# Open Science & FAIR

*Introduction to Data Management Practices course*

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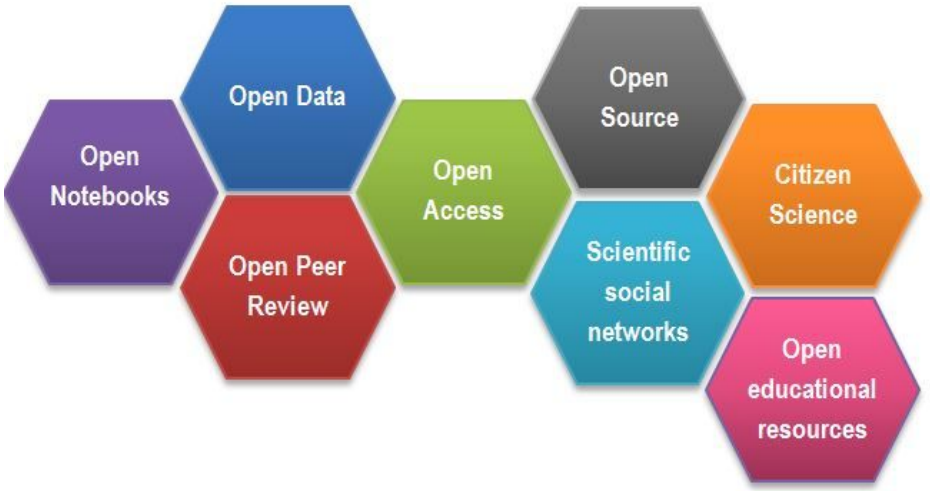
https://nbisweden.github.io/module-open-science-dm-practices/index.html

# Open Science

Make scientific research and its dissemination accessible to all levels of society.

- Open methodology
- **Open source**
- **Open data**
- Open access
- Open peer review
- Open educational resources



# What do you think are reasons for Open Data?

# Open Data

- Democracy and transparency
  - Publicly funded research data should be accessible to all
  - Published results and conclusions should be possible to check by others
- Research
  - Enables others to combine data, address new questions, and develop new analytical methods
  - Reduce duplication and waste
- Innovation and utilization outside research
  - Public authorities, companies, and private persons outside research can make use of the data
- Citation
  - Citation of data will be a merit for the researcher that produced it


Picture source: Karolinska institute library

# Ethical?

*Doing “sloppy” science & not being open and transparent*

Waste of resources

Contributing to the current research credibility crisis

Contributing to the current reproducibility crisis

*Harming the profession*

*Harming public trust in research*

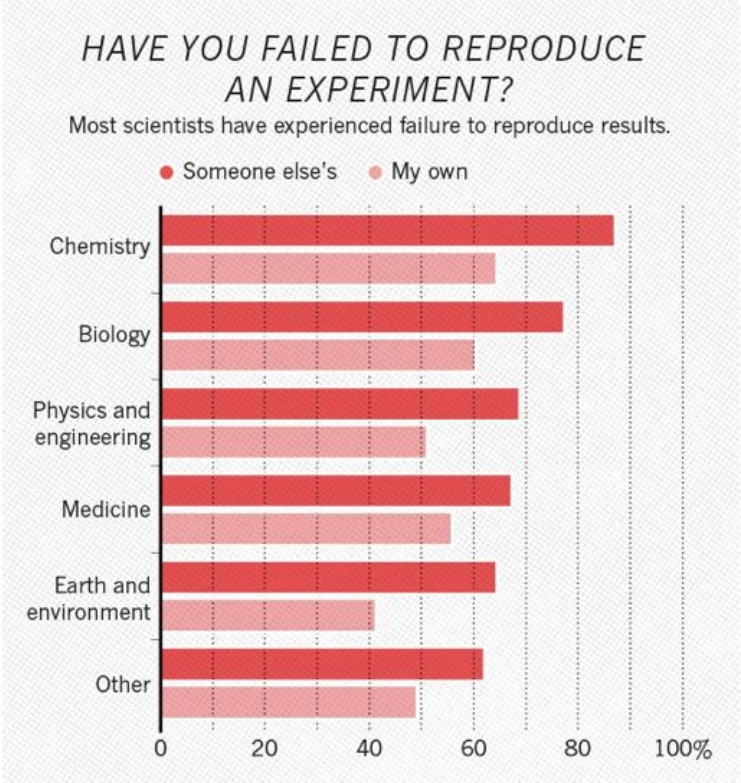
*My take of material by Rochelle Tractenberg “Unexpected Ethical Challenges in Bioinformatics and Genomics.”*

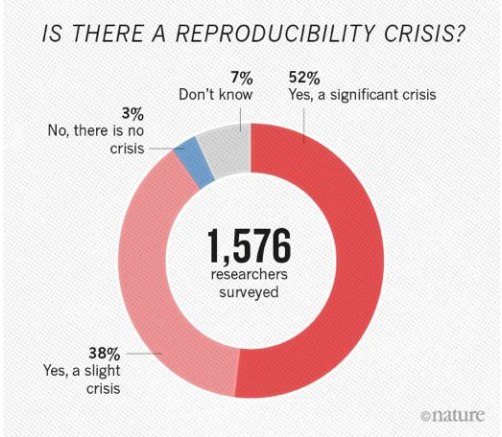
# Crisis?

**Do you think we have a credibility and/or reproducibility crisis?**

**If so, what are some of its causes?**

# A reproducibility crisis

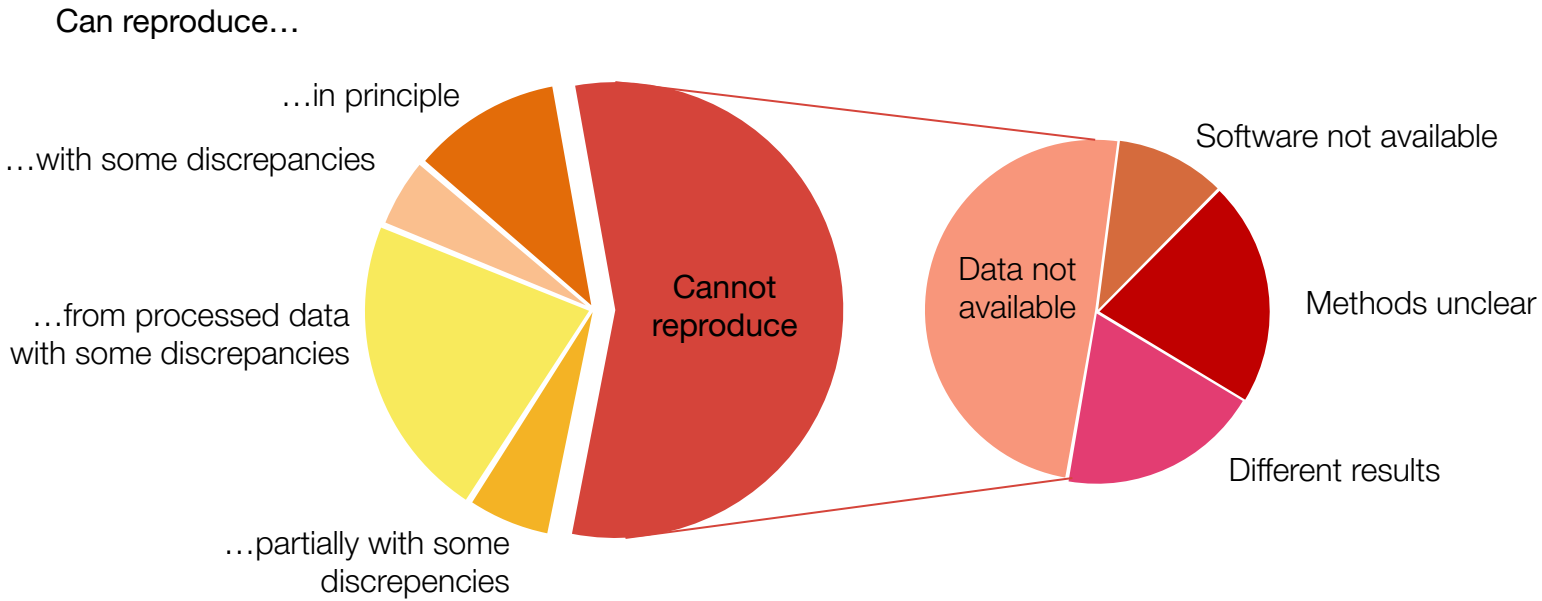



[1] "1,500 scientists lift the lid on reproducibility". Nature. 533: 452–454
[2] Begley, C. G.; Ellis, L. M. (2012). "Drug development: Raise standards for preclinical cancer research". Nature. 483 (7391): 531–533.

# A reproducibility crisis

Reproduction of data analyses in 18 articles on microarray-based gene expression profiling published in Nature Genetics in 2005–2006:




Summary of the efforts to replicate the published analyses.
Adopted from: Ioannidis et al. Repeatability of published microarray gene expression analyses. *Nature Genetics* **41** (2009) doi:10.1038/ng.295

# Data Management Snafu


https://www.youtube.com/watch?v=N2zK3sAtr-4

# FAIR

- To be useful for others data should be
  - ***FAIR*** - Findable, Accessible, Interoperable, and Reusable
    *… for both Machines and Humans*

Wilkinson, Mark et al. *"The FAIR Guiding Principles for scientific data management and stewardship"*. Scientific Data 3, Article number: 160018 (2016) http://dx.doi.org/10.1038/sdata.2016.18

www.nature.com/scientificdata

SCIENTIFIC DATA

OPEN

SUBJECT CATEGORIES
» Research data
» Publication characteristics

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## Comment: The FAIR Guiding Principles for scientific data management and stewardship

Mark D. Wilkinson *et al.*#

There is an urgent need to improve the infrastructure supporting the reuse of scholarly data. A diverse set of stakeholders—representing academia, industry, funding agencies, and scholarly publishers—have come together to design and jointly endorse a concise and measureable set of principles that we refer to as the FAIR Data Principles. The intent is that these may act as a guideline for those wishing to enhance the reusability of their data holdings. Distinct from peer initiatives that focus on the human scholar, the FAIR Principles put specific emphasis on enhancing the ability of machines to automatically find and use the data, in addition to supporting its reuse by individuals. This Comment is the first formal publication of the FAIR Principles, and includes the rationale behind them, and some exemplar implementations in the community.

### Supporting discovery through good data management

Good data management is not a goal in itself, but rather is the key conduit leading to knowledge discovery and innovation, and to subsequent data and knowledge integration and reuse by the

**Box 2** | The FAIR Guiding Principles

**To be Findable:**
F1. (meta)data are assigned a globally unique and persistent identifier
F2. data are described with rich metadata (defined by R1 below)
F3. metadata clearly and explicitly include the identifier of the data it describes
F4. (meta)data are registered or indexed in a searchable resource

**To be Accessible:**
A1. (meta)data are retrievable by their identifier using a standardized communications protocol
A1.1 the protocol is open, free, and universally implementable
A1.2 the protocol allows for an authentication and authorization procedure, where necessary
A2. metadata are accessible, even when the data are no longer available

**To be Interoperable:**
I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
I2. (meta)data use vocabularies that follow FAIR principles
I3. (meta)data include qualified references to other (meta)data

**To be Reusable:**
R1. meta(data) are richly described with a plurality of accurate and relevant attributes
R1.1. (meta)data are released with a clear and accessible data usage license
R1.2. (meta)data are associated with detailed provenance
R1.3. (meta)data meet domain-relevant community standards

# Findable

- Data have a **globally unique persistent identifier**
  - *e.g. a DOI, database accession number, etc*
- Data are described by **metadata**
  - *Information that explains the data*
- Data and metadata are findable in a **search resource**
  - *There must be ways of searching for the data*

# Accessible

- Data is retrievable through a **standardised communication protocol** (open, free, allowing authentication & authorisation where necessary)
  - *e.g. http, sftp, etc*
- Metadata are accessible, **even if data is no longer available**
  - *Information about the data can be found even if data is no longer available*

# Interoperable

- Metadata use a formal, accessible, shared **language for knowledge representation**
  - *Metadata is available in a form that even a computer can make use of*
- Metadata use **vocabularies** that follow the FAIR principles
  - *Standardised ways of capturing information about the data (that are in themselves FAIR)*
- Metadata include qualified **references** to other metadata
  - *If the data relies on other data, there must be links to those*

# Reusable

- Data have a clear **data usage license**
  - *It is obvious under what conditions the data can be reused*
- Metadata are associated with **detailed provenance**
  - *The metadata is detailed enough to understand for what research questions it is relevant to reuse*
- Metadata meet domain-relevant community **standards**
  - *Metadata is described according to existing standards in the research field*

# FAIR

- Both humans and machines are intended users of data
- The principles are not necessarily about *open* data
  - “As open as possible, as closed as necessary”
- FAIRness is not something absolute
  - Different levels of FAIR maturity
- FAIR does not enforce any particular technical standards

# Metadata?

## The data about the data (or anything really)

*Example: Spleen samples from mice*

| organism | strain | age | time unit | developmental stage | sex | organism part | individual | genotype |
|---|---|---|---|---|---|---|---|---|
| Mus musculus | C57BL/6J x 129Sv | 12 | week | adult | male | spleen | 287 - 2 | HellsF/F Mb1Cre+ |
| Mus musculus | C57BL/6J x 129Sv | 12 | week | adult | male | spleen | 287 - 2 | HellsF/F Mb1Cre+ |
| Mus musculus | C57BL/6J x 129Sv | 15 | week | adult | female | spleen | 278 - 6 | HellsF/F Mb1Cre+ |
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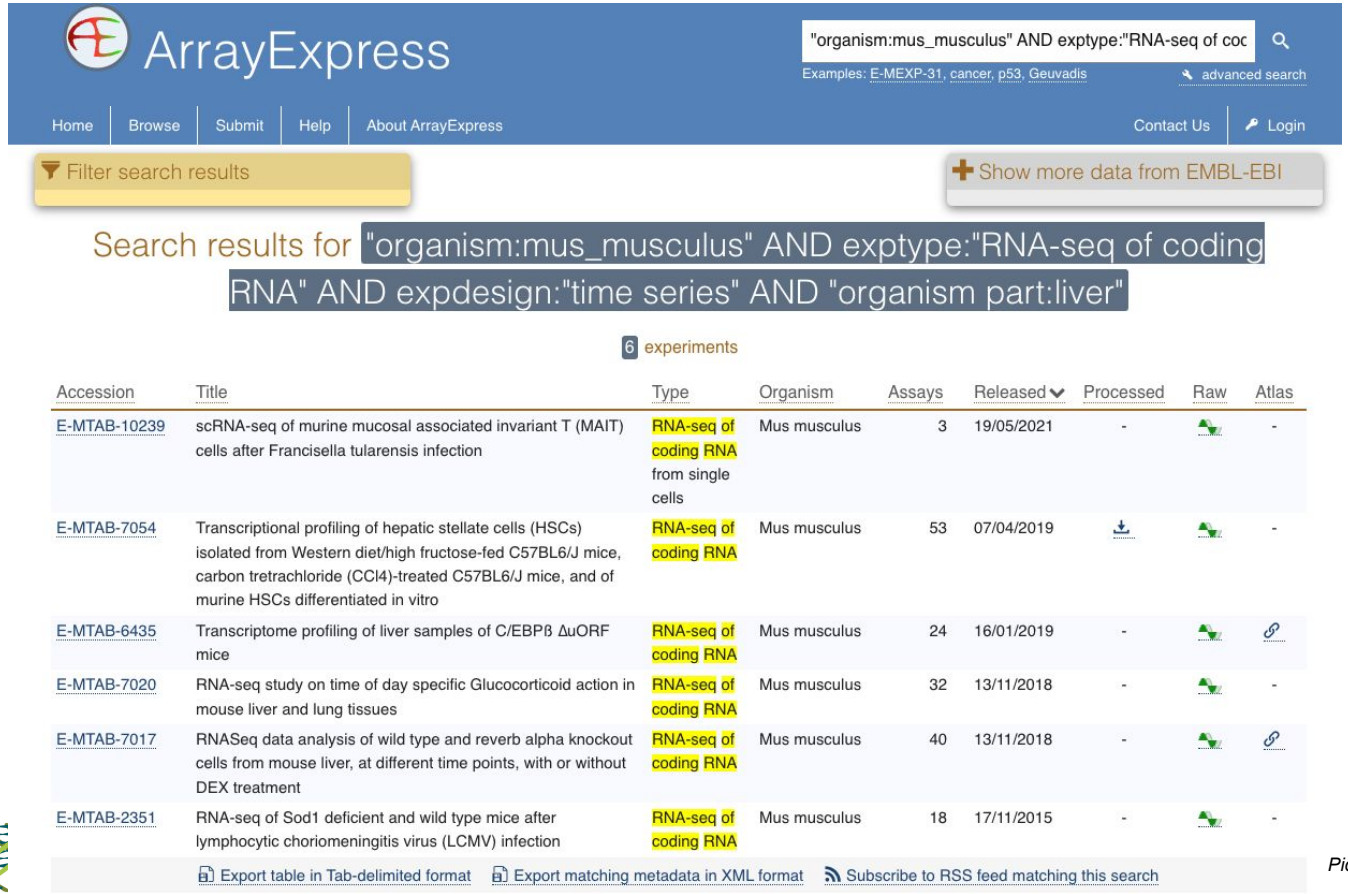
# Simple FAIR data example




*Picture source: ArrayExpress @ EMBL-EBI*

# When to be FAIR?

FAIR at source?


© rassco

Retroactively?

# Good Data Management Practices

- **Data Management Plans**, to do your thinking ahead of time
- **Using standard metadata descriptions**, to clearly define your data
- **Organising your analysis**, so you and others can understand what you have done
- **Use versioning control** to keep track of changes you do
- **Clean up metadata and data** to be consistent with the standards you have chosen
- **Submit your data to international public repositories**, so others can find and reuse your data
- **Use scripted analysis of your data**, that can be understood by others

# What data management practices do you apply in your research projects today?

| | Ad Hoc | One-Time | Active and Informative | Optimized for Re-Use |
|---|---|---|---|---|
| **Planning your project** | When it comes to my data, I have a "way of doing things" but no standard or documented plans. | I create some formal plans about how I will manage my data, but I generally don't refer back to them. | I develop detailed plans about how I will manage my data that I actively revisit and revise over the course of a project. | I design my plans for managing data to streamline future use by myself or others. |
| **Organizing your data** | I don't follow a consistent approach for keeping my data organized, so it often takes time to find things. | I have an approach for organizing my data, but I only put it into action after my project is complete. | I have an approach for organizing my data that I implement prospectively, but it not necessarily standardized. | I organize my data to the so that others can navigate, understand, and use it without me being present. |
| **Saving and backing up your data** | I decide what data is important while I am working on it and typically save it in a single location. | I know what data needs to be saved and I back it up after I'm done working on it to reduce the risk of loss. | I have a system for regularly saving important data while I am working on it. I have multiple backups. | I save my data in a manner and location designed maximize opportunities for re-use by myself and others. |
| **Getting your data ready for analysis** | I don't have a standardized or well documented process for preparing my data for analysis. | I have thought about how I will need to prepare my data, but I handle each case in a different manner. | My process for preparing data is standardized and well documented. | I prepare my data in such a way as to facilitate use by both myself and others in the future. |
| **Analyzing your data and handling the outputs** | I often have to redo my analyses or examine their products to determine what procedures or parameters were applied. | After I finish my analysis, I document the specific parameters, procedures, and protocols applied. | I regularly report the specifics of both my analysis workflow and decision making process while I am analyzing my data. | I have ensured that the specifics of my analysis workflow and decision making process can be put into action by others. |
| **Sharing and publishing your data** | I share the results of my research, but generally I do not share the underlying data. | I share my my data only when I'm required to do so or in response to direct requests from other researchers. | I regularly share the data that underlies my results and conclusions in a form that enables use by others. | Because of my excellent data management practices, I am able to efficiently share my data whenever I need to with whomever I need to. |

*Borghi, J. et al (2018). Support your Data.* [https://doi.org/10.3897/rio.4.e26439](https://doi.org/10.3897/rio.4.e26439)

# Voting

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https://bit.ly/support_your_data_rubric

# The Political landscape


**'We support appropriate efforts to promote open science and facilitate appropriate access to publicly funded research results on findable, accessible, interoperable and reusable (FAIR)'**

# The Political Landscape

- Policymakers are **pushing for research data to be made available** as openly as possible
- Big investments are being made in **infrastructure and skills for data sharing and reuse**

EUROPEAN OPEN SCIENCE CLOUD

elixir SWEDEN

SND
Swedish National Data Service

NBIS

# Policy landscape

- UNESCO's Recommendation on Open Science
- EU
  - Open Science Policy
  - Directives
  - European Research Council
  - Horizon Europe
  - EOSC
- Swedish research bills 2016 & 2020
  - Transition to open research data implemented by 2026
  - Government assignments to KB & VR
- SUHF national roadmap for open science
- University policies
- Lund Declaration on Maximising the Benefits of Research Data
- *National guidelines for open science* (KB)

*Open Science*
*FAIR*

*"FAIR […] open data sharing should become the default […]"*

*"As open as possible, as closed as necessary"*

# Motivators

https://www.pngwing.com/en/free-png-nlacv

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