govt data) – chaired by Minister for Science

European

DGs Connect & Research

International

ICSU (International Scientific Unions)
CODATA

UK-US-Chinese-Indian science academies

BUT: the science community is the driver of creative, workable, flexible solutions – the roles of the above bodies are:

1. Remove barriers
2. Intelligent facilitation

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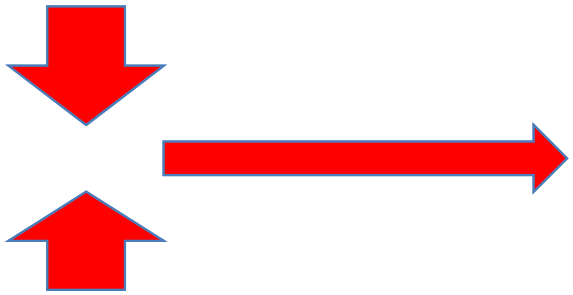
Challenge for the Commission as a funder of science

Top-down (present understanding)



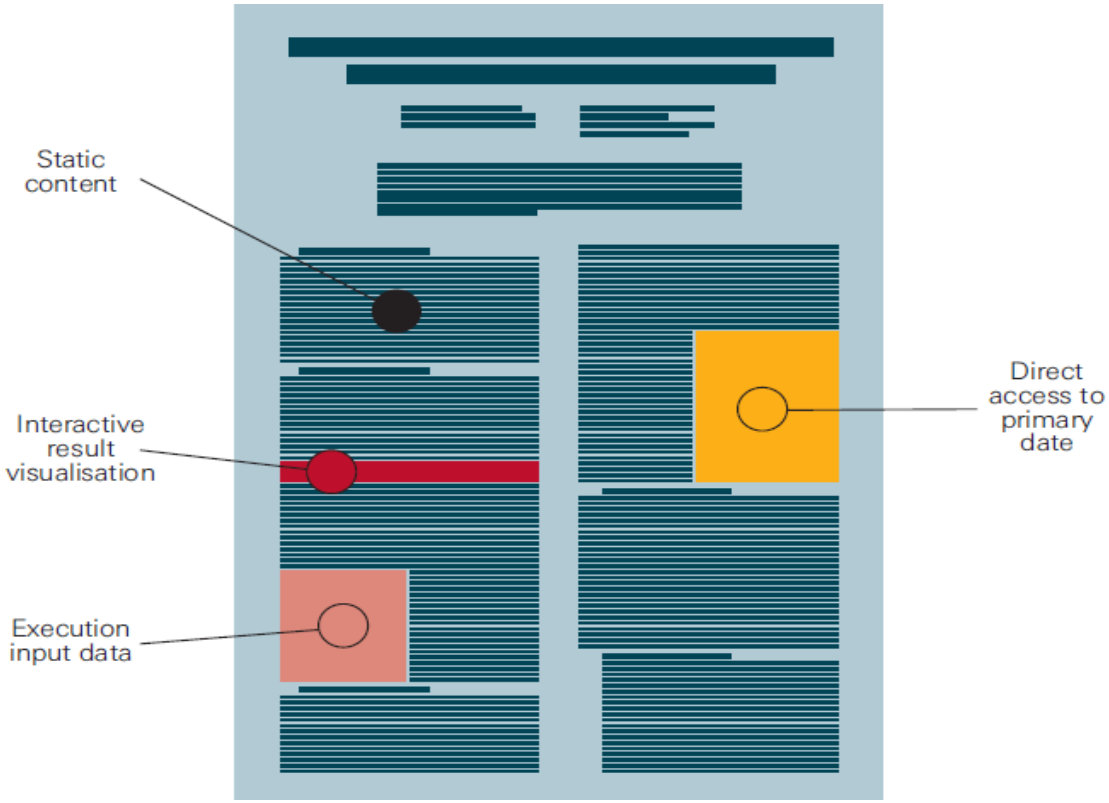
Bottom-up (new knowledge and experiment)

Digital European Research Area

1. Developing an open, interoperable e-infrastructure
2. Organising the European data space, through an open science policy
3. Opening communities, engaging individuals

… and remember - science is international!

A realiseable aspiration: all scientific literature online, all data online, and for them to interoperate



… and don't forget, this is a process, not an event!

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