BioData.pt

Ready for BioData Management?

Introduction to Research Data Management

Daniel Faria

Data, Information & Knowledge

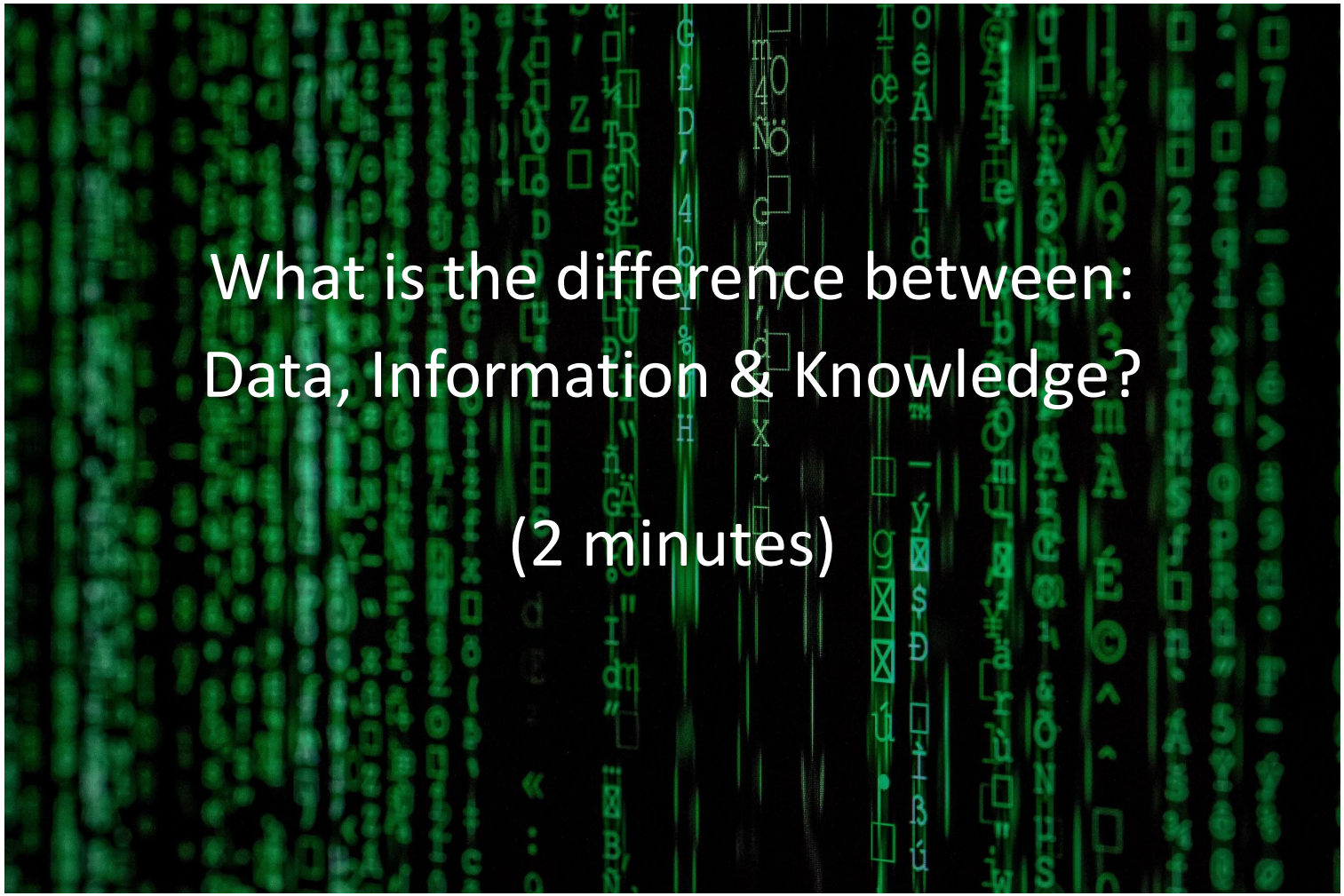
Learning Outcome 1:

Distinguish between Data, Information and Knowledge

Introduction

- Science is a knowledge discovery paradigm predicated on data acquisition and analysis
- Distinguishing between data, information and knowledge is critical for understanding the need for research data management!

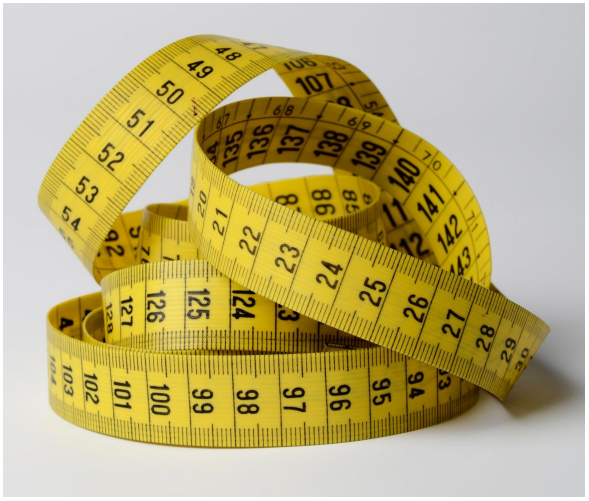
Group Discussion



By Markus Spiske temporausch.com from Pexels

Data

- Datum: an atomic fact or piece of “information”
  - Melting Point: 0℃
  - Boiling Point: 100℃
- Dataset: a collection of data that share an object or scope



By Marta Longas from Pexels

Information

- Information: data + context (metadata)
  - Substance: Water
  - Total Dissolved Solids: < 500 mg/L
  - Pressure: 1 atm

Metadata

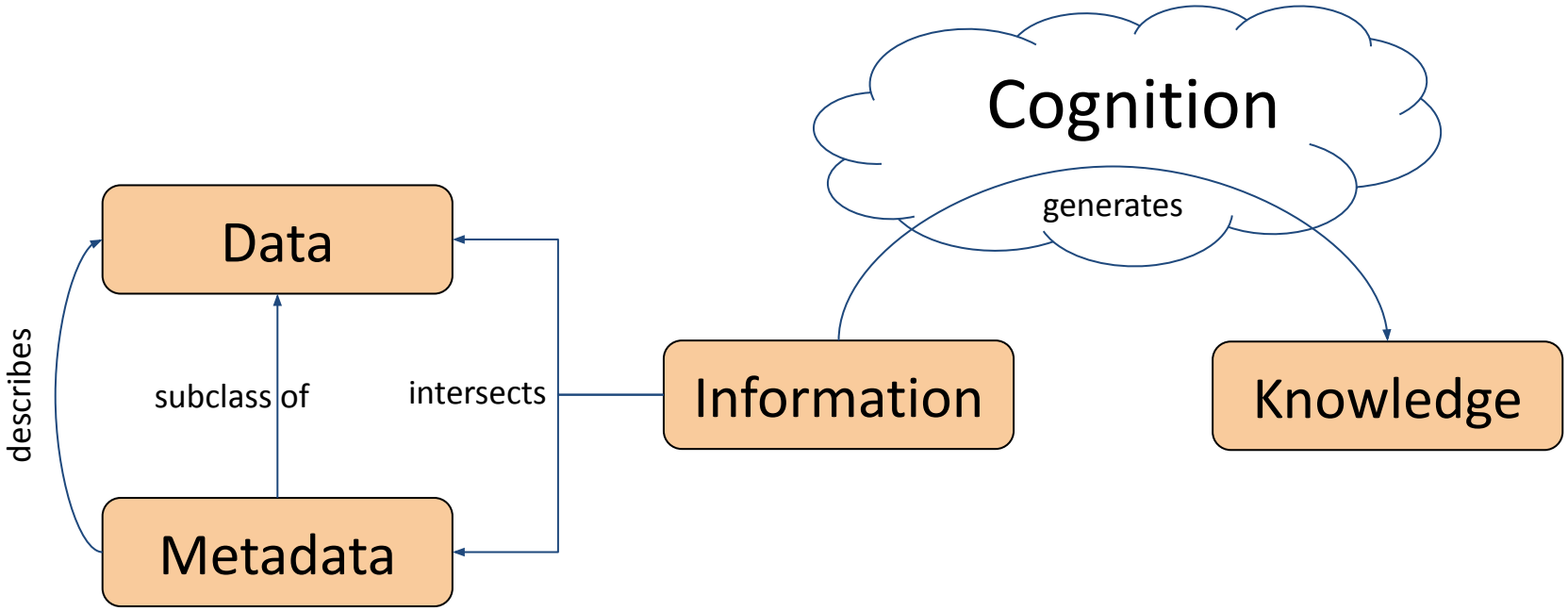
- Metadata is data about data, providing context:
  - Who produced the data?
  - When was the data produced?
  - What is the data about?
  - Why was the data produced?
  - How can the data be used? (license)

By Dr. Marcus Gossler - Own work, CC BY-SA 3.0

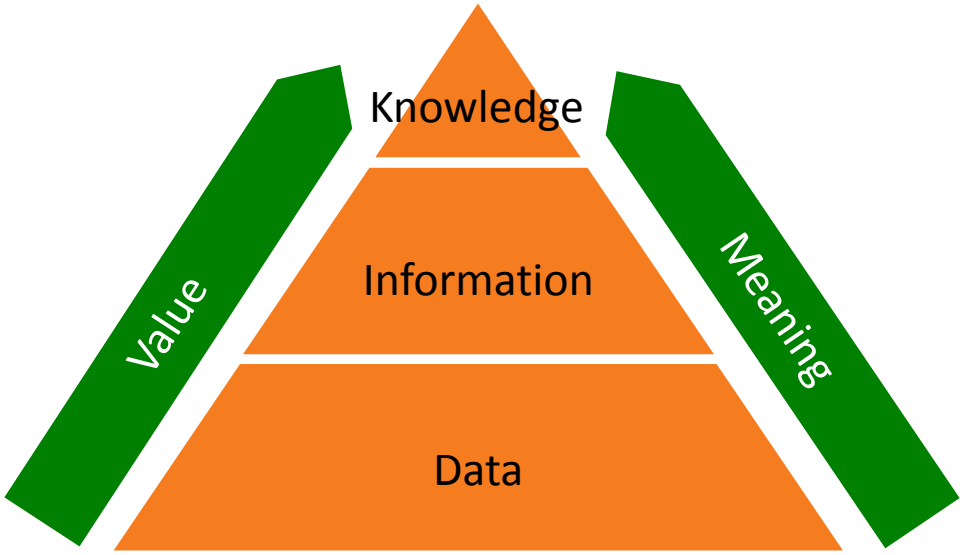
Knowledge

- Knowledge: information + (actionable) understanding
  - If I heat tap water until it starts boiling, I can cook food at 100℃
  - If I see water boiling, I shouldn't put my hand in it

Data, Information & Knowledge



Data, Information & Knowledge



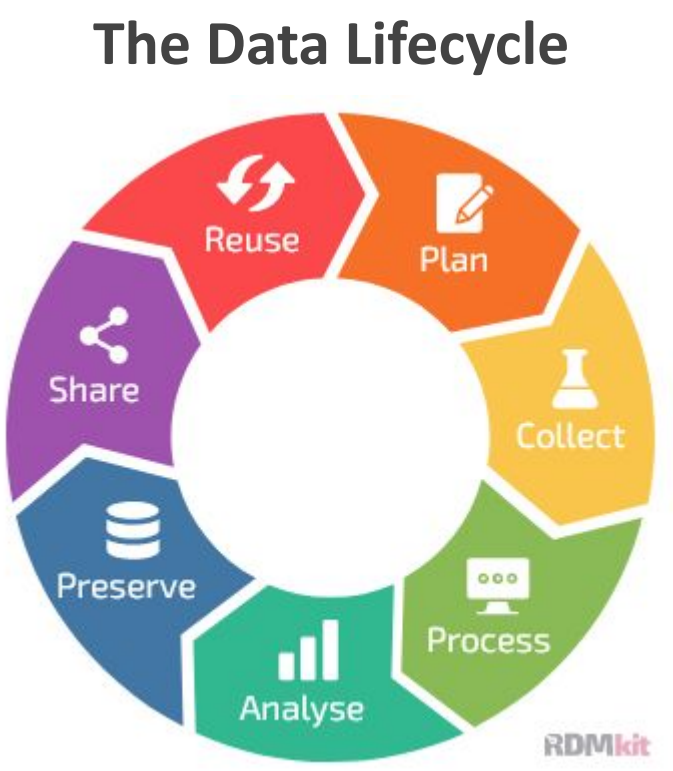
Data Reuse

Learning Outcome 2:

Identify the solutions to the data reuse problem

Introduction

- Scientists acquire data to discover knowledge, and are assessed for sharing knowledge in the form of scientific publications
- But the data itself has value for science:
  - It can be reused to discover further knowledge
  - New techniques or theories can require it to be reexamined



https://rdmkit.elixir-europe.org/

Introduction

- Data sharing has been an afterthought for most scientists
- For a few types of data, the norm is deposition in public databases, while in some cases the data is included as an appendix to the (digital) publication itself
- However, it is still not uncommon that you need to contact the author of a scientific publication to request the data

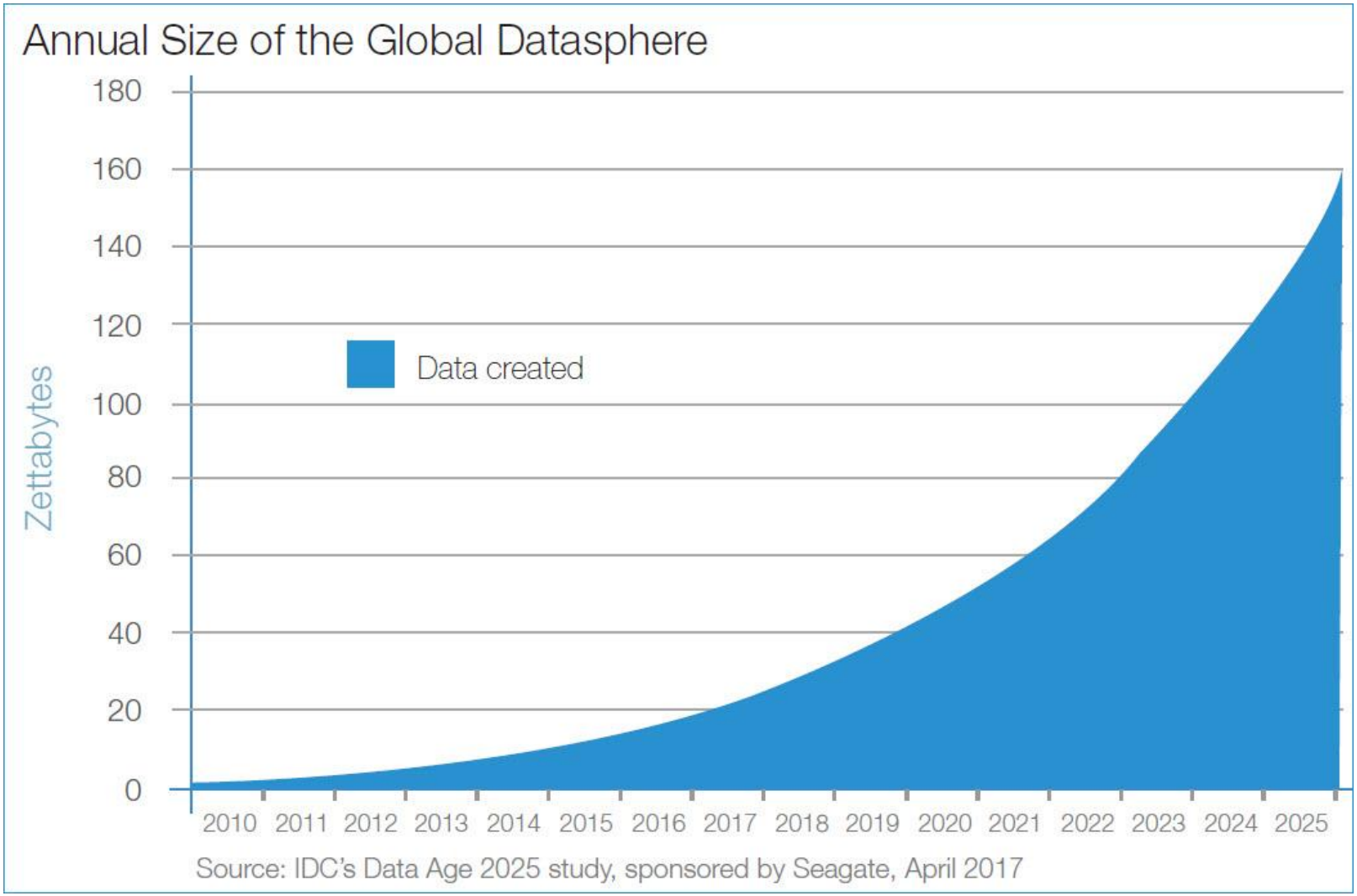
https://rdmkit.elixir-europe.org/

Introduction

- To reuse research data, we typically must:
  - Read the publication wherein it was described
  - Figure out if the data is relevant
  - And then extract the metadata needed for interpreting it
- This is not a scalable approach!

https://rdmkit.elixir-europe.org/

Problem: Exponential Data Production



Problem: Exponential Data Production

Findability:

- More data ⇒ harder search
- Things can get lost amid a sea of things
- If it is not findable, it might as well not exist

By Martin Handford, retrieved from: https://exploringyourmind.com/how-does-our-brain-find-waldo/

Problem: Exponential Data Production

Findability:

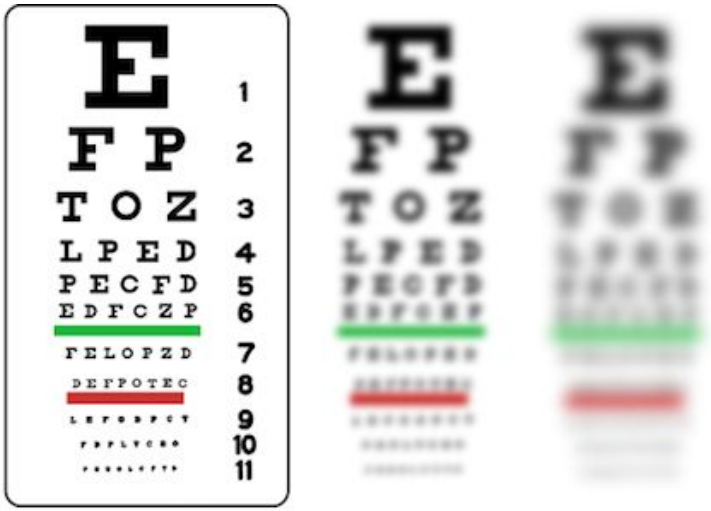
- More data ⇒ harder search
- Things can get lost amid a sea of things
- If it is not findable, it might as well not exist

By Martin Handford, retrieved from: https://exploringyourmind.com/how-does-our-brain-find-waldo/

Problem: Exponential Data Production

Interpretability:

- More data ⇒ more costly to interpret
- We become myopic by necessity—can't afford the time to read the fine-print (e.g. full research papers)
- If we cannot interpret it readily, then it is nearly useless

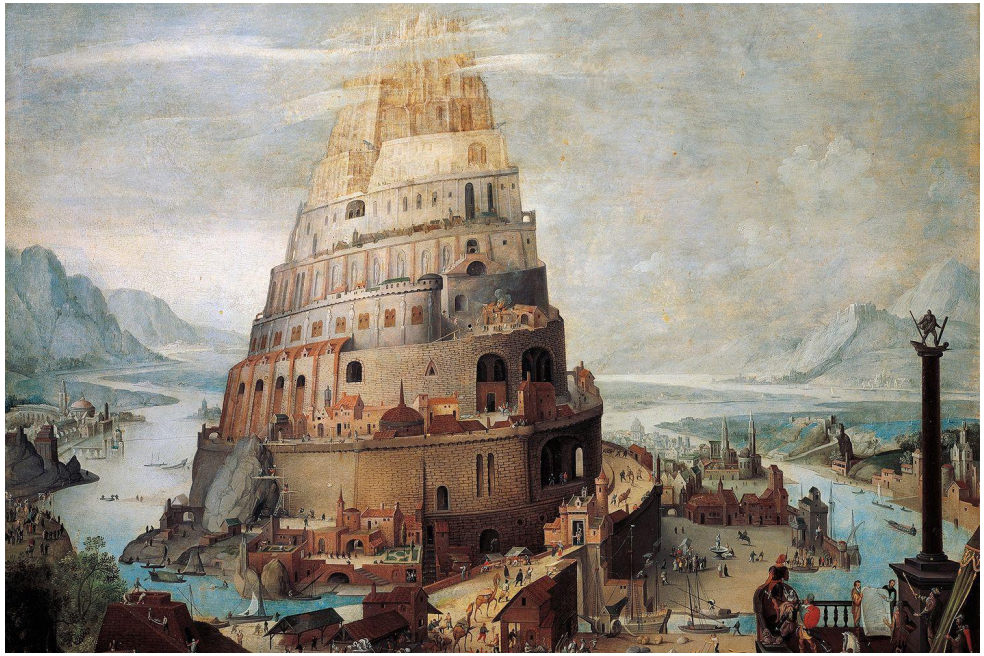


By Daniel P. B. Smith, CC BY-SA 3.0

Problem: Exponential Data Production

Interoperability:

- More data & specialization ⇒ vocabulary and viewpoint divergence
- Use of local dialects leads to sundered data and knowledge
- If we don't find common ground, we cannot integrate data from related domains



By Abel Grimmer, retrieved from: http://cbcpnews.net/cbcpnews/the-tower-of-babel/

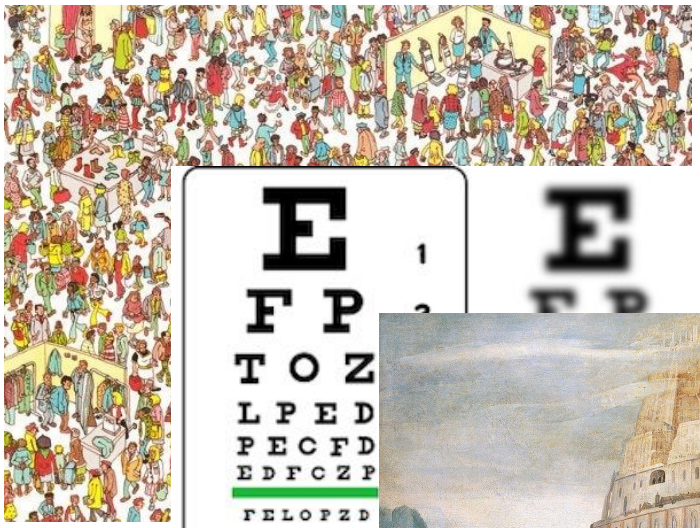
The Data Reuse Problem

Wrap-Up:

- Publishing data only in scientific papers is not enough
  - Papers are not efficient vehicles for knowledge transfer!!!
- If we want our data to be reusable, we must publish it in a form that is:
  - Findable
  - Interpretable
  - Interoperable

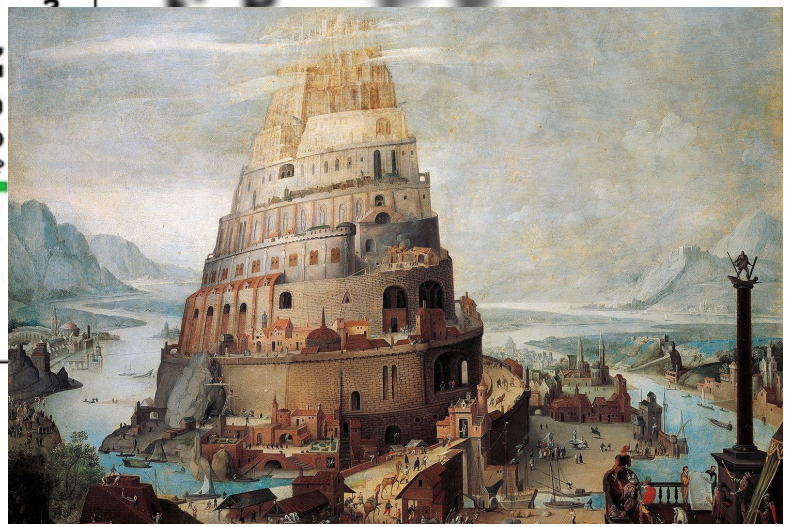
Group Discussion

How to make data:



Findable?

Interpretable?



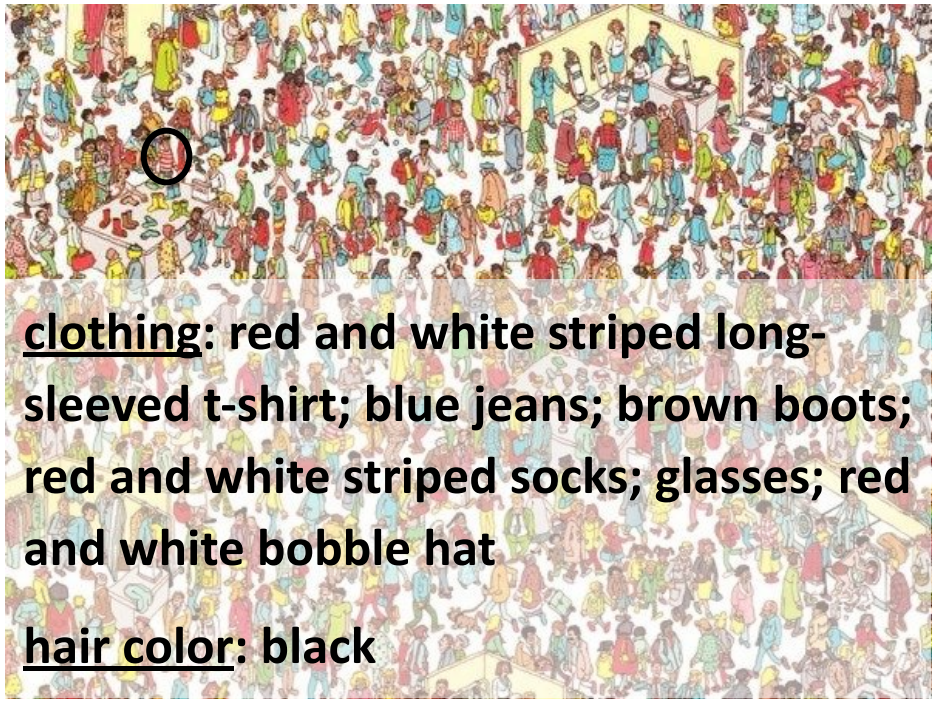
Interoperable?

(5 minutes)

Solutions

Findability:

- Describe data with precise metadata useful for searching
- Use a common (structured) controlled vocabulary for metadata fields and values
- Put data in a repository that:
  - Uses persistent unique identifiers
  - Indexes metadata and allows searches

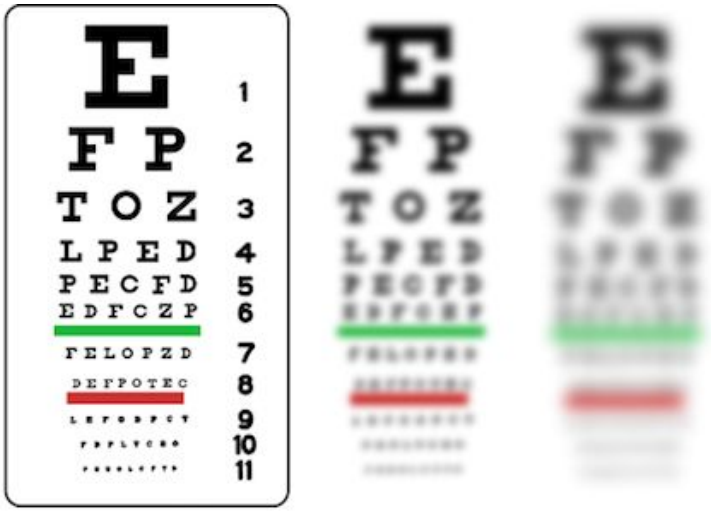


By Martin Handford, retrieved from: https://exploringyourmind.com/how-does-our-brain-find-waldo/

Solutions

Interpretability:

- Describe data with sufficient metadata for interpreting it and understanding the experimental context—each dataset should be fully self-contained
- Use a common (structured) controlled vocabulary for metadata fields and values

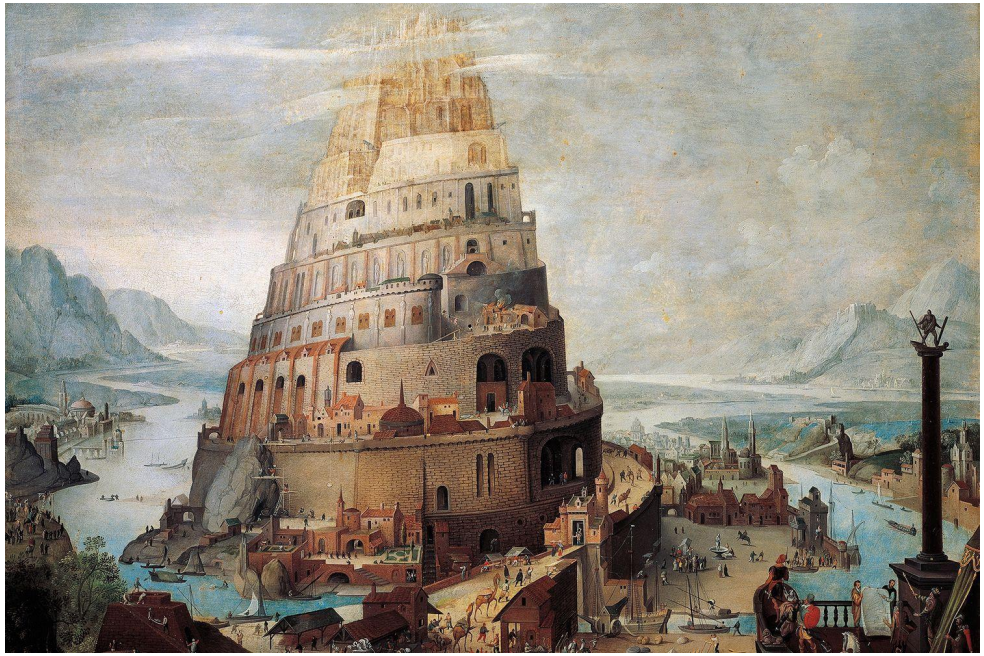


By Daniel P. B. Smith, CC BY-SA 3.0
https://en.wikipedia.org/wiki/File:Snellen-myopia.png

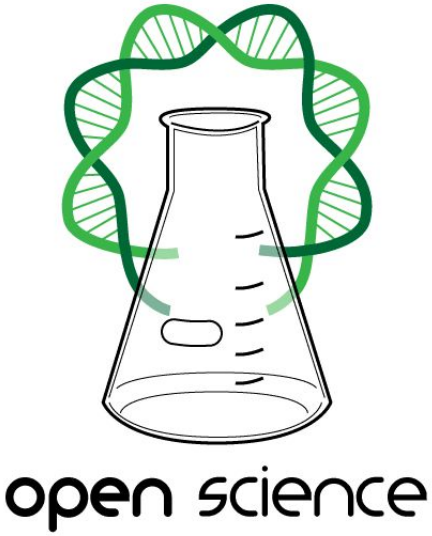
Solutions

Interoperability:

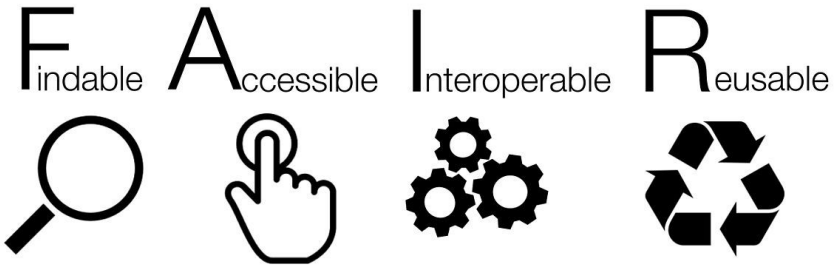
- Use a common (structured) controlled vocabulary for metadata fields and values
- Include cross-references to external data objects whenever suitable (e.g. NCBI taxon id)



By Abel Grimmer, retrieved from:
http://cbcpnews.net/cbcpnews/the-tower-of-babel/



By Greg Emmerich, CC BY-SA 3.0



By SangyaPundir - Own work, CC BY-SA 4.0

Open Science & FAIR Principles

Learning Outcome 3:

Recognize the demands of science funders
and debate their pros and cons

Introduction

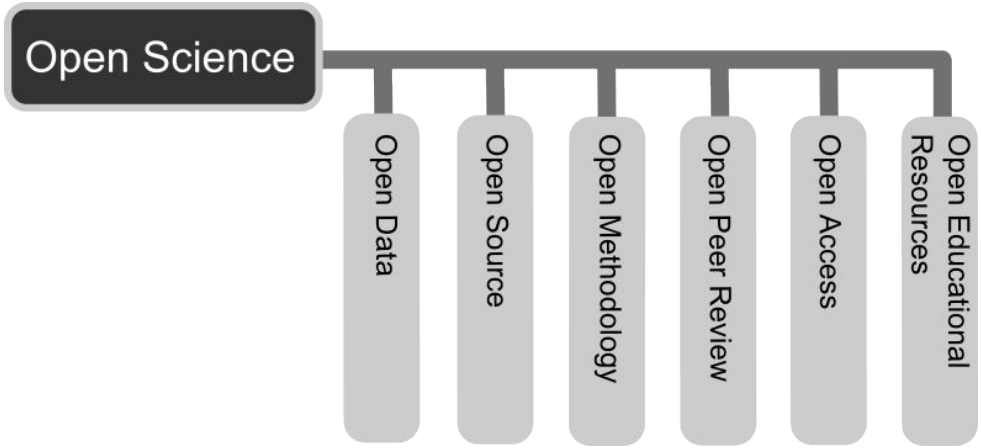
- The need to improve scientific dissemination has been recognized by research communities and publishers
- Leading to initiatives such as Open Science and the FAIR principles
- Funders recognized and are endorsing these initiatives (H2020 projects now require FAIR compliance)

TO DO OPEN SCIENCE AND PUBLISH FAIR DATA!

What is Open Science?

Goals:

- Scientific research and its dissemination accessible to all levels of society
  - publications
  - data
  - physical samples
  - software
  - ...



- Transparent and accessible knowledge shared and developed through collaborative networks

What is Open Science?

Layers:

- **Open Access**: research outputs distributed online, free of cost or access barriers
- **Open Research**: data, result and methodology clearly documented and freely available online
- **Open-Notebook Science**: primary record of a research project publicly available online as it is recorded—no insider information

What are the FAIR Data Principles?

A set of four principles detailed in fifteen guidelines, that establish what Open Research should aim for.

Findability – (Meta)data should be easy to find for both humans and computers

Accessibility – (Meta)data should have a defined access protocol with authentication and authorization rules

Interoperability – (Meta)data should be integratable with other similar datasets and interpretable by applications or workflows for analysis, storage, and processing

Reusability – (Meta)data should be well described so that it can be interpreted and reused

The FAIR Data Principles

=

The Solution for the Data Reuse Problem

Wait, we talked about Interpretability but not Accessibility or Reusability...

- Reusability is the end-goal, not the problem—it is contingent on Interpretability and Interoperability.

- Accessibility concerns data repositories, not really researchers, and it is already well addressed. As long as you publish your data in a well-established repository and define an authorization policy (when applicable, such as for sensitive data) you are well off.

Group Discussion

FAIR & Open Science—Pros & Cons

Pros:

- Facilitates knowledge discovery
- Promotes reproducibility / impedes fake science
- Enables networking
- Helps demystify science for the general public

Cons:

- Care with sensitive data and with knowledge that has dangerous misuse potential
- Harder to make money off of your research
- Harder to stay ahead of your competitors

FAQ

- **Can I receive credit for publishing data?**
  - This is not yet well established, but we are amidst a shift towards crediting data publishers as much as paper publishers.
- **Can't someone publish a paper ahead of me if I release my data?**
  - If someone can write a paper using your data ahead of you that supersedes yours, shame on you. If it does happen, you at least get credit for the use of your data, and will likely still be allowed to publish your paper as the original author of the data.
- **What if someone uses my data without giving me credit?**
  - The same can happen with paper publication. Reviewers and editors are expected to police this. Authors that do so can be red flagged.

To Be or Not to Be Open & FAIR???

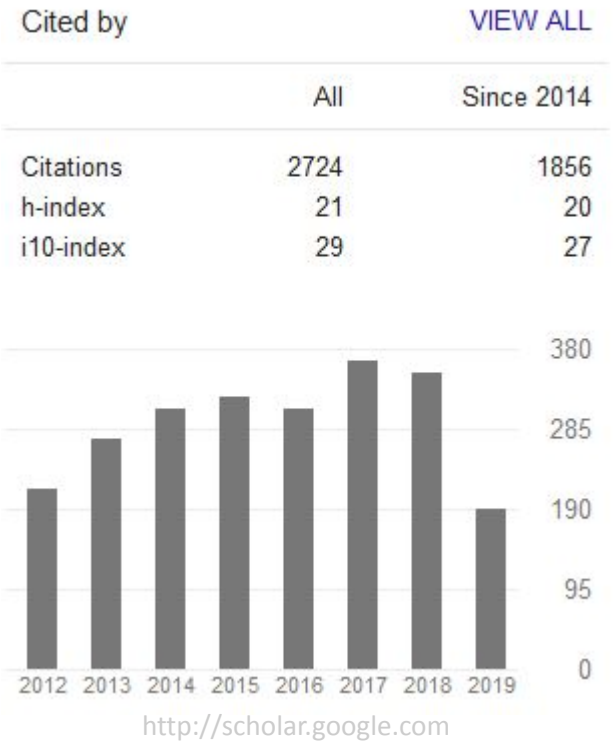
It Helps Science!

- Enables others to apply your knowledge in contexts beyond your foresight
- Enables others to reuse your data to make new research

To Be or Not to Be Open & FAIR???

It Helps You!

- It is easier to find and reuse your own data
- It is easier to write and submit a research paper
- If others apply or reuse your research, you get more citations (citing or crediting datasets is becoming common practice)



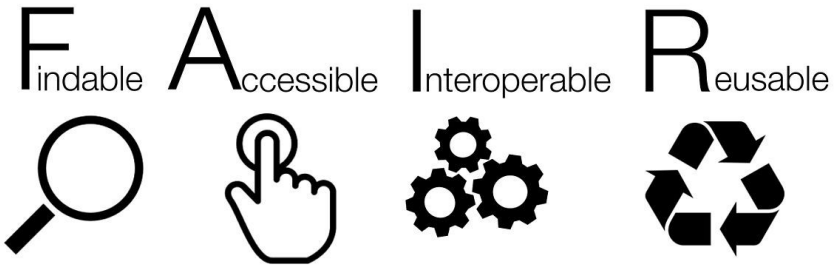
http://scholar.google.com

To Be or Not to Be Open & FAIR???

You'll Need It To Get Funded!

- Soon it will be impossible to get public funding in Europe without adherence to Open Science and FAIR
- FAIR compliance is starting to be verified
- A good track record will contribute to project approval

By Greg Emmerich, CC BY-SA 3.0



By SangyaPundir - Own work, CC BY-SA 4.0

Open Science & FAIR Principles

(Again!)

Learning Outcome 4:

Comply with the demands of science funders

Introduction

- We´ve seen that adherence to Open Science and compliance with the FAIR principles are being increasingly demanded by funding agencies
- And debated the merits and demerits of compliance
- What must be done in practice to comply with these demands?

TO DO OPEN SCIENCE AND PUBLISH FAIR DATA!

How to be Open & FAIR?

Step 1 – Do Your Homework

- Consult the data steward of your institution
- Learn the basics in RMKit
- Learn specific recipes in the FAIR Cookbook
- Lookup the best examples of FAIR data publication in your domain
- Consult information hubs about existing standards, such as FAIRsharing.org
- Search for key concepts through ontology lookup services, such as BioPortal

How to be Open & FAIR?

Step 1 – Do Your Homework

- Is there a default public database or repository for your research domain?
  - Does it have a metadata schema?
- Are there community metadata standards?
  - Do they cover your use case?
- Are there adequate ontologies?
  - If more than one, which is best?
- Are there default data (open) file formats?

How to be Open & FAIR?

Step 2 – Do Your Work-Work

- Organize, Document & Annotate:
  - Your code / scripts / workflows,
  - Your protocols
  - Your data & metadata
- According to the applicable guidelines / standards or the repository where you're depositing your data / materials
- Using domain ontologies, recommended file formats
- Cross-referencing all relevant information objects

Photo by cottonbro from Pexels

How to be Open & FAIR?

Step 3 – Deposit

- Deposit your data and materials in an appropriate public repository:
  - Code / scripts / workflows: GitHub, BitBucket
  - Protocols: Zenodo, FAIRDOMHub, Dataverse
  - Data: Domain database, one of the above
  - Metadata: Together with the data (as an accessory file, in the form of the repository)
- Under a declared usage license
- With a clear versioning policy

Photo by cottonbro from Pexels

How to be Open & FAIR?

Example – Transcriptomic Data

- Gene expression data:
  - Data repository:
    - ArrayExpress (EU) or Gene Expression Omnibus (US)
  - Metadata standard:
    - MIAME
  - Ontologies:
    - Experimental Factor Ontology
    - ...
  - Data file formats:
    - MAGE-Tab (metadata)
    - FASTQ (raw sequencing data)
    - Tabular text (read count data, differential expression data)

How to be Open & Fair?

The Main Hurdles

- The Biomedical Ontology landscape is complex and hard to navigate:
  - There are often overlapping ontologies for a given domain
  - And worse, the same concepts appear in several ontologies, sometimes with the same URI!!!
  - But there are also domains with no (suitable) ontology
- Metadata standards exist only for a few domains, and not all specify a data format for publication
- Generic data repositories (e.g. FAIRDOMHub, Zenodo, Dataverse) have rigid data models that are not compatible with all domains / standards

How to be Open & FAIR?

That sounds like a lot of work!

- It is, especially if you only do it at the time of publication:
  - Have to trace all the data—risk of data loss
  - Have to recall all the details about the experiment—risk of metadata loss, compromises reproducibility
  - It is a lot of boring work to do at once—inertia and rush lead to poor job

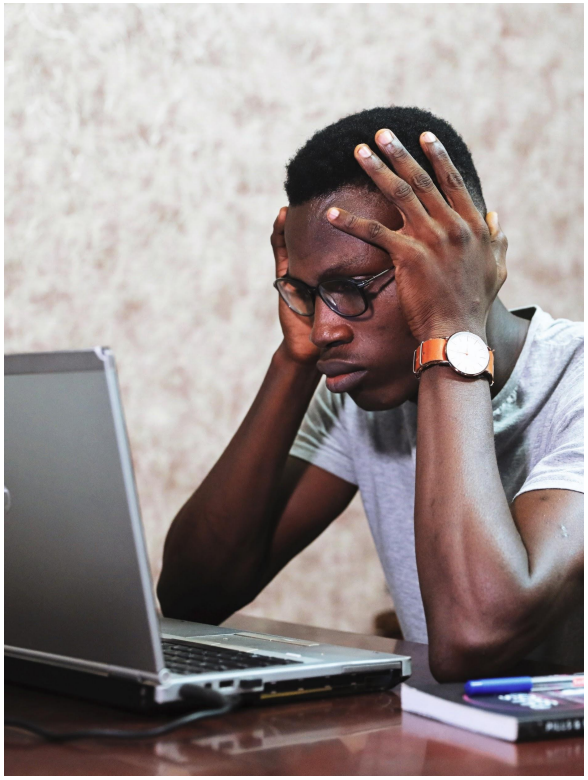


Photo by Oladimeji Ajegbile from Pexels

How to be Open & FAIR?

The Data Lifecycle

https://rdmkit.elixir-europe.org/

Manage research data across its whole lifecycle!

Research Data Management

Learning Outcome 5:

Recognize the supportive role of data management in science

Introduction

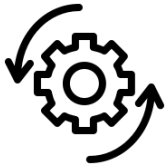
- Data management is a research domain in each own right
- Devoted to topics such as: Data Architecture, Data Modeling, Data Storage & Maintenance, Data Security, Data Integration, Metadata, Data Quality
- Researchers needn't be data management experts
- But just like driving or using a computer, basic knowledge of data management is invaluable for a life in research

Why Should I Care About Data Management?

Improve research:

By LAFS, CC BY 2.0

Effectiveness – obtain more/better results



By Youmena, CC BY 2.0

Efficiency – improve productivity and cost-efficiency

By ROZMOWA, CC BY 2.0

Security – reduce data loss / control access to data

By Nithinan Tatah, CC BY 2.0

Impact – facilitate dissemination and knowledge discovery

Data Management Commandments

- Thou shalt make a Data Management Plan for thy research project, even if it isn't funded by a grant
- Thou shalt allocate some time after each day experimenting to document everything, preferably in a digital platform (e.g. electronic lab notebook, local shared repository)
    - Thou shalt document the documentation process
    - Thou shalt use version control (e.g. git)
    - Thou shalt use controlled vocabularies (public or your own, documented)
- For every data file (or collection thereof) thou shalt create a metadata file

Data Management Resources

- DMP platforms
  - Data Stewardship Wizard
- Electronic lab notebooks
- Data analysis platforms
  - Galaxy
  - Jupyter Notebook
- Data management platforms
  - Dataverse
  - FAIRDOM SEEK
- Information hubs
  - RMKit
  - FAIR Cookbook
  - FAIRsharing.org

Take Home Messages

Do the Best You Can!

- FAIRness is a spectrum, and FAIRer is a step forward

Reach Out For Help!

- Data stewards and data managers can provide guidance

Things Will Get Easier!

- There are people working towards more user-friendly data management solutions—they need feedback on what can be improved