Metadata

Introduction to Data Management Practices course

NBIS DM Team

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

What is the problem?

“Someone unfamiliar with your project should be able to look at your computer files and understand in detail what you did and why.”

“Your primary collaborator is yourself six months from now, and your past self don’t answer e-mails.”

Metadata

The data about the data (or anything really)

“One person’s metadata, is another person’s data”

Metadata

- Describe data at different levels
  - e.g. a whole study vs the samples

Examples

- Creators
- File types and formats of the data
- Licence for re-use of the data
- Methodology for data collection
- Analytical and procedural information
- Sources of samples
- Sample treatment
- Geolocation(s) of samples

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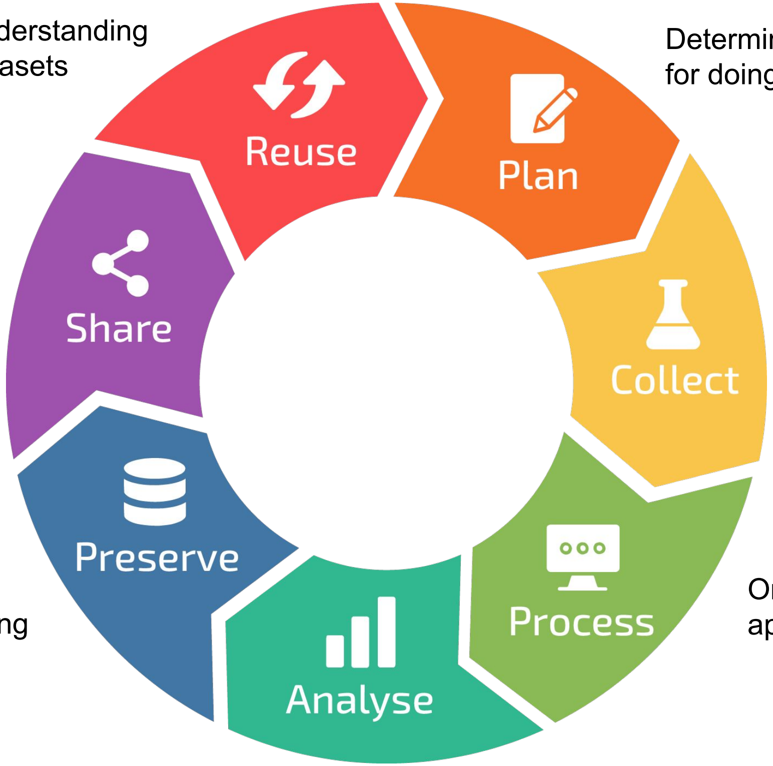
Metadata in the Data Life Cycle

SciLifeLab



Understanding datasets

Determine what metadata is needed for doing the project and sharing data

Collecting metadata

Organising metadata in appropriate format(s)

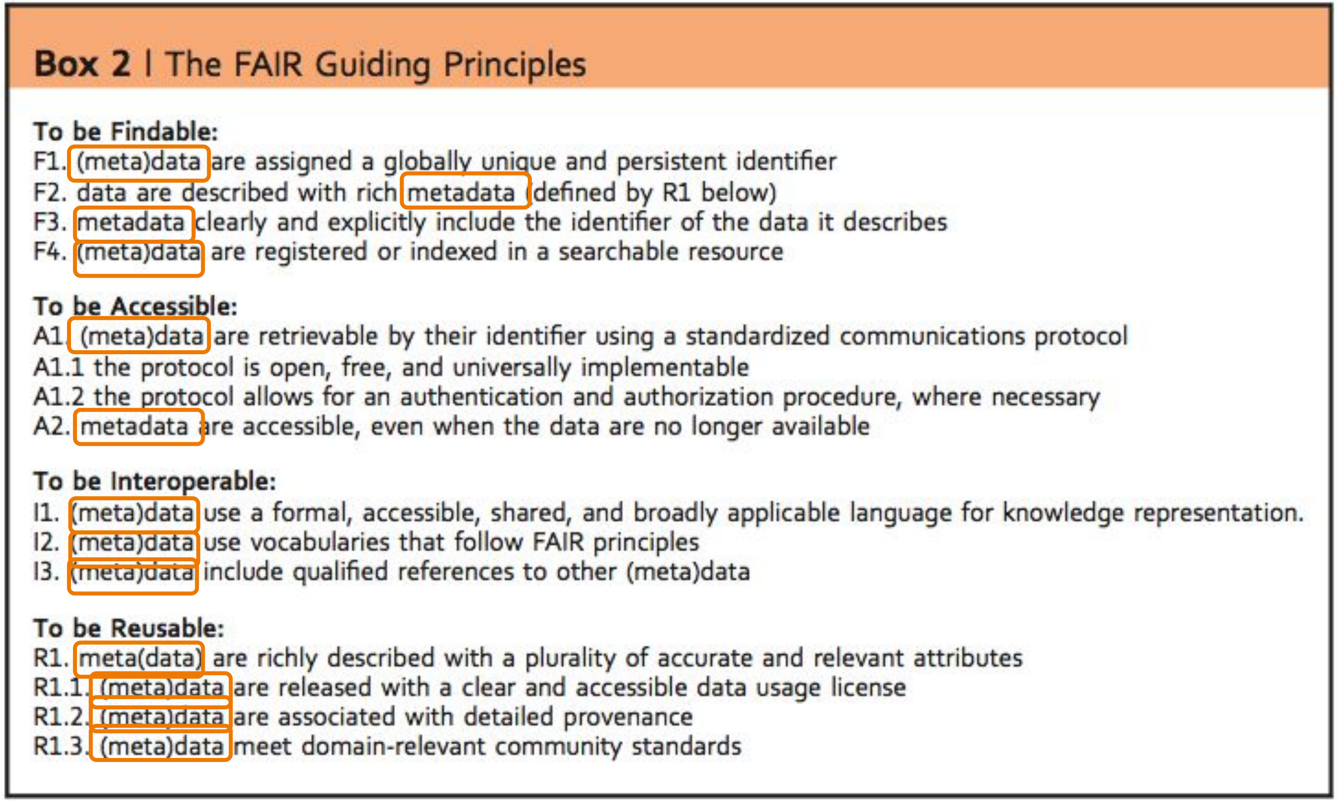
Using metadata to perform analysis

Describing datasets

Describing datasets

RDM life cycle, by ELIXIR RDMkit

FAIR principles



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

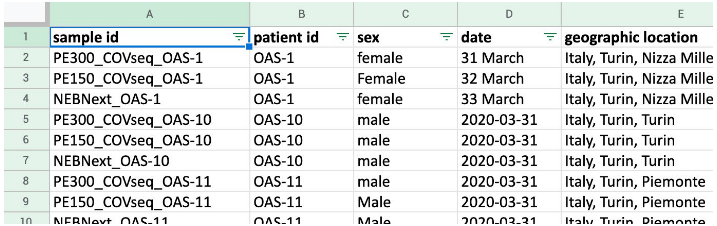
R1.1. (meta)data are released with a clear and accessible data usage license

R1.2. (meta)data are associated with detailed provenance

R1.3. (meta)data meet domain-relevant community standards

from 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

What problems do you see with the descriptions of these samples?



	A	B	C	D	E
1	sample id	patient id	sex	date	geographic location
2	PE300_COVseq_OAS-1	OAS-1	female	31 March	Italy, Turin, Nizza Mille
3	PE150_COVseq_OAS-1	OAS-1	Female	32 March	Italy, Turin, Nizza Mille
4	NEBNext_OAS-1	OAS-1	female	33 March	Italy, Turin, Nizza Mille
5	PE300_COVseq_OAS-10	OAS-10	male	2020-03-31	Italy, Turin, Turin
6	PE150_COVseq_OAS-10	OAS-10	male	2020-03-31	Italy, Turin, Turin
7	NEBNext_OAS-10	OAS-10	male	2020-03-31	Italy, Turin, Turin
8	PE300_COVseq_OAS-11	OAS-11	male	2020-03-31	Italy, Turin, Piemonte
9	PE150_COVseq_OAS-11	OAS-11	Male	2020-03-31	Italy, Turin, Piemonte
10	NEBNext_OAS-11	OAS-11	Male	2020-03-31	Italy, Turin, Piemonte

samples_metadata_lesson.csv

Problems

- Date formats
- Different terms for the same information
- Misspelled terms
- Not clear what a data point means
- Not clear what unit

Stringency

- Descriptions must be understandable over time - *not only for you*
- FAIR principles → also for computers
- Consistency
  - Date formats
  - Units
  - Terms

How much metadata?

- What is necessary for you to do your particular analysis
- What is necessary for someone to understand the data
- All the metadata you have

- *“How can I make this dataset as useful as possible for others?”*

Terms

“A biologist would rather share a toothbrush with another biologist than share a gene name”

- Consistency and stringency

- **Controlled vocabularies**
- **Ontologies**
- Thesauruses (Thesauri)
- Taxonomies

How many different medical conditions do you think this list of terms describes?

Bloodstream Infection, Circulatory Failure, Toxic Shock Syndrome, Pyemia, Circulatory Collapse, Blood Poisoning, Endotoxin Shock, Pyohemia, Hypovolemic Shock, Septicemia, Sepsis-associated hypotension, Pyaemia

Solution

Sepsis	Shock	Septic shock
Blood Poisoning	Circulatory Collapse	Endotoxin Shock
Bloodstream Infection	Circulatory Failure	Sepsis-associated hypotension
Pyaemia	Hypovolemic Shock	Toxic Shock Syndrome
Pyemia		
Pyohemia		
Septicemia		

Controlled vocabulary

- List of terms to describe some domain of knowledge
- Only one term per phenomenon
- Term definition
- List synonyms
- Each term has a unique identifier

Medical Subject Headings - MeSH

Sepsis

Definition: Systemic inflammatory response syndrome with a proven or suspected infectious etiology.

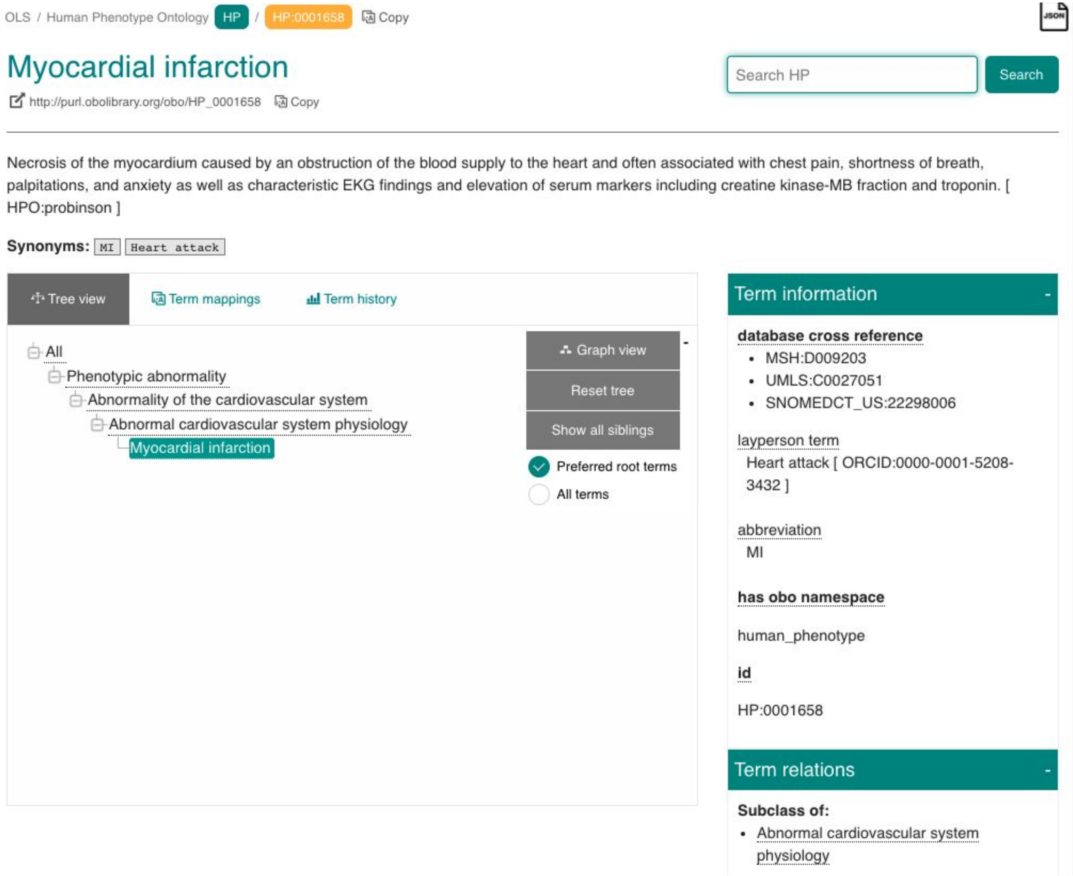
Synonyms: Blood Poisoning, Bloodstream Infection, Pyaemia, Pyemia, …

MeSH Unique ID: D018805

Ontology

- A controlled vocabulary
- Captures term relationships, e.g.
  - *is a*
  - *part of*
  - *contained in*
  - *produced by*
- Hierarchy / Tree
  - A term can be present at several places in the hierarchy

Human Phenotype Ontology



Myocardial infarction

http://purl.obolibrary.org/obo/HP_0001658 Copy

Necrosis of the myocardium caused by an obstruction of the blood supply to the heart and often associated with chest pain, shortness of breath, palpitations, and anxiety as well as characteristic EKG findings and elevation of serum markers including creatine kinase-MB fraction and troponin. [HPO:probinson]

Synonyms: `MI` `Heart attack`

- All
  - Phenotypic abnormality
    - Abnormality of the cardiovascular system
      - Abnormal cardiovascular system physiology
        - Myocardial infarction

✓ Preferred root terms

○ All terms

database cross reference

- MSH:D009203
- UMLS:C0027051
- SNOMEDCT_US:22298006

layperson term

Heart attack [ORCID:0000-0001-5208-3432]

abbreviation

MI

has obo namespace

human_phenotype

id

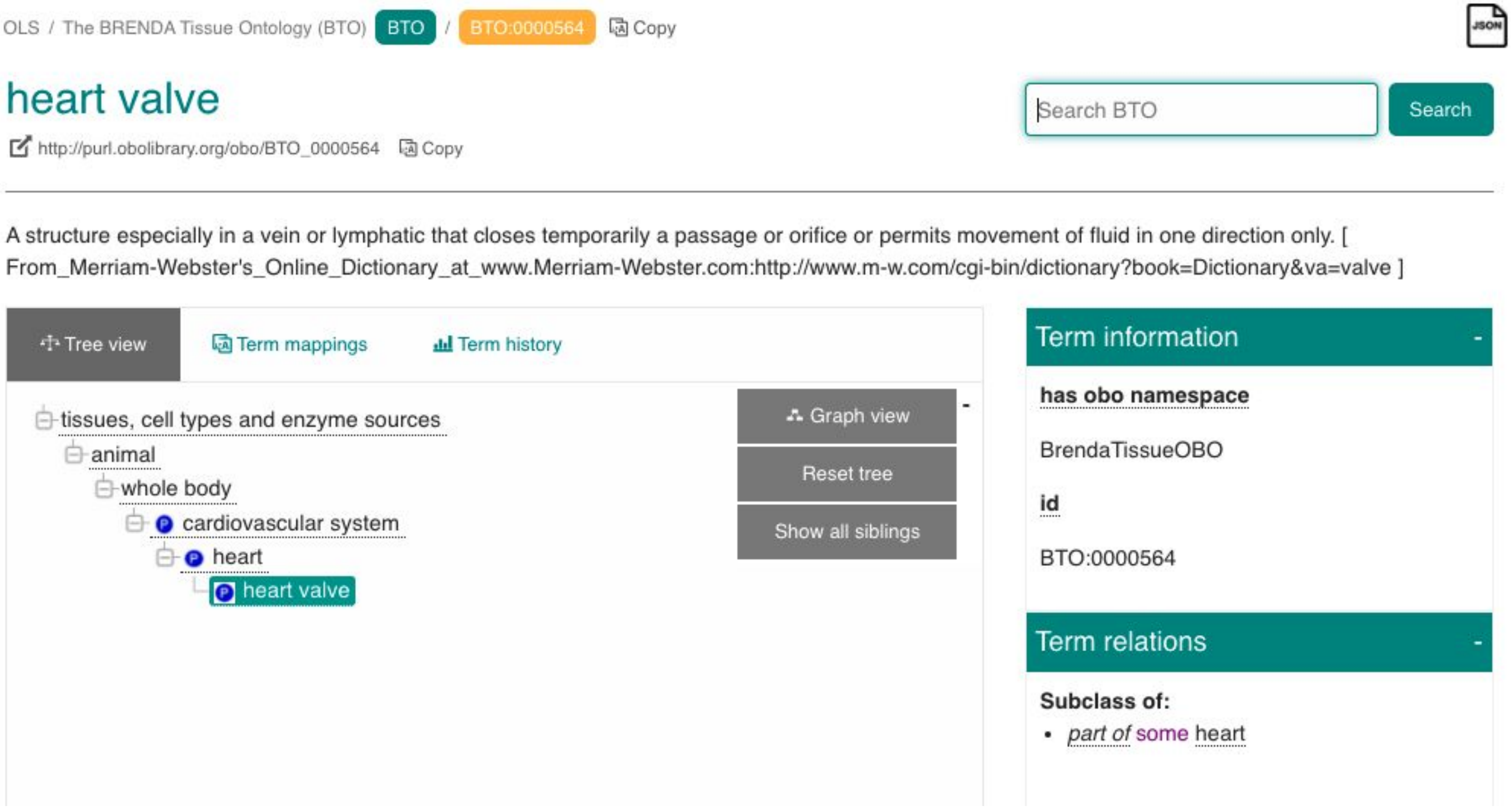
HP:0001658

Subclass of:

- Abnormal cardiovascular system physiology

https://www.ebi.ac.uk/ols/ontologies/hp/terms?iri=http%3A%2F%2Fpurl.obolibrary.org%2Fobo%2FHP_0001658

Brenda Tissue Ontology



OLS / The BRENDA Tissue Ontology (BTO) BTO / BTO:0000564 Copy

heart valve

http://purl.obolibrary.org/obo/BTO_0000564 Copy

A structure especially in a vein or lymphatic that closes temporarily a passage or orifice or permits movement of fluid in one direction only. [From_Merriam-Webster's_Online_Dictionary_at_www.Merriam-Webster.com:http://www.m-w.com/cgi-bin/dictionary?book=Dictionary&va=valve]

- tissues, cell types and enzyme sources
  - animal
    - whole body
      - P cardiovascular system
        - P heart
          - P heart valve

Term information

has obo namespace

BrendaTissueOBO

id

BTO:0000564

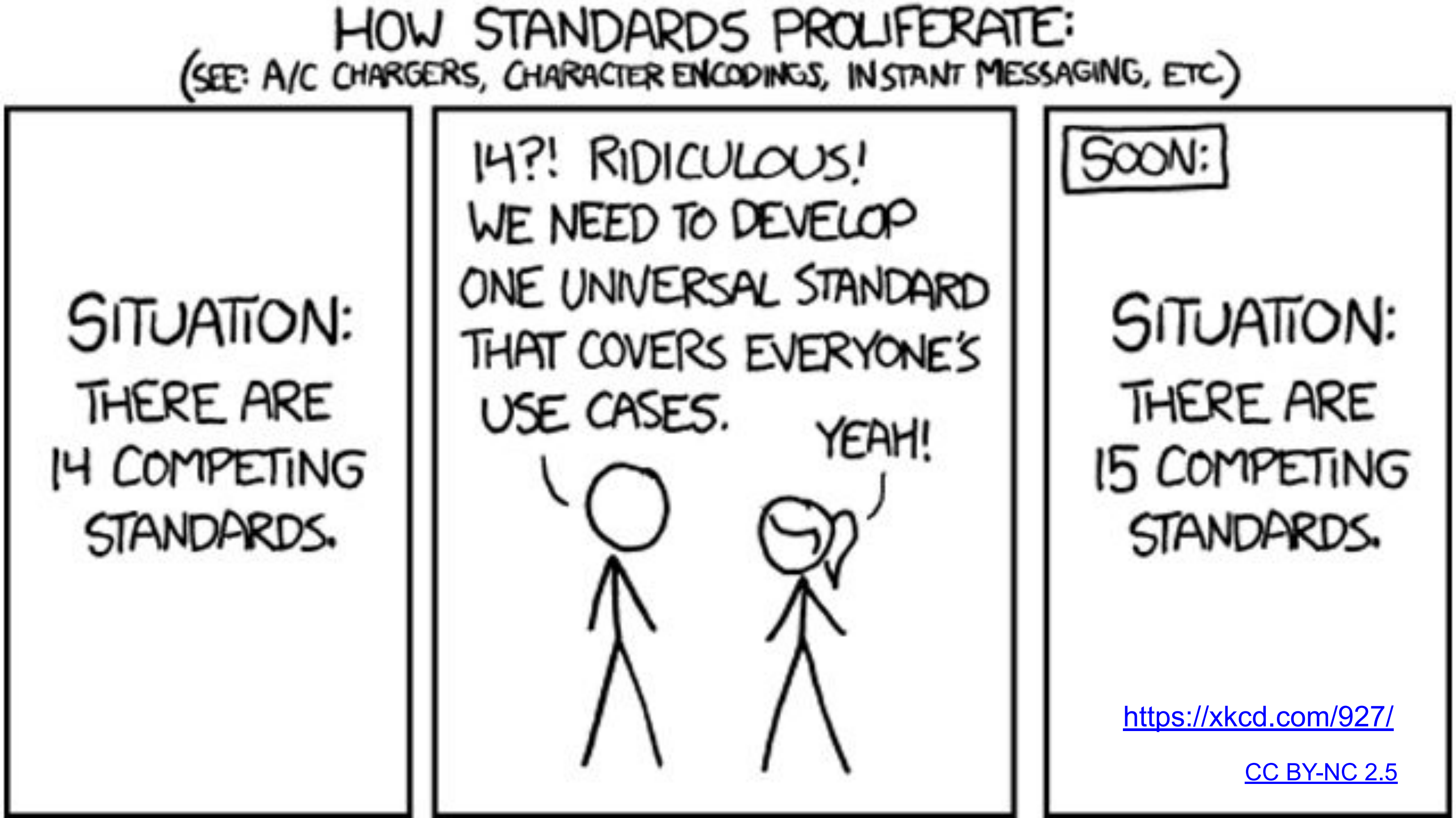
Term relations

Subclass of:

- *part of* some heart

https://www.ebi.ac.uk/ols/ontologies/bto/terms?iri=http%3A%2F%2Fpurl.obolibrary.org%2Fobo%2FBTO_0000564

A universal standard


HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC.)
SITUATION: THERE ARE 14 COMPETING STANDARDS.
14?! RIDICULOUS! WE NEED TO DEVELOP ONE UNIVERSAL STANDARD THAT COVERS EVERYONE'S USE CASES.
YEAH!
SOON:
SITUATION: THERE ARE 15 COMPETING STANDARDS.

https://xkcd.com/927/

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Making your own?

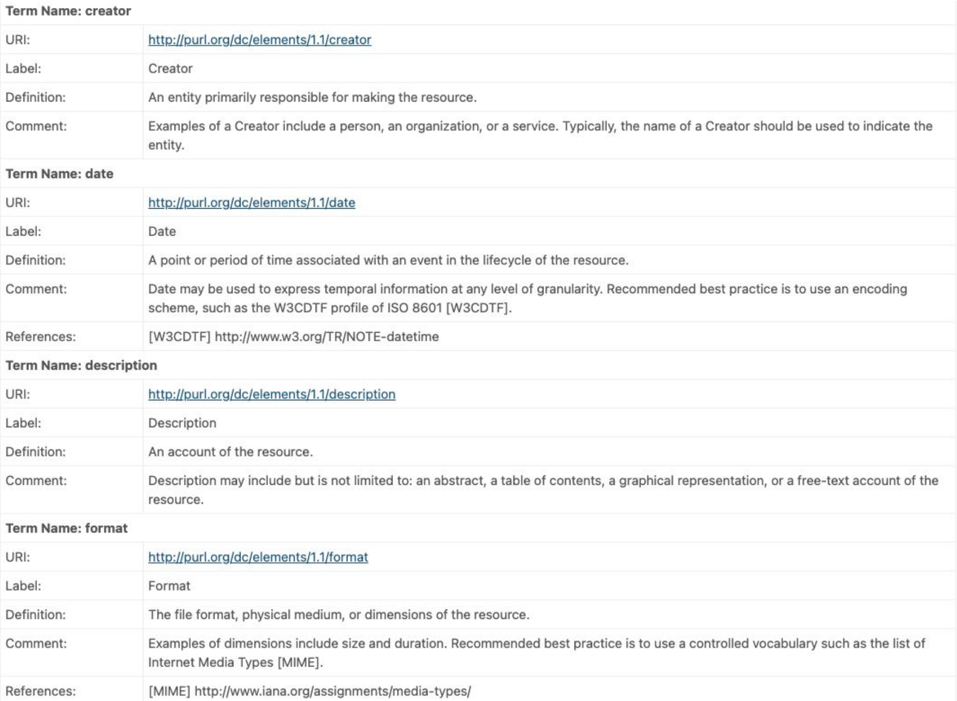
- At what point does it make sense to use something that exists?
  - Number of terms
  - Nature of terms
  - Relationships of terms
  - Terms management
    - Definitions
- FAIRness
  - Unique identifiers
  - Home brew vocabularies makes it harder to achieve machine readability

Metadata standards

- Collections of metadata **elements** of relevance for a particular purpose
- Elements
  - Mandatory, Recommended, or Optional
  - Defined input value type
    - Free text, data, geographical position, numerical values, ontology terms
  - Can itself be an ontology term
- Stricter → potentially increased FAIRness
- Generic to Specific

Generic - Dublin Core

- Describing digital and physical resources
- 15 elements



Term Name: creator	
URI:	http://purl.org/dc/elements/1.1/creator
Label:	Creator
Definition:	An entity primarily responsible for making the resource.
Comment:	Examples of a Creator include a person, an organization, or a service. Typically, the name of a Creator should be used to indicate the entity.
Term Name: date	
URI:	http://purl.org/dc/elements/1.1/date
Label:	Date
Definition:	A point or period of time associated with an event in the lifecycle of the resource.
Comment:	Date may be used to express temporal information at any level of granularity. Recommended best practice is to use an encoding scheme, such as the W3CDTF profile of ISO 8601 [W3CDTF].
References:	[W3CDTF] http://www.w3.org/TR/NOTE-datetime
Term Name: description	
URI:	http://purl.org/dc/elements/1.1/description
Label:	Description
Definition:	An account of the resource.
Comment:	Description may include but is not limited to: an abstract, a table of contents, a graphical representation, or a free-text account of the resource.
Term Name: format	
URI:	http://purl.org/dc/elements/1.1/format
Label:	Format
Definition:	The file format, physical medium, or dimensions of the resource.
Comment:	Examples of dimensions include size and duration. Recommended best practice is to use a controlled vocabulary such as the list of Internet Media Types [MIME].
References:	[MIME] http://www.iana.org/assignments/media-types/

https://www.dublincore.org/specifications/dublin-core/dces/

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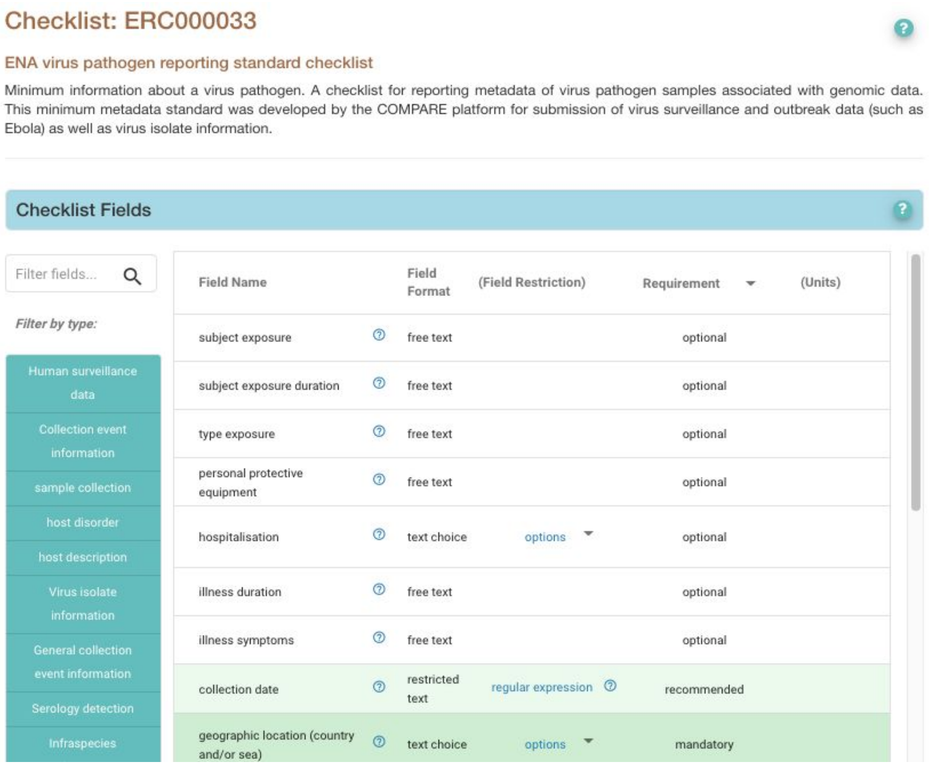
Specific - an ENA checklist

- *ENA virus pathogen reporting standard checklist*
- Reporting metadata of virus pathogen samples associated with genomic data
- 35 elements - 9 mandatory and 15 recommended



Checklist: ERC000033

ENA virus pathogen reporting standard checklist

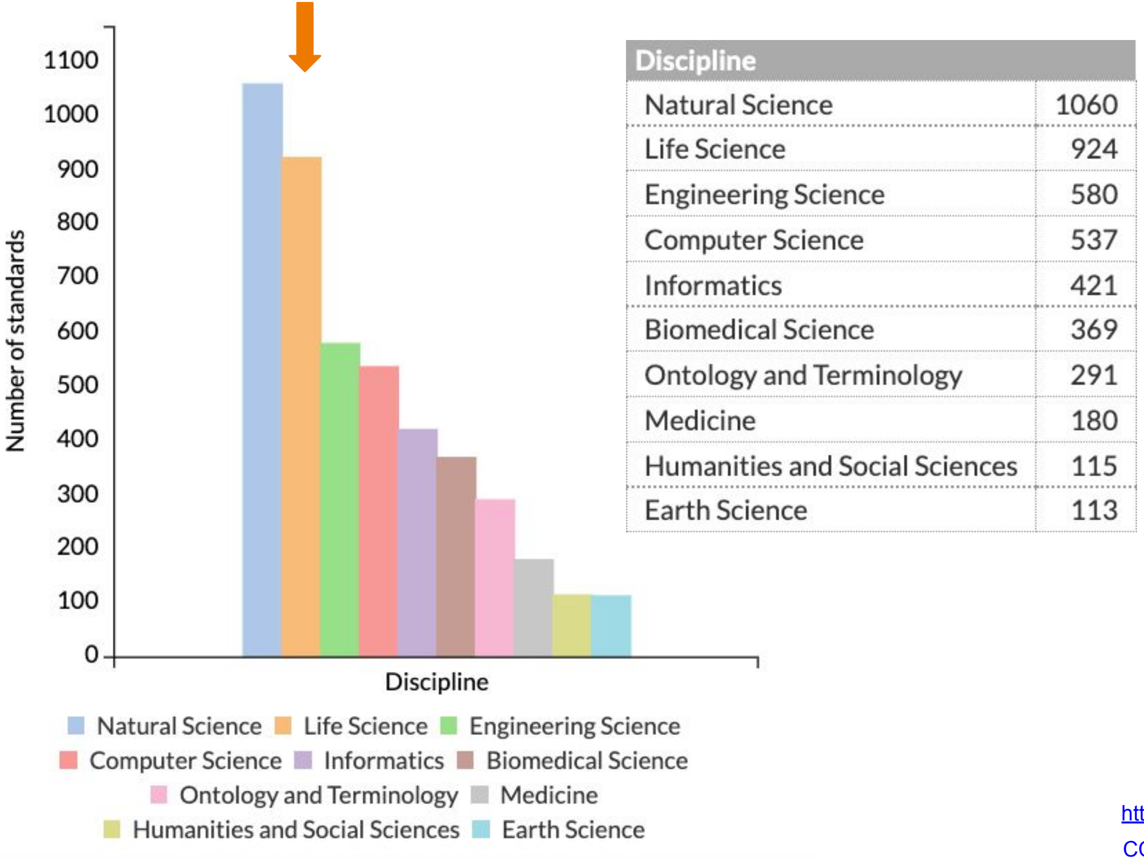
Minimum information about a virus pathogen. A checklist for reporting metadata of virus pathogen samples associated with genomic data. This minimum metadata standard was developed by the COMPARE platform for submission of virus surveillance and outbreak data (such as Ebola) as well as virus isolate information.

Checklist Fields

Field Name	Field Format	(Field Restriction)	Requirement	(Units)
subject exposure	free text		optional	
subject exposure duration	free text		optional	
type exposure	free text		optional	
personal protective equipment	free text		optional	
hospitalisation	text choice	options	optional	
illness duration	free text		optional	
illness symptoms	free text		optional	
collection date	restricted text	regular expression	recommended	
geographic location (country and/or sea)	text choice	options	mandatory	

https://www.ebi.ac.uk/ena/browser/view/ERC000033

How do I know what to use?



Discipline	
Natural Science	1060
Life Science	924
Engineering Science	580
Computer Science	537
Informatics	421
Biomedical Science	369
Ontology and Terminology	291
Medicine	180
Humanities and Social Sciences	115
Earth Science	113

https://fairsharing.org/summary-statistics/

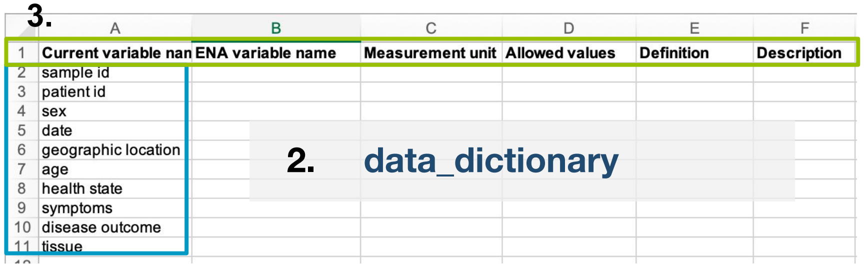
Data dictionary

- Your own metadata standard
- Document what type of information is supposed to be entered for the metadata fields
- Name, units, allowed values, definitions, ...

Exercise:
Start a data dictionary

Start a Data dictionary

1. Open **samples_metadata_lesson.csv**
2. Create a new **data_dictionary** file
3. Add headings to **data_dictionary**
   - Current variable name
   - ENA variable name
   - Measurement unit
   - Allowed values
   - Definition
   - Description

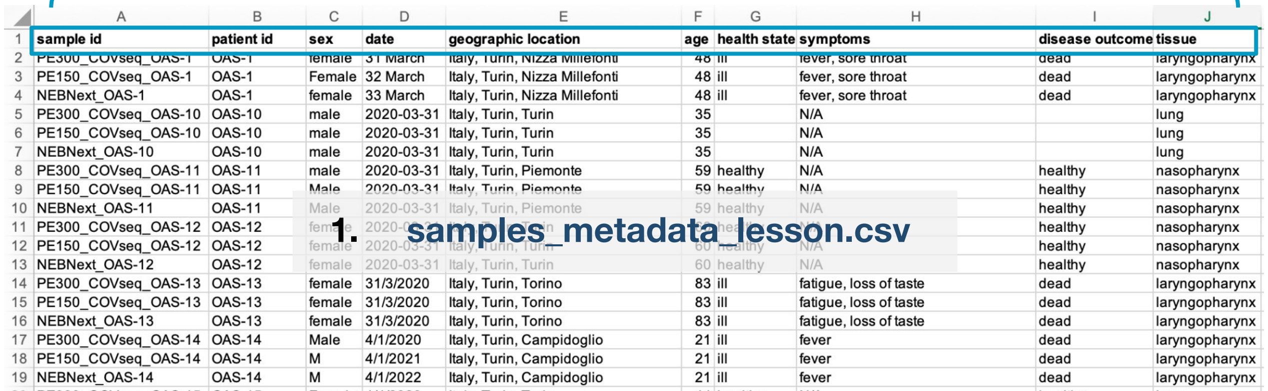


3.

	A	B	C	D	E	F
1	**Current variable nan**	**ENA variable name**	**Measurement unit**	**Allowed values**	**Definition**	**Description**
2	sample id					
3	patient id					
4	sex					
5	date					
6	geographic location					
7	age					
8	health state					
9	symptoms					
10	disease outcome					
11	tissue					

2. **data_dictionary**

4.



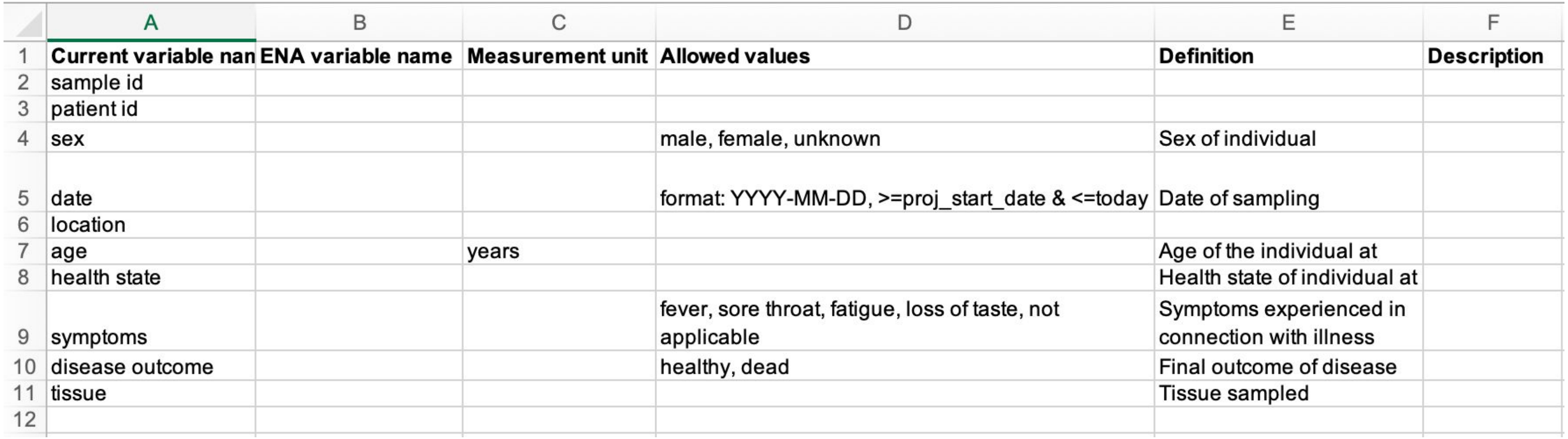
	A	B	C	D	E	F	G	H	I	J
1	**sample id**	**patient id**	**sex**	**date**	**geographic location**	**age**	**health state**	**symptoms**	**disease outcome**	**tissue**
2	PE300_COVseq_OAS-1	OAS-1	female	31 March	Italy, Turin, Nizza Millefonti	48	ill	fever, sore throat	dead	laryngopharynx
3	PE150_COVseq_OAS-1	OAS-1	Female	32 March	Italy, Turin, Nizza Millefonti	48	ill	fever, sore throat	dead	laryngopharynx
4	NEBNext_OAS-1	OAS-1	female	33 March	Italy, Turin, Nizza Millefonti	48	ill	fever, sore throat	dead	laryngopharynx
5	PE300_COVseq_OAS-10	OAS-10	male	2020-03-31	Italy, Turin, Turin	35		N/A		lung
6	PE150_COVseq_OAS-10	OAS-10	male	2020-03-31	Italy, Turin, Turin	35		N/A		lung
7	NEBNext_OAS-10	OAS-10	male	2020-03-31	Italy, Turin, Turin	35		N/A		lung
8	PE300_COVseq_OAS-11	OAS-11	male	2020-03-31	Italy, Turin, Piemonte	59	healthy	N/A	healthy	nasopharynx
9	PE150_COVseq_OAS-11	OAS-11	Male	2020-03-31	Italy, Turin, Piemonte	59	healthy	N/A	healthy	nasopharynx
10	NEBNext_OAS-11	OAS-11	Male	2020-03-31	Italy, Turin, Piemonte	59	healthy	N/A	healthy	nasopharynx
11	PE300_COVseq_OAS-12	OAS-12	female	2020-03-31	Italy, Turin, Turin	60	healthy	N/A	healthy	nasopharynx
12	PE150_COVseq_OAS-12	OAS-12	female	2020-03-31	Italy, Turin, Turin	60	healthy	N/A	healthy	nasopharynx
13	NEBNext_OAS-12	OAS-12	female	2020-03-31	Italy, Turin, Turin	60	healthy	N/A	healthy	nasopharynx
14	PE300_COVseq_OAS-13	OAS-13	female	31/3/2020	Italy, Turin, Torino	83	ill	fatigue, loss of taste	dead	laryngopharynx
15	PE150_COVseq_OAS-13	OAS-13	female	31/3/2020	Italy, Turin, Torino	83	ill	fatigue, loss of taste	dead	laryngopharynx
16	NEBNext_OAS-13	OAS-13	female	31/3/2020	Italy, Turin, Torino	83	ill	fatigue, loss of taste	dead	laryngopharynx
17	PE300_COVseq_OAS-14	OAS-14	Male	4/1/2020	Italy, Turin, Campidoglio	21	ill	fever	dead	laryngopharynx
18	PE150_COVseq_OAS-14	OAS-14	M	4/1/2021	Italy, Turin, Campidoglio	21	ill	fever	dead	laryngopharynx
19	NEBNext_OAS-14	OAS-14	M	4/1/2022	Italy, Turin, Campidoglio	21	ill	fever	dead	laryngopharynx

1. **samples_metadata_lesson.csv**

4. Copy headings from **samples_metadata_lesson.csv** to **rows** in **data_dictionary**

- Add some definitions
- Add some units
- Add some allowed value definitions

Data dictionary - start



	A	B	C	D	E	F
1	**Current variable nan**	**ENA variable name**	**Measurement unit**	**Allowed values**	**Definition**	**Description**
2	sample id					
3	patient id					
4	sex			male, female, unknown	Sex of individual	
5	date			format: YYYY-MM-DD, >=proj_start_date & <=today	Date of sampling	
6	location					
7	age		years		Age of the individual at	
8	health state				Health state of individual at	
9	symptoms			fever, sore throat, fatigue, loss of taste, not applicable	Symptoms experienced in connection with illness	
10	disease outcome			healthy, dead	Final outcome of disease	
11	tissue				Tissue sampled	
12						

Plan ahead

- Use standards of deposition databases were you plan to publish your data
- Helps with selecting elements
- Makes data submission much easier

Exercise:

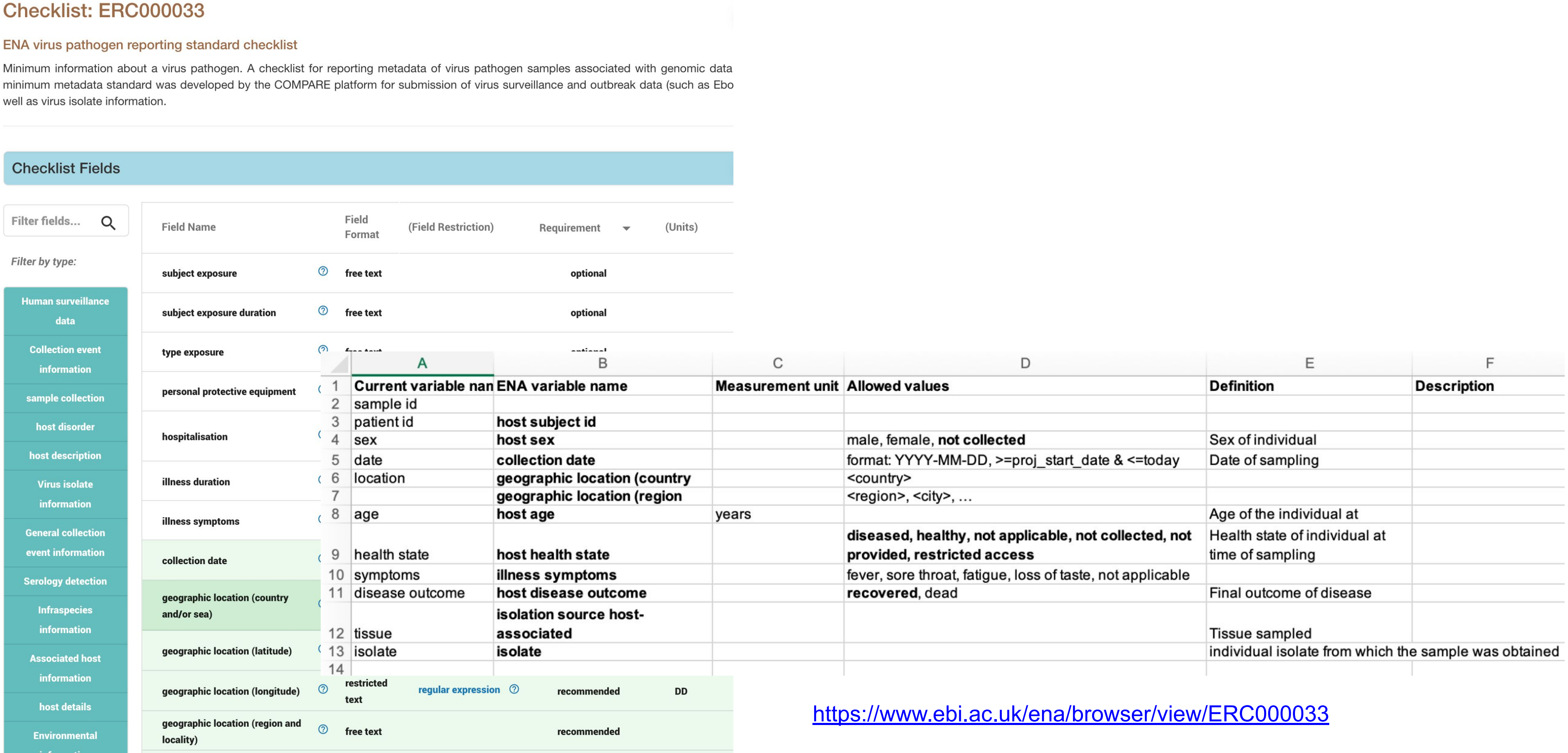
Look up an ENA checklist to improve the data dictionary

Improve data dictionary

1. Go to https://www.ebi.ac.uk/ena/browser/checklists to see the available checklists
2. Scroll down the listing until you find the **ERC000033 ENA virus pathogen reporting standard checklist**

3. Go through the data dictionary and find suitable field names in the ENA default sample checklist for those fields. Add them to the ENA Variable name column of your data dictionary file.
   a. Are all mandatory fields present, or will you need to add fields?
   b. Are there fields that need to be split into more fields?
   c. Are there controlled vocabularies you should adhere to?

Improve data dictionary



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Minimum information about a virus pathogen. A checklist for reporting metadata of virus pathogen samples associated with genomic data minimum metadata standard was developed by the COMPARE platform for submission of virus surveillance and outbreak data (such as Ebo well as virus isolate information.

Checklist Fields

Filter fields...

Filter by type:

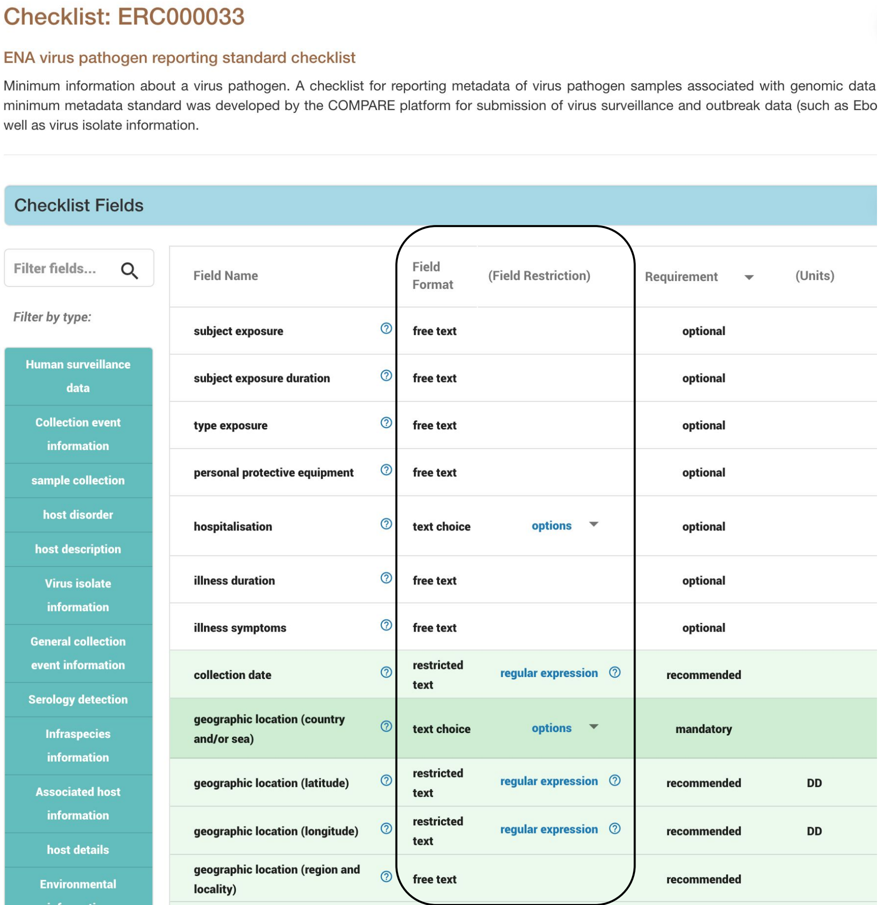
- Human surveillance data
- Collection event information
- sample collection
- host disorder
- host description
- Virus isolate information
- General collection event information
- Serology detection
- Infraspecies information
- Associated host information
- host details
- Environmental information

Field Name	Field Format	(Field Restriction)	Requirement	(Units)
subject exposure	free text		optional	
subject exposure duration	free text		optional	
type exposure	free text		optional	
personal protective equipment				
hospitalisation				
illness duration				
illness symptoms				
collection date				
geographic location (country and/or sea)				
geographic location (latitude)				
geographic location (longitude)	restricted text	regular expression	recommended	DD
geographic location (region and locality)	free text		recommended	

	A	B	C	D	E	F
1	**Current variable nan**	**ENA variable name**	**Measurement unit**	**Allowed values**	**Definition**	**Description**
2	sample id					
3	patient id	**host subject id**				
4	sex	**host sex**		male, female, **not collected**	Sex of individual	
5	date	**collection date**		format: YYYY-MM-DD, >=proj_start_date & <=today	Date of sampling	
6	location	**geographic location (country**		<country>		
7		**geographic location (region**		<region>, <city>, …		
8	age	**host age**	years		Age of the individual at	
9	health state	**host health state**		**diseased, healthy, not applicable, not collected, not provided, restricted access**	Health state of individual at time of sampling	
10	symptoms	**illness symptoms**		fever, sore throat, fatigue, loss of taste, not applicable		
11	disease outcome	**host disease outcome**		**recovered**, dead	Final outcome of disease	
12	tissue	**isolation source host-associated**			Tissue sampled	
13	isolate	**isolate**			individual isolate from which the sample was obtained	
14						

https://www.ebi.ac.uk/ena/browser/view/ERC000033

Finding ontologies



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- Associated host information
- host details
- Environmental

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subject exposure duration	free text		optional	
type exposure	free text		optional	
personal protective equipment	free text		optional	
hospitalisation	text choice	options	optional	
illness duration	free text		optional	
illness symptoms	free text		optional	
collection date	restricted text	regular expression	recommended	
geographic location (country and/or sea)	text choice	options	mandatory	
geographic location (latitude)	restricted text	regular expression	recommended	DD
geographic location (longitude)	restricted text	regular expression	recommended	DD
geographic location (region and locality)	free text		recommended	

- This standard is liberal when it comes the allowed values for the different fields
- *We can do better!*
- Use ontology terms
  - Improves FAIRness
  - But which ontologies…?

https://www.ebi.ac.uk/ena/browser/view/ERC000033

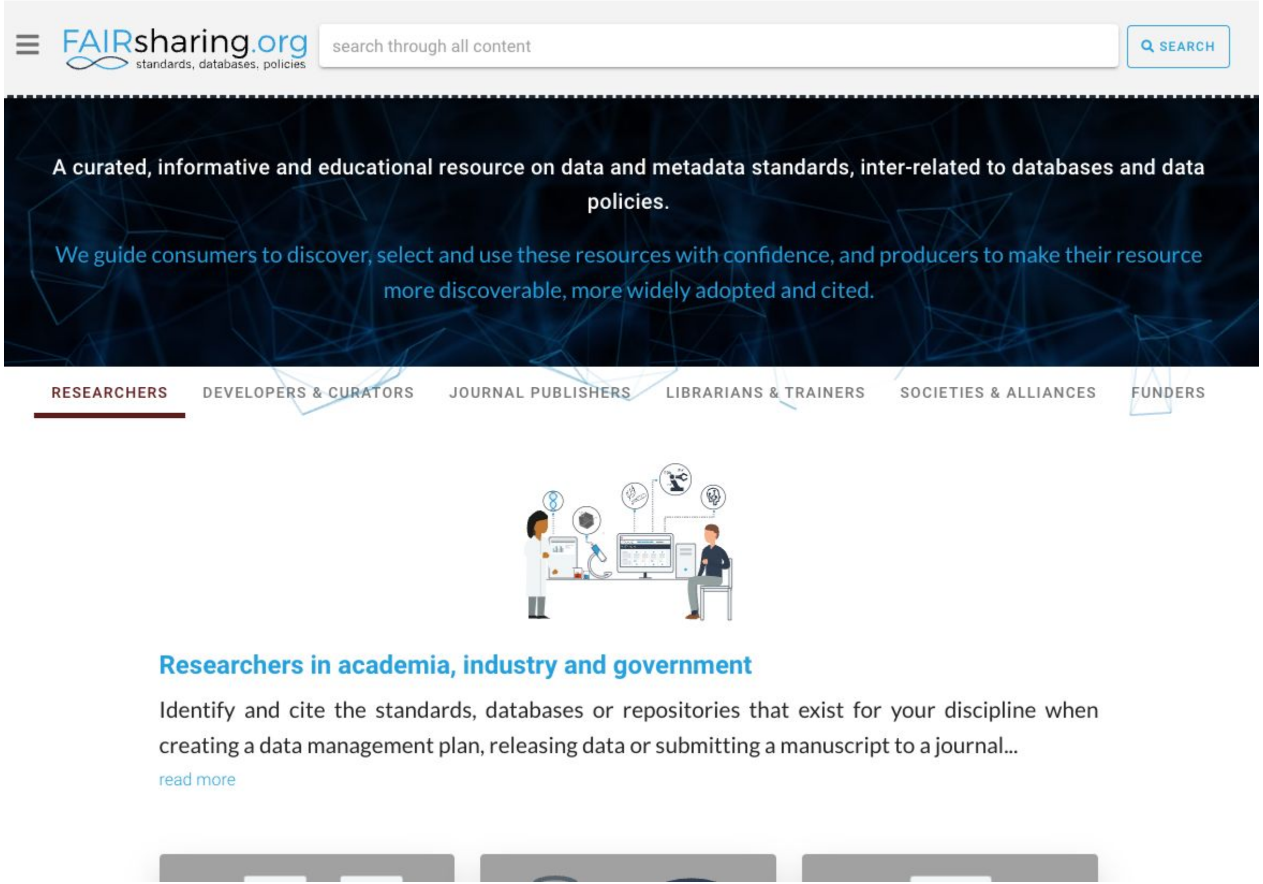
Finding ontologies

- Tools
  - FAIRsharing.org
  - EBI Ontology Tooling page
    - Ontology Lookup Service - OLS
    - Zooma - map free text to ontology terms

- Not an exact science… There is no perfect way...
- Sometimes hard
- Trial and error

https://fairsharing.org/ https://www.ebi.ac.uk/spot/ontology/

FAIRsharing.org



A curated, informative and educational resource on data and metadata standards, inter-related to databases and data policies.

We guide consumers to discover, select and use these resources with confidence, and producers to make their resource more discoverable, more widely adopted and cited.

Researchers in academia, industry and government

Identify and cite the standards, databases or repositories that exist for your discipline when creating a data management plan, releasing data or submitting a manuscript to a journal...

read more

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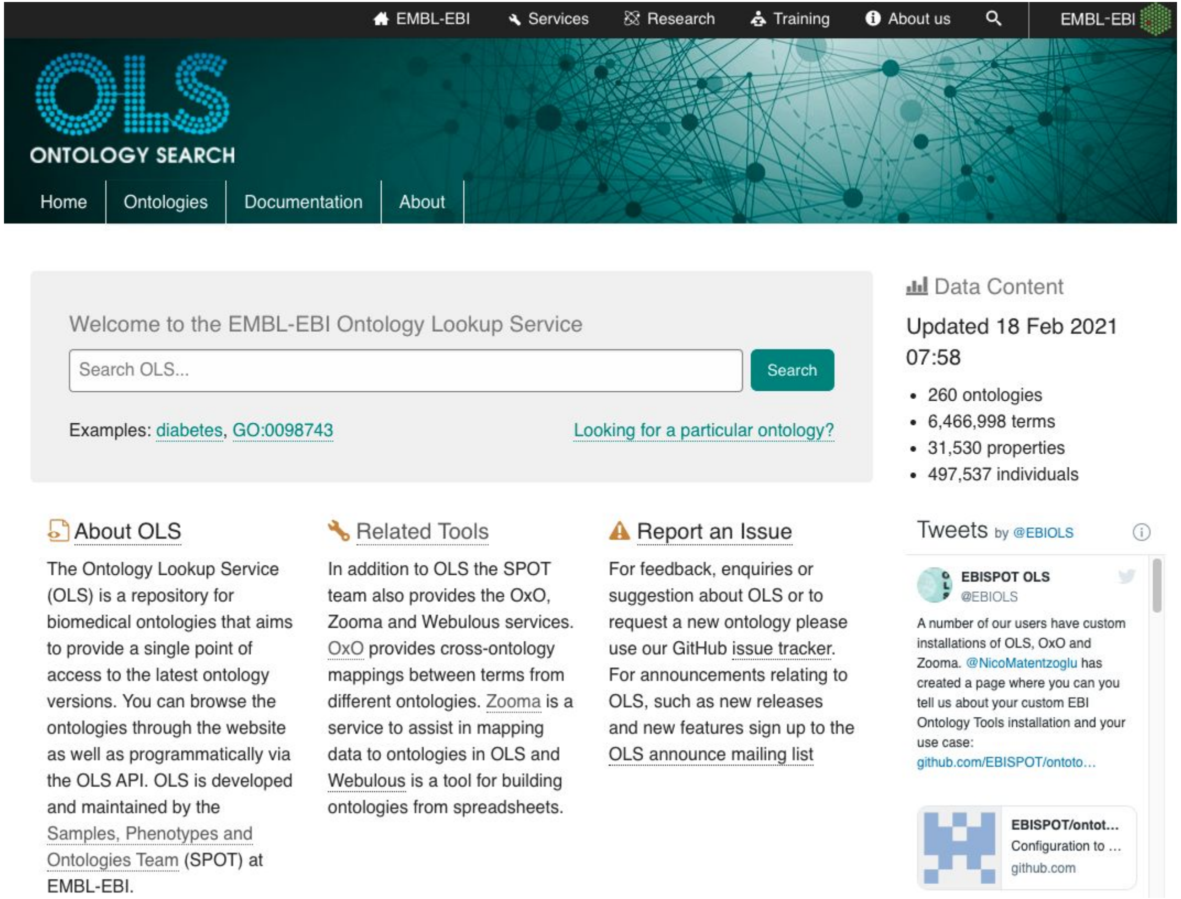
OLS

SciLifeLab



Welcome to the EMBL-EBI Ontology Lookup Service

Examples: diabetes, GO:0098743

Looking for a particular ontology?

Data Content

Updated 18 Feb 2021 07:58

- 260 ontologies
- 6,466,998 terms
- 31,530 properties
- 497,537 individuals

About OLS

The Ontology Lookup Service (OLS) is a repository for biomedical ontologies that aims to provide a single point of access to the latest ontology versions. You can browse the ontologies through the website as well as programmatically via the OLS API. OLS is developed and maintained by the Samples, Phenotypes and Ontologies Team (SPOT) at EMBL-EBI.

Related Tools

In addition to OLS the SPOT team also provides the OxO, Zooma and Webulous services. OxO provides cross-ontology mappings between terms from different ontologies. Zooma is a service to assist in mapping data to ontologies in OLS and Webulous is a tool for building ontologies from spreadsheets.

Report an Issue

For feedback, enquiries or suggestion about OLS or to request a new ontology please use our GitHub issue tracker. For announcements relating to OLS, such as new releases and new features sign up to the OLS announce mailing list

Tweets by @EBIOLS

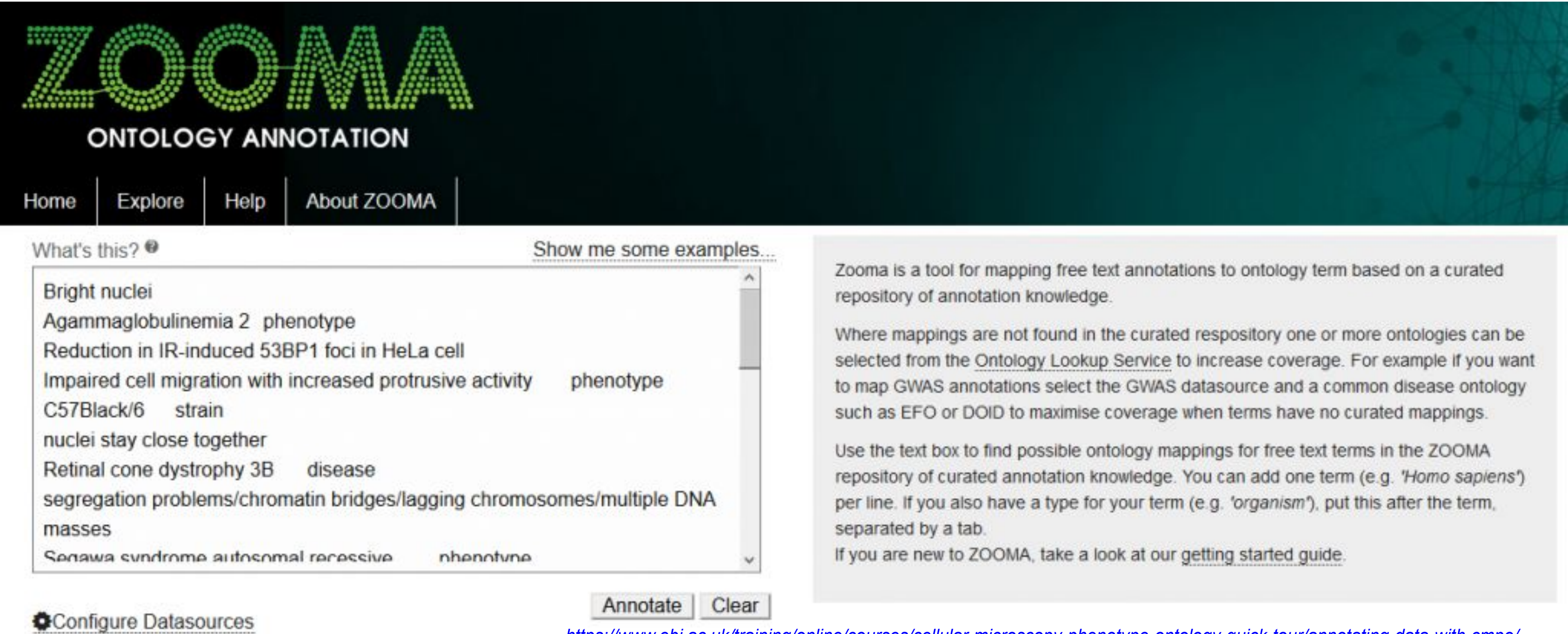
EBISPOT OLS
@EBIOLS

A number of our users have custom installations of OLS, OxO and Zooma. @NicoMatentzoglu has created a page where you can you tell us about your custom EBI Ontology Tools installation and your use case: github.com/EBISPOT/ontoto…

EBISPOT/ontot…
Configuration to …
github.com

https://www.ebi.ac.uk/ols/

Zooma



Bright nuclei
Agammaglobulinemia 2 phenotype
Reduction in IR-induced 53BP1 foci in HeLa cell
Impaired cell migration with increased protrusive activity phenotype
C57Black/6 strain
nuclei stay close together
Retinal cone dystrophy 3B disease
segregation problems/chromatin bridges/lagging chromosomes/multiple DNA masses
Segawa syndrome autosomal recessive phenotype

Zooma is a tool for mapping free text annotations to ontology term based on a curated repository of annotation knowledge.

Where mappings are not found in the curated respository one or more ontologies can be selected from the Ontology Lookup Service to increase coverage. For example if you want to map GWAS annotations select the GWAS datasource and a common disease ontology such as EFO or DOID to maximise coverage when terms have no curated mappings.

Use the text box to find possible ontology mappings for free text terms in the ZOOMA repository of curated annotation knowledge. You can add one term (e.g. *'Homo sapiens'*) per line. If you also have a type for your term (e.g. *'organism'*), put this after the term, separated by a tab.
If you are new to ZOOMA, take a look at our getting started guide.

https://www.ebi.ac.uk/training/online/courses/cellular-microscopy-phenotype-ontology-quick-tour/annotating-data-with-cmpo/
CC BY 4.0

https://www.ebi.ac.uk/spot/zooma/

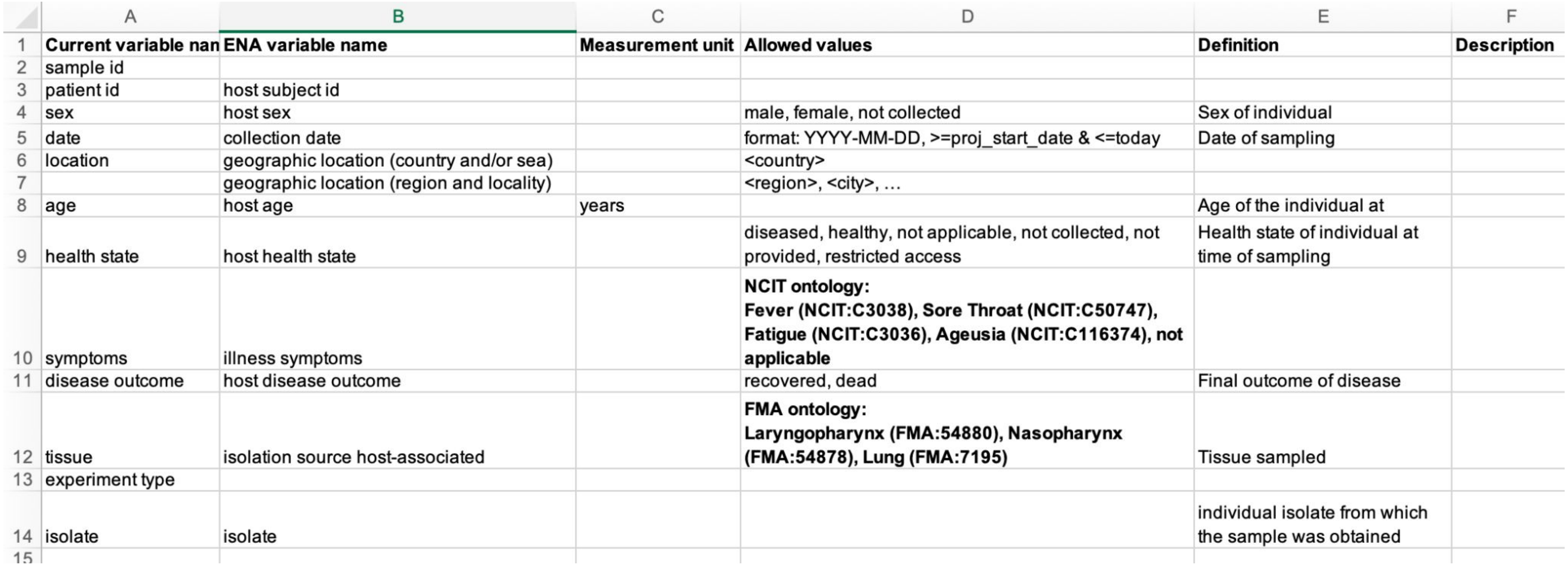
Exercise:
Find suitable ontologies for your data

Finding ontologies and terms

Try finding and deciding on suitable ontologies and terms to use for the data file

- **illness symptoms,** using OLS
- **isolation source host-associated,** using FAIRsharing.org

Update data dictionary



	A	B	C	D	E	F
1	**Current variable nan**	**ENA variable name**	**Measurement unit**	**Allowed values**	**Definition**	**Description**
2	sample id					
3	patient id	host subject id				
4	sex	host sex		male, female, not collected	Sex of individual	
5	date	collection date		format: YYYY-MM-DD, >=proj_start_date & <=today	Date of sampling	
6	location	geographic location (country and/or sea)		<country>		
7		geographic location (region and locality)		<region>, <city>, …		
8	age	host age	years		Age of the individual at	
9	health state	host health state		diseased, healthy, not applicable, not collected, not provided, restricted access	Health state of individual at time of sampling	
10	symptoms	illness symptoms		**NCIT ontology:** **Fever (NCIT:C3038), Sore Throat (NCIT:C50747), Fatigue (NCIT:C3036), Ageusia (NCIT:C116374), not applicable**		
11	disease outcome	host disease outcome		recovered, dead	Final outcome of disease	
12	tissue	isolation source host-associated		**FMA ontology:** **Laryngopharynx (FMA:54880), Nasopharynx (FMA:54878), Lung (FMA:7195)**	Tissue sampled	
13	experiment type					
14	isolate	isolate			individual isolate from which the sample was obtained	
15						

Summary

- Information about data is called **metadata**
- Good metadata is a necessity for understanding the data - FAIRness
- Try to be **consistent** when describing data
- Use **controlled vocabularies** and **ontologies** when specifying metadata
- **Metadata standards** - generic and domain specific
- Use **data dictionaries** to document standards for your data
- There are tools to help you decide on ontologies and terms to use