

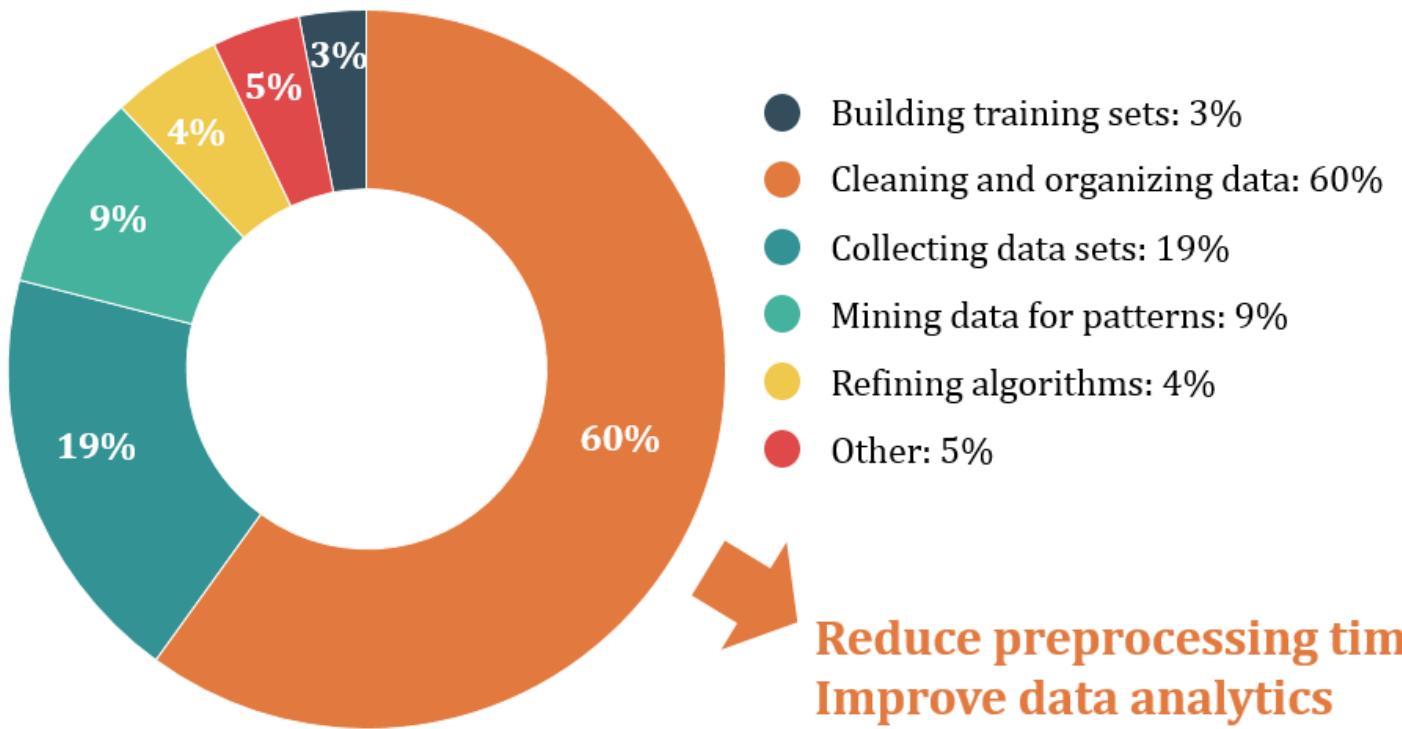
# Introduction to the Life Sciences

## Semantic Web



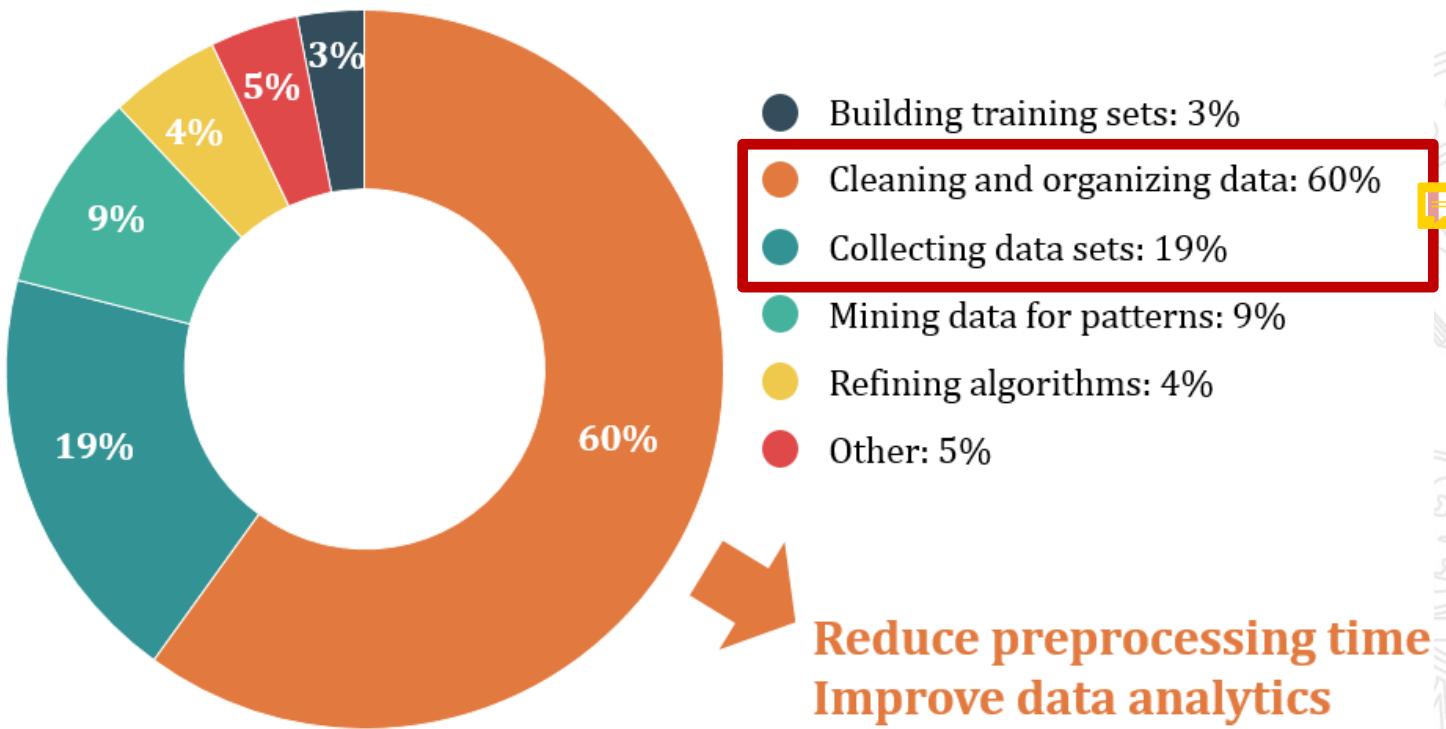
# Need for semantics

Where do data scientists spend the most time?

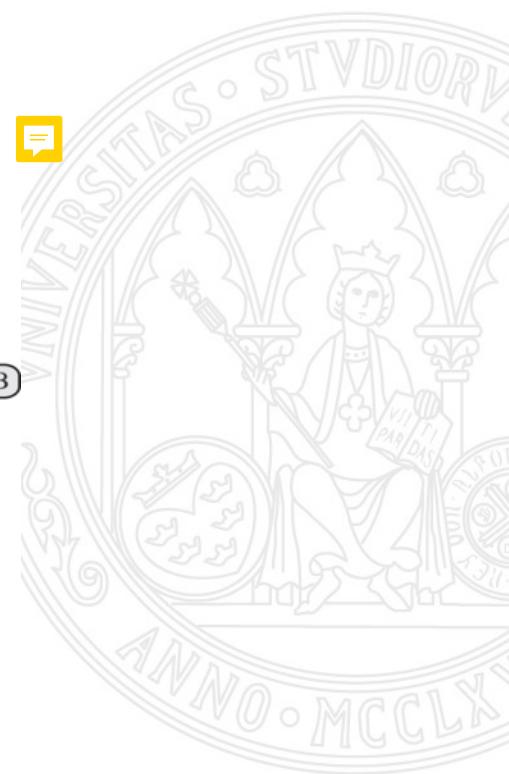
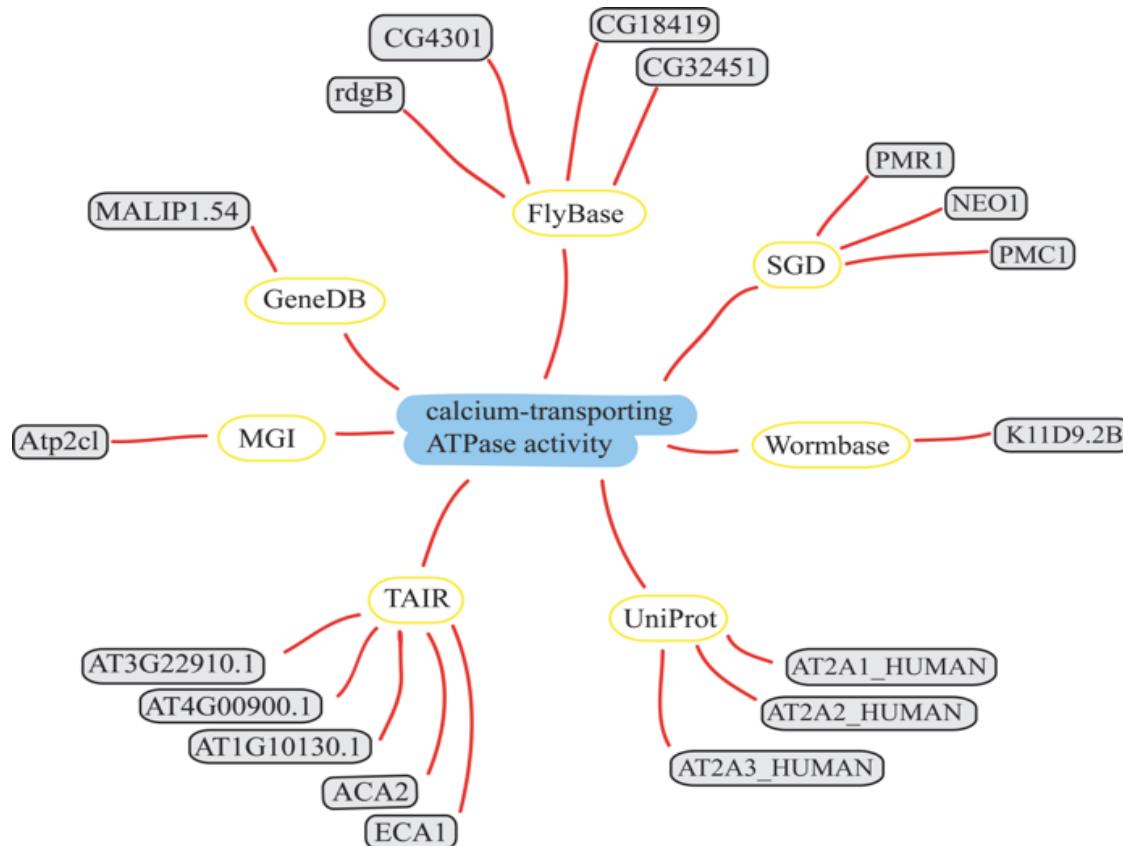


# Need for semantics

Where do data scientists spend the most time?

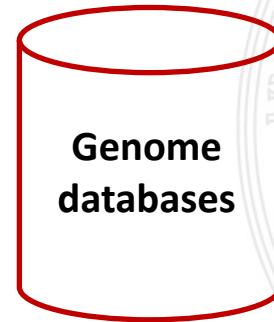
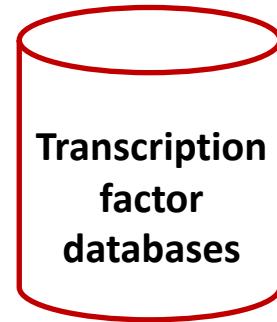
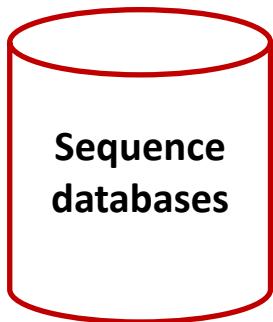


# Need for data interoperability



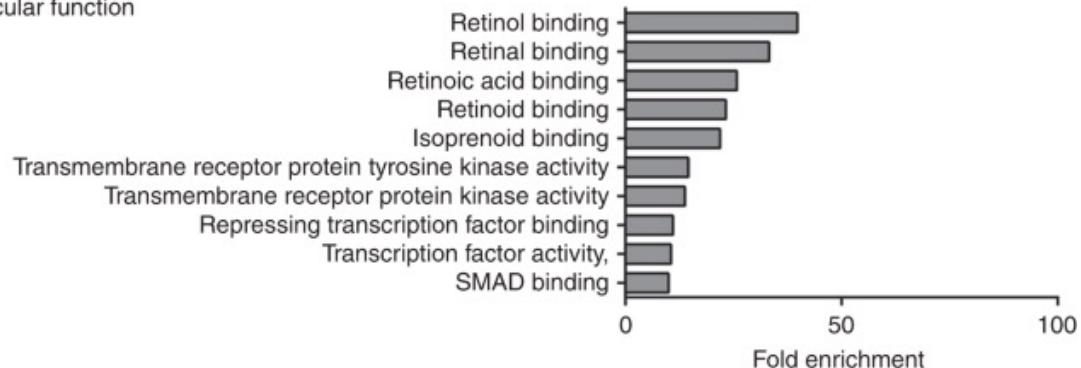
# Need for interoperability

- How does a particular mutation affect gene regulation in the patient?

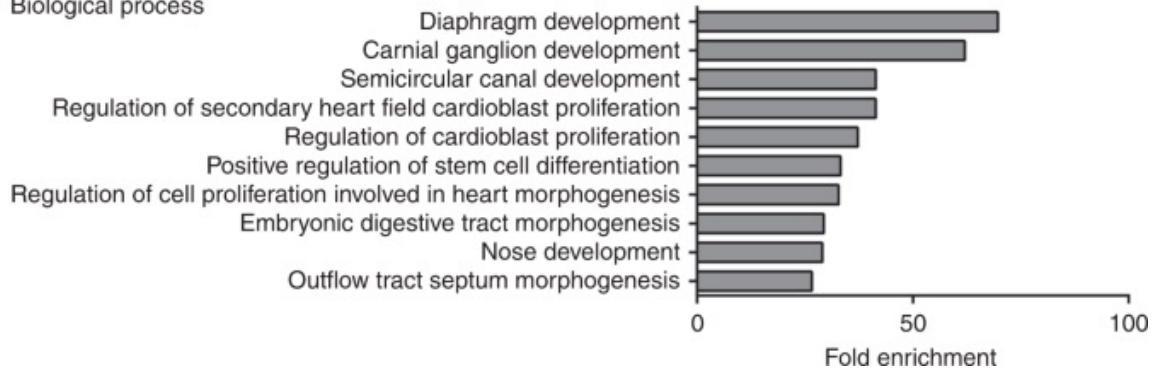


# Need for data analysis support

a Molecular function



b Biological process



Dalmer, Timothy RA,  
and Robin D.  
Clugston. "Gene  
ontology enrichment  
analysis of congenital  
diaphragmatic hernia-  
associated genes."  
*Nature Pediatric  
research* 85.1 (2019):  
13-19.

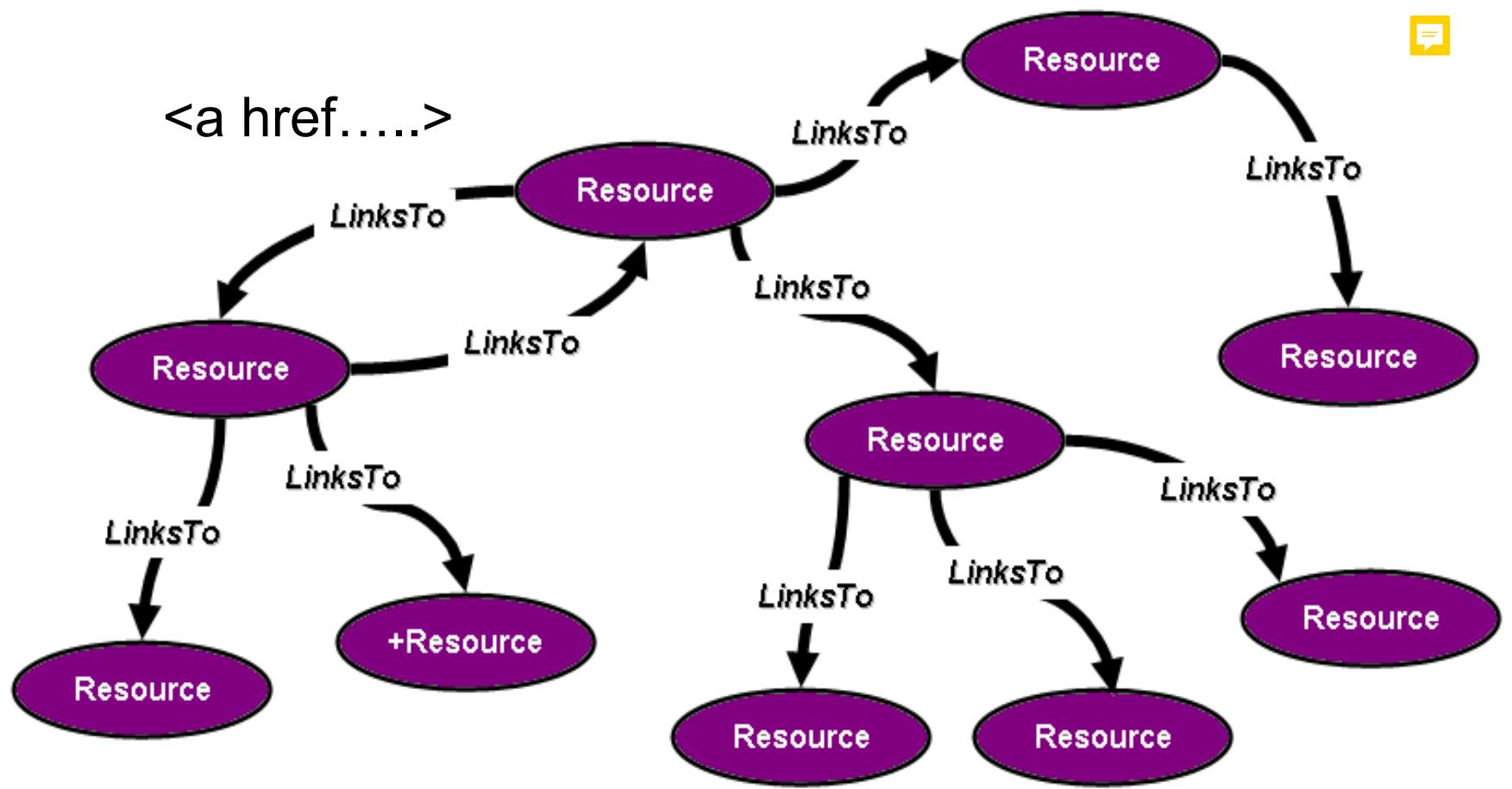
# Do you know this guy?



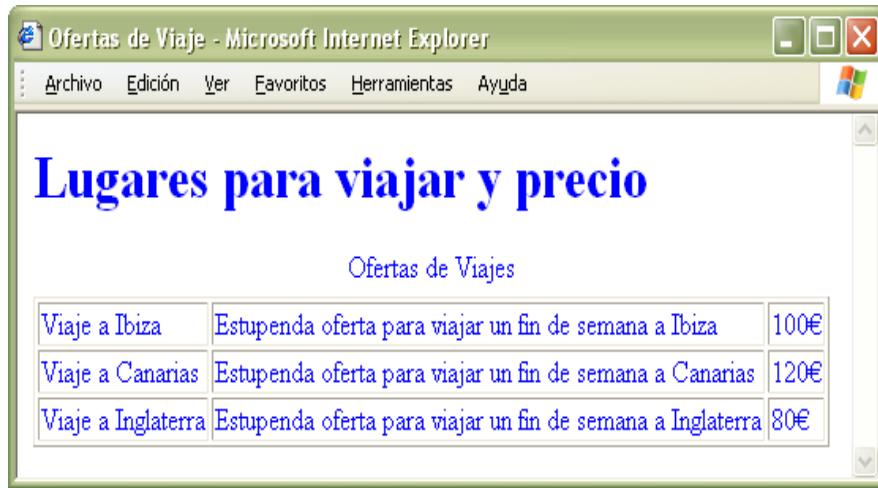
**Sir Tim Berners-Lee**



# The World Wide Web



# The World Wide Web



Places to travel and  
price  
Trip offers  
Trip to Ibiza  
Great offer.....

```
<html><head><title>Ofertas de  
Viaje</title></head>  
<body bgcolor="white" text="Blue">  
<h1>Lugares para viajar y precio</h1>  
<table border="1">  
<caption>Ofertas de Viajes</caption>  
<tr>  
<td>Viaje a Ibiza</td><td>Estupenda  
oferta para viajar un fin de semana a Ibiza  
</td><td>100&euro;</td>  
</tr>  
...  
</body>  
</html>
```

```
<html><head><title>仮想マウスボタン マルチ  
クリックerML</title></head>  
<body bgcolor="white" text="Blue">  
<h1>クリックボタンを複数回同時に押す  
マルチクリックerML</h1>  
<table border="1">  
...  
</body>  
</html>
```

# The Semantic Web

The Semantic Web will bring structure to the **meaningful content** of Web pages, creating an environment where **software agents** roaming from page to page can readily **carry out sophisticated tasks** for users.

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The semantic web. *Scientific american*, 284(5), 28-37.

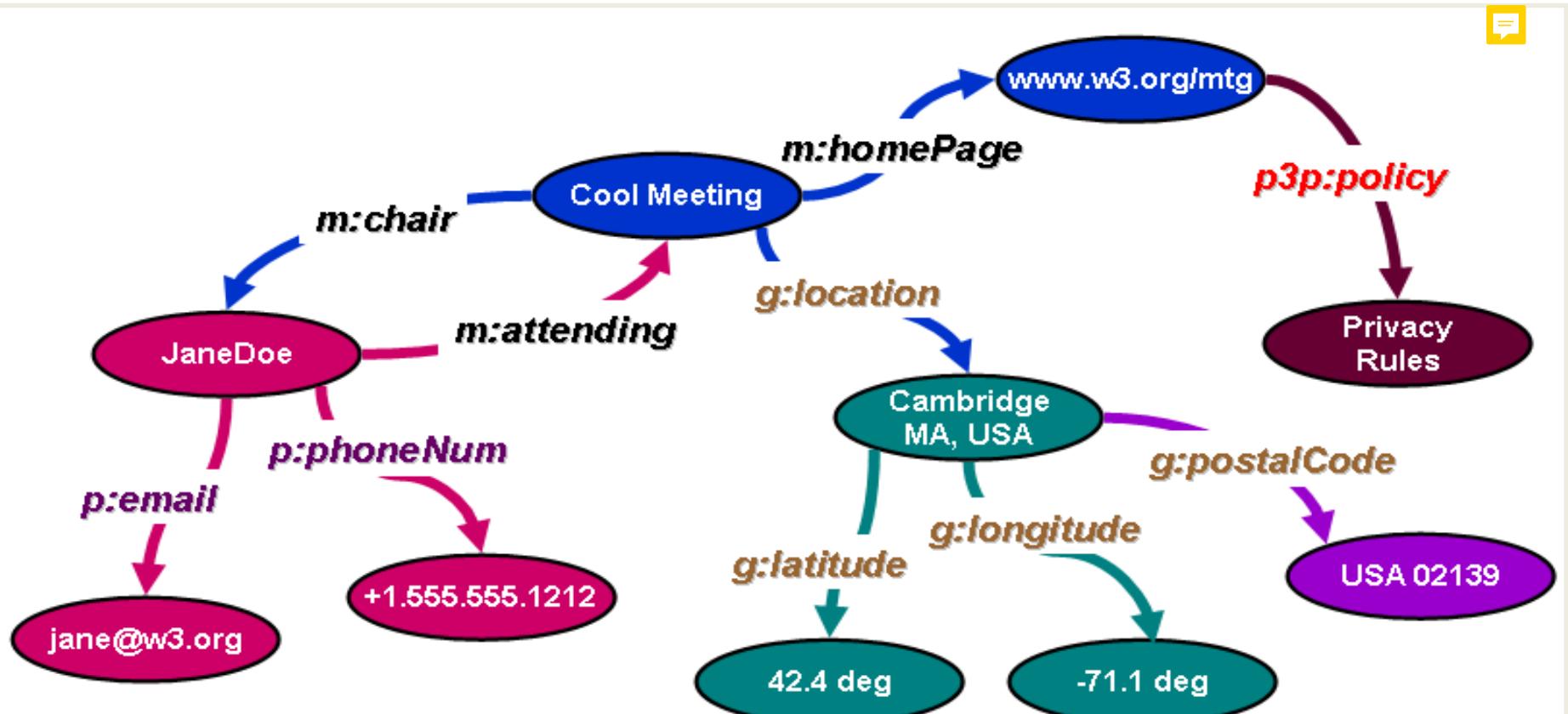
## The semantic web

T Berners-Lee, J Hendler, O Lassila - *Scientific american*, 2001 - JSTOR

... **Web** of today but rather the **Semantic Web** ... **Web** pages with data targeted at computers and by adding documents solely for computers, we will transform the **Web** into the **Semantic Web**...

☆ Save 99 Cite Cited by 28391 Related articles All 62 versions

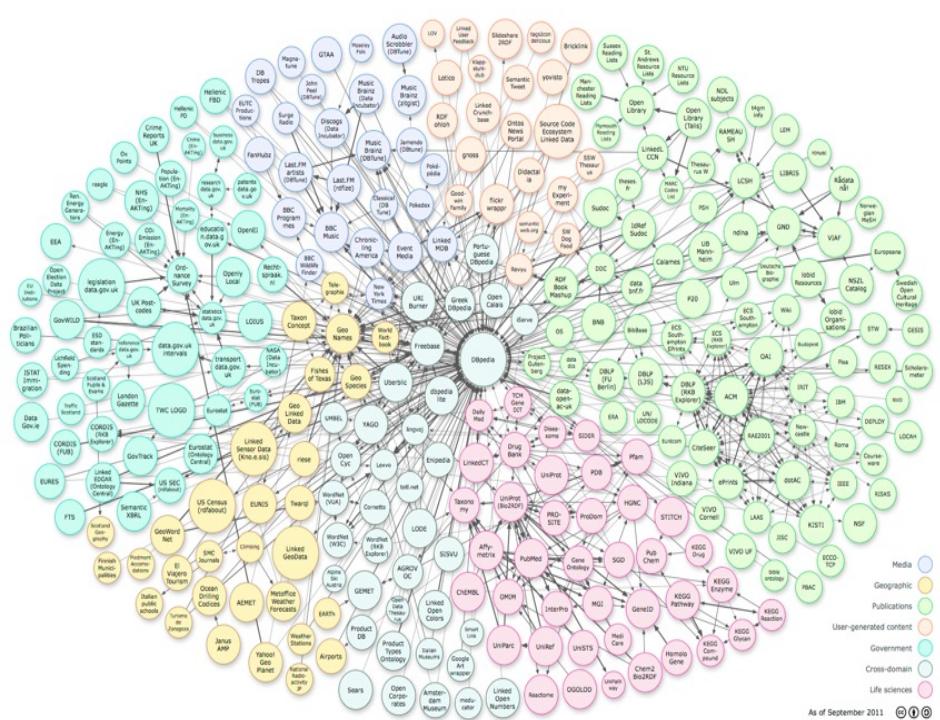
# Objective: The Semantic Web



# Do you know now this guy?



# Web of Data: Linked Data



## Linked data: The story so far

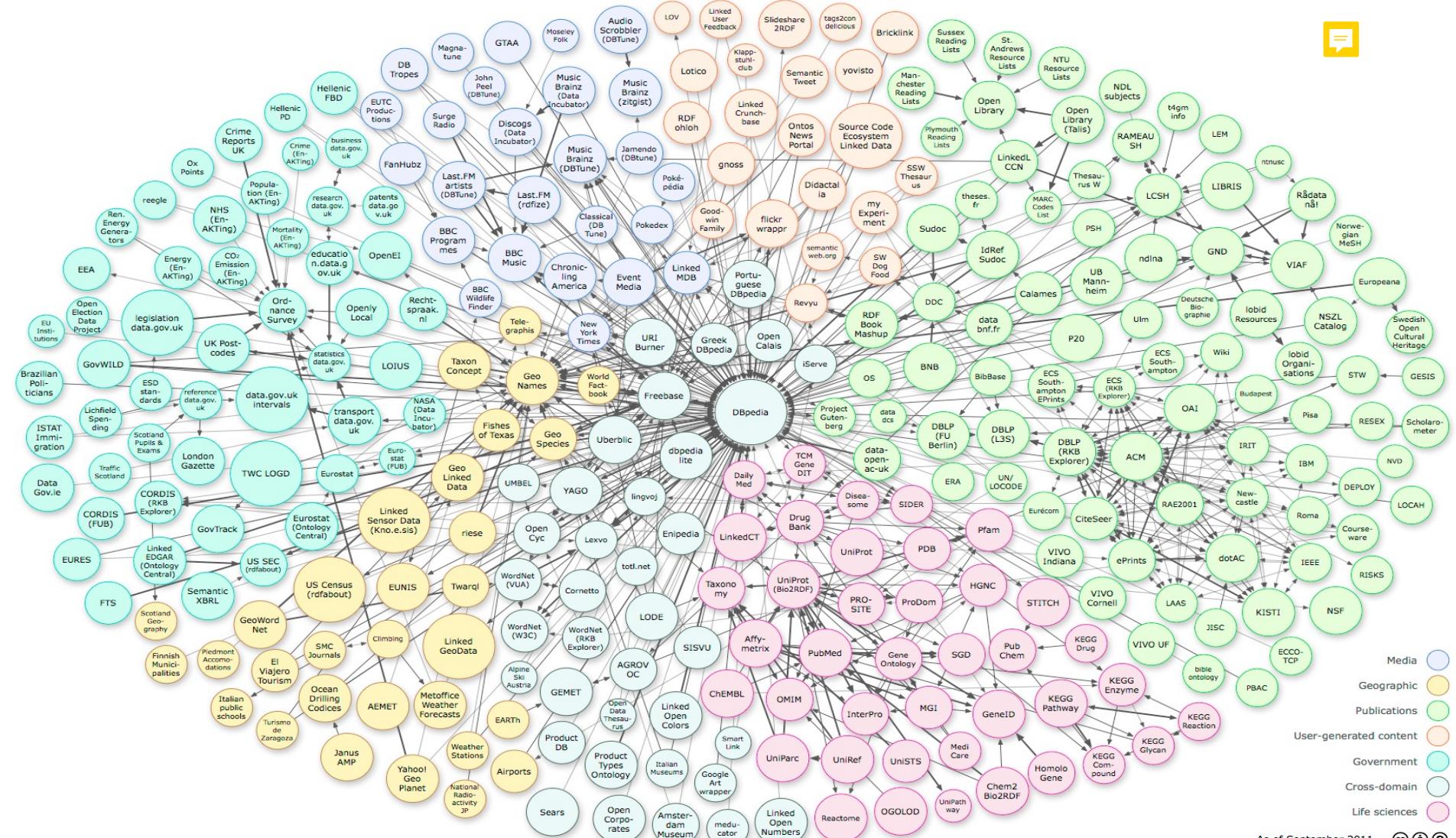
[C Bizer, T Heath, T Berners-Lee - Semantic services, interoperability ...](#), 2011 - [igi-global.com](#)

... of Data. In this article, the authors present the concept and technical principles of **Linked Data**,  
... They describe progress to date in publishing **Linked Data** on the Web, review applications ...

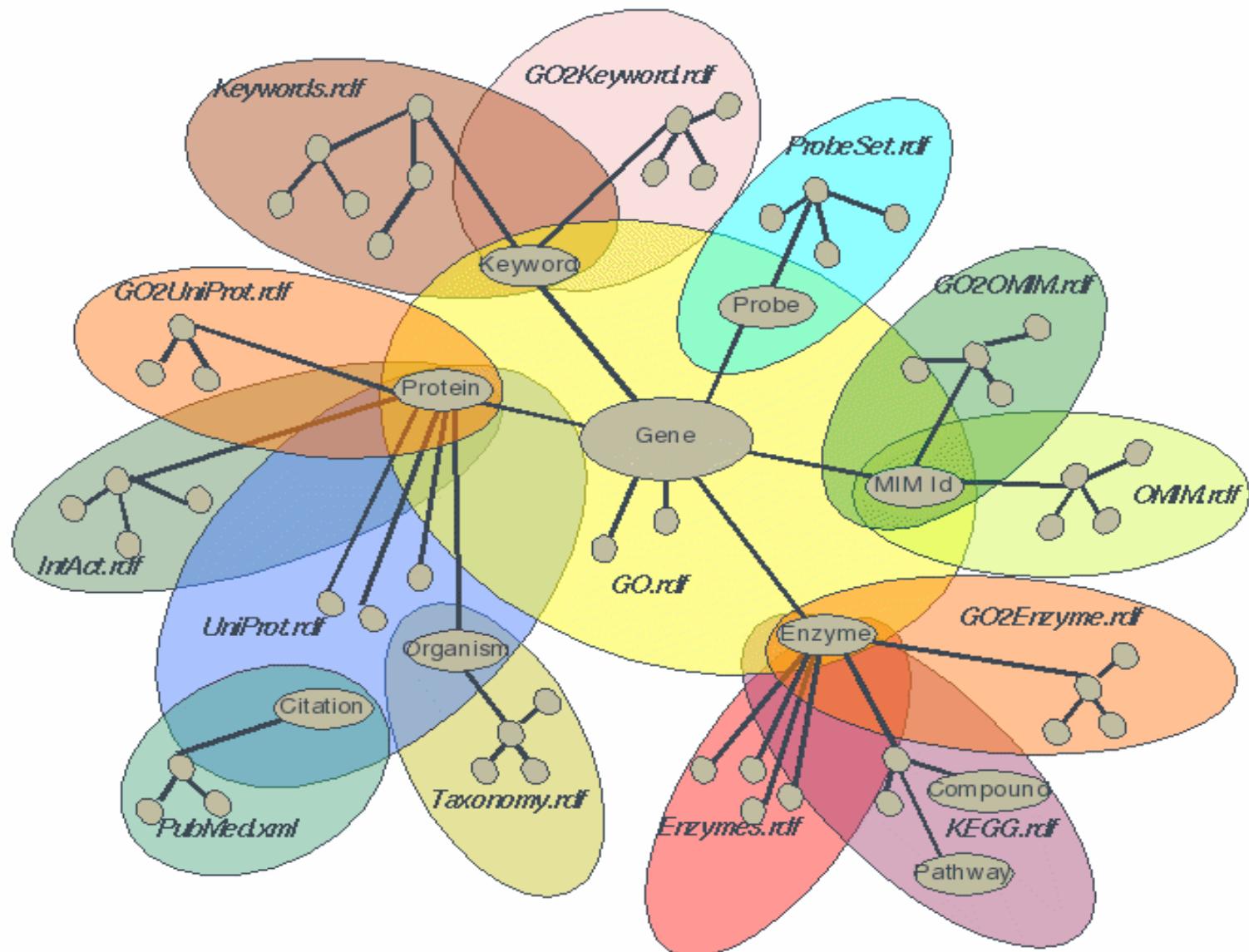
☆ Save ♫ Cite Cited by 7357 Related articles All 37 versions



# Natural space for data integration



# Objective: The Life Sciences Semantic Web



# The Semantic Web @ TED Talks



## The next web

[Read transcript](#)

20 years ago, Tim Berners-Lee invented the World Wide Web. For his next project, he's building a web for open, linked data that could do for numbers what the Web did for words, pictures, video: unlock our data and reframe the way we use it together.

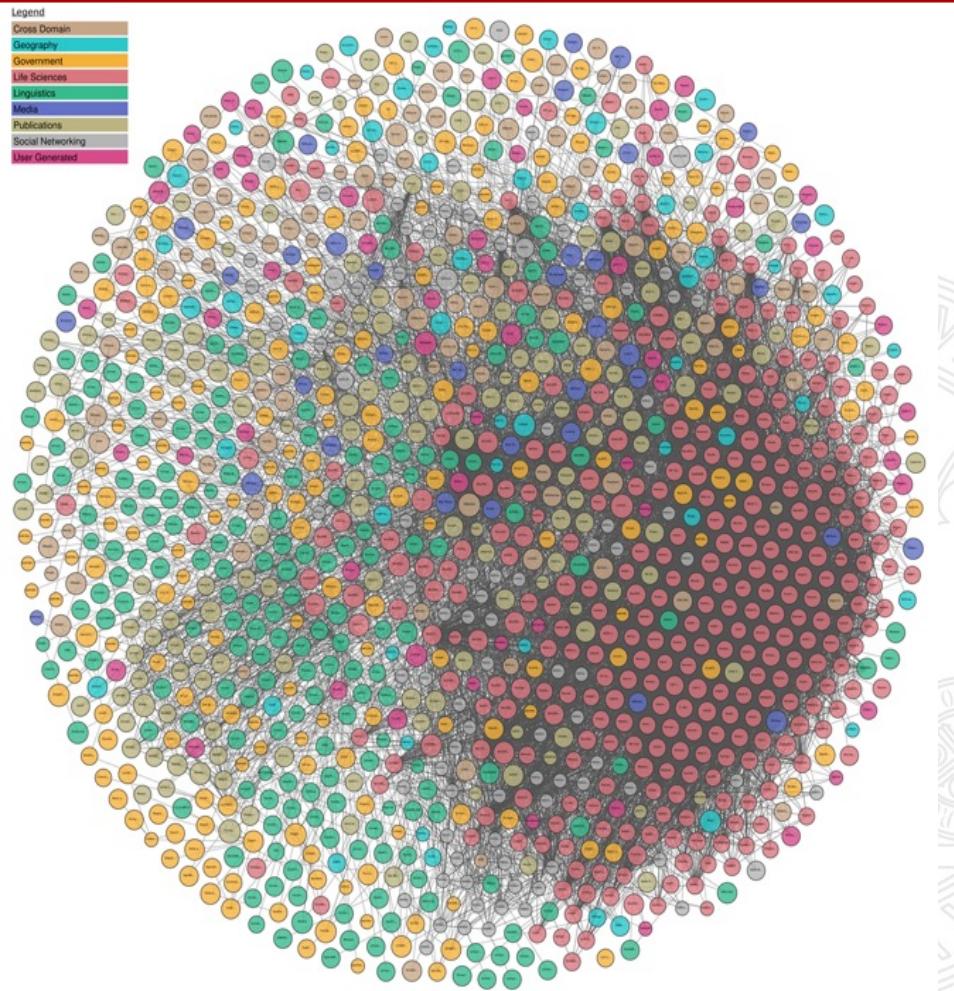
[https://www.ted.com/talks/tim\\_berners\\_lee\\_on\\_the\\_next\\_web?language=en](https://www.ted.com/talks/tim_berners_lee_on_the_next_web?language=en)



# The Linked Open Data Cloud

<https://lod-cloud.net/>

- Spend 5 minutes visiting this website
- Check the content of the subclouds
- Browse datasets:  
<https://lod-cloud.net/datasets>



## Semantic Web in Health Care and Life Sciences

Community Group : <https://www.w3.org/community/hclscg/>

## Bioschemas for lifesciences:

<https://www.w3.org/community/bioschemas/>

<https://bioschemas.org>



# Semantics in the current web



# Semantics in the current web

## [Salad - Thai Green Mango Salad Recipe](#)



★★★★★ 5 reviews - Total cook time: 20 mins

You asked for a one-page printable version of my step-by-step Green Mango Salad recipe, so here it is! This salad will blow you away with its ...

[thaifood.about.com/od/thaisnacks/r/greenmangosalad.htm](http://thaifood.about.com/od/thaisnacks/r/greenmangosalad.htm) -

[Cached](#) - [Similar](#)

## [Calendar of Events - San Jose, CA - Official Website](#)

[www.sanjoseca.gov/Calendar.aspx](http://www.sanjoseca.gov/Calendar.aspx) ▾ San Jose ▾

Arts, Entertainment & Events (3) · Calendar Overlay ... San José City Hall and other City offices will close in observance of Thanksgiving and reopen on Monday, ...

Thu, Nov 20	<a href="#">Teen Project: Make a tiny hat</a>	Seven Trees Branch Library
Thu, Nov 20	<a href="#">Steampunk Crafts</a>	Joyce Ellington Branch Library
Fri, Nov 21	<a href="#">FY 2015-16 Operating Grants ...</a>	San Jose City Hall, Tower 1446

## [Cut the Rope FULL FREE - Android Apps on Google Play](#)



<https://play.google.com/store/apps/details?id=com.supercell.cuttherope&hl=en> ▾

★★★★★ Rating: 4.5 - 1,116,042 votes - Free

Cut the rope to feed candy to little monster Om Nom®! 500 million downloads around the world of this phenomenal puzzle game. 400 levels and more to come!

# An example of microdata

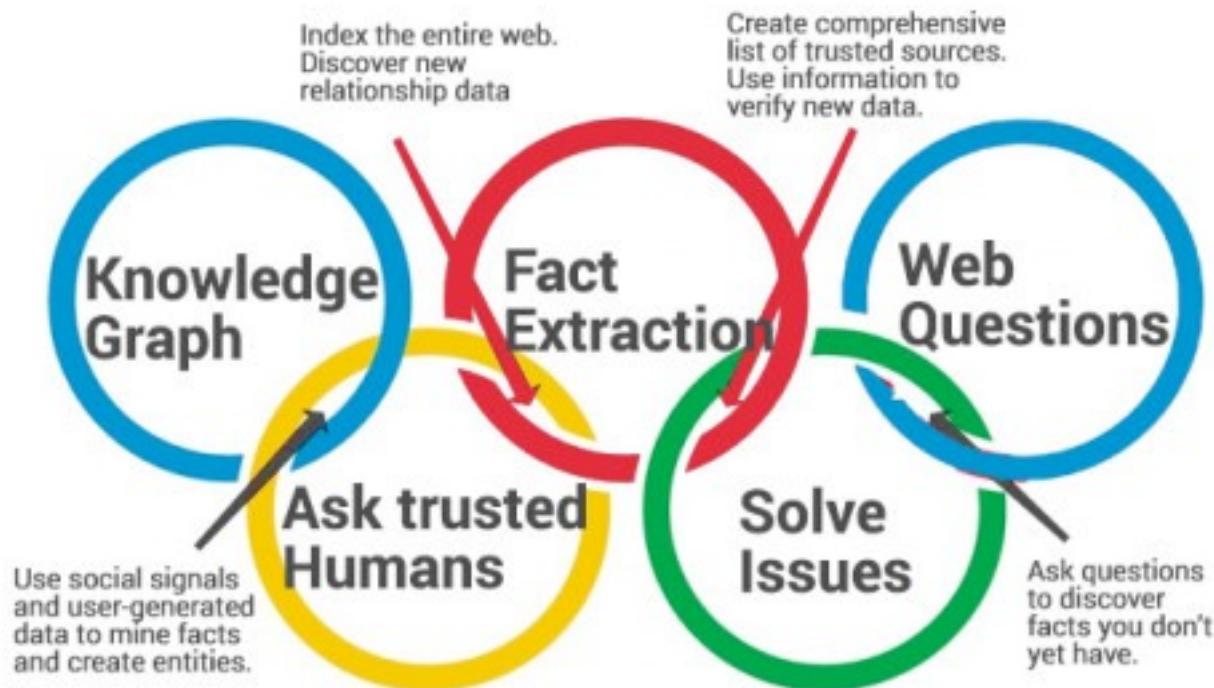


```
<div itemscope itemtype="http://schema.org/Recipe">
  <h1 itemprop="name">Grandma's Holiday Apple Pie</h1>
  
  By <span itemprop="author" itemscope itemtype="http://schema.org/Person">
    <span itemprop="name">Carol Smith</span>
  </span>
  Published: <time datetime="2009-11-05" itemprop="datePublished">
    November 5, 2009</time>
  <span itemprop="description">This is my grandmother's apple pie recipe. I like to add a dash of nutmeg.</span>
  <span itemprop="aggregateRating" itemscope itemtype="http://schema.org/AggregateRating">
    <span itemprop="ratingValue">4.0</span> stars based on
    <span itemprop="reviewCount">35</span> reviews </span>
  Prep time: <time datetime="PT30M" itemprop="prepTime">30 min</time>
  Cook time: <time datetime="PT1H" itemprop="cookTime">1 hour</time>
  Total time: <time datetime="PT1H30M" itemprop="totalTime">1 hour 30 min</time>
  Yield: <span itemprop="recipeYield">1 9" pie (8 servings)</span>
  <span itemprop="nutrition" itemscope itemtype="http://schema.org/NutritionInformation">
    Serving size: <span itemprop="servingSize">1 medium slice</span>
    Calories per serving: <span itemprop="calories">250 cal</span>
    Fat per serving: <span itemprop="fatContent">12 g</span>
  </span>
  Ingredients:
    <span itemprop="recipeIngredient">Thinly-sliced apples: 6 cups</span>
    <span itemprop="recipeIngredient">White sugar: 3/4 cup</span>
  ...

```

# Semantics in the current web

## The 5 Steps of Google's Semantic Search



**Each step leads to a more semantic web**

# Google's recommendation

- Create content that is understandable.
- Try to identify the “companion” words that usually follow the keyword and insert them into your content. That way, you’ll be able to provide some clues related to the subject of your content to search engines.
- Use variations and synonyms of words that are directly related to the subject matter of your content.
- Use the keywords effectively to take complete advantage of semantic search.
- Link to third-party websites related to some aspect of your business/domain/industry to provide your users with more value.
- Mark up your content on specific social networking sites.
- Use tools like schema.org, Yandex Checker, AlchemyAPI, Schema Creator, Gruff etc. to add more semantic value to your content.



# Semantics in HTML5 / Rich snippets

- Microdata: <http://schema.org>
- RDFa: <http://www.w3.org/TR/rdfa-syntax/>
- JSON
  - JSON-Linked Data: <http://www.w3.org/TR/json-ld/>

# Browser extensions



## OpenLink Structured Data Sniffer por OpenLink Software Inc

Adds structured data discovery and handling of multiple content-types to your browser. Reveals Structured Metadata embedded within HTML pages in notations including POSH (Plain Old Semantic HTML), Microdata, JSON-LD, RDF-Turtle, and RDFa.

Eliminar

This add-on is not actively monitored for security by Mozilla. Make sure you trust it before installing. [Saber más](#)

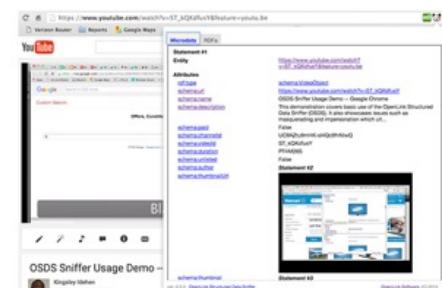
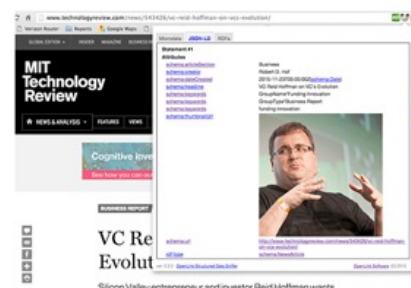
### Califica tu experiencia

¿Cuál es tu experiencia con **OpenLink Structured Data Sniffer**?

Inicia sesión para evaluar esta extensión

Informar de un uso indebido en este complemento

### Capturas de pantalla



# Who is using rich snippets?

Es noticia | Guerra Ucrania Rusia última hora | Huelga transporte | Esketamina | Elecciones EEUU | Shakira

**EL MUNDO** ESPAÑA OPINIÓN ECONOMÍA INTERNACIONAL DEPORTES

Economía | Actualidad económica | Consumistas | Macroeconomía

META • Empresas de tecnología

## Llegan los primeros (y masivos) despidos del metaverso

La compañía se prepara para anunciar un recorte que podría afectar a más del 10% de los 87.314 trabajadores en todo el mundo



Mark Zuckerberg, en Nueva York. AP

El momento más crítico  
de Zuckerberg Meta se

La primera sensación que muchas personas tienen al entrar por primera vez en un entorno de realidad virtual es un poco

Fact Collection #1	
Entity	<a href="https://www.elmundo.es/economia/empresas/2022/11/08/63694d26e4d4d811508b45ad.html">https://www.elmundo.es/economia/empresas/2022/11/08/63694d26e4d4d811508b45ad.html</a>
Attributes	
<a href="#">rdf:type</a>	<a href="#">schema:WebPage</a>
Fact Collection #2	
Entity	<a href="#">#NewsArticle</a>
Attributes	
<a href="#">rdf:type</a>	<a href="#">schema:NewsArticle</a>
<a href="#">rdf:type</a>	<a href="#">schema:ReportageNewsArticle</a>
<a href="#">schema:articleBody</a>	
<a href="#">schema:articleSection</a>	
<a href="#">schema:author</a>	
<a href="#">schema:dateModified</a>	
<a href="#">schema:datePublished</a>	
<a href="#">schema:description</a>	
<a href="#">schema:hasPart</a>	
<a href="#">schema:headline</a>	
<a href="#">schema:image</a>	
<a href="#">schema:isAccessibleForFree</a>	
<a href="#">schema:isPartOf</a>	
<a href="#">schema:mainEntityOfPage</a>	
<a href="#">schema:publisher</a>	
<a href="#">schema:publishingPrinciples</a>	
Fact Collection #3	
Entity	<a href="#">#Person</a>
Attributes	

OpenLink Structured Data Sniffer ver: 2.21.6

Copyright © 2015-2022 OpenLink Software

# Who is using rich snippets?

## UniProtKB - Q17446 (PMK1\_CAEEL)

Display

[Help video](#)[BLAST](#)[Align](#)[Format](#)[Add to basket](#)[History](#)

Entry

Publications

Feature viewer

Feature table

None

Function

Protein

pn

Ca

Gene

Organism

Status

### Mitogen-activated protein kinase pmk-1

RDFa POSH

## Statement Collection #1

Entity

<https://www.uniprot.org/uniprot/Q17446>

Attributes

[rdf:type](#)[schema:WebPage](#)[xhv:license](#)<https://creativecommons.org/licenses/by/4.0/>[rdfa:usesVocabulary](#)[schema:](#)[schema:help](#)<https://www.uniprot.org/uploadlists>[schema:help](#)<https://www.uniprot.org/peptidesearch>[schema:help](#)<https://www.uniprot.org/help/>[schema:mainEntity](#)<http://purl.uniprot.org/uniprot/Q17446>[schema:copyrightYear](#)["2020"@en](#)[schema:creator](#)<https://www.uniprot.org/help/about#UniProt>[schema:reviewedBy](#)<https://www.coretrustseal.org/>[schema:reviewedBy](#)<https://www.elixir-europe.org/platforms/data/core-data-resources>[schema:funder](#)<https://www.nih.gov/>[schema:funder](#)<https://www.embl.org/>[schema:funder](#)<https://www.sbf1.admin.ch/sbf1/en/home.html>

## Statement Collection #2

Entity

<http://purl.uniprot.org/uniprot/Q17446>

Attributes

[rdf:type](#)[schema:CreativeWork](#)[schema:alternateName](#)["UniProtKB - Q17446 \(PMK1\\_CAEEL\)"@en](#)[schema:alternateName](#)["\(PMK1\\_CAEEL\)"@en](#)[schema:alternateName](#)

"EC:2.7.11.24Search proteins in UniProtKB for this EC number.See the description of this EC number in ENZYME.3 PublicationsManual assertion based on experiment iniRef.1"Isolation and characterization of pmk-(1-3): three p38 homologs in *Caenorhabditis elegans*."Berman K., McKay J., Avery L., Cobb M.Mol. Cell Biol. Res. Commun. 4:337-344(2001) [PubMed] [Europe PMC] [Abstract]Cited for: NUCLEOTIDE SEQUENCE [GENOMIC DNA], FUNCTION, CATALYTIC

# Wikipedia: cdk1

## Cyclin-dependent kinase 1

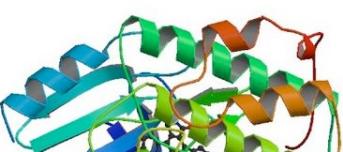
From Wikipedia, the free encyclopedia

**Cyclin-dependent kinase 1** also known as **CDK1** or **cell division cycle protein 2 homolog** is a highly conserved a serine/threonine **kinase**, and is a key player in **cell cycle** regulation.<sup>[5]</sup> It has been highly studied in the budding yeast the fission yeast *S. pombe*, where it is encoded by **genes** *cdc28* and *cdc2*, respectively.<sup>[6]</sup> In humans, Cdk1 is encoded by the *CDK1* gene.<sup>[7]</sup> With its **cyclin** partners, Cdk1 forms complexes that **phosphorylate** a variety of target substrates (over 75 have been identified in budding yeast); phosphorylation of these proteins leads to cell cycle progression.<sup>[8]</sup>

### Contents [hide]

- 1 Structure
- 2 Function
- 3 Regulation
- 4 Interactions
- 5 See also
- 6 References
- 7 Further reading
- 8 External links

## Structure [edit]



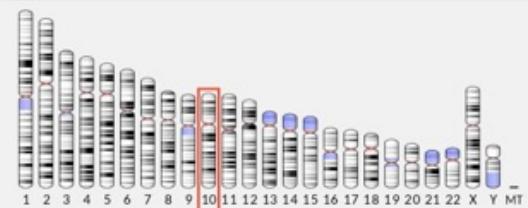
Cdk1 is a small protein (approximately 34 kilodaltons), and is highly conserved across eukaryotes. It is a homolog of Cdk1, *CDC2*, shares approximately 63% amino-acid identity with Cdk1. Furthermore, human *CDC2* is capable of rescuing fission yeast carrying a *cdc28* mutation. The Cdk1 kinase domain is comprised mostly by the bare protein kinase motif, which other protein kinases share. Unlike other kinases, contains a cleft in which **ATP** fits. Substrates of Cdk1 bind in this cleft, and Cdk1 residues catalyze the covalent bonding of the  $\gamma$ -phosphate group.



### Available structures

PDB	Ortholog search: PDBe RCSB
	List of PDB id codes
<a href="#">[show]</a>	
Aliases	CDK1, CDC2, CDC28A, P34CDC2, cyclin-dependent kinase 1, cyclin dependent kinase 1
External IDs	OMIM: 116940 MGI: 88351 HomoloGene: 68203 GeneCards: CDK1

### Gene location (Human) [hide]





# Cyclin dependent kinase 1 (Q1147372)

mammalian protein found in *Homo sapiens*

cell cycle controller CDC2 | cell division control protein 2 homolog | p34 protein kinase | 1 | CDK1 | cell division cycle 2, G1 to S and G2 to M

## Statements

instance of	<a href="#">protein</a> <a href="#">edit</a> <a href="#">1 reference</a>	<a href="#">+ add value</a>
-------------	--	-----------------------------

part of	<a href="#">Protein kinase-like domain superfamily</a> <a href="#">edit</a> <a href="#">1 reference</a>	
	<a href="#">animal nuclear pore complex</a> <a href="#">edit</a> <a href="#">1 reference</a>	
	<a href="#">Protein kinase domain, protein family</a> <a href="#">edit</a> <a href="#">1 reference</a>	
	<a href="#">Protein kinase, ATP binding site, protein family</a> <a href="#">edit</a> <a href="#">1 reference</a>	
	<a href="#">Serine/threonine-protein kinase, active site, protein family</a> <a href="#">edit</a> <a href="#">1 reference</a>	

# Wikipedia: Scarlet fever

## Scarlet fever

From Wikipedia, the free encyclopedia

*For other uses, see [Scarlet fever \(disambiguation\)](#).*

**Scarlet fever** is a disease resulting from a [group A streptococcus](#) ([group A strep](#)) infection, also known as *Streptococcus pyogenes*.<sup>[1]</sup> The signs and symptoms include a [sore throat](#), [fever](#), headaches, [swollen lymph nodes](#), and a characteristic rash.<sup>[1]</sup> The rash is red and feels like [sandpaper](#) and the tongue may be red and bumpy.<sup>[1]</sup> It most commonly affects children between five and 15 years of age.<sup>[1]</sup>

Scarlet fever affects a small number of people who have [strep throat](#) or [streptococcal skin infections](#).<sup>[1]</sup> The bacteria are usually spread by people coughing or sneezing.<sup>[1]</sup> It can also be spread when a person touches an object that has the bacteria on it and then touches their mouth or nose.<sup>[1]</sup> The characteristic rash is due to the [erythrogenic toxin](#), a substance produced by some types of the bacterium.<sup>[1][4]</sup> The diagnosis is typically confirmed by [culturing the throat](#).<sup>[1]</sup>

As of 2020 there is no [vaccine](#).<sup>[5]</sup> Prevention is by frequent [handwashing](#), not sharing personal items, and staying away from other people when sick.<sup>[1]</sup> The disease is treatable with [antibiotics](#), which prevent most complications.<sup>[1]</sup> Outcomes with scarlet fever are typically good if treated.<sup>[3]</sup> Long-term complications as a result of scarlet fever include [kidney disease](#), [rheumatic heart disease](#), and [arthritis](#).<sup>[1]</sup> In the early [20th century](#), before antibiotics were available, it was a leading cause of death in children.<sup>[6][7]</sup> An [antitoxin](#) was produced before antibiotics; however, it was never made in sufficient quantities, and could not be used to treat any other disease as antibiotics can.

There have been signs of antibiotic resistance, and there have been recent outbreaks in [Hong Kong](#) in 2011 and in the UK in 2014, with occurrence rising 68% in the UK in the four years up to 2018. Research published in October 2020 has shown that infection of the bacterium by three viruses has led to stronger strains of the bacterium.<sup>[5]</sup>

## External links [ edit ]

# Open Data

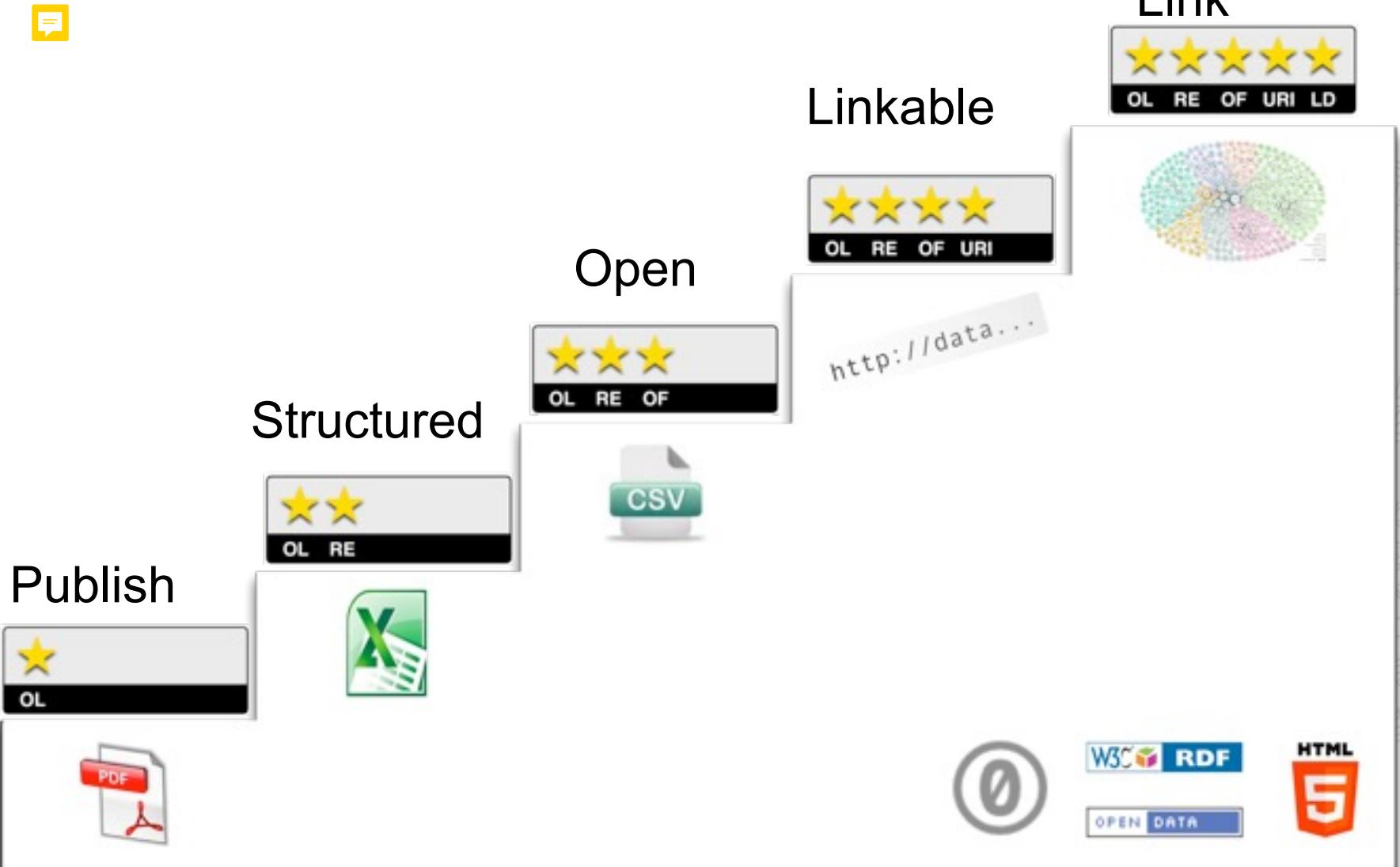


Making data available to citizens....but also to machines



# 5 ★ Open Data (Berners-Lee)

UNIVERSIDAD DE  
MURCIA





NEWS • 05 SEPTEMBER 2018

# Google unveils search engine for open data

*The tool, called Google Dataset Search, should help researchers to find the data they need more easily.*

## Dataset Search

Buscar conjuntos de datos



Probar [coronavirus covid-19](#) o [global temperatures](#).

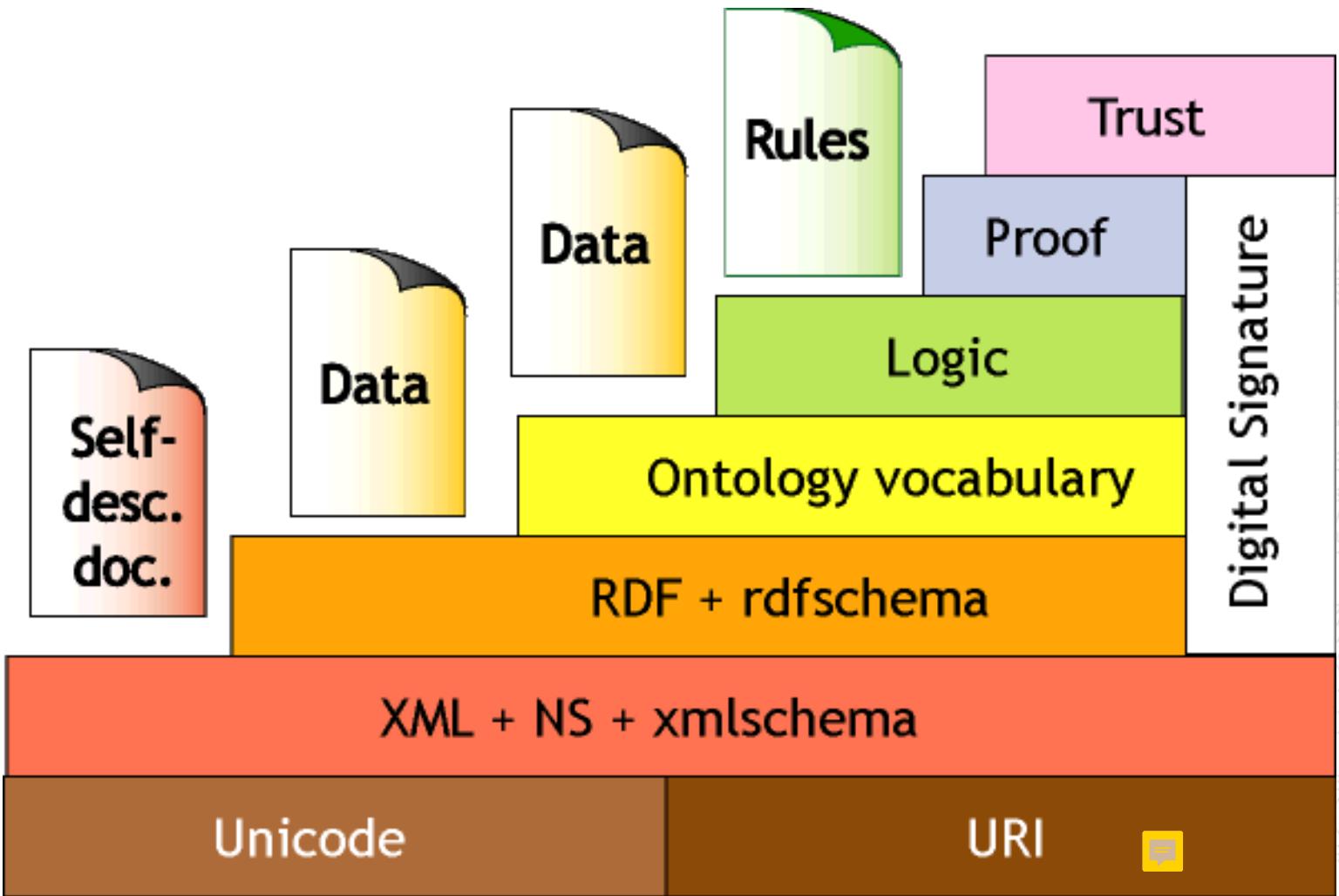
[Consulta más información](#) sobre la inclusión de tus conjuntos de datos en Búsqueda de Datasets.

# Google Datasets

- Spend five minutes exploring the Google Datasets
- Search for “RDF Genomics”



# The Semantic Web Stack



# The Semantic Web Stack

- Charset
  - Computers must be able to recognize the characters exchanged

Unicode



# URI as fundamental resource

- Current web: Each *document* has a URL (Uniform Resource Locator)
  - <http://www.google.com>
- Semantic web: Each *resource* has a URI (Uniform Resource Identifier)
  - URL is a type of URI
  - Role of URI in the Internet of Things
  - IRI = Internationalized Resource Identifier (Unicode characters)



Unicode

URI

# The importance of URI

- Do you have a URI?



Unicode

URI

# The importance of URI

- Do you have a URI? 
- How many John Smiths exist in the US?



Unicode

URI

# The importance of URI

## HowManyOfMe.com

There are 332,494,115 people in the U.S.  
How many have your name?

[Home](#) | [Famous Names](#) | [Statistics](#) | [Random Famous Person](#)

First Name:

Last Name:



Emergency Alerts  
save lives.

[Learn More](#)

### John

- There are **5,457,891** people in the U.S. with the first name John.
- Statistically the 2nd most popular first name.
- 99.63 percent of people with the first name John are male.
- Names similar to John:

- [Hans](#)
- [Ian](#)
- [Ivan](#)
- [Jack](#)
- [Jackie](#)

[click to see 6 more](#)

### Smith

- There are **2,928,783** people in the U.S. with the last name Smith.
- Statistically the 1st most popular last name.
- Famous people with the last name Smith:

- [Adam Smith](#)
- [Adrian Smith](#)
- [Alex Smith](#)
- [Anna Nicole Smith](#)
- [Antowain Smith](#)

[click to see 36 more](#)

### John Smith

- There are **48,076** people in the U.S. named John Smith.

# The importance of URI

- Do you have a URI?
- How many John Smiths exist in the US?
- How many URIs would be needed?



Unicode

URI

# The importance of URI

- Do you have a URI?
- How many John Smiths exist in the US?
- How many URIs would be needed?
- Is there any limit to the length of URI? 



Unicode

URI

# Efforts for permanent and persistent URI



<http://identifiers.org/>

- o <http://identifiers.org/pubmed/16333295>
- o <http://identifiers.org/taxonomy/9606>
- o <http://identifiers.org/ec-code/1.1.1.1>



[Resolution](#)   [Registry](#)   [Browse the registry](#)   [Request prefix](#)   [Documentation](#)   [Legacy platform](#)   [Feedback](#)

## Identifiers.org Resolution Service

The Identifiers.org Resolution Service provides consistent access to life science data using Compact Identifiers. Compact Identifiers consist of an assigned unique prefix and a local provider designated accession number (prefix:accession). The resolving location of Compact Identifiers is determined using information that is stored in the Identifiers.org Registry.

Resolve a Compact Identifier

Enter an identifier to resolve

Resolve

# Efforts for permanent and persistent URI

<https://purl.org>

PURL Administration help

## PURL Administration

Home

PURLs are persistent URLs, they provide permanent addresses for resources on the web.

### Search

### Create a new domain

Login or sign up to create a new domain.

The PURL service is an initiative of the [Internet Archive](#), a 501(c)(3) non-profit,  
building a digital library of Internet sites and other cultural artifacts in digital form.  
For help and assistance please email [info@archive.org](mailto:info@archive.org).



# Best practices URI

[https://www.ebi.ac.uk/rdf/documentation/good\\_practice\\_uri/](https://www.ebi.ac.uk/rdf/documentation/good_practice_uri/)

- **Globally unique:** One URI should never refer to two different concepts at the same time, even ones that may seem equivalent.
- **Persistent:** A URI should continue to resolve for the foreseeable future. The URI should survive between website re-engineering exercises, for example.
- **Stable:** A URI should never be re-used for different things between data releases, even if the original is deleted.
- **Resolvable (dereferenceable):** Simply, when a user clicks on a URI in their browser, we want them to be redirected to a suitable document. That doesn't necessarily mean it should be capable of returning RDF content.

# Opaque URLs

## Non-opaque URLs

<<http://example.com/people/janet.thornton>> foaf:knows

<<http://example.com/people/sally.Smith>>

<<http://example.com/people/janet.thornton>> foaf:name "Janet Thornton"

<<http://example.com/people/sally.Smith>> foaf:name "Sally Smith"

## Opaque URLs

<<http://example.com/people/123456789>> foaf:knows

<<http://example.com/people/987654321>>

<<http://example.com/people/123456789>> foaf:name "Janet Thornton"

<<http://example.com/people/987654321>> foaf:name "Sally Smith"

# FAIR principles

[www.nature.com/scientificdata](http://www.nature.com/scientificdata)

# SCIENTIFIC DATA

110110  
0111101  
11011110  
011101101

OPEN

## SUBJECT CATEGORIES

- » Research data
- » Publication characteristics

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

Mark D. Wilkinson *et al.*<sup>#</sup>

Received: 10 December 2015

Accepted: 12 February 2016

Published: 15 March 2016

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

# 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

# Knowledge graphs

huawei p8 lite review

Todo Videos Shopping Imágenes Noticias Más Configuración Herramientas

Aproximadamente 1.220.000 resultados (0,45 segundos)

**Huawei P8 Lite 2017, análisis, review con características, precio y ...**  
<https://www.xatakamovil.com/analisis/huawei-p8-lite-2017-analisis> ▾  
 29 mar. 2018 - Hemos analizado la renovación del Huawei P8 Lite, el emblema de la gama media de un fabricante que decidió reeditarlo en una versión 2017 que ya puede comprarse.

**Huawei P8 Lite, Review en español - YouTube**  
 15:57  
[https://www.youtube.com/watch?v=\\_dOwPPYkJyY](https://www.youtube.com/watch?v=_dOwPPYkJyY) ▾  
 23 jul. 2015 - Subido por Topes de Gama  
 Puedes comprar tu P8 Lite en Gearbest aquí: <http://goo.gl/CQTgNG> Suscríbete a Andro4all: <http://goo.gl/LuuzTb> ...

**Huawei P8 Lite 2017, análisis review en español - YouTube**  
 5:18  
<https://www.youtube.com/watch?v=43AqZFrzxwE> ▾  
 10 mar. 2017 - Subido por Xataka TV  
 Review Huawei P8 Lite 2017, análisis de un gama media con un buen rendimiento, Más info <https://www...>

**Huawei P8 Lite Review | Trusted Reviews**  
[www.trustedreviews.com](http://www.trustedreviews.com/reviews/mobile/mobile-phones/huawei-p8-lite-2017) ▾ Reviews ▾ Mobile ▾ Mobile Phones ▾ Traducir esta página  
 ★★★★☆ Valoración: 7/10 - Reseña de Michael Passingham  
 19 abr. 2017 - Huawei P8 Lite review: A solid but uninspiring mid-range Android smartphone.

**Huawei P8 Lite (2017) review | TechRadar**  
<https://www.techradar.com/reviews/huawei-p8-lite-2017> ▾ Traducir esta página  
 ★★★★☆ Valoración: 4 - Reseña de Damien McFerran  
 16 mar. 2017 - The Huawei P8 Lite 2017 has a fingerprint scanner, NFC and more, but does it get the basics right?

**Huawei P8 Lite 2017 review: This slick-looking Moto rival now costs ...**  
[www.expertreviews.co.uk](http://www.expertreviews.co.uk/mobile/huawei-p8-lite-2017) ▾ Huawei ▾ Traducir esta página  
 ★★★★☆ Valoración: 4 - Reseña de Christopher Miniasians  
 22 ene. 2018 - Huawei P8 Lite 2017: Despite stiff competition, the P8 Lite 2017 is a good budget smartphone.

**Huawei P8 Lite 2017 review: still a good vintage? - Hardware reviews ...**  
<https://www.androidpit.com/huawei-p8-lite-2017-test> ▾ Traducir esta página  
 ★★★★☆ Valoración: 7/10 - Reseña de Pierre Vitré  
 8 mar. 2017 - Unveiled at CES 2017, the Huawei P8 Lite 2017 is Huawei's accessibly priced mid-range phone. Click through to see how it fared in our review.

**Huawei P8 lite 2017 Smartphone 4G - LTPS TFT, 3G - Negro**  
 4,5 ★★★★★ 5.668 reseñas de usuarios

**Comprar ahora** Patrocinados

Negro ▾	
179,00 € · Media Markt · De Google	Envío gratuito
179,00 € · Phone House · De Google	
189,00 € · Yoigo · De Google	Envío gratuito
149,00 € · costomovil · De Kelkoo	
179,00 € · eBay · De Google	Envío gratuito
<b>▼ Ver todos los vendedores y precios</b>	

**Detalles del producto**

Marca: Huawei  
 Sistema operativo: Android  
 Elementos de seguridad: Sensor de huella dactilar  
 Características: 4G LTE, Cuatribanda, Dual SIM  
 Red móvil: Red GSM  
 Resolución de pantalla: 1920x1080

**Productos similares**



# Knowledge graphs & Semantic Web

- Data from different sources
- Need for a common schema
  - Data structure schemas
  - Ontology
- Joint representation of data and knowledge (meaning, schema)

The screenshot shows a search result for a "Huawei P8 Lite 2017 Smartphone 4G - LTPS TFT, 3G - Negro". The product image is a black smartphone. Below it, there are several price listings from different sellers: Media Markt (179,00 €), Phone House (179,00 €), Yoigo (189,00 €), costomovil (149,00 €), and eBay (179,00 €). A "Comprar ahora" button is visible, along with a "Negro" dropdown menu and a "Patrocinados" button. The page also includes sections for "Detalles del producto" (Marca: Huawei, Sistema operativo: Android, etc.) and "Productos similares".

# Google Knowledge Graph

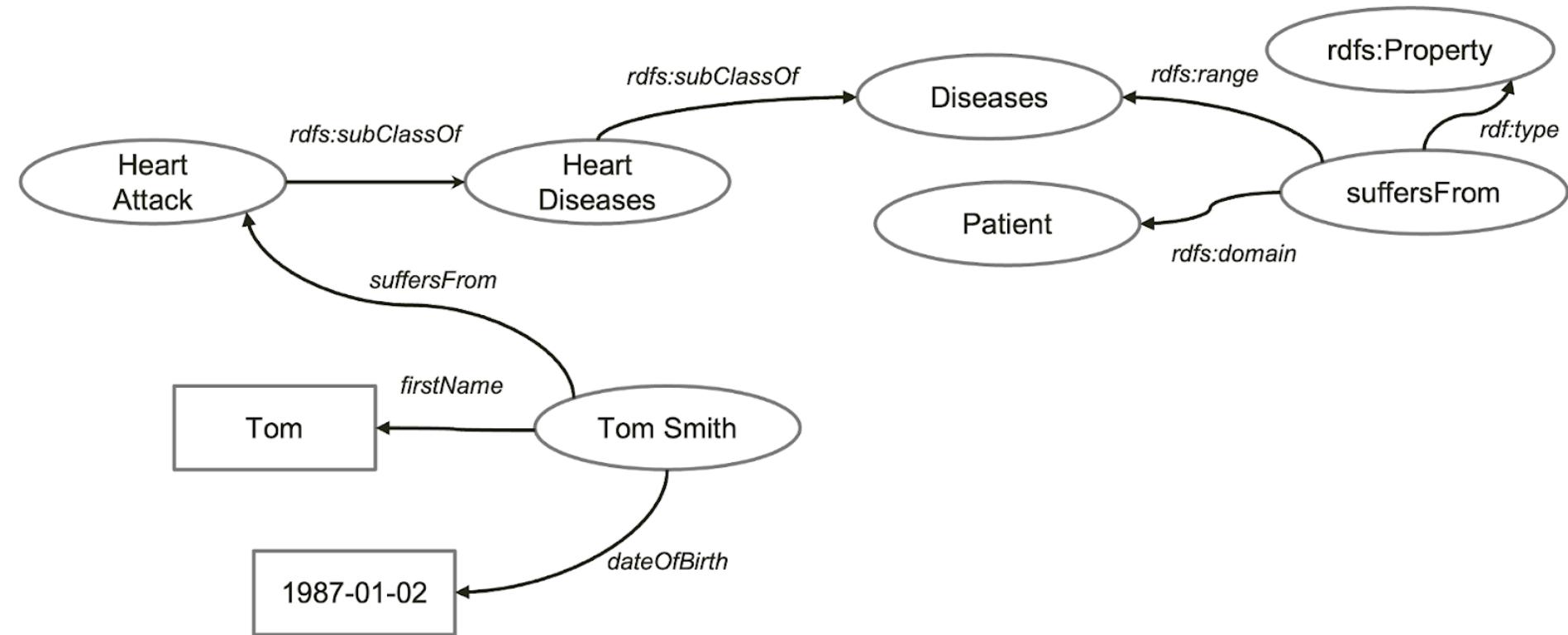
## How Google's Knowledge Graph works

Google's search results sometimes show information that comes from our Knowledge Graph, our database of billions of facts about people, places, and things. The Knowledge Graph allows us to answer factual questions such as "How tall is the Eiffel Tower?" or "Where were the 2016 Summer Olympics held." Our goal with the Knowledge Graph is for our systems to discover and surface publicly known, factual information when it's determined to be useful.

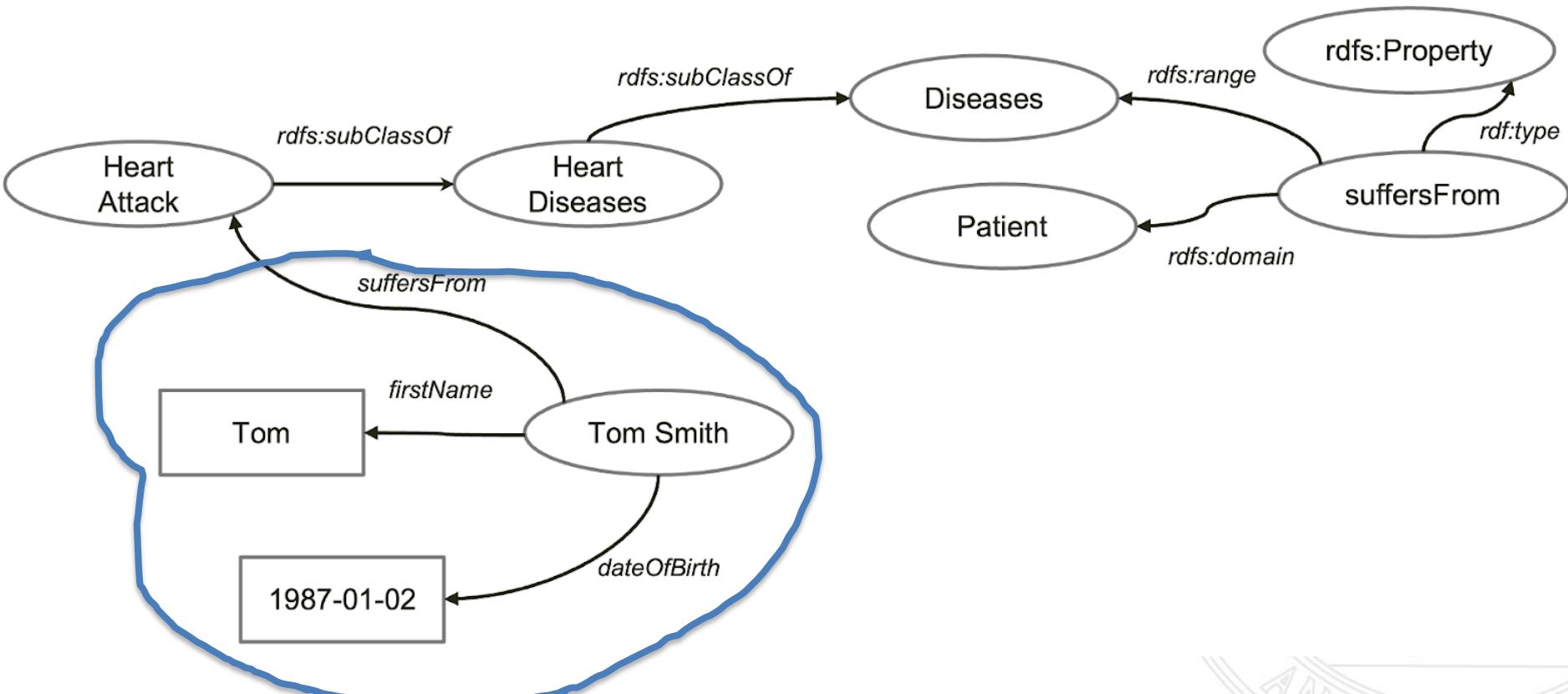
## Where do Knowledge Graph facts come from?

Facts in the Knowledge Graph come from a variety of sources that compile factual information. In addition to public sources, we license data to provide information such as sports scores, stock prices, and weather forecasts. We also receive factual information directly from content owners in various ways, including from those who suggest changes to [knowledge panels](#) they've [claimed](#).

# Excerpt of Knowledge Graph



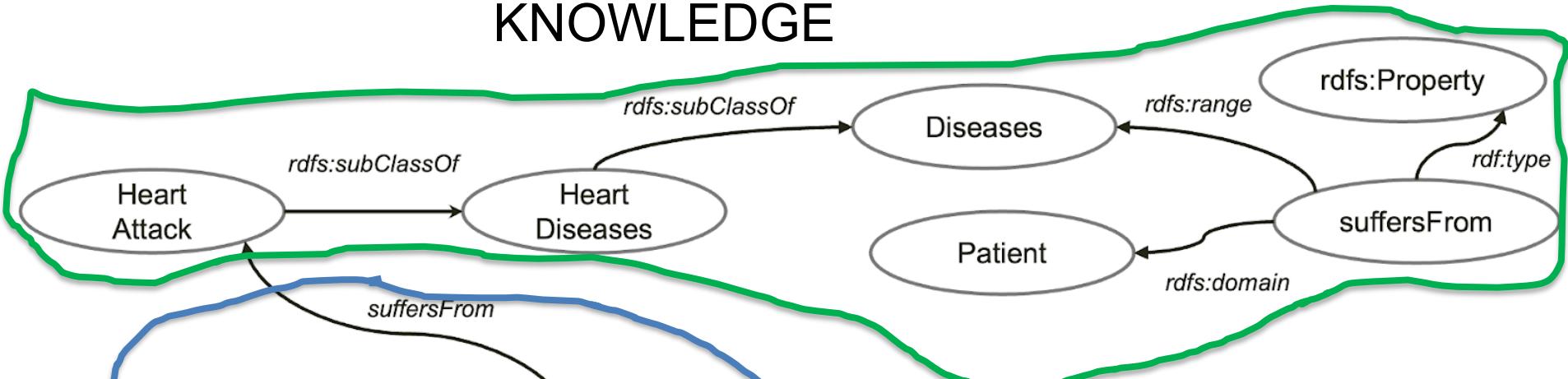
# Excerpt of Knowledge Graph



DATA

# Excerpt of Knowledge Graph

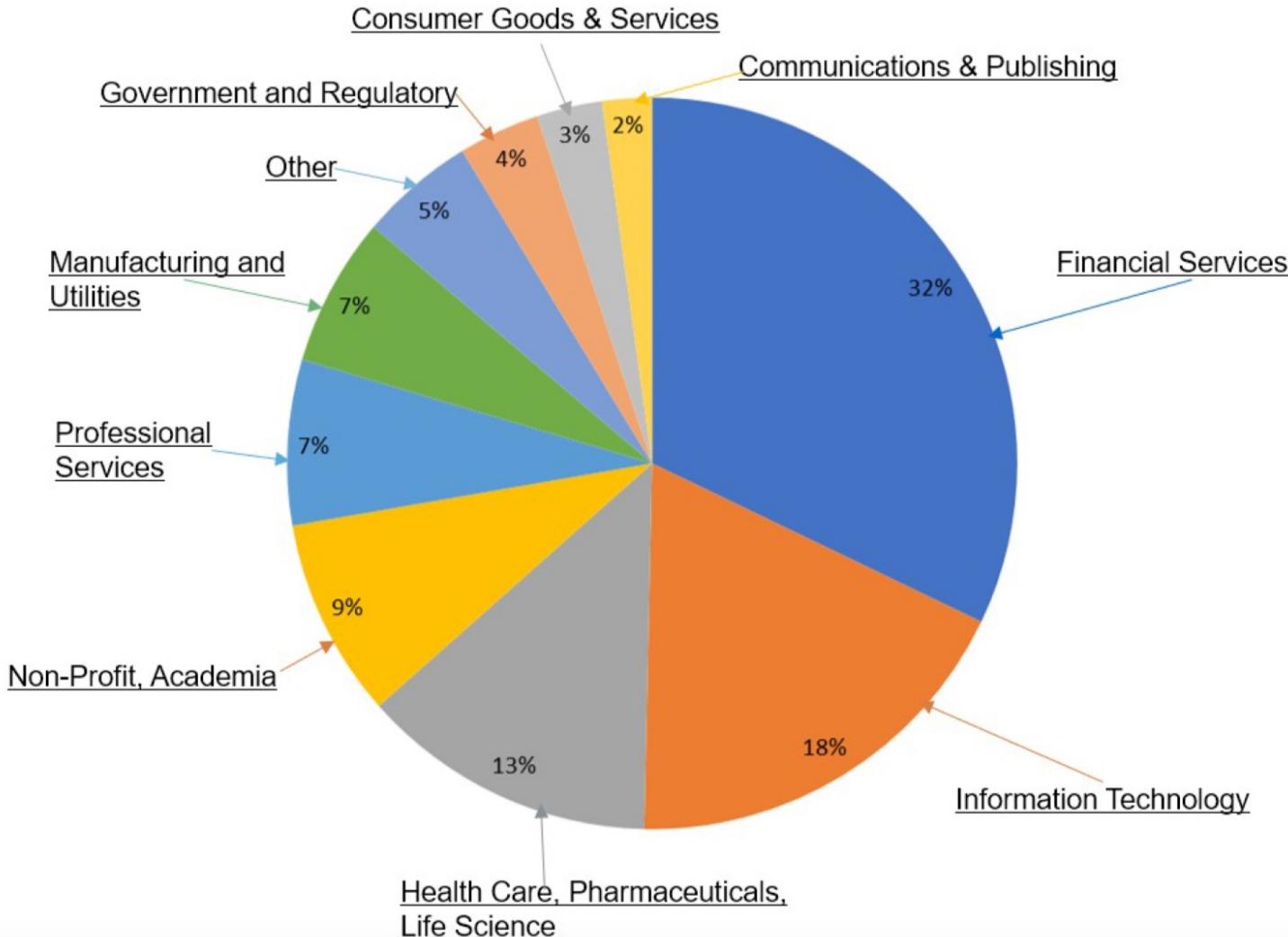
## KNOWLEDGE



DATA



# Enterprise Knowledge Graph Survey



# Some users of knowledge graphs



NETFLIX



Morgan  
Stanley



SIEMENS

AstraZeneca



# Questions, comments,...

