Open Data and the Future of Science

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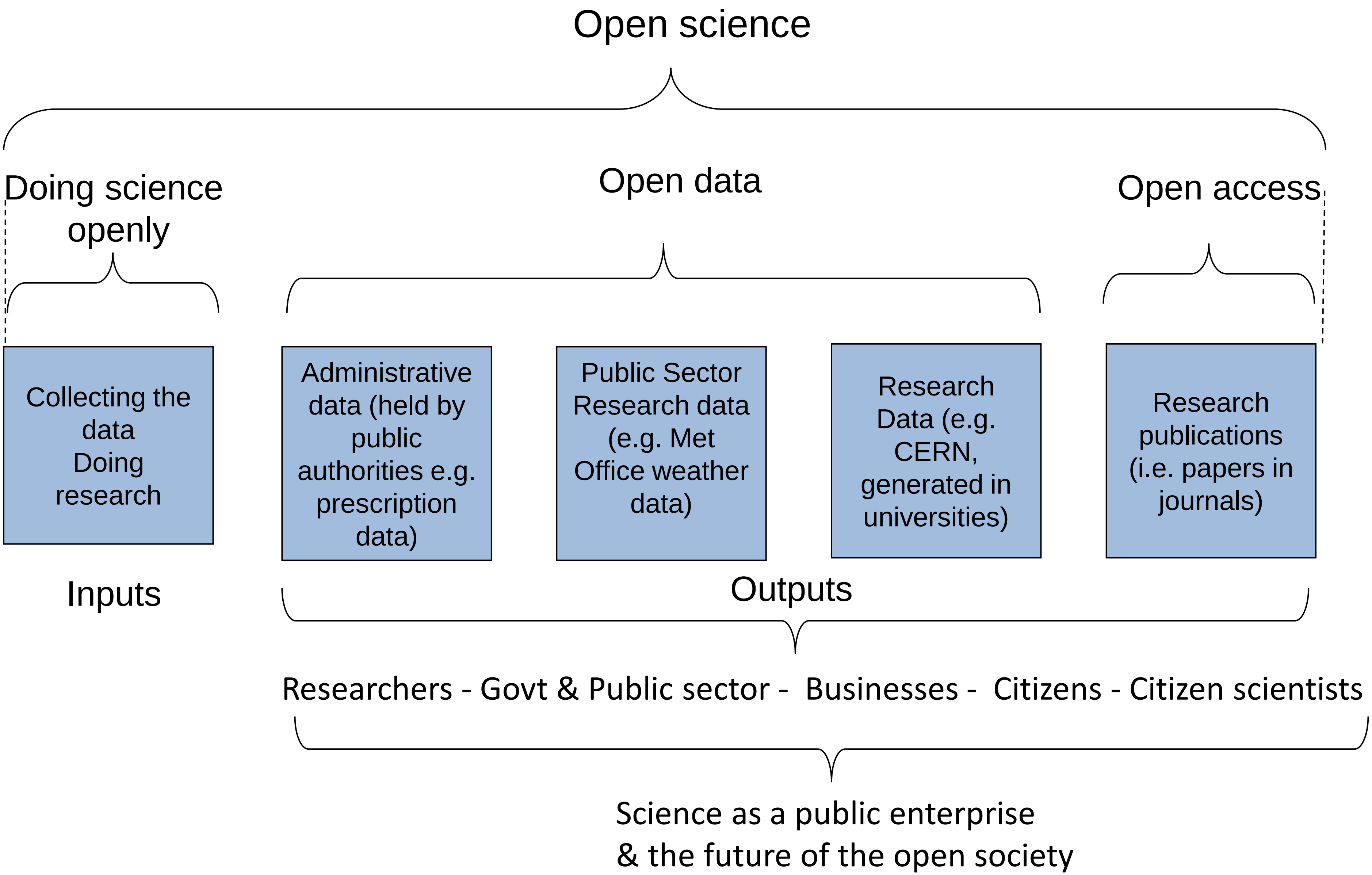
Munin Conference on Scholarly Publishing

Universitetet i Tromso
November 2014

A taxonomy of openness



Open science

Doing science openly

Open data

Open access

Collecting the data
Doing research

Administrative data (held by public authorities e.g. prescription data)

Public Sector Research data (e.g. Met Office weather data)

Research Data (e.g. CERN, generated in universities)

Research publications (i.e. papers in journals)

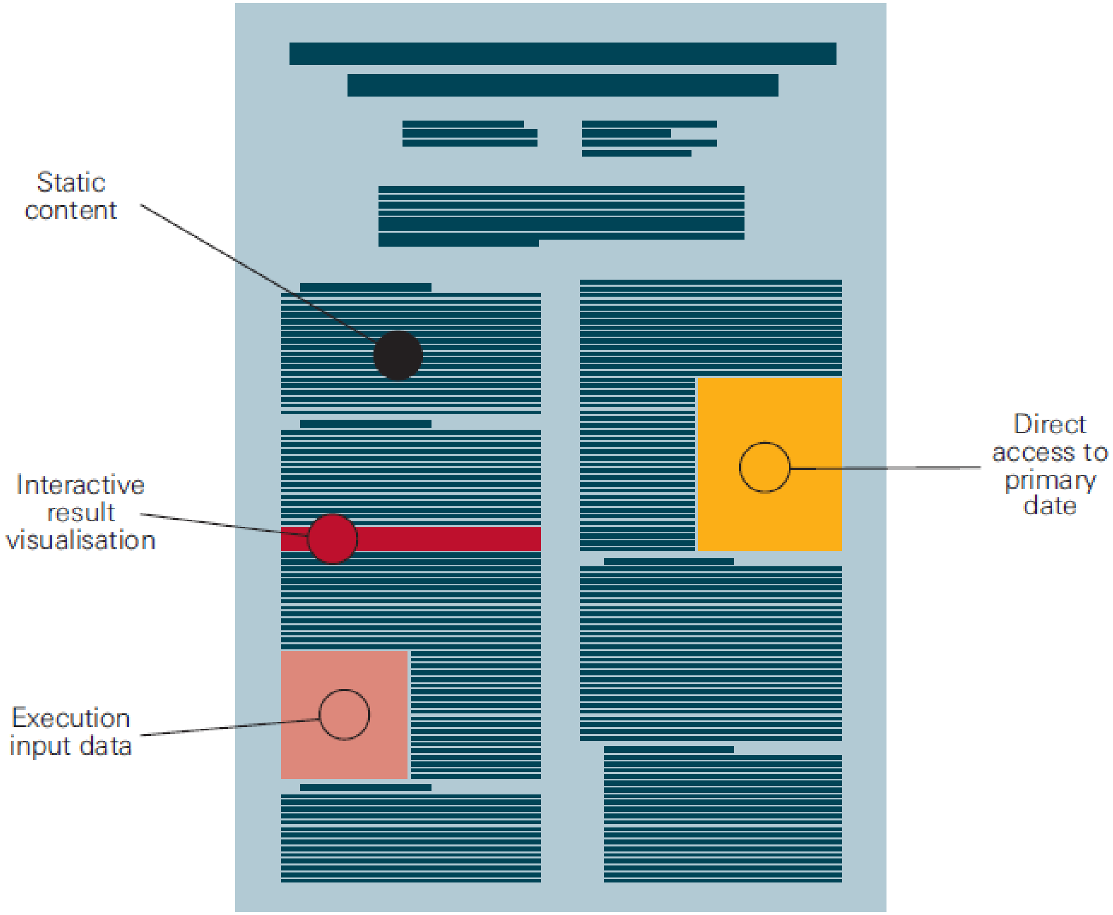
Inputs

Outputs

Researchers - Govt & Public sector - Businesses - Citizens - Citizen scientists

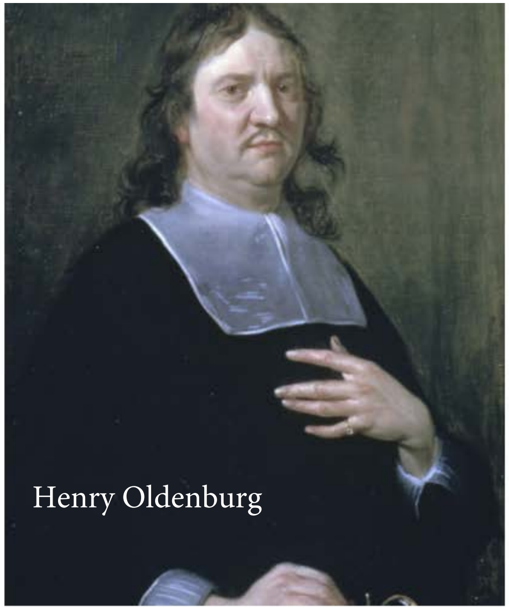
Science as a public enterprise
& the future of the open society

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

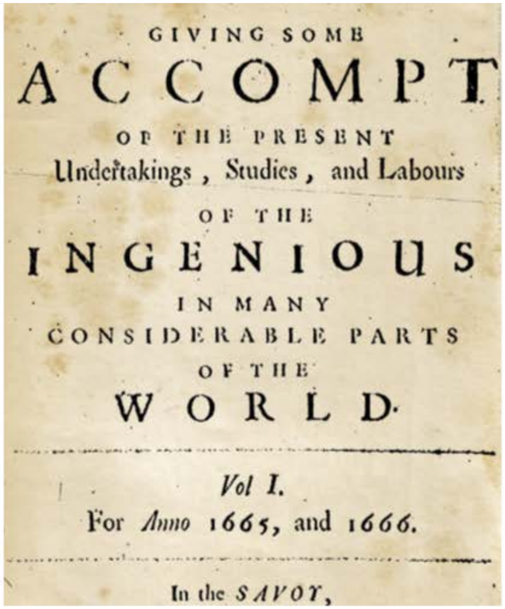

Static content
Interactive result visualisation
Execution input data
Direct access to primary date

… and to be accessible to all?

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



Henry Oldenburg



GIVING SOME

ACCOMPT

OF THE PRESENT

Undertakings, Studies, and Labours

OF THE

INGENIOUS

IN MANY

CONSIDERABLE PARTS

OF THE

WORLD.

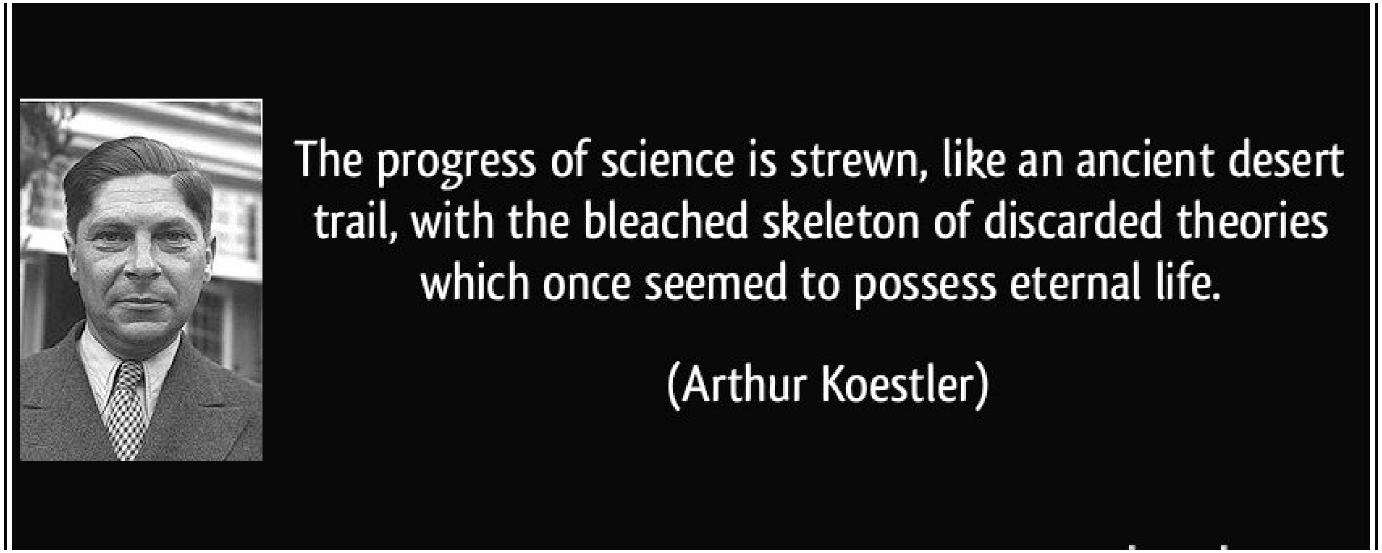
Vol I.

For *Anno* 1665, and 1666.

In the *SAVOY*,

Scientific self correction

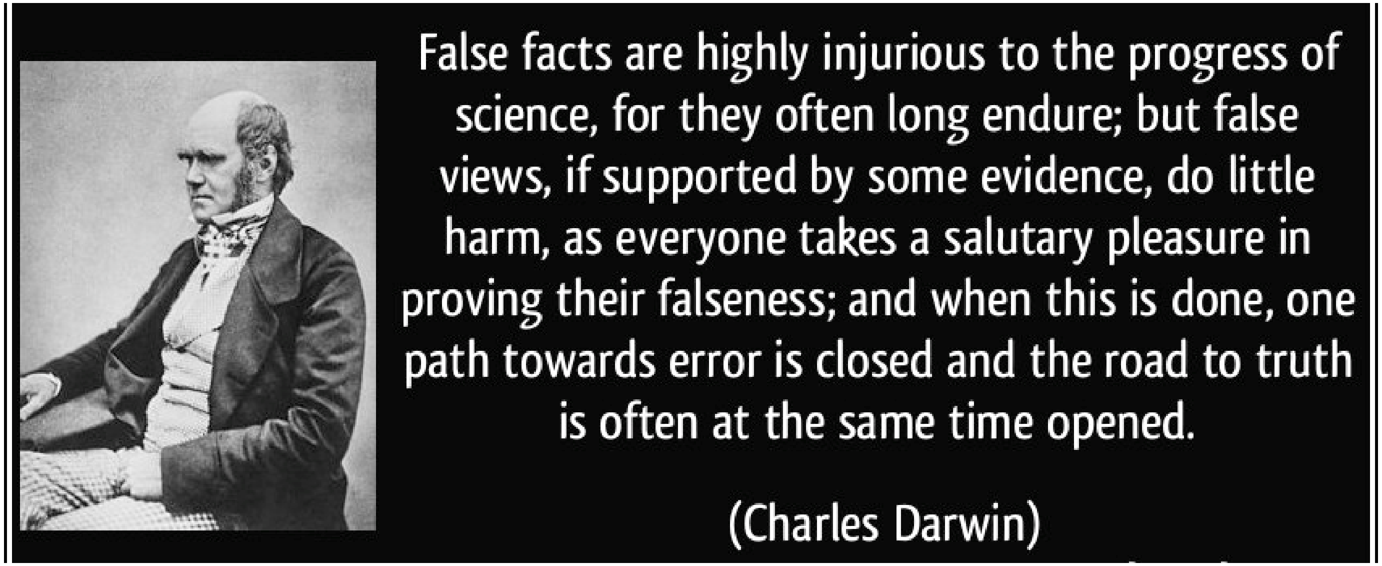
Creative destruction



The progress of science is strewn, like an ancient desert trail, with the bleached skeleton of discarded theories which once seemed to possess eternal life.

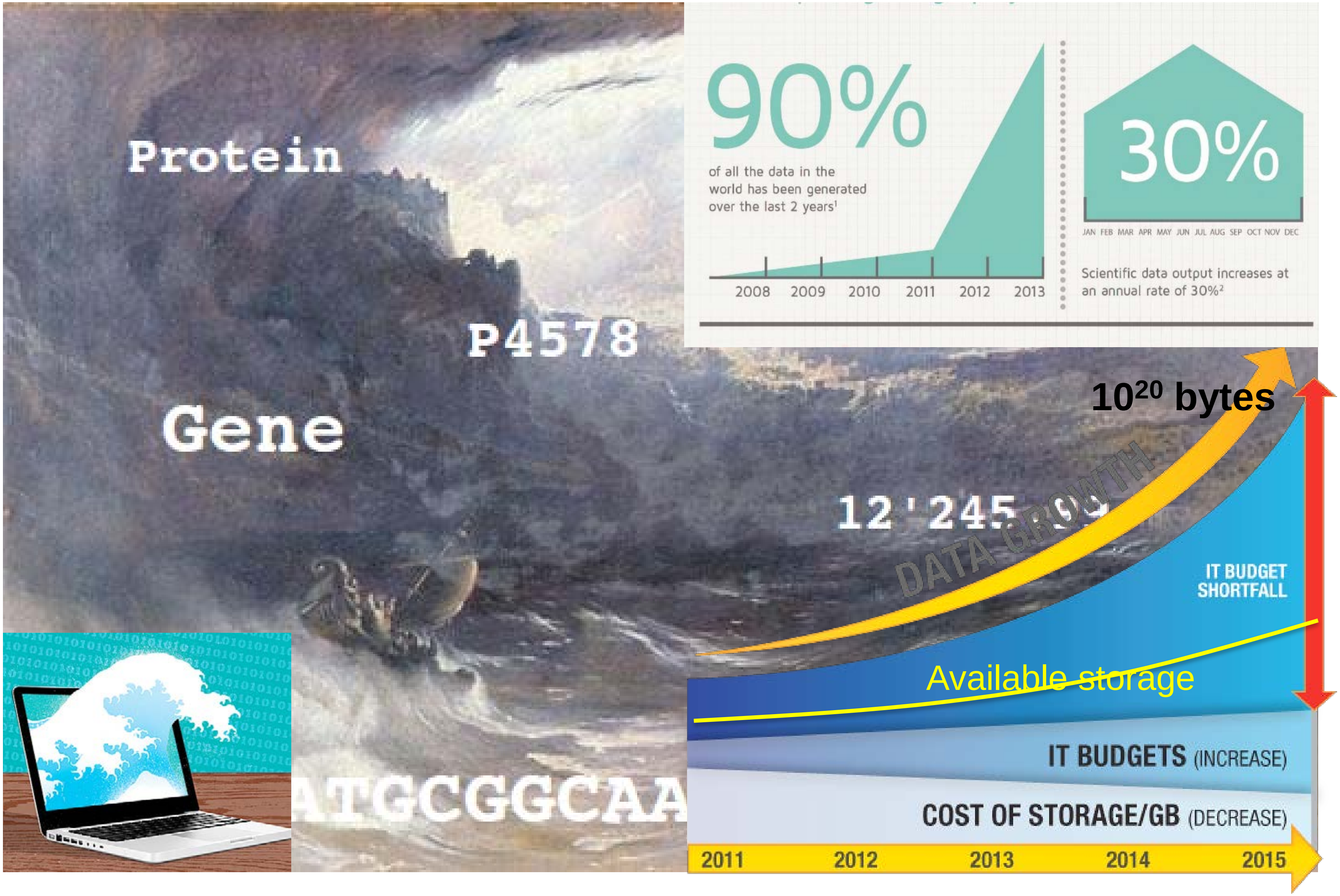
(Arthur Koestler)

Good & bad retraction



False facts are highly injurious to the progress of science, for they often long endure; but false views, if supported by some evidence, do little harm, as everyone takes a salutary pleasure in proving their falseness; and when this is done, one path towards error is closed and the road to truth is often at the same time opened.

(Charles Darwin)



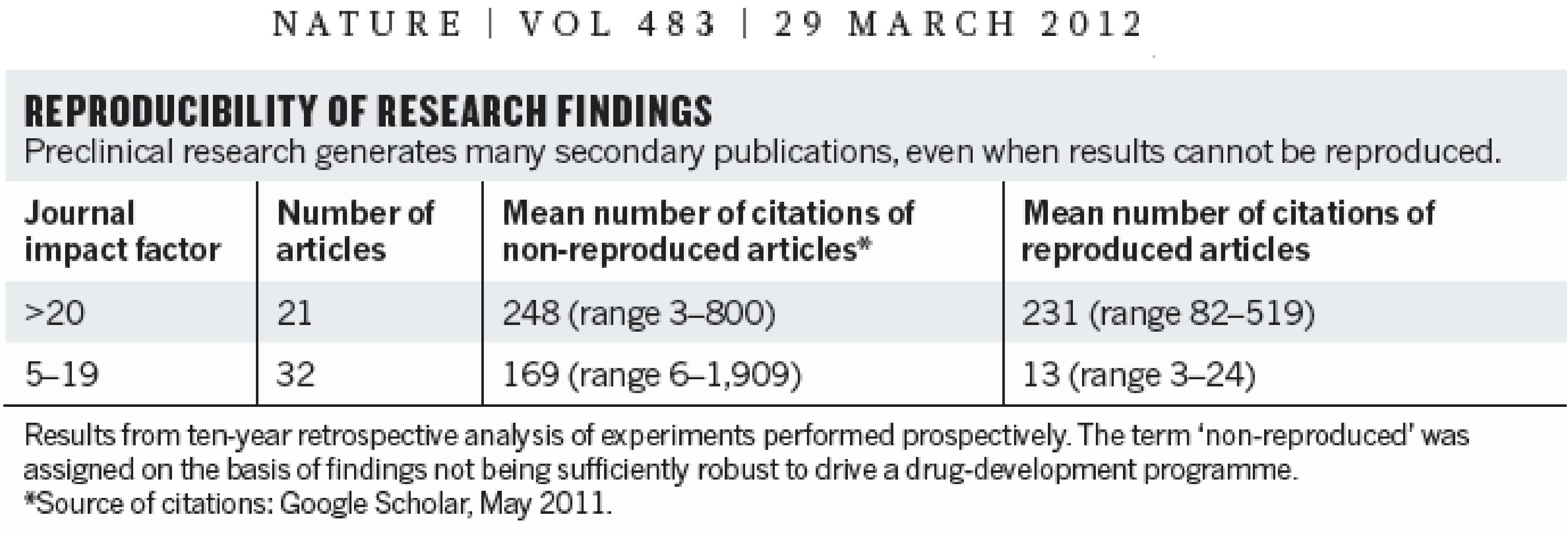
of all the data in the world has been generated over the last 2 years[1]

Scientific data output increases at an annual rate of 30%[2]

The Challenge: the “Data Storm” is undermining “self correction”

THEN AND NOW

A crisis of replicability and credibility?



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.

A fundamental principle: the data providing the evidence for a published concept MUST be concurrently published, together with the metadata

To do otherwise should come to be regarded as scientific MALPRACTICE.

The Economist

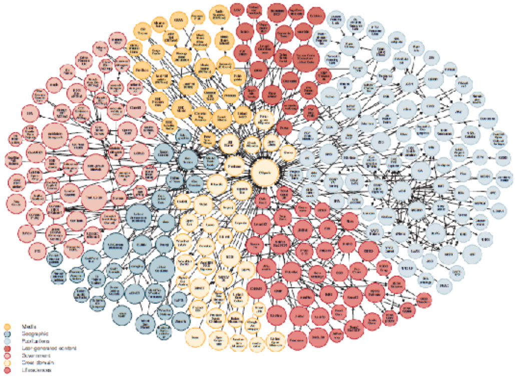
“Scientists like to think of science as self-correcting. To an alarming degree, it is not.”

Seizing the opportunities

The opportunity: 1. identifying hitherto unresolvable patterns in phenomena

Enabling agreements/ tools/ solutions needed:

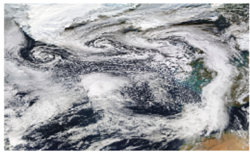
- low access thresholds
- metadata
- integration
- provenance
- persistent identifiers
- standards
- data citation formats
- algorithm integration
- file-format translation
- inter-operability
- software-archiving
- automated data reading
- metadata generation
- timing of data release
- certification
- "fair data"



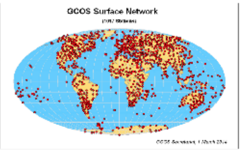
The semantic web?

The opportunity: 2. data-modelling: iterative integration

Satellite observation

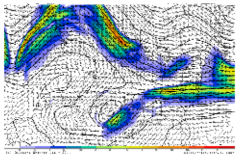


Surface monitoring

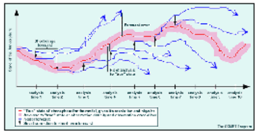


Initial conditions

Model forecast



Model-data iteration - forecast correction

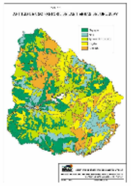


The opportunity: 3. deepening data integration

Scientific opportunity

UNEP
United Nations Environment Programme

4500 Variables: e.g.
Annual Precipitation
Annual Temperature
Anthropogenic impacts on Marine Ecosystems
- Nutrient Pollution (Fertilizer)
Aquaculture Production - Inland Water
Aquaculture Production - Marine
Aquaculture Production - Total
Arable Land
Arable and Permanent Crops
Arsenic in Groundwater - Probability of



Commercial opportunity

MONSANTO
BIOTECHNOLOGY
innovation – collaboration – speed

Purchases

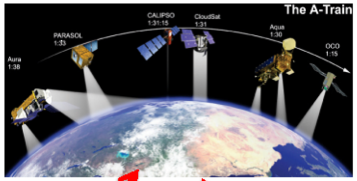
For $930 million

Historic rainfall & infiltration data
Soil properties & quality

In order to:
Predict agricultural yields to ascend to "the next level of agricultural evaluation"

The opportunity: 4. linked sensors & machine learning

The "Internet of Things"

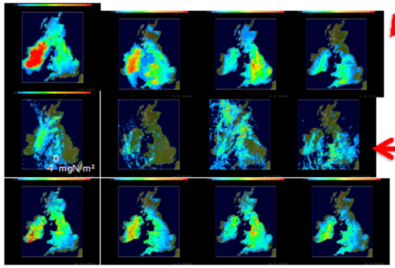


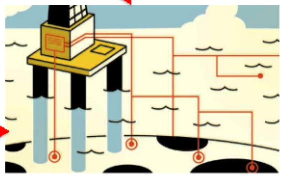
December 2005
1st 2nd 3rd 4th

Air conc .NH_3

Wet dep.

Dry dep.



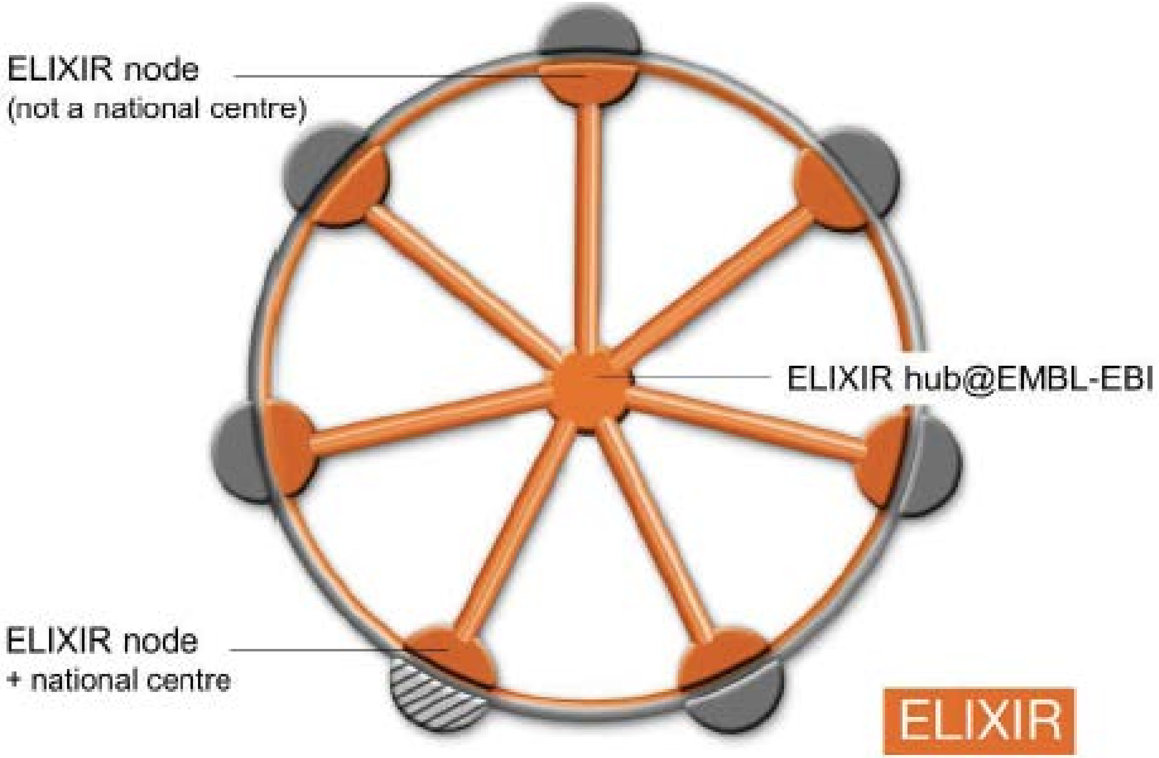


acquisition – integration
analysis - feedback

But seizing these opportunities depends on an ethos of data-sharing

Example:

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



EXAMPLES OF WHERE AN OPEN DATA ETHOS OPERATES OR IS DEVELOPING

Operating

- Crystallography
- Genomics/Bioinformatics

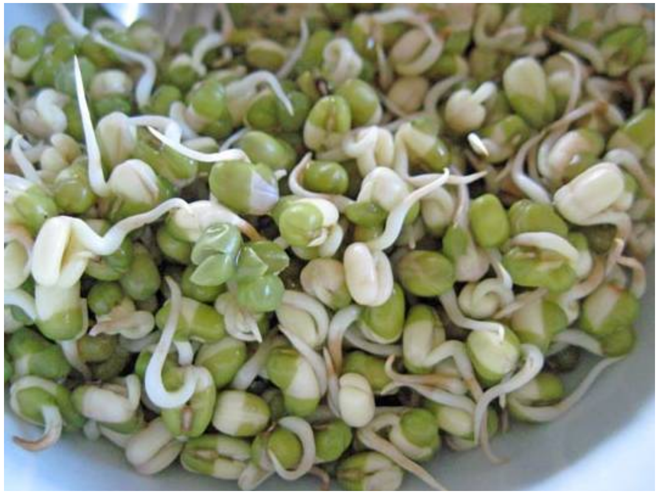
Developing

- Geosciences
- Chemistry
- Ecology
- Longitudinal studies in social statistics

Data sharing for emergencies & global challenges

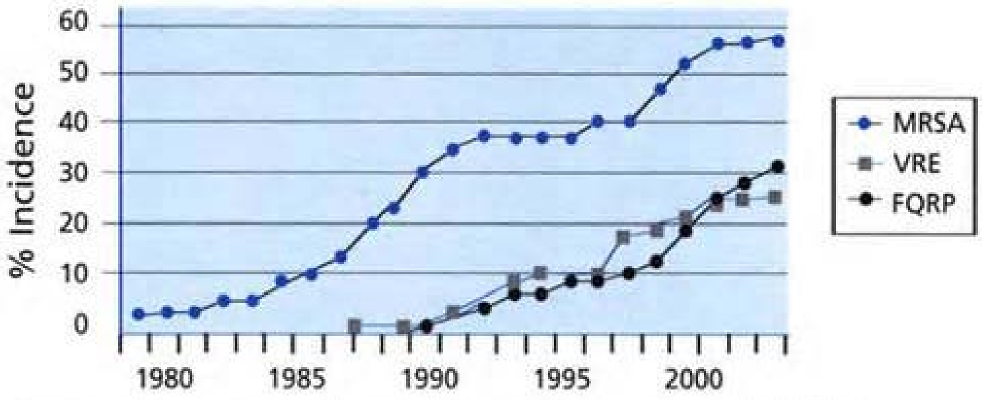
e.g. Response to Gastro-intestinal infection in Hamburg

- E-coli outbreak spread through several countries affecting 4000 people
- Strain analysed and genome released under an open data license.
- Two dozen reports in a week with interest from 4 continents
- Crucial information about strain's virulence and resistance



e.g. Global challenges – e.g rise of antibiotic resistance

- A global challenge that inevitably needs a global response based on data sharing



MRSA = methicillin-resistant *Staphylococcus aureus*; VRE = Vancomycin-resistant *enterococci*
FQRP = Fluoroquinolone-resistant *Pseudomonas aeruginosa*

But it is also vital that we apply appropriate statistical approaches and techniques to our data

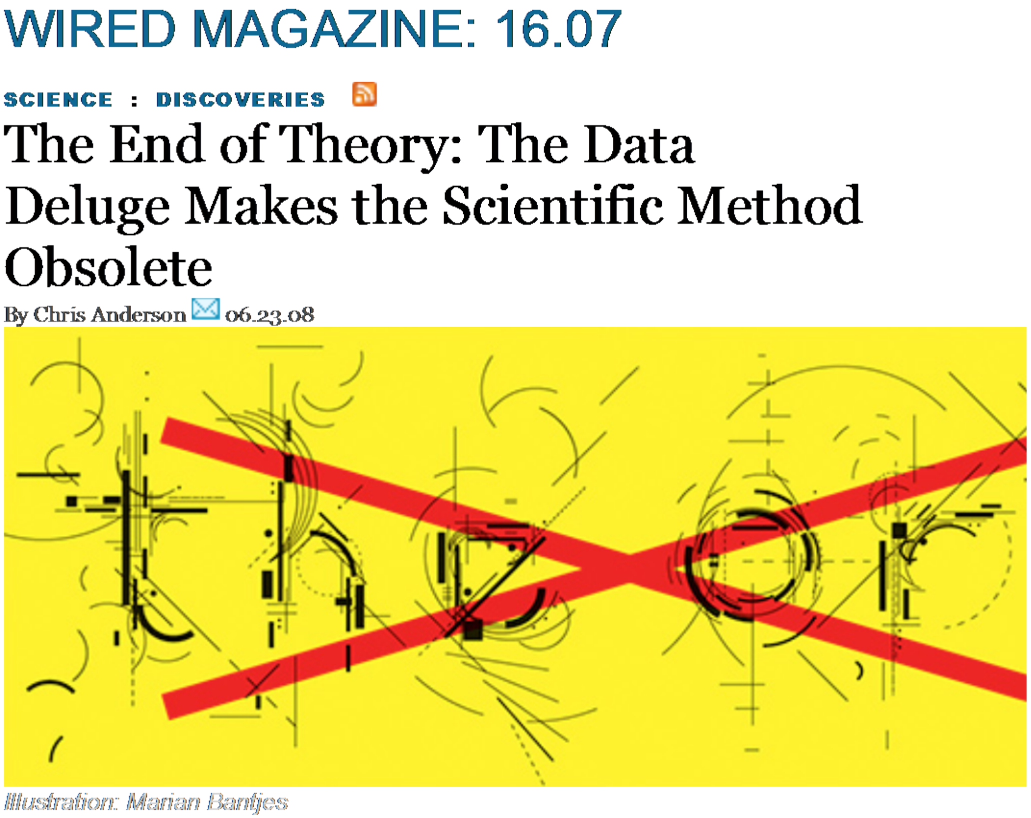
Jim Gray - “When you go and look at what scientists are doing, day in and day out, in terms of data analysis, it is truly dreadful. We are embarrassed by our data!”

....and Big Data compounds the problem.

So what are the priorities?

1. Ensuring valid reasoning
2. Innovative manipulation to create new information
3. Effective management of the data ecology
4. Education & training in data informatics & statistics

…and a new fundamental debate in the petabyte world



WIRED MAGAZINE: 16.07

SCIENCE : DISCOVERIES

The End of Theory: The Data Deluge Makes the Scientific Method Obsolete

By Chris Anderson 06.23.08

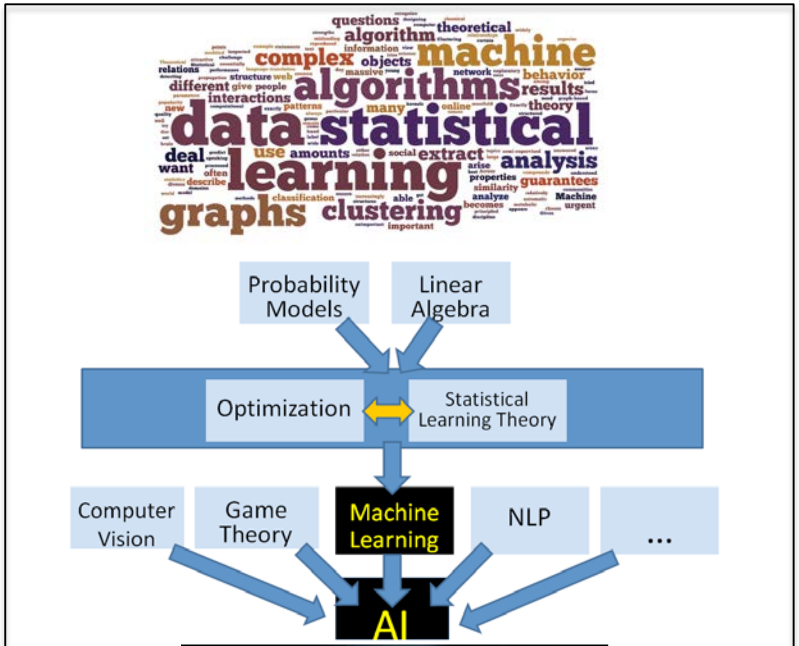
Illustration: Marian Bantjes

Thesis: Correlation is not causation.

Anti-thesis: Correlation is enough.

Question: If we know “how things are”, do we need to know “why they are?”

The nightmare: disconnect between machine analysis & human cognition



Probability Models

Linear Algebra

Optimization

Statistical Learning Theory

Computer Vision

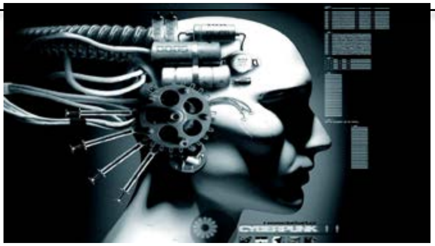
Game Theory

Machine Learning

NLP

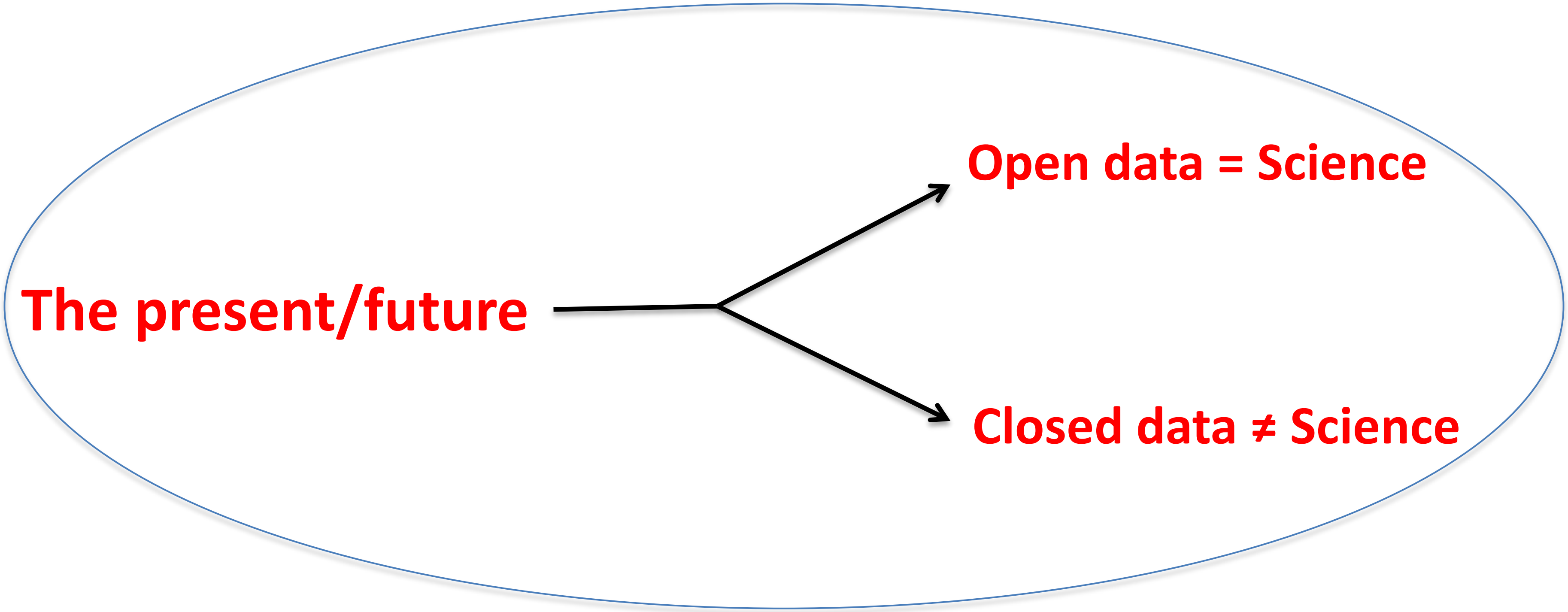
...

AI



What is the human role?
Can we analyse & scrutinise what is in the black box?
What does it mean to be a researcher in a data intensive age?
Who owns the box: the tragedy of the commons in understanding?

The future of “science”?



The present/future

Open data = Science

Closed data ≠ Science

Openness of data *per se* has little value:

open science is more than disclosure

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

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

Only when these criteria are fulfilled are data properly open.

But, intelligent openness must be audience sensitive.

Open data to whom and for what?

Scientists – Citizen scientists - Citizens

Boundaries of openness?

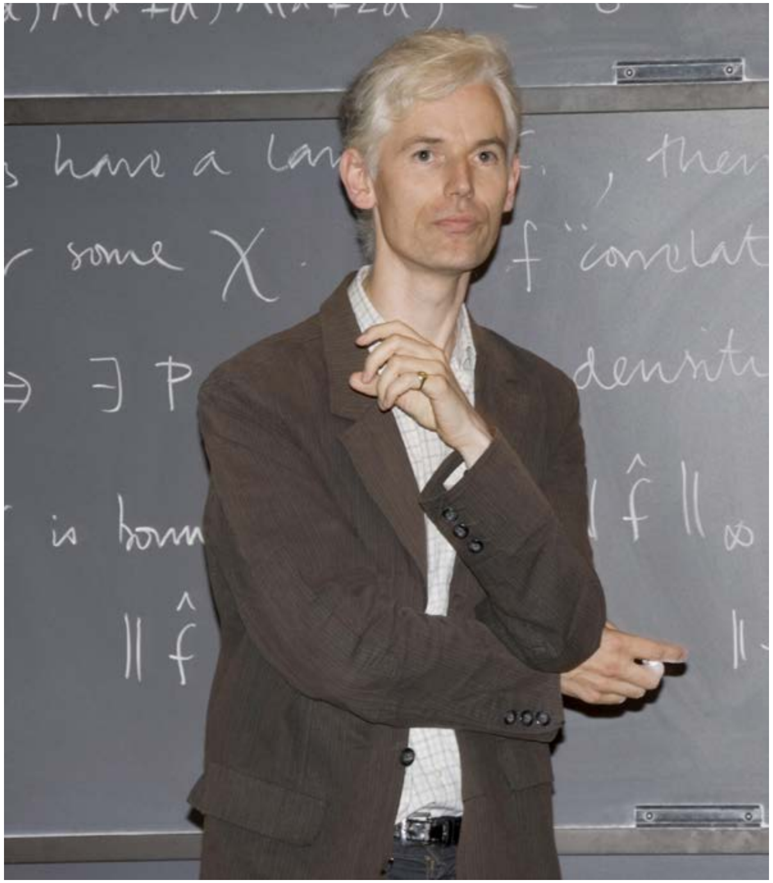
Openness should be the default position, with proportional exceptions for:

- **Legitimate commercial interests** **(sectoral variation)**
- **Privacy** **("safe data" v open data – the anonymisation problem)**
- **Safety, security & dual use** **(impacts contentious)**

All these boundaries are fuzzy

New modes of technology-Enabled creativity:

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**

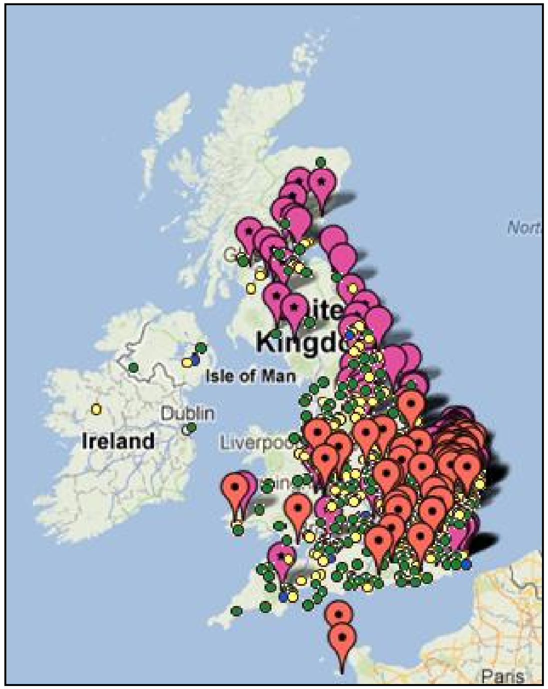
– ALTMETRICS THE ANSWER?

a changing social dynamic in science?

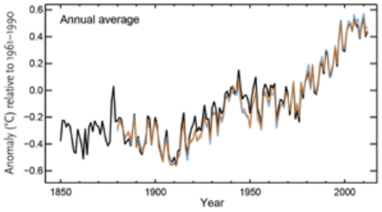
Citizen science

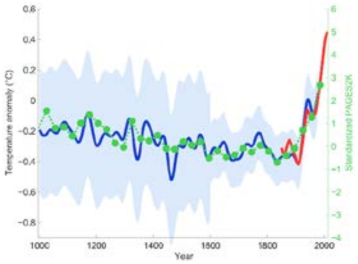
ASHTAG

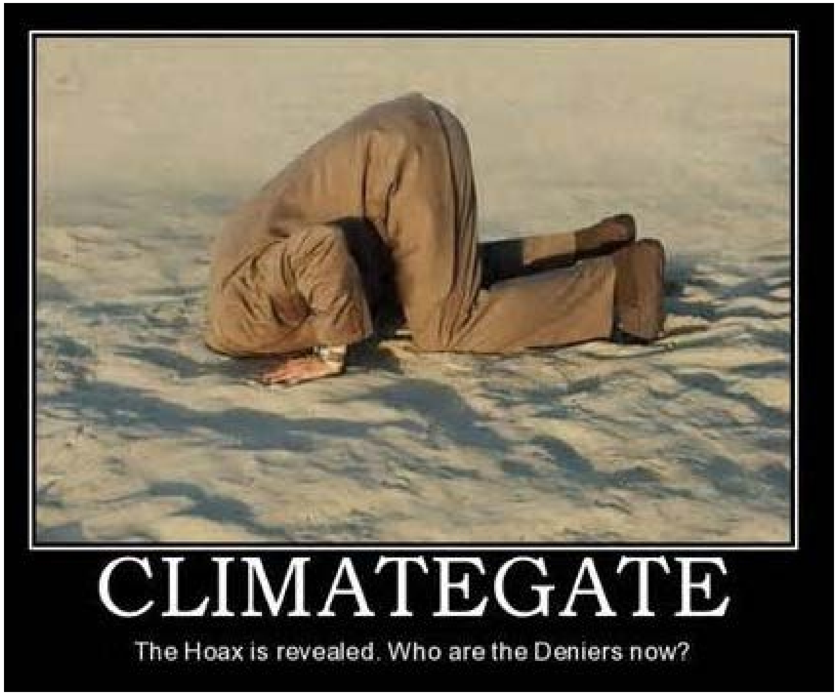
Available on the App Store



Opening the evidence to public scrutiny







Open data & the inhibition of scientific fraud

theguardian

"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:

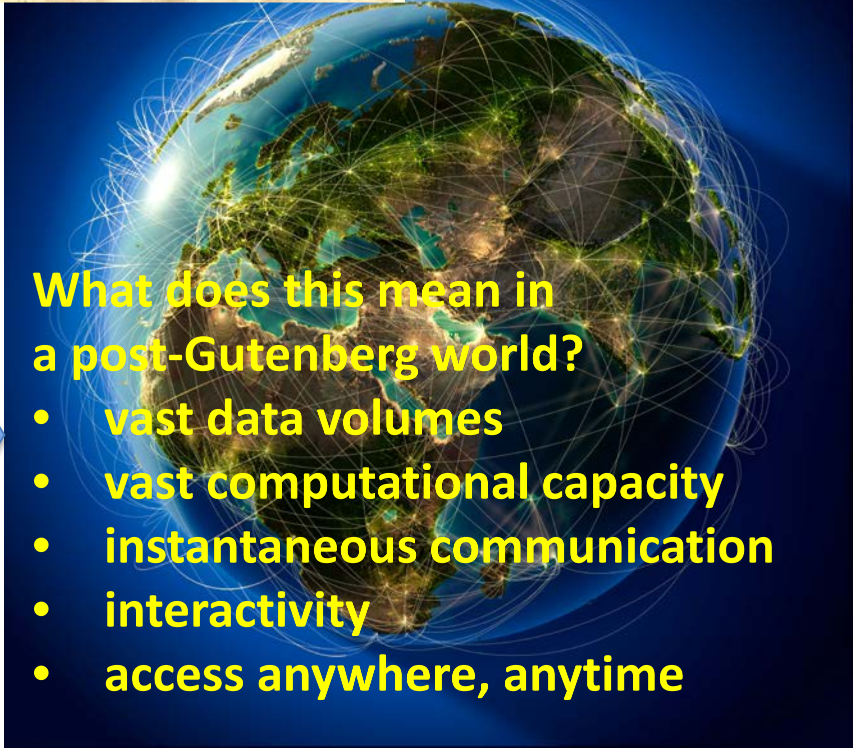
Open data for replication
Transparent peer review
Not just personal integrity – but system integrity

EXCELLENCE IN SCIENCE

THE ROYAL SOCIETY

Infrastructure: e.g. changing technology & the historic role of the library

to collect, to organize, to preserve knowledge, and to make it accessible



What does this mean in a post-Gutenberg world?

- vast data volumes
- vast computational capacity
- instantaneous communication
- interactivity
- access anywhere, anytime

Changing and adapting: whose responsibilities?

- **Scientists:** - changing the mindset
- **Learned Societies:** - influencing their communities
- **Universities / Insts:**
  - incentives & promotion criteria
  - proactive, not just compliant
  - the library function
  - management processes
- **Funders of research:**
  - mandate intelligent openness
  - accept diverse outputs
  - cost of open data is a cost of science
  - strategic funding for technical solutions (a priority for international collaboration)
- **Publishers:** - mandate concurrent open deposition
- **Governments & the EU:** - do not over-engineer an ecology with emergent properties

Its mostly people & institutions – not systems, regulation & hardware

Don’t preach – Incentivise

Researchers

- Advancement & promotion
- Data citation – 2 for the price of 1

Universities/institutes

- Funding incentives for open data
- Greater potential for scientific value

Systems

International

CODATA

- Standards
- Protocols
- Tools
- Interoperable systems

Research Data Alliance

- Domain specific solutions
- Community stimulation

Data Bases

- WDS
- GEO
- Etc

Inter-Govt support

- Horizon 2020
- G8 statement
- Obama White House

Janus

National

Funding bodies

- Research Councils
- University Funding Councils
- Research charities

Research performers

- Universities
- Institutes

Learned societies

- National academies
- Disciplinary societies

Technical bodies

- British library
- JISC
- PLOS
- etc

Publishers

UK Research Data Forum

Universities/Institutes; Funders; Publishers; Learned Societies; Technical Bodies

(UUK, Russell Group, RCUK, HEFCE, British Library, JISC, RIN, RSC, W3C, PLOS, Nature, Wellcome Trust, Dryad, CODATA, W3C etc)

Purpose

- articulate the rationale, principles, processes and priorities
- coherent approach across the research process
- consistent with and influencing international developments
- practical steps to implement an open data regime & remove barriers
- advise Govt on its proper role (thro' RSTB)

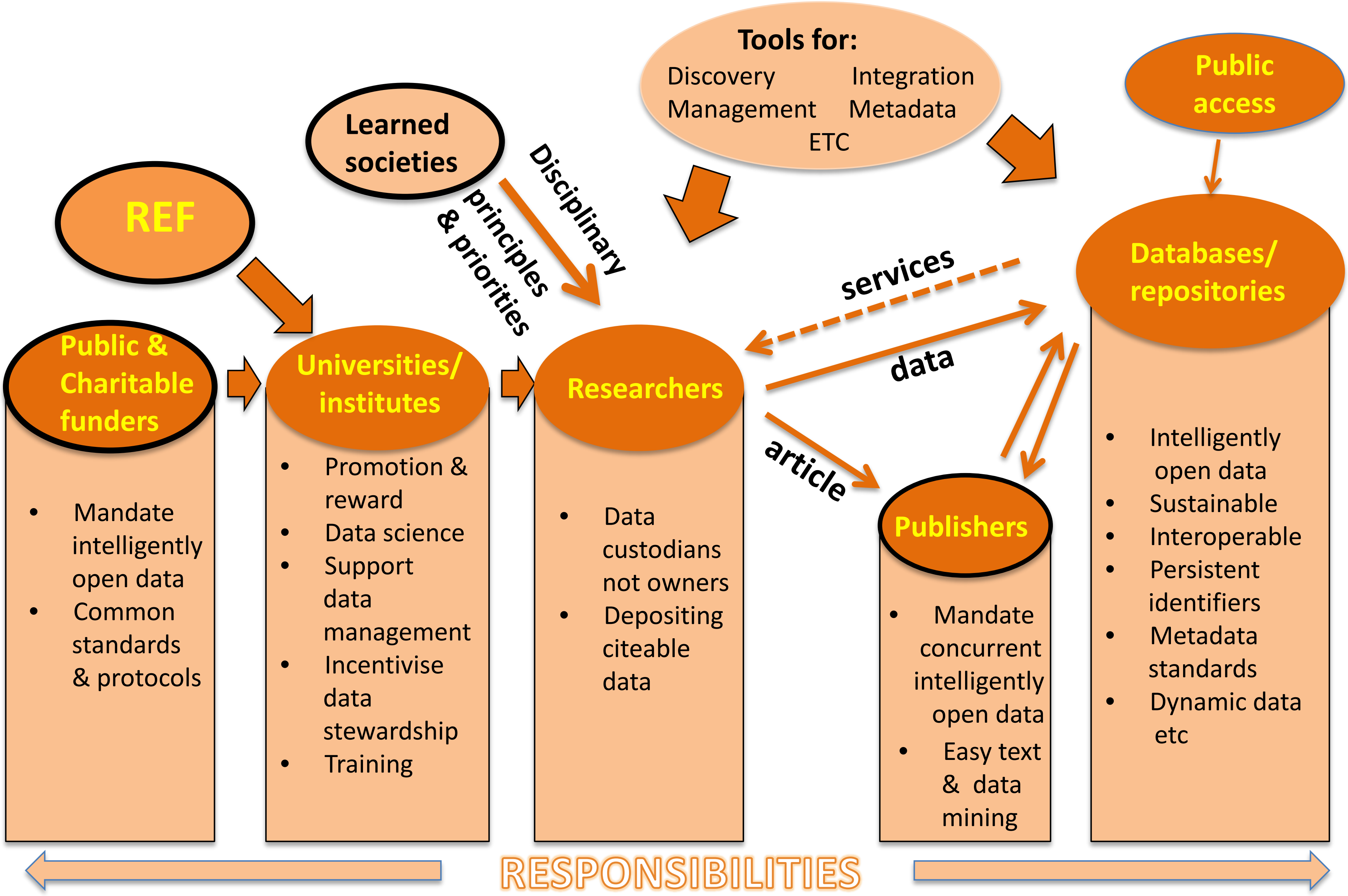
First targets

- RC/FC/Univs/Insts concordat (similar to that on research integrity)
- Data citation using Datacite
- Adoption of "intelligent openness" criteria by RCs
- Database registers
- Joint development of SHARE with US "Coherence committee"

Dangers on the flank

- Publishers inhibition of text and data mining
- EU confidentiality regulation

A data infrastructure ecology: drivers and self-organising components (the rationale for the UK Open Data Forum)



Public & Charitable funders

- Mandate intelligently open data
- Common standards & protocols

Universities/ institutes

- Promotion & reward
- Data science
- Support data management
- Incentivise data stewardship
- Training

Researchers

- Data custodians not owners
- Depositing citeable data

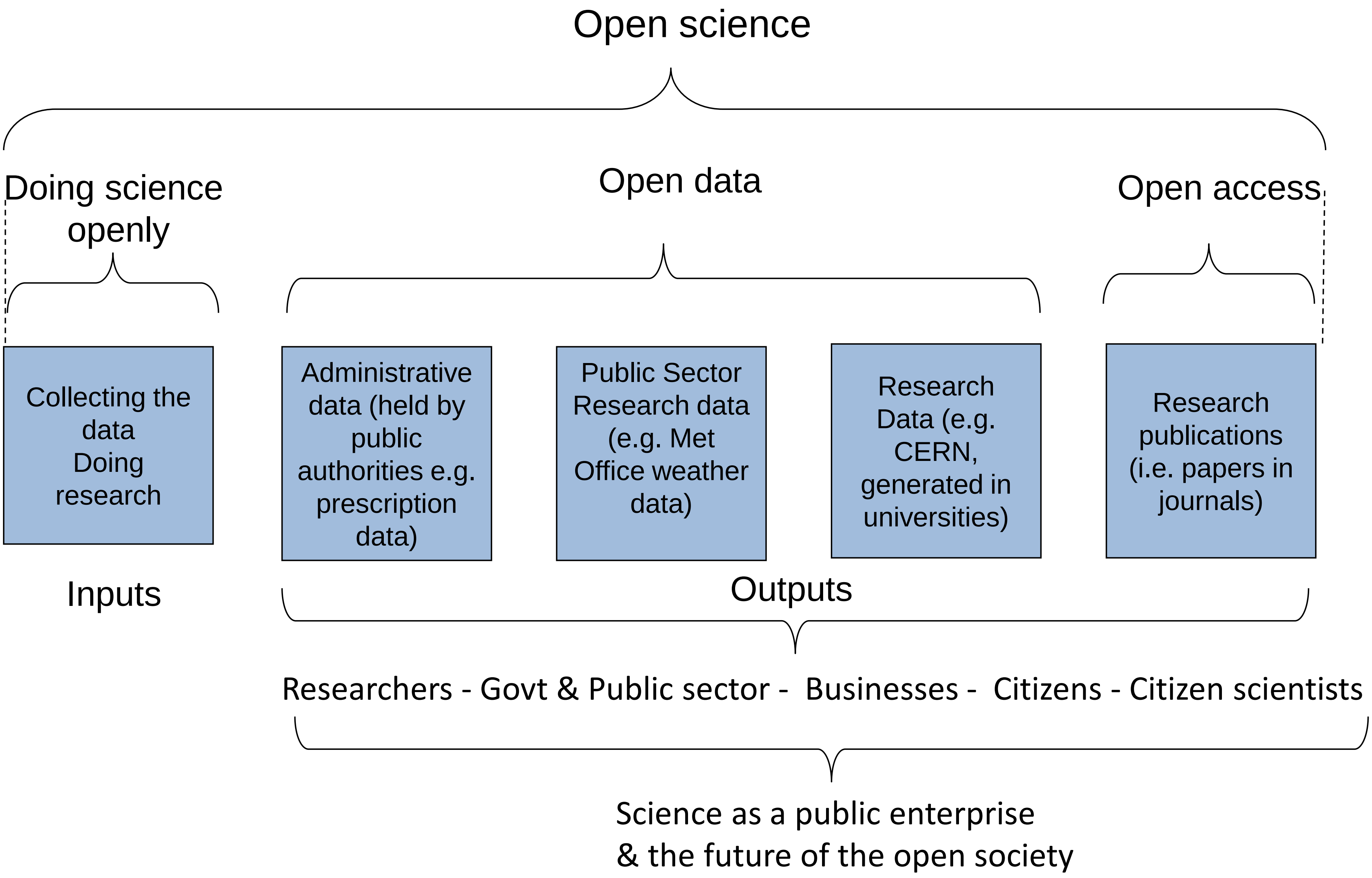
Publishers

- Mandate concurrent intelligently open data
- Easy text & data mining

Databases/ repositories

- Intelligently open data
- Sustainable
- Interoperable
- Persistent identifiers
- Metadata standards
- Dynamic data etc

A taxonomy of openness



Open science

Doing science openly

Open data

Open access

Collecting the data
Doing research

Administrative data (held by public authorities e.g. prescription data)

Public Sector Research data (e.g. Met Office weather data)

Research Data (e.g. CERN, generated in universities)

Research publications (i.e. papers in journals)

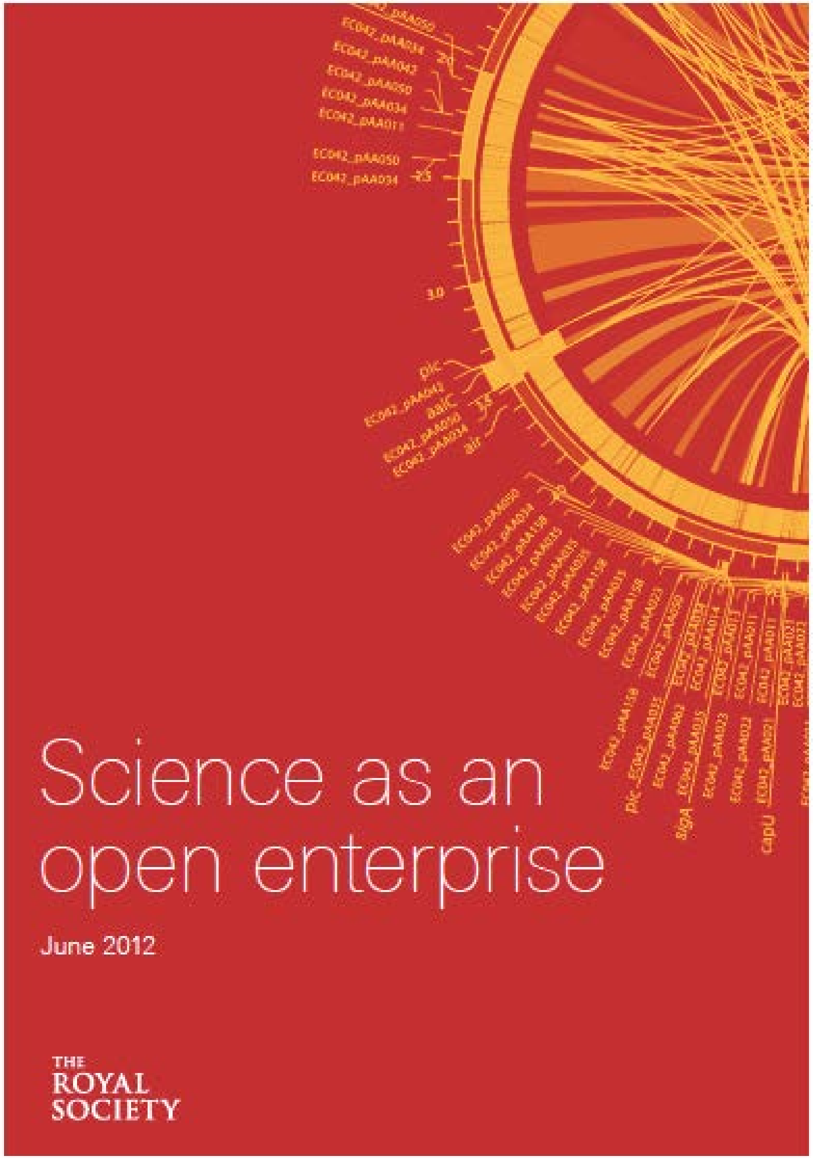
Inputs

Outputs

Researchers - Govt & Public sector - Businesses - Citizens - Citizen scientists

Science as a public enterprise
& the future of the open society

www.royalsociety.org



Science as an open enterprise

June 2012

THE
ROYAL
SOCIETY