

07 March 2022 | NFDI InfraTalks | online

# nfdi4Culture

## Knowledge Graphs (and Wikibase) for Research Data Management

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Leibniz-Institut für Informationsinfrastruktur

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Citation: NFDI4Culture, Consortium for research data on material and immaterial cultural heritage, <https://nfdi4culture.de/>



# Knowledge Graphs @ FIZ Karlsruhe

## Projects, Services & NFDIs

**QPTDat**

Quality | Plasma Technology | Data



**MATERIALD1G1TAL**



**SciHi Blog**

daily blog on science, tech & art in history

**refer**

**linked stage graph**



**FIZ Karlsruhe**

Leibniz-Institut für Informationsinfrastruktur

**nfdi**

Nationale  
Forschungsdaten  
Infrastruktur

100 JAHRE  
WEIMARER  
REPUBLIK

Weimar –  
Die erste deutsche  
Demokratie

**archivportal**



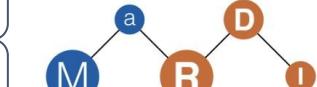
2019

**CnFdI CULTURE**



2020

**NFDI Mat Werk**



**NFDI4 DataScience**

**NFDI4Phys**

**NFDI4Objects**

**NFDI for memory**

# FAIR Data Resources and Services

- NFDI4Culture is a **huge data integration effort**
    - federated and heterogeneous research data resources from 70+ partner institutions
  - Goals:
    - **low effort research data integration**
    - **semantic and exploratory search**
    - **intelligent recommendations & question answering**
- } nfdi4Culture Knowledge Graph  
(based on ontologies)

a quantity ?  
a point in time ?  
a time span?  
a length?  
a weight?  
a measurement?  
a code ?  
a character string?

# 42



Alice in Wonderland has 42 illustrations [3]



Object 42 in the Messier catalogue, M42 [5]

Answer to the  
Ultimate Question of  
Life, the Universe, and  
Everything



Molybdenum has atomic number 42 [4]

a quantity ?  
a point in time ?  
a time span?  
a length?  
a weight?  
a measurement?  
a code ?  
a character string?

# 42

We need  
**(formal) Semantics**  
to represent the  
meaning of the  
data

# Where is the Semantics?

**<data>**

**<software>**

# Traditional Scenario

**<data>**

**<software>**

The **semantics** is in the programme code  
Written by **programmers**  
Depending on the  
**understanding/interpretation** of the  
**individual programmer**

# Traditional Scenario

**<data>**

**<software>**

Extensive software maintenance  
necessary (for any data structure  
changes)

Error prone (understanding /  
interpretation of the programmer)

The semantics is in the programme code  
Written by programmers  
Depending on the individual  
**understanding/interpretation of the  
data by the programmer**

# Semantic Web Scenario

<data>

<software>

- The **semantics** is in the **data**
- Written by **data provider**
- Depending on the original  
**understanding/interpretation of the**  
**data by its provider**

# Semantic Web Scenario

- Less software maintenance (regarding changes in the data structure)
- Less error prone
- Simpler data integration
- Simpler data reuse

<**data**>

- The **semantics** is in the **data**
- Written by **data provider**
- Depending on the original **understanding/interpretation of the data by its provider**

<**software**>

# Knowledge Graphs enable FAIR Data Management

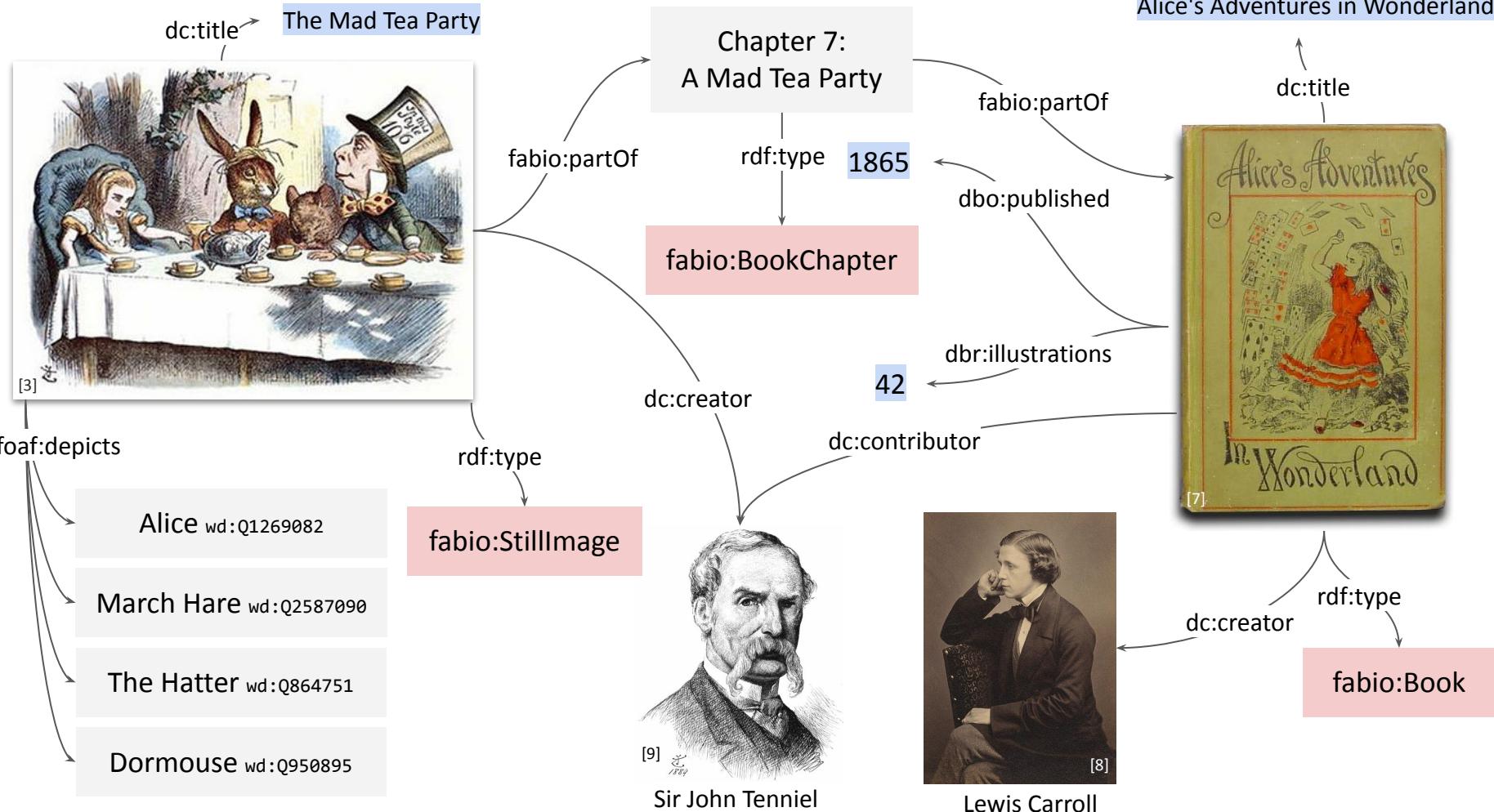
<data>

Ontologies

(formal semantics)



Knowledge  
Graph(s)



# nfdi4Culture Knowledge Graph

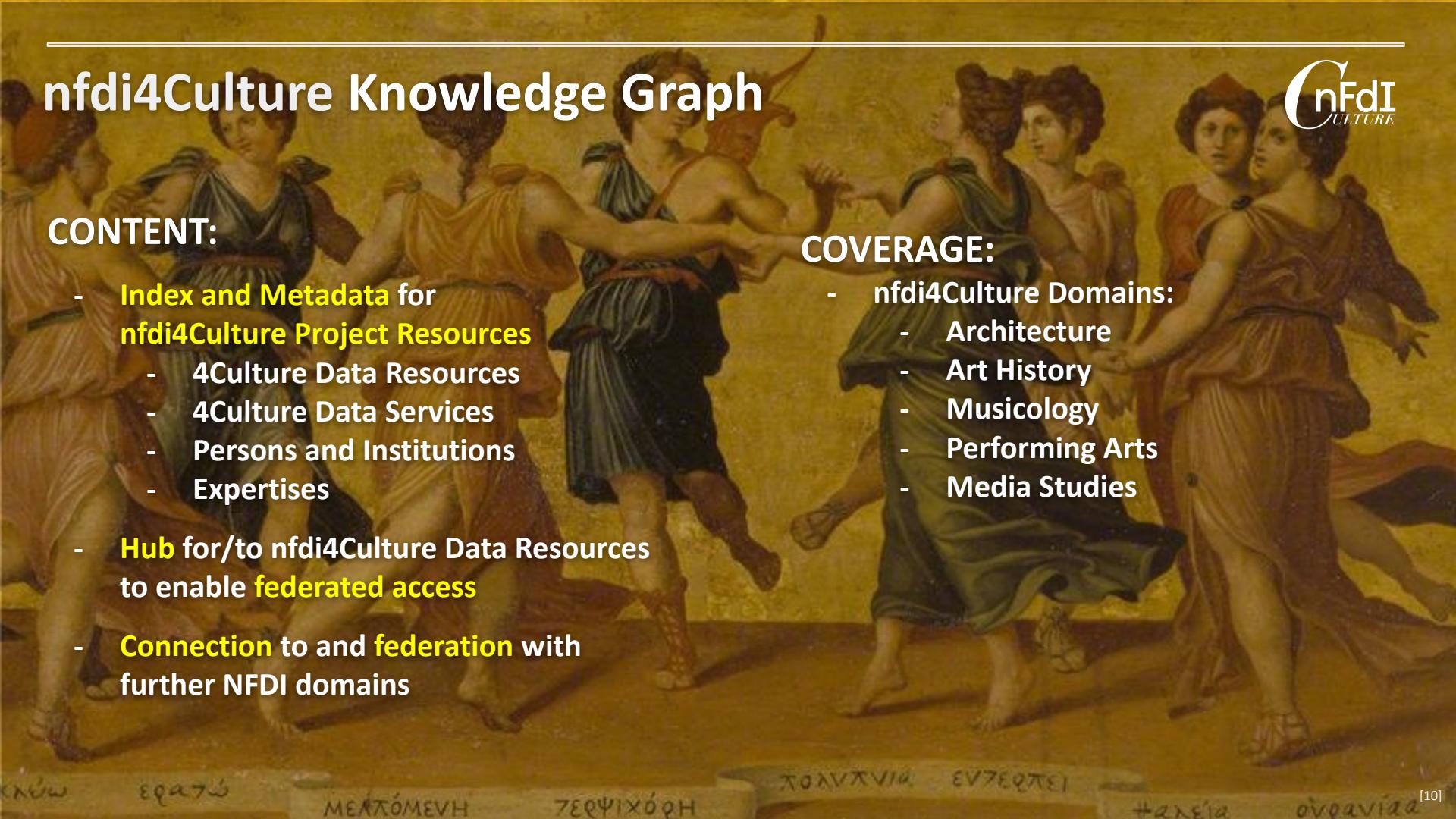


## CONTENT:

- Index and Metadata for nfdi4Culture Project Resources
  - 4Culture Data Resources
  - 4Culture Data Services
  - Persons and Institutions
  - Expertises
- Hub for/to nfdi4Culture Data Resources to enable federated access
- Connection to and federation with further NFDI domains

## COVERAGE:

- nfdi4Culture Domains:
  - Architecture
  - Art History
  - Musicology
  - Performing Arts
  - Media Studies



# nfdi4Culture Knowledge Graph



Data Provider  
Responsible Person

Contributor

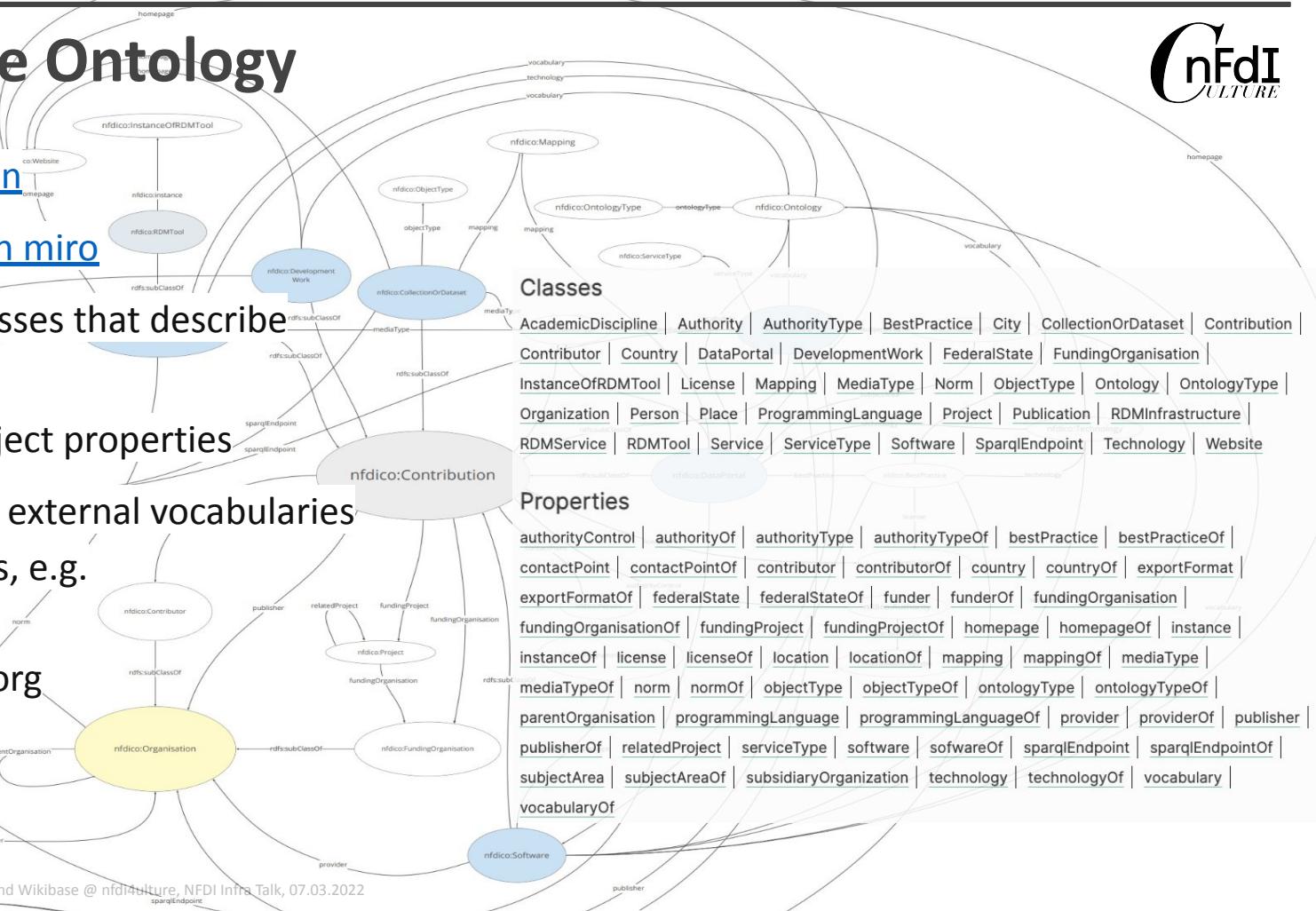
funded

DP Unique ID	DP Name	Akro	DP Website	DP Website_1	DP Contact_1	DP Provider	DP Contributor	P Funding Organisat	Academic Disc	Short
bach-digital	Bach digital		<a href="http://https://www.bach-digital.de">http://https://www.bach-digital.de</a>		christine-blanken	martina.bach-archiv-leipzig	staatsbibliothek-zu-berlin;s.deutsche-forschungsgemeinde	music	Col	
beethoven-haus-archives	Beethoven-Haus Archives		<a href="http://https://www.beethoven.de/en/archive/list">http://https://www.beethoven.de/en/archive/list</a>		friederike-grigat	beethoven-haus-bonn		beauftragte-der-bundesreg	music	Col
musixplora	MusiXplora		<a href="http://https://musixplora.de">http://https://musixplora.de</a>		josef-focht	musikinstrumentenmuseum-c			music	Musi
digitisation-of-bernd-alois-zimmermann	Digitisation of Bernd Alois Zimmermann's		<a href="http://https://www.zimmermann-gesamtausgabe.de/apps/baz">http://https://www.zimmermann-gesamtausgabe.de/apps/baz</a>		benjamin-w-bohl	adr mat akademie-der-wissenschaften			music	Col
freischuetz-digital	Freischuetz Digital	FreDi	<a href="http://https://freischuetz-digital.de">http://https://freischuetz-digital.de</a>		daniel-roewenstrunk	universitaet-paderborn			music	End
freischuetz-digital-multitrackdataset	Freischuetz Digital MultitrackDataset		<a href="http://https://audiolabs-erlangen.de/resources/MIR/Fre">http://https://audiolabs-erlangen.de/resources/MIR/Fre</a>		daniel-roewenstrunk	universitaet-paderborn			music	End
digitale-edition-der-carl-maria-von-w	Digitale Edition der Carl-Maria von Web		<a href="http://https://www.weber-gesamtausgabe.de/de/Projekt/Proj">http://https://www.weber-gesamtausgabe.de/de/Projekt/Proj</a>		peter-stadler	universitaet-paderborn;staats union-der-deutschen-akademie			music	Col
detmolder-hoftheater	Detmolder Hoftheater		<a href="http://https://hoftheater-detmold.de">http://https://hoftheater-detmold.de</a>		kristina-richts	universitaet-paderborn		deutsche-forschungsgemeinde	music;theater	Digi
kultsam	KultSam		<a href="http://https://www.kultsam.de">http://https://www.kultsam.de</a>		georg-hohmann	deutsches-museum-digital-m	deutsches-museum-digital		cultural-heritage	Digi
bereitstellung-filmbestaende	Bereitstellung Filmbestände		<a href="http://https://projects.tib.eu/delf/">http://https://projects.tib.eu/delf/</a>		thomas-baehr	margre	technische-informationsbiblio leibniz-gemeinschaft-berlin	bundesministerium-fuer-bil	film-studies	Digi
rara-digitalisate-der-bibliotheca-hertziana	Rara-Digitalisate der Bibliotheca Hertziana		<a href="http://rara.biblhertz.it/">http://rara.biblhertz.it/</a>				bibliotheca-hertziana-rom		literature	Digi
digitised-volumes-der-bibliotheca-hertziana	Digitised Volumes der Biblioteca dLib		<a href="http://https://dlib.biblhertz.it/">http://https://dlib.biblhertz.it/</a>				bibliotheca-hertziana-rom		literature	Digi
digitalisate-der-fotothek	Digitalisate der Fotothek		<a href="http://https://foto.biblhertz.it">http://https://foto.biblhertz.it</a>				bibliotheca-hertziana-rom		literature;art-hist	Digi
schedarium-noack	Schedarium Noack		<a href="http://db.biblhertz.it/noack/noack.xql">http://db.biblhertz.it/noack/noack.xql</a>				bibliotheca-hertziana-rom		art-history	Digi
archaeologische-literatur-digital	Archäologische Literatur - digital		<a href="http://https://archaeologie-digital.uni-hd.de">http://https://archaeologie-digital.uni-hd.de</a>		maria-effinger	universitaetsbibliothek-heidelberg	bibliotheca-hertziana-rom		archeology	Ret
aegyptologische-literatur-digital	Ägyptologische Literatur - digital		<a href="http://https://aegyptologie-digital.uni-hd.de/">http://https://aegyptologie-digital.uni-hd.de/</a>		maria-effinger	universitaetsbibliothek-heidelberg	bibliotheca-hertziana-rom		egyptology	Ret
kunstwissenschaftliche-literatur-digital	Kunstwissenschaftliche literatur - digital		<a href="http://https://www.ub.uni-heidelberg.de/helios/fachinfo/www/k">http://https://www.ub.uni-heidelberg.de/helios/fachinfo/www/k</a>		maria-effinger	universitaetsbibliothek-heidelberg			art-history	Ret
deutsche-fotothek-slub	Deutsche Fotothek SLUB		<a href="http://https://www.deutschefotothek.de/">http://https://www.deutschefotothek.de/</a>		jens-bove	saechsische-landesbibliothek		deutsche-forschungsgemeinde	media-sciences	Digi
digitale-sammlungen-slub	Digitale Sammlungen SLUB		<a href="http://https://digital.slub-dresden.de/kollektionssuche/">http://https://digital.slub-dresden.de/kollektionssuche/</a>		annika-valeska-walzel	saechsische-landesbibliothek			literature	Digi

# nfdi4culture Ontology

- Documentation
- Visualisation in miro
- 37 defined classes that describe contributions
- 62 defined object properties
- Mapped to 24 external vocabularies and ontologies, e.g.

- frapo
- schema.org
- fabio
- void



# nfdi4culture Data Exploration



SPARQL Endpoint: <https://nfdi.fiz-karlsruhe.de/>

```
PREFIX wd: <http://www.wikidata.org/entity/>
PREFIX nfdico: <http://www.nfdi4culture.de/resource/nfdico#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX direct: <http://www.wikidata.org/prop/direct/>
PREFIX gnd: <http://d-nb.info/gnd/>
PREFIX wdorg: <http://www.wikidata.org/entity/>
PREFIX nfdi4culture: <http://www.nfdi4culture.de/resource/>
PREFIX nfdico: <http://www.nfdi4culture.de/resource/nfdico#>

SELECT ?contlabel ?organisation ?orgalabel ?wdorg
WHERE {
    ?organisation nfdico:contributor ?contlabel ;
        rdfs:label ?contlabel .
    ?organisation rdfs:label ?orgalabel .
    ?gndorg owl:sameAs ?organisation
    FILTER(REGEX(str(?gndorg), "http://d-nb.info/gnd/"))
    BIND(replace(str(?gndorg), "http://d-nb.info/gnd/", "") as ?gndo
    SERVICE <https://query.wikidata.org/sparql> {
        ?wdorg wdt:P227 ?gndorg ;
        wdt:P31 wd:Q207694 .
    }
}
```

- Show all contributions provided by art museums

Federation via Wikidata to retrieve contributions by organizations classified as art museums (Q207694)

contlabel	organisation	orgalabel	wdorg
Grosse Deutsche Kunstausstellung	<a href="https://www.nfdi4culture.de/resource/haus-der-kunst-muenchen">https://www.nfdi4culture.de/resource/haus-der-kunst-muenchen</a>	Haus der Kunst München	<a href="http://www.wikidata.org/entity/Q697782">http://www.wikidata.org/entity/Q697782</a>
Sachsen.digital	<a href="https://www.nfdi4culture.de/resource/staatliche-kunstsammlungen-dresden">https://www.nfdi4culture.de/resource/staatliche-kunstsammlungen-dresden</a>	Staatliche Kunstsammlungen Dresden	<a href="http://www.wikidata.org/entity/Q653002">http://www.wikidata.org/entity/Q653002</a>
Nürnberger Topografie in Raum und Zeit	<a href="https://www.nfdi4culture.de/resource/germanisches-nationalmuseum-nuernberg">https://www.nfdi4culture.de/resource/germanisches-nationalmuseum-nuernberg</a>	Germanisches Nationalmuseum	<a href="http://www.wikidata.org/entity/Q478695">http://www.wikidata.org/entity/Q478695</a>
Kulturelles Erbe Köln	<a href="https://www.nfdi4culture.de/resource/museum-schnuetgen">https://www.nfdi4culture.de/resource/museum-schnuetgen</a>	Museum Schnütgen	<a href="http://www.wikidata.org/entity/Q950">http://www.wikidata.org/entity/Q950</a>
Kulturelles Erbe Köln	<a href="https://www.nfdi4culture.de/resource/museum-ludwig-koeln">https://www.nfdi4culture.de/resource/museum-ludwig-koeln</a>	Museum Ludwig	<a href="http://www.wikidata.org/entity/Q703640">http://www.wikidata.org/entity/Q703640</a>
KultSam	<a href="https://www.nfdi4culture.de/resource/germanisches-nationalmuseum-nuernberg">https://www.nfdi4culture.de/resource/germanisches-nationalmuseum-nuernberg</a>	Germanisches Nationalmuseum	<a href="http://www.wikidata.org/entity/Q478695">http://www.wikidata.org/entity/Q478695</a>
Kulturelles Erbe Köln	<a href="https://www.nfdi4culture.de/resource/museum-fuer-ostasiatische-kunst-koeln">https://www.nfdi4culture.de/resource/museum-fuer-ostasiatische-kunst-koeln</a>	Museum für Ostasiatische Kunst	<a href="http://www.wikidata.org/entity/Q884204">http://www.wikidata.org/entity/Q884204</a>

# Technological Framework



# (Why) WikiBase?



- **GUI for interactive collaborative editing of structured data**
- **Convenient way to enable/engage Communities**
- **Connects to a Semantic Data store**

Item Discussion

## Johann Adam Weishaupt (Q1308)

\* February 6, 1748, + November 18, 1830, professor of law and canon law, writer and court councilor, Ingolstadt, member of the Illuminati under the code names Spartacus and Scipio Aemilianus

Adam Weishaupt | Weishaupt | Spartacus | Scipio Aemilianus

▼ In more languages  
Configure

Language	Label	Description
English	Johann Adam Weishaupt	* February 6, 1748, + November 18, 1830, professor of law and canon law, writer and court councilor, Ingolstadt, member of the Illuminati under the code names Spartacus and Scipio Aemilianus

All entered languages

### Statements

Instance of	Human	0 references
GND ID	118766384	0 references
Date of birth	6 February 1748 Gregorian	0 references
Grave	Gotha Begin date 18 November 1830 Gregorian	0 references
Illuminati code name	Spartacus	0 references

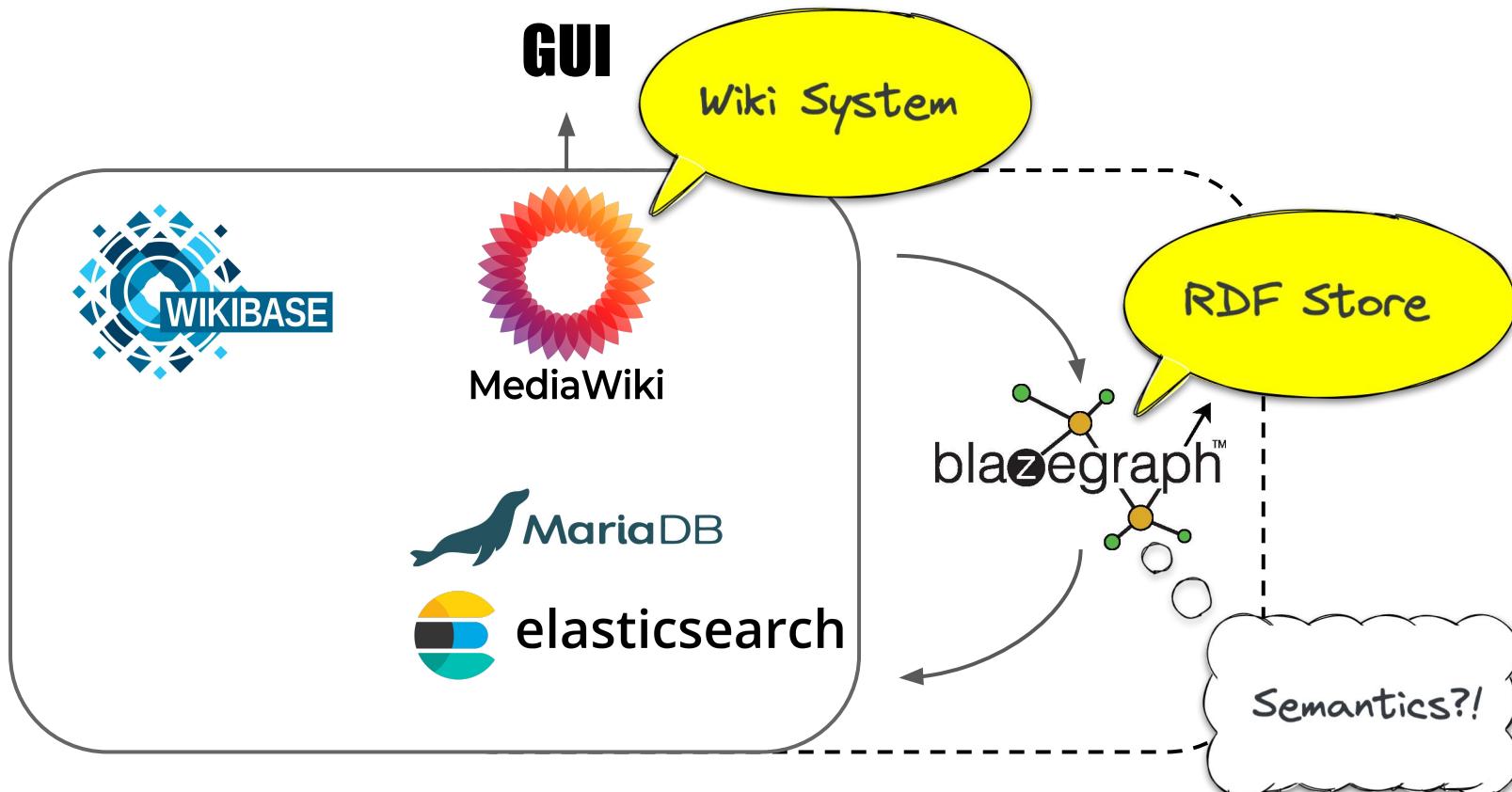
Wikivoyage (0 entries)

Other sites (1 entry)  
wikidatawiki Q159481

<https://database.factorid.de/wiki/Item:Q1308>



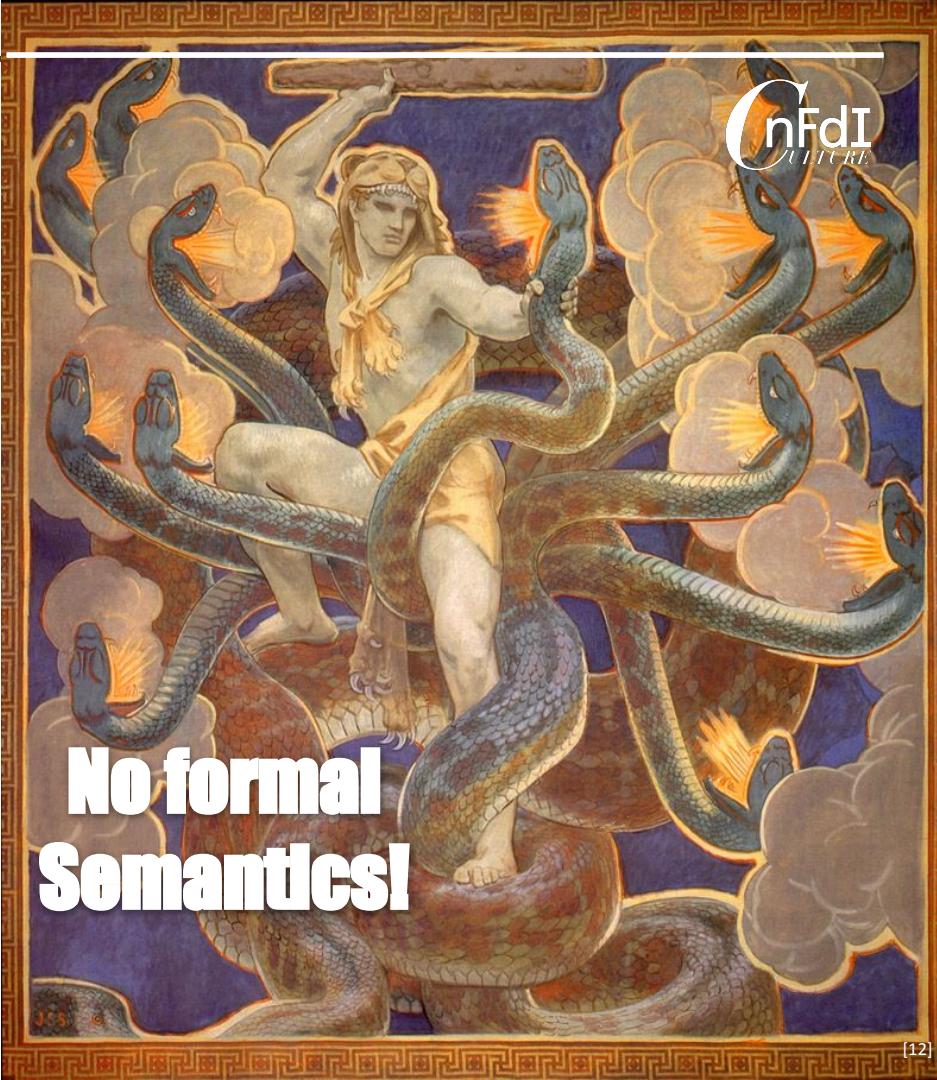
# WikiBase Architecture



# (One) WikiBase Problem



- Wikibase is originally a **Wiki only** and **no native RDF triple store**
- Data is only **relational data** (MariaDB/mySQL)
- Attached Triple Store only contains "**flat**" triples without explicit semantics
  - **No use of standard W3C Semantic Web vocabularies (RDF, RDFS, OWL)**



# ...and how to deal with it



- Evaluation of **viable workarounds and solutions** to enable real data semantics with existing Wikibase
  - Declarative semantic mapping
  - Data import / export
  - Semantic Extension



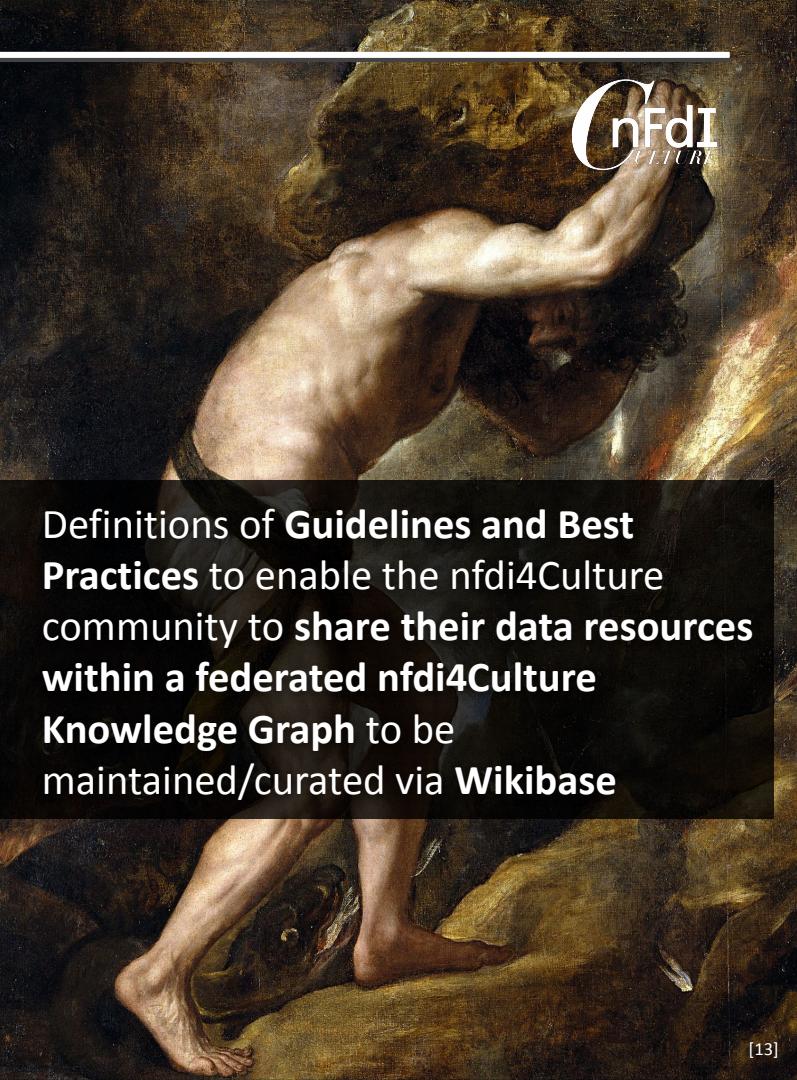
# ...and how to deal with it



- Evaluation of **viable workarounds and solutions** to enable real data semantics with existing Wikibase
  - Declarative semantic mapping
  - Data import / export
  - Semantic Extension



Definitions of **Guidelines and Best Practices** to enable the nfdi4Culture community to **share their data resources within a federated nfdi4Culture Knowledge Graph** to be maintained/curated via **Wikibase**



# (Another) WikiBase Problem

Item Discussion

## Hydra (Q170379)

ancient serpent-like chthonic water monster, with reptilian traits, that possessed many heads, in Greek mythology

Lernaean Hydra | Lernean Hydra | The Lernean Hydra | Lernæan Hydra

[edit](#)

▼ In more languages

Configure

Language	Label	Description	Also known as
English	Hydra	ancient serpent-like chthonic water monster, with reptilian traits, that possessed many heads, in Greek mythology	Lernaean Hydra Lernean Hydra The Lernean Hydra Lernæan Hydra
German	Hydra	Ungeheuer der griechischen Mythologie	Lernäische Schlange
French	Hydre de Lerne	monstre possédant plusieurs têtes qui se régénèrent doublement lorsqu'elles sont tranchées	Hydre
Bavarian	No label defined	No description defined	

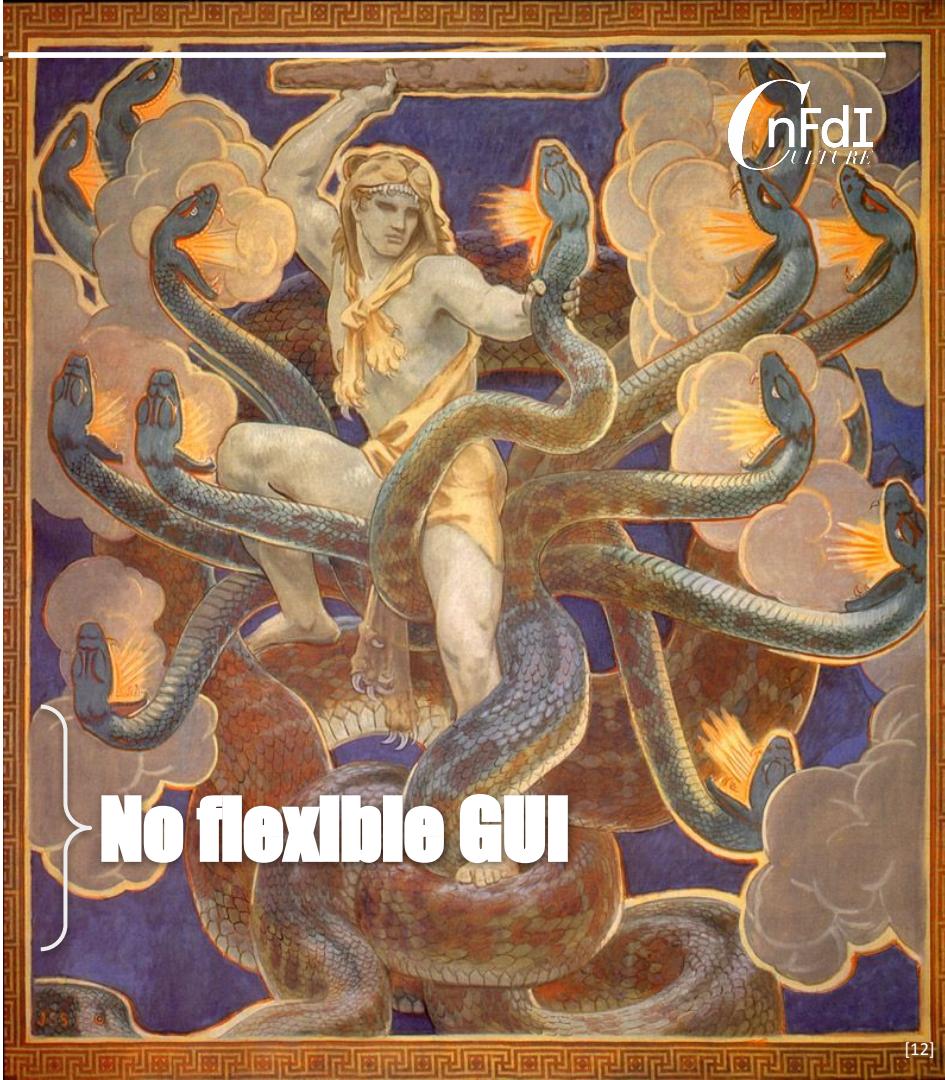
[All entered languages](#)

## Statements

instance of	<a href="#">mythological serpent</a> <a href="#">+ 0 references</a>	<a href="#">edit</a>
	<a href="#">mythological Greek character</a> <a href="#">+ 0 references</a>	<a href="#">edit</a>
		<a href="#">+ add reference</a> <a href="#">+ add value</a>

part of

<a href="#">Labours of Hercules</a>	<a href="#">+ 0 references</a>	<a href="#">edit</a>
		<a href="#">+ add reference</a>



CnFdI  
CULTURE

No flexible GUI

# Alternative Solution(s) ?



# Flexible GUI for nfdi4culture KG Architecture(s)



The screenshot shows a website header with navigation links: What we do, News & Events, About us, Resources, Contact, a search icon, and DE. Below the header is a portrait of Prof. Dr. Harald Sack. To the right of the portrait is his name, IRI: E1925, and the text FIZ Karlsruhe - Leibniz-Institut für Informationsinfrastruktur. Below the portrait is a section titled "Further Information" and "Participation in Consortium". Under "Participation in Consortium", there are links to "Overarching technical, ethical and legal activities", "Culture Spokespersons Committee", and "Culture Steering Board".

## Culture Information Portal

<https://nfdi4culture.de/>

TYPO3  
(or other CMS)



# Take Home Messages

- Knowledge Graphs are (should be) based on **Ontologies**
- **Ontologies (formal semantics)** can enhance **data management efficiency**
- **Wikibase does not provide formal semantics**
- **Wikibase may not always be the best fit for research data management**
- **nfdi4culture Ontology and nfdi4culture Knowledge Graph**



Thank you very much  
for your attention!



# Picture References



- [1] Harald Sack, *The Creation of Linked Open Data* (2014), remixing Michelangelo, *The Creation of Adam* (1511) [https://commons.wikimedia.org/wiki/File:Michelangelo\\_-\\_Creation\\_of\\_Adam\\_\(cropped\).jpg](https://commons.wikimedia.org/wiki/File:Michelangelo_-_Creation_of_Adam_(cropped).jpg), and *Linking Open Data cloud diagram*, by Richard Cyganiak and Anja Jentzsch. <http://lod-cloud.net/>, [CC-BY-SA 3.0]
- [2] Carole Raddato, *Oedipus and the Sphinx of Thebes*, Red Figure Kylix, c. 470 BC, from Vulci, attributed to the Oedipus Painter, Vatican Museums, [https://commons.wikimedia.org/wiki/File:Oedipus\\_and\\_the\\_Sphinx\\_of\\_Thebes,\\_Red\\_Figure\\_Kylix,\\_c.\\_470\\_BC,\\_from\\_Vulci,\\_attributed\\_to\\_the\\_Oedipus\\_Painter,\\_Vatican\\_Museums\\_\(9665213064\).jpg](https://commons.wikimedia.org/wiki/File:Oedipus_and_the_Sphinx_of_Thebes,_Red_Figure_Kylix,_c._470_BC,_from_Vulci,_attributed_to_the_Oedipus_Painter,_Vatican_Museums_(9665213064).jpg), [CC-BY-SA 2.0]
- [3] John Tenniel, *Alice's Mad Tea Party*, Alice in Wonderland (1865), [https://commons.wikimedia.org/wiki/File:John\\_Tenniel-\\_Alice%27s\\_mad\\_tea\\_party,\\_colour.jpg](https://commons.wikimedia.org/wiki/File:John_Tenniel-_Alice%27s_mad_tea_party,_colour.jpg), [public domain]
- [4] *Alchemist-hp*, *Molybdenum crystalline fragment and 1cm3 cube* (2010), [https://commons.wikimedia.org/wiki/File:Molybdenum\\_crystalline\\_fragment\\_and\\_1cm3\\_cube.jpg](https://commons.wikimedia.org/wiki/File:Molybdenum_crystalline_fragment_and_1cm3_cube.jpg), [CC-BY-NC-ND 3.0]
- [5] NASA, ESA, M. Robberto (Space Telescope Science Institute/ESA) and the Hubble Space Telescope Orion Treasury Project Team, *Orion Nebula - Hubble 2006*, [https://commons.wikimedia.org/wiki/File:Orion\\_Nebula\\_-\\_Hubble\\_2006\\_mosaic\\_18000.jpg](https://commons.wikimedia.org/wiki/File:Orion_Nebula_-_Hubble_2006_mosaic_18000.jpg), [public domain]
- [6] Pixabay, <https://pixabay.com/photos/data-computer-internet-online-www-2899901/>, [pixabay license, <https://pixabay.com/service/license/>]
- [7] Lewis Carroll, *Alice's Adventures in Wonderland*, 1898 edition, <https://commons.wikimedia.org/wiki/File:Alicesadventuresinwonderland1898.jpg>, [public domain]
- [8] Portrait of Lewis Carroll: This was first published in Carroll's biography by his nephew, Stuart Dodgson Collingwood: Collingwood, Stuart Dodgson (1898) *The Life and Letters of Lewis Carroll*, London, 1857, <https://commons.wikimedia.org/wiki/File:LewisCarrollSelfPhoto.jpg>, [public domain]
- [9] John Tenniel - Scanned from M.H. Spielmann's *The History of "Punch"* (Cassell & sons, 1895). Page 462, [https://commons.wikimedia.org/wiki/File:John\\_Tenniel.png](https://commons.wikimedia.org/wiki/File:John_Tenniel.png), [public domain]
- [10] Baldassare Peruzzi (1481-1536) (after) - *Apollo and the Muses Dancing* - 609020 - National Trust (1890-1899), Art UK, [https://commons.wikimedia.org/wiki/File:Baldassare\\_Peruzzi\\_\(1481-1536\)\\_\(\\_after\)\\_-\\_Apollo\\_and\\_the\\_Muses\\_Dancing\\_-\\_609020\\_-\\_National\\_Trust.jpg?uselang=de](https://commons.wikimedia.org/wiki/File:Baldassare_Peruzzi_(1481-1536)_(_after)_-_Apollo_and_the_Muses_Dancing_-_609020_-_National_Trust.jpg?uselang=de) [public domain]
- [11] Jan Brueghel the Elder, *Venus at the Forge of Vulcan; Allegory of fire*, 1606-1613, [https://commons.wikimedia.org/wiki/File:Workshop\\_of\\_Jan\\_Brueghel\\_the\\_Elder\\_-\\_Venus\\_at\\_the\\_Forge\\_of\\_Vulcan.jpg](https://commons.wikimedia.org/wiki/File:Workshop_of_Jan_Brueghel_the_Elder_-_Venus_at_the_Forge_of_Vulcan.jpg), [public domain]
- [12] John Singer-Sargent, *Hercules* (1921), [https://commons.wikimedia.org/wiki/Category:Paintings\\_of\\_Hercules\\_\(Heracles\)\\_and\\_Lernaean\\_Hydra#/media/File:Singer\\_Sargent,\\_John\\_-\\_Hercules\\_-\\_1921.jpg](https://commons.wikimedia.org/wiki/Category:Paintings_of_Hercules_(Heracles)_and_Lernaean_Hydra#/media/File:Singer_Sargent,_John_-_Hercules_-_1921.jpg), [public domain]
- [13] Titian, *Sisyphus* (cropped) (1548/49), [https://commons.wikimedia.org/wiki/File:Punishment\\_sisyph.jpg](https://commons.wikimedia.org/wiki/File:Punishment_sisyph.jpg), [public domain]
- [14] Jacques-Louis David, *The Oath of the Horatii* (1784), [https://commons.wikimedia.org/wiki/File:David-Oath\\_of\\_the\\_Horatii-1784.jpg](https://commons.wikimedia.org/wiki/File:David-Oath_of_the_Horatii-1784.jpg), [public domain]