


Semantic Web and its Application in Research Data Management

JSON-LD, RO-Crate, schema.org, ARC

What is Semantic Web?


Motivation






The Lord of the Rings

Film series




The Lord of the Rings: Gollum

Video game




The Lord of the Rings: Return to Moria




The Lord of the Rings: The Rings of Power

Television series



The Lord of the Rings Online

Online game



lord of the rings series

The Lord of the Rings: The Fellowship of the Ring — 2001 film

Google Search

I'm Feeling Lucky

Report inappropriate predictions

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Germany

Advertising Business How Search works

Privacy Terms Settings



lord of the rings



News

Images

Videos

Shopping

Books

Maps

Flights

Finance

All filters ▾

Tools

SafeSearch ▾

About 506,000,000 results (0.52 seconds)



The Lord of the Rings

Film series

Overview

Movies

Cast

Trailers & clips

Actors

Movies >



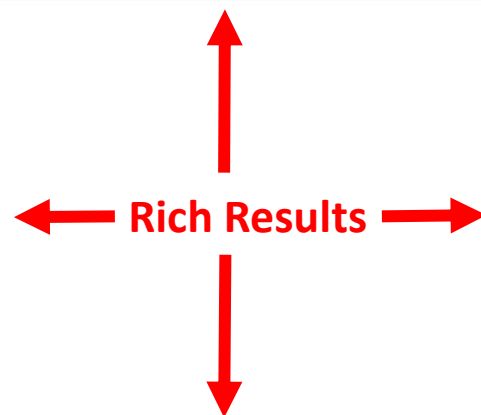
The Lord of the Rings: T...
2001



The Lord of the Rings: T...
2002



The Lord of the Rings: T...
2003



About

The Lord of the Rings is a series of three epic fantasy adventure films directed by Peter Jackson, based on the novel The Lord of the Rings by J. R. R. Tolkien. The films are subtitled The Fellowship of the Ring, The Two Towers, and The Return of the King. [Wikipedia](#)

Director: [Peter Jackson](#)

Adapted from: [The Lord of the Rings](#)

Production companies: [New Line Cinema](#), [WingNut Films](#), [Saul Zaentz Film Co.](#)

Box office: Total (3 films): \$2.993 billion

Release date: 2001–2003

[Feedback](#)

Cast >



Elijah Wood
Frodo Baggins



Viggo Mortensen
Aragorn



Sean Astin
Samwise Gam...



Dominic Monaghan
Merry Brandyb...



Orlando Bloom
Legolas



Billy Boyd
Pippin Took



Wikipedia

https://en.wikipedia.org/wiki/The_Lord_of_the_Rings

The Lord of the Rings

People also search for



The Lord of the Rings:
The Fello...



The Lord of the Rings:
The Retur...



The Lord of the Rings:
The Two...




The Lord of the Rings:
The Ring...

See more →

2001 • PG-13 • 2h 58m

2001 • PG-13 • 2h 58m



 This video cannot be played because of a problem with your internet connection. (Error Code: 221000)

11 VIDEOS

99+ PHOTOS

Action Adventure Drama

A meek Hobbit from the Shire and eight companions set out on a journey to destroy the powerful One Ring and save Middle-earth from the Dark Lord Sauron.

Director Peter Jackson

Writers J.R.R. Tolkien · Fran Walsh · Philippa Boyens

Stars Elijah Wood · Ian McKellen · Orlando Bloom

IMDbPro See production, box office & company info [↗](#)

Top rated movie #9

Won 4 Oscars 123 wins & 127 nominations total

 See Showtimes

☰ More watch options

+ Add to Watchlist
Added by 890K users

5.7K User reviews **233** Critic reviews

92 Metascore



```
1 {
2   "@context": "https://schema.org",
3   "@type": "Movie",
4   "url": "https://www.imdb.com/title/tt0120737/",
5   "name": "The Lord of the Rings: The Fellowship of the Ring",
6   "image": "https://m.media-amazon.com/images/M/MV5BN2EyZjM3NzUtNWUzMi00MTgxLWI0NTctMzY4M2VlOTdjZWRiXkEyXkFqcGdeQXVyNDUzOTQ5MjY@. V1 .jpg",
7   "description": "A meek Hobbit from the Shire and eight companions set out on a journey to destroy the powerful One Ring and save Middle-earth from the Dark Lord Sauron.",
8   "review": { ...
22 },
23   "aggregateRating": {
24     "@type": "AggregateRating",
25     "ratingCount": 1925669,
26     "bestRating": 10,
27     "worstRating": 1,
28     "ratingValue": 8.8
29   },
30   "contentRating": "PG-13",
31   "genre": [
32     "Action",
33     "Adventure",
34     "Drama"
35   ],
36   "datePublished": "2001-12-19",
37   "keywords": "ring,quest,hobbit,middle earth,elf",
38   "trailer": { ...
51 },
52   "actor": [
53     {
54       "@type": "Person",
55       "url": "https://www.imdb.com/name/nm0000704/",
56       "name": "Elijah Wood"
57     },
58     {
59       "@type": "Person",
60       "url": "https://www.imdb.com/name/nm0005212/",
61       "name": "Ian McKellen"
62     },
63     {
64       "@type": "Person",
65       "url": "https://www.imdb.com/name/nm0089217/",
66       "name": "Orlando Bloom"
67     }
68   ],
69   "director": [
70     {
71       "@type": "Person",
72       "url": "https://www.imdb.com/name/nm0001392/",
73       "name": "Peter Jackson"
74     }
75   ],
76 }
```

What is Semantic Web?

Technologies

JSON: JavaScript Object Notation

- Human- and machine-readable format
- Objects are simple lists of key-value pairs
- Attribute identifiers are strings
- Values are strings, numerical values, lists or objects


```
1 {
2   "@context": "https://schema.org",
3   "@type": "Movie",
4   "url": "https://www.imdb.com/title/tt0120737/",
5   "name": "The Lord of the Rings: The Fellowship of the Ring",
6   "image": "https://m.media-amazon.com/images/M/MV5BN2EyZjM3NzUtNWUzMi00MTgxLWI0NTctMzY4M2VlOTdjZWRiXkEyXkFqcGdeQXVyNDUzOTQ5MjY@. V1 .jpg",
7   "description": "A meek Hobbit from the Shire and eight companions set out on a journey to destroy the powerful One Ring and save Middle-earth from the Dark Lord Sauron.",
8 >   "review": { ...
22 },
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67     }
68   ],
69   "director": [
70     {
71       "@type": "Person",
72       "url": "https://www.imdb.com/name/nm0001392/",
73       "name": "Peter Jackson"
74     }
75   ],
76 }
```

JSON-LD: JSON for Linked Data

- Objects have a unique property "@id", preferably an URI
- Objects have a "@type", referencing some vocabulary
- Types are specified within a "@context"
- Example:

```
1 {  
2   "@context": "https://json-ld.org/contexts/person.jsonld",  
3   "@id": "http://dbpedia.org/resource/John_Lennon",  
4   "@type": "Person",  
5   "name": "John Lennon",  
6   "born": "1940-10-09",  
7   "spouse": "http://dbpedia.org/resource/Cynthia_Lennon"  
8 }
```

Global identifier

Type definition


Embedding in Websites

- Google requires JSON-LD markup for rich results
- Must be in the header of html-websites
- Must use schema.org vocabulary
- Google adds additional constraints

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Movie

A Schema.org Type

Thing > CreativeWork > Movie

A movie.

[more...]

Property	Expected Type	Description
Properties from Movie		
actor	Person	An actor, e.g. in TV, radio, movie, video games etc., or in an event. Actors can be associated with individual items or with a series, episode, clip. Supersedes actors .
countryOfOrigin	Country	The country of origin of something, including products as well as creative works such as movie and TV content. In the case of TV and movie, this would be the country of the principle offices of the production company or individual responsible for the movie. For other kinds of CreativeWork it is difficult to provide fully general guidance, and properties such as contentLocation and locationCreated may be more applicable. In the case of products, the country of origin of the product. The exact interpretation of this may vary by context and product type, and cannot be fully enumerated here.
	Person	A director of e.g. TV, radio, movie, video gaming etc. content, or of an event. Directors can be associated with individual items or with a series, episode, clip. Supersedes directors .
	Duration	The duration of the item (movie, audio recording, event, etc.) in ISO 8601 date format .
duration	MusicGroup or Person	The composer of the soundtrack.
musicBy	Organization	The production company or studio responsible for the item, e.g. series, video game, episode etc.
productionCompany	Language or Text	Languages in which subtitles/captions are available, in IETF BCP 47 standard format .
subtitleLanguage	Text or URL	An EIDR (Entertainment Identifier Registry) identifier representing at the most general/abstract level, a work of film or television. For example, the motion picture known as "Ghostbusters" has a titleEIDR of "10.5240/7EC7-228A-510A-053E-CBB8-J". This title (or work) may have several variants, which EIDR calls "edits". See editEIDR . Since schema.org types like Movie , TVEpisode , TVSeason , and TVSeries can be used for both works and their multiple expressions, it is possible to use titleEIDR alone (for a general description), or alongside editEIDR for a more edit-specific description.
titleEIDR	VideoObject	The trailer of a movie or TV/radio series, season, episode, etc.
Properties from CreativeWork		
about	Thing	The subject matter of the content. Inverse property: subjectOf

Person

A Schema.org Type

Thing > Person

A person (alive, dead, undead, or fictional).

[more...]

Property	Expected Type	Description
Properties from Person		
additionalName	Text	An additional name for a Person, can be used for a middle name.
address	PostalAddress or Text	Physical address of the item.
affiliation	Organization	An organization that this person is affiliated with. For example, a school/university, a club, or a team.
alumniOf	EducationalOrganization or Organization	An organization that the person is an alumni of. Inverse property: alumni
award	Text	An award won by or for this item. Supersedes awards .
birthDate	Date	Date of birth.
birthPlace	Place	The place where the person was born.
brand	Brand or Organization	The brand(s) associated with a product or service, or the brand(s) maintained by an organization or business person.
callSign	Text	A callsign , as used in broadcasting and radio communications to identify people, radio and TV stations, or vehicles.
children	Person	A child of the person.
colleague	Person or URL	A colleague of the person. Supersedes colleagues .
contactPoint	ContactPoint	A contact point for a person or organization. Supersedes contactPoints .
deathDate	Date	Date of death.
deathPlace	Place	The place where the person died.
duns	Text	The Dun & Bradstreet DUNS number for identifying an organization or business person.
email	Text	Email address.
familyName	Text	Family name. In the U.S., the last name of a Person.
faxNumber	Text	The fax number.
follows	Person	The most generic uni-directional social relation.
funder	Organization or Person	A person or organization that supports (sponsors) something through some kind of financial contribution.
funding	Grant	A Grant that directly or indirectly provide funding or sponsorship for this item. See also ownershipFundingInfo .
		Inverse property: fundedItem

JSON-LD: JSON for *Linked Data*

- Unique IDs allow flattened form
- Example:

```
1  {
2    "@context": {
3      "@vocab": "http://xmlns.com/foaf/0.1/"
4    },
5    "@id": "http://manu.sporny.org/about#manu",
6    "@type": "Person",
7    "name": "Manu Sporny",
8    "knows": {
9      "@id": "https://greggkellogg.net/foaf#me",
10     "@type": "Person",
11     "name": "Gregg Kellogg"
12   }
13 }
```

```
1  {
2    "@context": {
3      "@vocab": "http://xmlns.com/foaf/0.1/"
4    },
5    "@graph": [
6      {
7        "@id": "http://manu.sporny.org/about#manu",
8        "@type": "Person",
9        "name": "Manu Sporny",
10       "knows": { "@id": "https://greggkellogg.net/foaf#me" }
11     },
12     {
13       "@id": "https://greggkellogg.net/foaf#me",
14       "@type": "Person",
15       "name": "Gregg Kellogg"
16     }
17   ]
18 }
```


JSON-LD Contexts

- Aliases can be defined in the "@context" field
- Example:

```
1  {
2    "@context": {
3      "@vocab": "http://xmlns.com/foaf/0.1/"
4    },
5    "@id": "http://manu.sporny.org/about#manu",
6    "@type": "Person",
7    "name": "Manu Sporny",
8    "knows": {
9      "@id": "https://greggkellogg.net/foaf#me",
10     "@type": "Person",
11     "name": "Gregg Kellogg"
12   }
13 }
```

```
1  {
2    "@context": {
3      "@vocab": "http://xmlns.com/foaf/0.1/"
4    },
5    "@graph": [
6      {
7        "@id": "http://manu.sporny.org/about#manu",
8        "@type": "Person",
9        "name": "Manu Sporny",
10       "knows": { "@id": "https://greggkellogg.net/foaf#me" }
11      },
12      {
13        "@id": "https://greggkellogg.net/foaf#me",
14        "@type": "Person",
15        "name": "Gregg Kellogg"
16      }
17    ]
18 }
```

Semantic Web for Research Data

What has this to do with RDM?

We want this ↓ for Research Data

The screenshot shows a Google search for "The Lord of the Rings". The search bar at the top contains the text "lord of the rings". Below the search bar, the results are categorized into "News", "Images", "Videos", "Shopping", "Books", "Maps", "Flights", and "Finance". The main results section is titled "The Lord of the Rings" and includes a "Film series" label. Below this, there are tabs for "Overview", "Movies", "Cast", "Trailers & clips", and "Actors". The "Movies" tab is selected, showing three movie posters: "The Lord of the Rings: The Fellowship of the Ring", "The Lord of the Rings: The Two Towers", and "The Lord of the Rings: The Return of the King". The "Cast" tab is also visible, showing a list of actors including Elijah Wood, Viggo Mortensen, Sean Astin, Dominic Monaghan, Orlando Bloom, and Billy Boyd. The "About" section on the right provides a brief overview of the series, its director (Peter Jackson), and its production companies. The "People also search for" section at the bottom right shows related search terms like "The Lord of the Rings: The Fellowship of the Ring", "The Lord of the Rings: The Two Towers", and "The Lord of the Rings: The Return of the King".

Google

lord of the rings

News Images Videos Shopping Books Maps Flights Finance

About 506,000,000 results (0.52 seconds)

The Lord of the Rings
Film series

Overview Movies Cast Trailers & clips Actors

Movies

The Lord of the Rings: The Fellowship of the Ring
The Lord of the Rings: The Two Towers
The Lord of the Rings: The Return of the King

Cast

Elijah Wood
Viggo Mortensen
Sean Astin
Dominic Monaghan
Orlando Bloom
Billy Boyd

About

The Lord of the Rings is a series of three epic fantasy adventure films directed by Peter Jackson, based on the novel The Lord of the Rings by J. R. R. Tolkien. The films are subtitled The Fellowship of the Ring, The Two Towers, and The Return of the King. [Wikipedia](#)

Director: Peter Jackson
Adapted from: The Lord of the Rings
Production companies: New Line Cinema, WingNut Films, Saul Zaentz Film Co.
Box office: Total (3 films): \$2.993 billion
Release date: 2001–2003

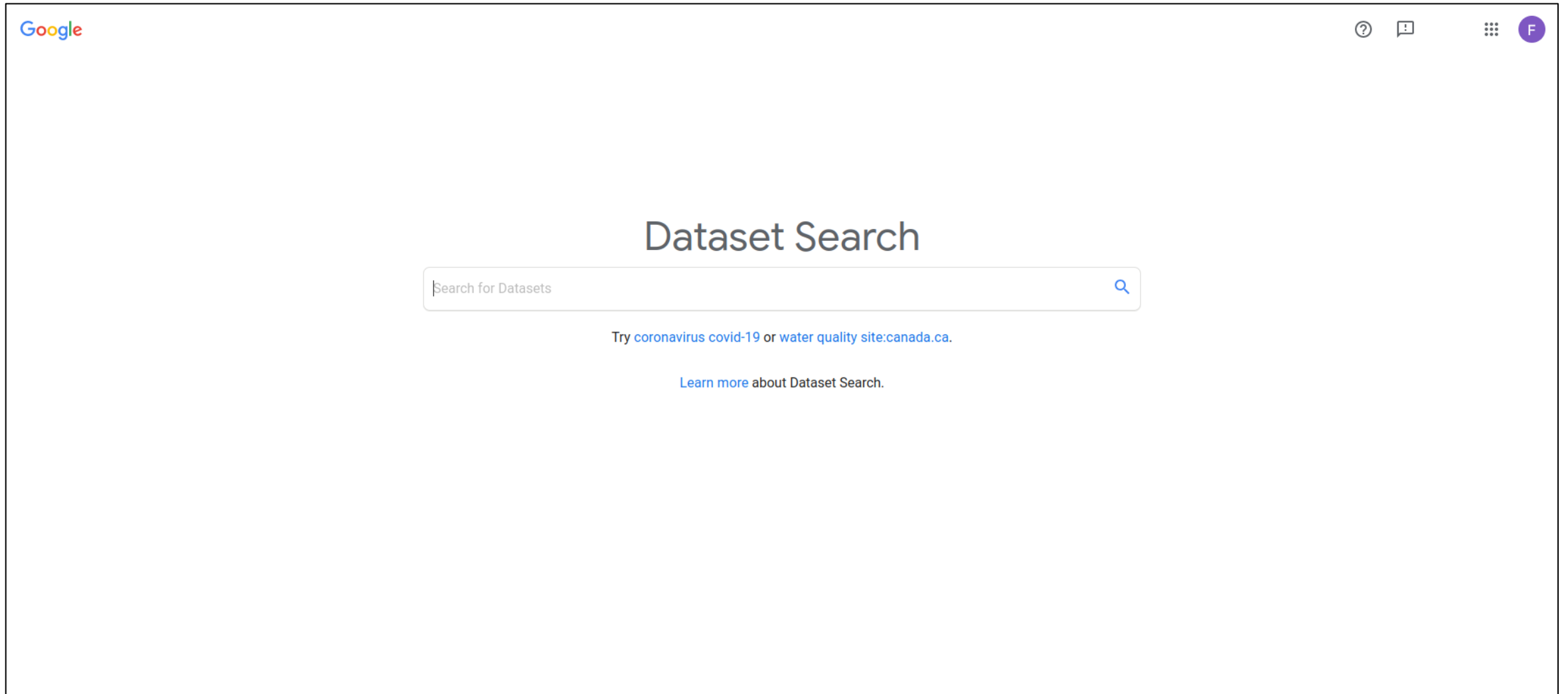
People also search for

The Lord of the Rings: The Fellowship of the Ring
The Lord of the Rings: The Two Towers
The Lord of the Rings: The Return of the King
The Lord of the Rings: The Rings of Power


See more →

Wikipedia
https://en.wikipedia.org/wiki/The_Lord_of_the_Rings
The Lord of the Rings

First Step: Google Dataset Search




First Step: Google Dataset Search


 RNA sequencing


Last updatedDownload formatUsage rightsTopicFree


Saved datasets

100+ datasets found

 Human liver RNA-Seq gene expression (903 samples)
kaggle.com
zip
Updated Oct 23, 2019

 pbmc single cell RNA-seq matrix
zenodo.org
csv
Updated Apr 29, 2021

 RNA-seq of 675 commonly used human cancer cell lines
omicsdi.org
ebi.ac.uk
+1more
xml
Updated Mar 1, 2018

 Single-cell RNA-sequencing of Platynereis dumerilii larval brain...
ebi.ac.uk
omicsdi.org
Updated Dec 12, 2014

RNA-seq of 675 commonly used human cancer cell lines

Explore at: omicsdi.org ebi.ac.uk datamed.org

7 scholarly articles cite this dataset ([View in Google Scholar](#))

xml

Dataset updated

Mar 1, 2018

Authors

Christiaan Klijn

Variables measured

Transcriptomics, Multiomics

Description

Tumor-derived cell lines have served as vital models to advance our understanding of oncogene function and therapeutic response¹. Although substantial effort has been directed to defining the genomic constitution of cancer cell line panels²⁴, the transcriptome which represents the active program of a cell remains understudied. Here, we describe RNA sequencing and SNP array analysis of 675 commonly used human cancer cell lines. We explore numerous transcriptome features including coding and non-coding gene expression, transcribed mutations, gene fusion and expression of non-human sequences. Aside from many known aberrations we find new surprising characteristics, including more than 2200 unique fusion gene pairs representing a vast, testable repertoire of oncogenic fusions, many of which have analogs found in primary human tumors. We show that a combination of multiple genome and transcriptome features in a novel pathway-based approach enhances prediction of response to various targeted therapeutics. Our results provide valuable new insights into these critical pre-clinical models and provide added context for interpreting the numerous studies that employ these widely used cell lines. The raw sequence files were submitted to the European Genome-Phenome Archive (EGA) under accession EGAS00001000610 (<https://www.ebi.ac.uk/ega/datasets/EGAD00001000725>). Processed, human non-identifiable data, together with a README file describing the data (140625_Klijn_README.txt) are available here in E-MTAB-2706.additional.*.zip files: <https://www.ebi.ac.uk/arrayexpress/experiments/E-MTAB-2706/files> .

Semantic Web for Research Data

Technologies

RO-Crate

- Filesystem-based format for Datasets based on JSON-LD
- Data entities: files and directories
- Contextual entities: people, publications, organizations, measurement
- Mostly uses schema.org terminology

Datasets in schema.org

Dataset

A Schema.org Type

Thing > CreativeWork > Dataset

[more...]

A body of structured information describing some topic(s) of interest.

Property	Expected Type	Description
Properties from Dataset		
distribution	DataDownload	A downloadable form of this dataset, at a specific location, in a specific format. This property can be repeated if different variations are available. There is no expectation that different downloadable distributions must contain exactly equivalent information (see also DCAT on this point). Different distributions might include or exclude different subsets of the entire dataset, for example.
includedInDataCatalog	DataCatalog	A data catalog which contains this dataset. Supersedes includedDataCatalog , catalog . Inverse property: dataset
issn	Text	The International Standard Serial Number (ISSN) that identifies this serial publication. You can repeat this property to identify different formats of, or the linking ISSN (ISSN-L) for, this serial publication.
measurementMethod	DefinedTerm or MeasurementMethodEnum or Text or URL	A subproperty of measurementTechnique that can be used for specifying specific methods, in particular via MeasurementMethodEnum .
measurementTechnique	DefinedTerm or MeasurementMethodEnum or Text or URL	<p>A technique, method or technology used in an Observation, StatisticalVariable or Dataset (or DataDownload, DataCatalog), corresponding to the method used for measuring the corresponding variable(s) (for datasets, described using variableMeasured; for Observation, a StatisticalVariable). Often but not necessarily each variableMeasured will have an explicit representation as (or mapping to) an property such as those defined in Schema.org, or other RDF vocabularies and "knowledge graphs". In that case the subproperty of variableMeasured called measuredProperty is applicable.</p> <p>The measurementTechnique property helps when extra clarification is needed about how a measuredProperty was measured. This is oriented towards scientific and scholarly dataset publication but may have broader applicability; it is not intended as a full representation of measurement, but can often serve as a high level summary for dataset discovery.</p> <p>For example, if variableMeasured is: molecule concentration, measurementTechnique could be: "mass spectrometry" or "nmr spectroscopy" or "colorimetry" or "immunofluorescence". If the variableMeasured is "depression rating", the measurementTechnique could be "Zung Scale" or "HAM-D" or "Beck Depression Inventory".</p> <p>If there are several variableMeasured properties recorded for some given data object, use a PropertyValue for each variableMeasured and attach the corresponding measurementTechnique. The value can also be from an enumeration, organized as a MeasurementMethodEnumeration.</p>
variableMeasured	Property or PropertyValue or StatisticalVariable or Text	The variableMeasured property can indicate (repeated as necessary) the variables that are measured in some dataset, either described as text or as pairs of identifier and description using PropertyValue , or more explicitly as a StatisticalVariable .
Properties from CreativeWork		

CreativeWork

A Schema.org Type

Thing > CreativeWork

[more...]

The most generic kind of creative work, including books, movies, photographs, software programs, etc.

Property	Expected Type	Description
Properties from CreativeWork		
about	Thing	The subject matter of the content. Inverse property: subjectOf
abstract	Text	An abstract is a short description that summarizes a CreativeWork .
accessMode	Text	The human sensory perceptual system or cognitive faculty through which a person may process or perceive information. Values should be drawn from the approved vocabulary .
accessModeSufficient	ItemList	A list of single or combined accessModes that are sufficient to understand all the intellectual content of a resource. Values should be drawn from the approved vocabulary .
accessibilityAPI	Text	Indicates that the resource is compatible with the referenced accessibility API. Values should be drawn from the approved vocabulary .
accessibilityControl	Text	Identifies input methods that are sufficient to fully control the described resource. Values should be drawn from the approved vocabulary .
accessibilityFeature	Text	Content features of the resource, such as accessible media, alternatives and supported enhancements for accessibility. Values should be drawn from the approved vocabulary .
accessibilityHazard	Text	A characteristic of the described resource that is physiologically dangerous to some users. Related to WCAG 2.0 guideline 2.3. Values should be drawn from the approved vocabulary .
accessibilitySummary	Text	A human-readable summary of specific accessibility features or deficiencies, consistent with the other accessibility metadata but expressing subtleties such as "short descriptions are present but long descriptions will be needed for non-visual users" or "short descriptions are present and no long descriptions are needed."
accountablePerson	Person	Specifies the Person that is legally accountable for the CreativeWork.
acquireLicensePage	CreativeWork or URL	Indicates a page documenting how licenses can be purchased or otherwise acquired, for the current item.
aggregateRating	AggregateRating	The overall rating, based on a collection of reviews or ratings, of the item.
alternativeHeadline	Text	A secondary title of the CreativeWork.
archivedAt	URL or WebPage	Indicates a page or other link involved in archival of a CreativeWork . In the case of MediaReview , the items in a MediaReviewItem may often become inaccessible, but be archived by archival, journalistic, activist, or law enforcement organizations. In such cases, the referenced page may not directly publish the content.
assesses	DefinedTerm or Text	The item being described is intended to assess the competency or learning outcome defined by the referenced term.
associatedMedia	MediaObject	A media object that encodes this CreativeWork. This property is a synonym for encoding .
audience	Audience	An intended audience, i.e. a group for whom something was created. Supersedes serviceAudience .
audio	AudioObject or Clip or MusicRecording	An embedded audio object.
author	Organization or Person	The author of this content or rating. Please note that author is special in that HTML 5 provides a special mechanism for indicating authorship via the rel tag. That is equivalent to this and may be used interchangeably.
award	Text	An award won by or for this item. Supersedes awards .
character	Person	Fictional person connected with a creative work.
citation	CreativeWork or Text	A citation or reference to another creative work, such as another publication, web page, scholarly article, etc.
comment	Comment	Comments, typically from users.
commentCount	Integer	The number of comments this CreativeWork (e.g. Article, Question or Answer) has received. This is most applicable to works published in Web sites with commenting system; additional comments may exist elsewhere.

What metadata should be annotated?

Barebone metadata

- E.g. authors, publications, description, organism studied
- Easy to set up
- Vocabulary needed already available in schema.org
- Important information may be lost

All available metadata in full detail

- E.g. detailed protocols used, computational workflows with language/parameters/etc.
- Maybe overly complicated
- Specific vocabulary required (ontologies)
- Users can search for any interesting characteristics

Exercise

- Write JSON-LD markup for your own Investigation with at least
 - Author
 - Title
 - Description
- Test your markup in schema.org and google test tools
 - Schema Markup Validator: <https://validator.schema.org/>
 - Google Rich Result Test: <https://search.google.com/test/rich-results>