Epistemology, Ontology & Semantic Web

Epistemology is the research field revolving around knowledge and how to reach it. *Ontology* is what reality actually is. *Semantic Web* ameliorates the Web in such a way that it can be read directly by computers.

Contents

The author apologizes to those philosophers and formalists who may be offended by her casual use of such important concepts :)

Intended Audience

- *for those who are present* :)
- software engineers and developers who are interested in learning the Semantic Web technology in general
- future working ontologists
- and users of information retrieval systems in general.

What is a Web 1.0 ? (1989-2005)

From contentional viewpoint

HTML 3.2 elements like frames and tables,
HTML forms get/sent through e-mails,
content comes from the server's filesystem, not from a RDBMS,
Encyclopedia Britannica online.

From technical/technological viewpoint

no user-to-server communication,
static websites,
content browsing only,
hyper-linking and bookmarking pages.

What is a Web 2.0 ? (1999-2012)

From contentional viewpoint

offers free information sorting, allowing users to retrieve and classify data collectively,

contains dynamic content that responds to the user's input,

employs developed APIs,

encourages self-usage and allows several forms of interaction (podcasting, social media, blogging, commenting, ...), Wikipedia.

From technical/technological viewpoint

Web applications introduced,

functions such as online documents, video streaming, ... ,

everything moves online; information and apps are stored on servers,

cloud computing operations,

centralized data,

read/write Web.

What is a Web 3.0 ? (2006-ongoing)

From contentional viewpoint

AI,
Machine Learning,
Natural Language Processing (NLP),
Internet of Things (IoT),
the Semantic Web.

From technical/technological viewpoint

intelligent, web-based functionalities and applications,
decentralized processes,
fusion of Web technology and knowledge representation (RDF, RDFs, OWL, OWL-2),
behavioral advertising and engagement,
live videos,
semantic searches,
read/write/control Web.

There's a large amount of website owners who are unaware of the semantic web's importance.

What is a Web 4.0 ? (2020-?)

From contentional viewpoint

is about mobility and voice interaction between the user and robots.
symbiotic interaction between man and machine,
Internet is a Web OS. Information can be transmitted from every part of the world,
total transparency; all actions are traceable,
offers higher speed and reliability than ever before.

From technical/technological viewpoint

?

What will (probably) be Web 5.0 ? (?-?)

From contentional viewpoint

Web 5.0 is the *emotional Web*,
total control over your identity,
offering true ownership of user data,
expanded emotional intelligence aspect,
DAOs*.

From technical/technological viewpoint

?

*DAO (Decentralised Autonomous Organisation) is an organisation governed by a set of rules or parameters encoded in a computer program and controlled by the users of the program rather than a central authority.

Back to Web 3.0:
Advantages/Disadvantages of the Semantic Web (Web 3.0)

Possessing huge quantities of **data**, **information**, and **knowledge**

which is **translated to be comprehensible** and ready for including

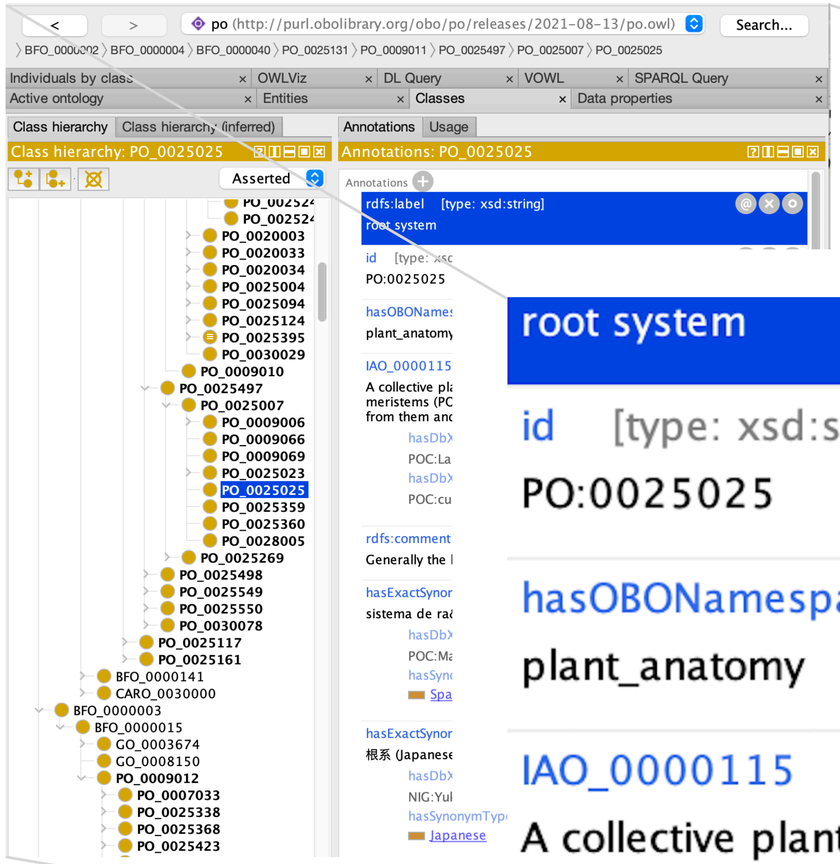
virtual assistants,
software agents,
and AI bots*.

The main three problems, when using the Web 3.0

it is very new and there are very few resources available to help us learn and use it,
it quite complex and there are many different ways to use it,
it is very buggy and there are many ways to make mistakes while using it.

*AI (ro)bots are self-learning bots that are programmed with Natural Language Processing (NLP) and Machine Learning. A chatbot system uses conversational artificial intelligence (AI) technology to simulate a discussion (or a chat) with a user in natural language via messaging applications, websites, mobile apps or the phone.

Ontology in Praxis: Class in Protégé

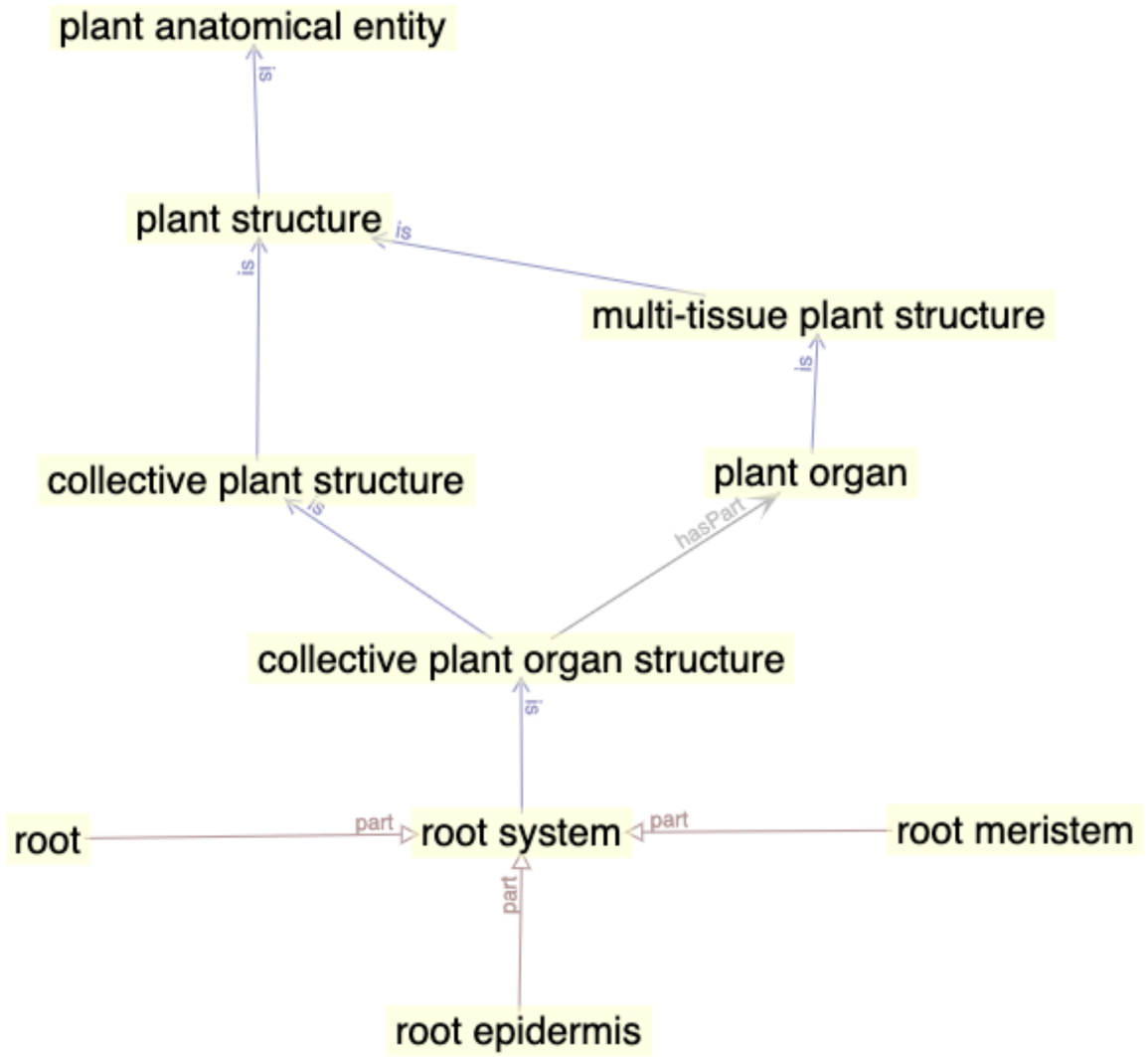


Protégé is a free, open-source ontology editor and framework for building intelligent systems.

Ontology in Praxis: Class in OLSVis (1)*

OLSVis is an animated, interactive visual browser for bioontologies

More than one million terms from biomedical ontologies and controlled vocabularies are available through the Ontology Lookup Service (OLS).



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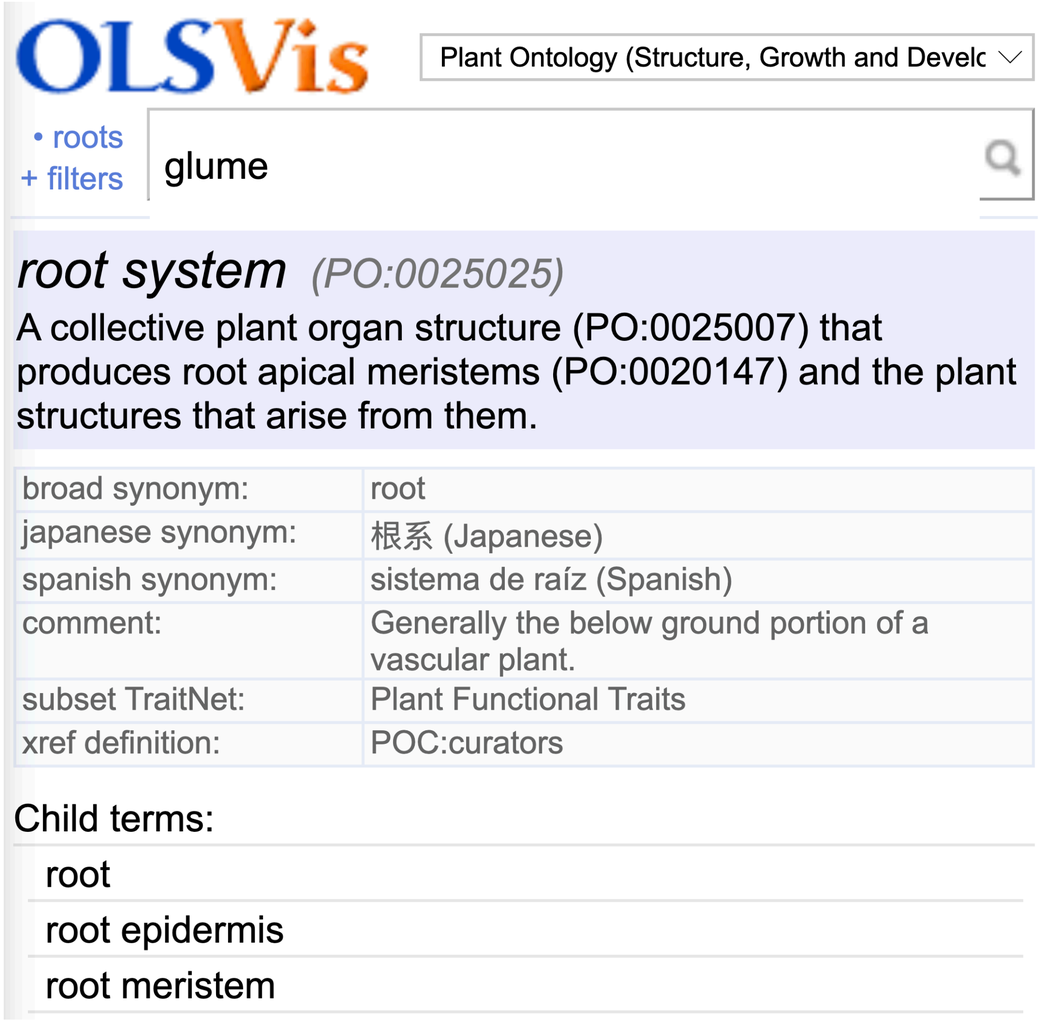
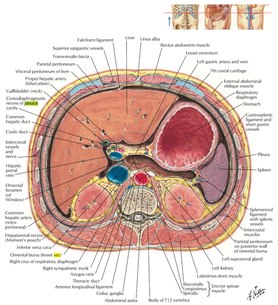
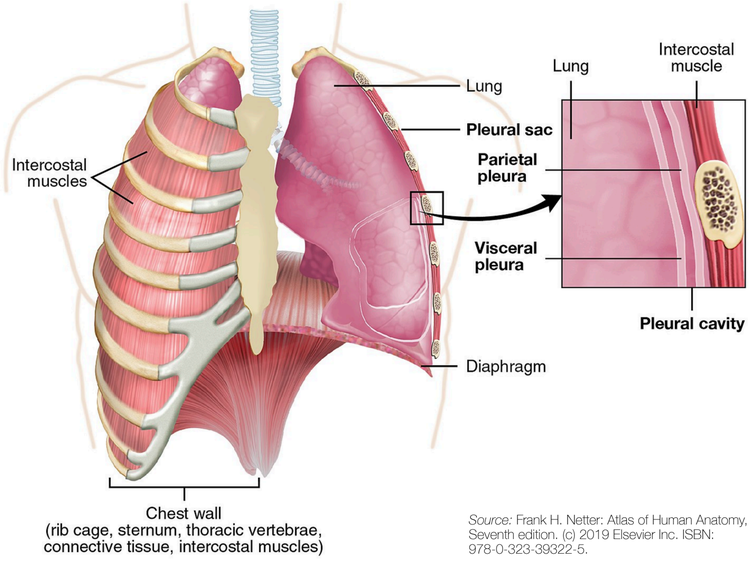


Anatomical Ontology Example*

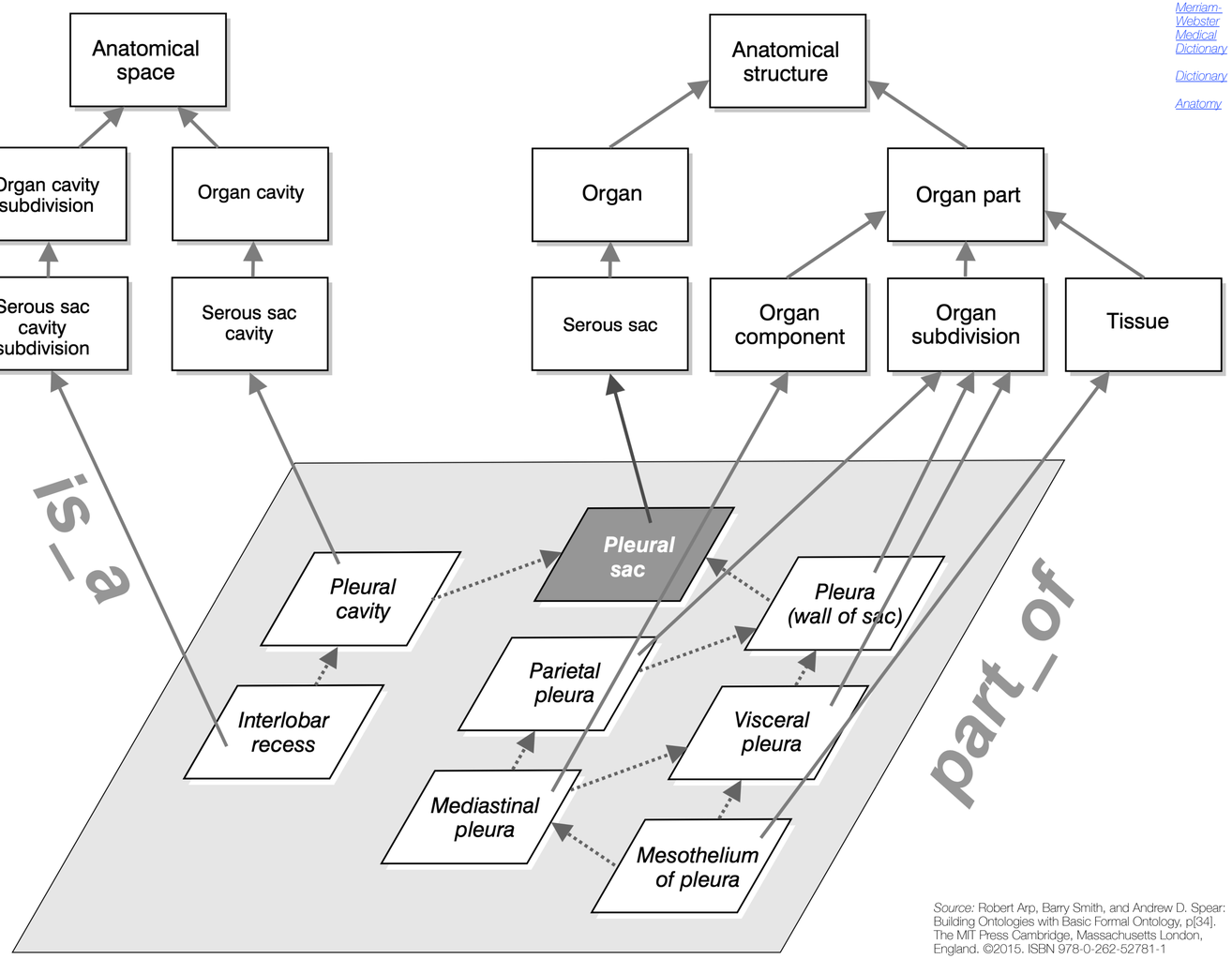
Pleural sac in situ



click on to enlarge...



Source: Frank H. Netter: Atlas of Human Anatomy, Seventh edition. (c) 2019 Elsevier Inc. ISBN: 978-0-323-39322-5.



Merriam-Webster Medical Dictionary

Dictionary

Anatomy

Source: Robert Arp, Barry Smith, and Andrew D. Spear: Building Ontologies with Basic Formal Ontology, p[34]. The MIT Press Cambridge, Massachusetts London, England. ©2015. ISBN 978-0-262-52781-1

Basic Terms (1)

Vocabulary

- domain-independent logical symbols and reserved terms,
- domain-dependent constants, identifying individuals, properties or relations,
- variables, whose range is governed by quantifiers,
- punctuations that separate or group other symbols.

Syntax

- Rules for combining the symbols into well-formed expressions.

Semantics

- A theory of reference that determines how the constants and variables are associated with things in the universe of discourse.

Taxonomy

- a scheme of classification,
- methodology and principles of systematic ordering and sets up arrangements of the kinds of the artifacts in hierarchies of superior and subordinate groups.

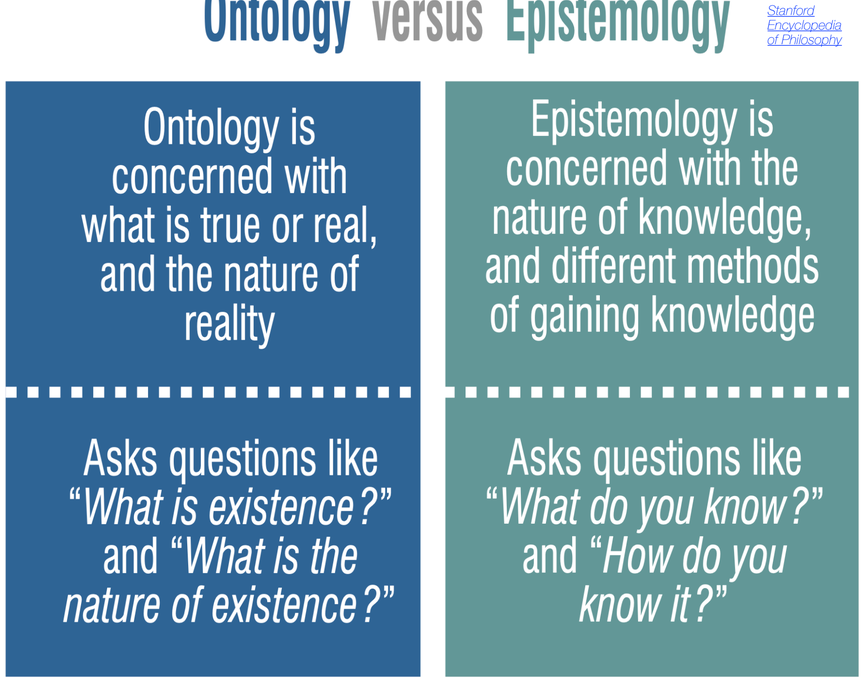
Basic Terms (2)

Ontology

- conceptual model of some aspect of a particular universe of discourse,
- ontology is the study of beings or their being—what is.

Epistemology

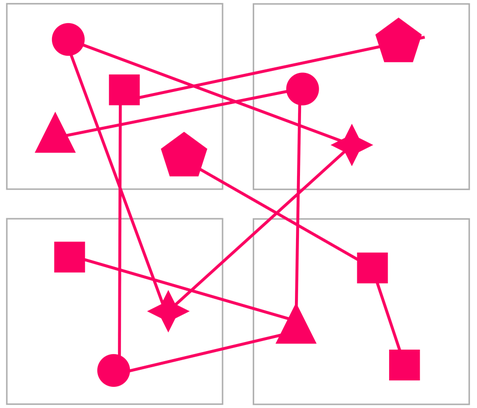
- the theory of knowledge, especially with regard to its methods, validity, and scope, and the distinction between justified belief and opinion.



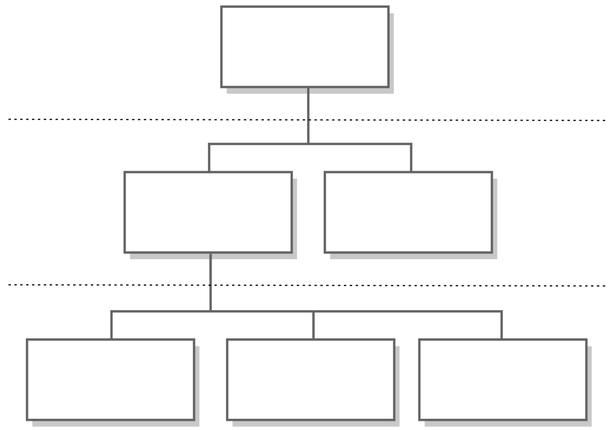
Basic Terms (3)

Ontology versus Taxonomy

- ontologies allow **multidimensional relationships** to be defined,
- an ontology identifies and distinguishes concepts and their relationships,
- ontologies achieve a **higher level of sophistication** by providing richer information, including information about the **relationships among entities**.



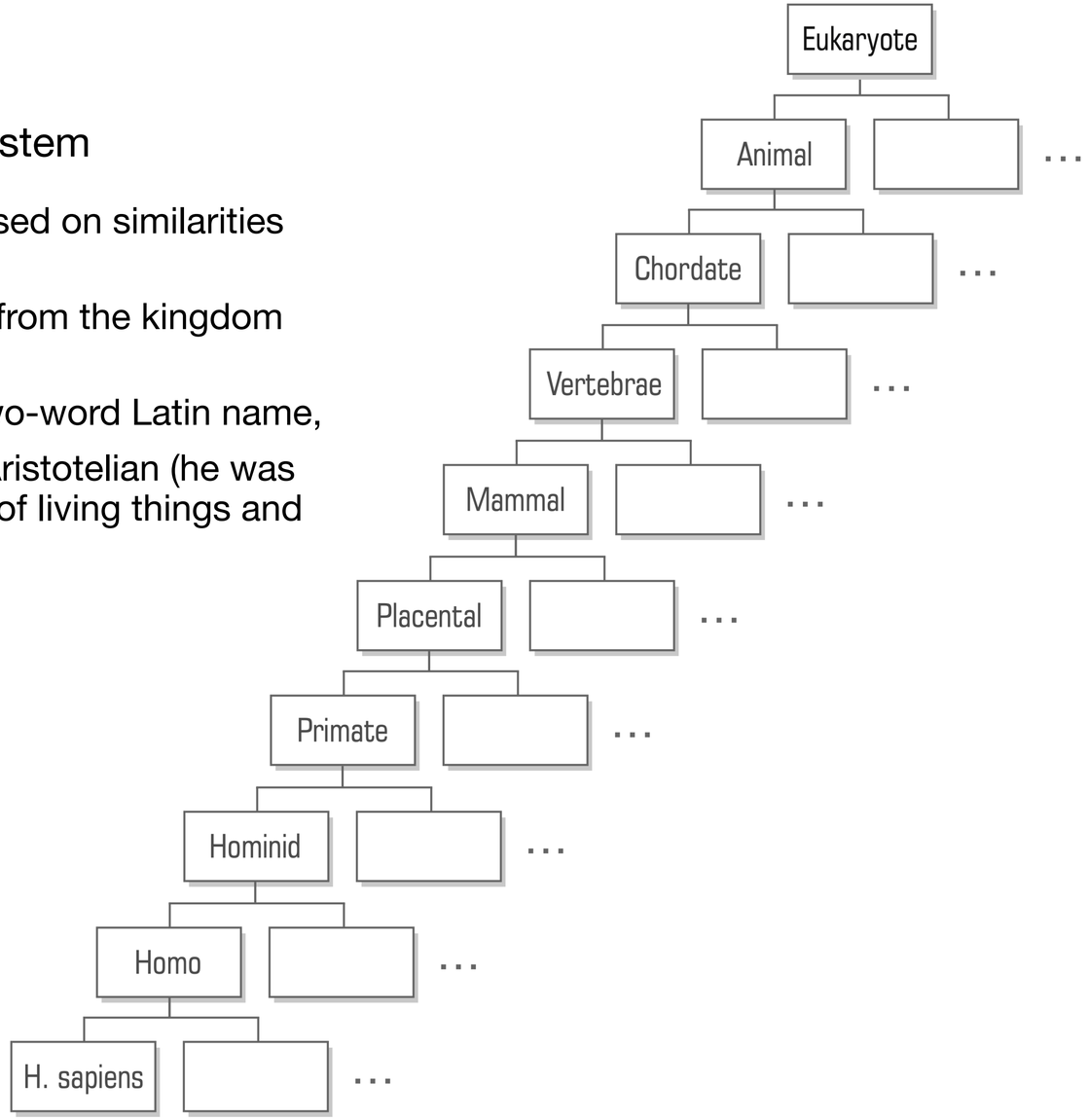
- a taxonomy is a form of classification scheme,
- the taxonomy identifies **hierarchical relationships** within a category,
- each taxonomy is **designed to categorize items** within just one dimension.
- a taxonomy is a kind of knowledge map,
- a taxonomy formalizes the hierarchical relationships among concepts.



Basic Terms (4)

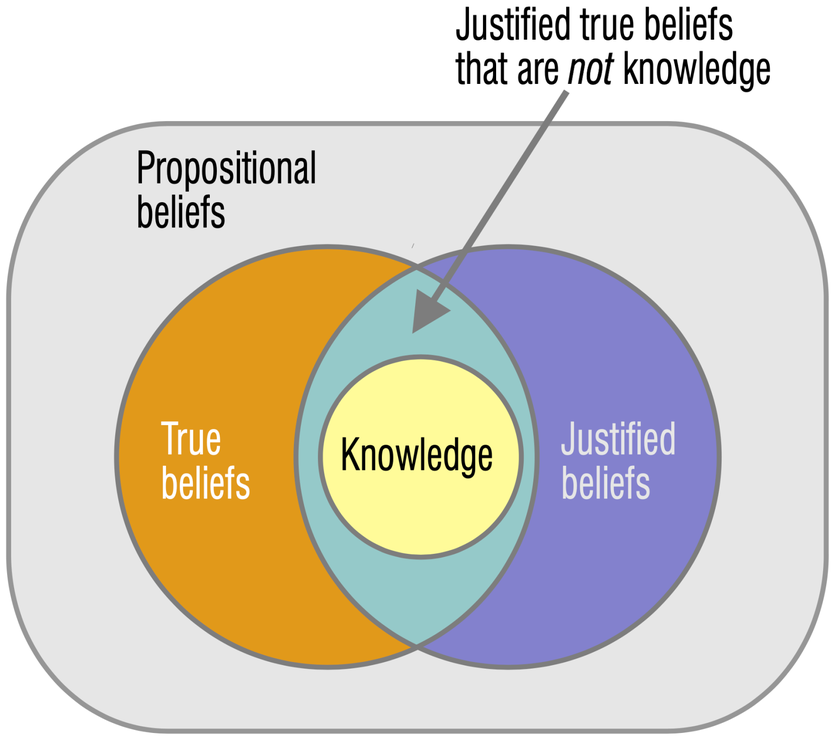
Sample Taxonomy: the Linnaean system

- the Linnaean system (1758) is based on similarities in obvious physical traits,
- it consists of a hierarchy of taxa, from the kingdom to the species,
- each species is given a unique two-word Latin name,
- Carolus Linnaeus' concept was Aristotelian (he was the idea of the essential features of living things and his logic).



Basic Terms (5)*

What is knowledge ?



Critics of Justified-True-Beliefs (JTB) Theory Edmund Gettier (1963)

Situation: A ball in front of me appears to be red

1) I **b**elieve it is red.
2) I'm **j**ustified in this belief, the ball appears red to me.
3) It's also **t**rue that the ball is red.

However, it turns out that the ball is illuminated by a red light, a fact that I'm unaware of. Under the red each colour would appear red, but I made a lucky guess anyway :)

Facit: **The JTB conditions are fullfilled**, but JTB definition of knowledge is seriously flawed.

Basic Terms (6)*

Sources of Knowledge and Justification

Perception

[AH] Limits of cognitive success, general skepticism

Memory

[AH] The preservation and reconstruction of the past

Introspection

[H] Lat.: ‘to look within’. Introspective consciousness can produce inner seeing and other sensuous ideas.

Reason

[H] Understanding, insight, and intellectual power

Testimony

[H] The social foundation of knowledge

Basic Terms (7)*

Inferential Chains*

- infinite inferential chain,
- circular inferential chain,
- inferential chains terminating in belief not constituting knowledge,
- inferential chains terminating in knowledge

the last link must be

non-inferential,
direct (from perception, memory, introspection, or from testimony)

expressing otherwise:

the last link must be direct knowledge, knowledge *not based on* other knowledge (or on justified belief)

*[9] Robert Audi: Epistemology - A Contemporary Introduction to the Theory of Knowledge. Third edition. ©2011 Taylor & Francis. ISBN 978-0-415-87922-4. Ch. 9. The architecture of knowledge.

Basic Terms (8)*

Common Logical Fallacies

1) **The False Dilemma Fallacy** (e.g.: "We can either agree with Barbara's plan, or just let the project fail. There is no other option.")

2) **The Correlation/Causation Fallacy** (e.g.: "If two things appear to be correlated, this doesn't necessarily indicate that one of those things irrefutably caused the other thing.")

3) **Temporality is not causality** (e.g.: "Post hoc ergo propter hoc - Since event Y followed event X, event Y must have been caused by event X"

4) **Fallacy of division** (e.g.: Dogs are frequently encountered in the streets.
Afghan hounds are dogs.
Therefore Afghan hounds are frequently encountered in the streets.

. . .

100) **The Personal Incredulity Fallacy** (If you have difficulty understanding how or why something is true, that doesn't automatically mean the thing in question is false.)

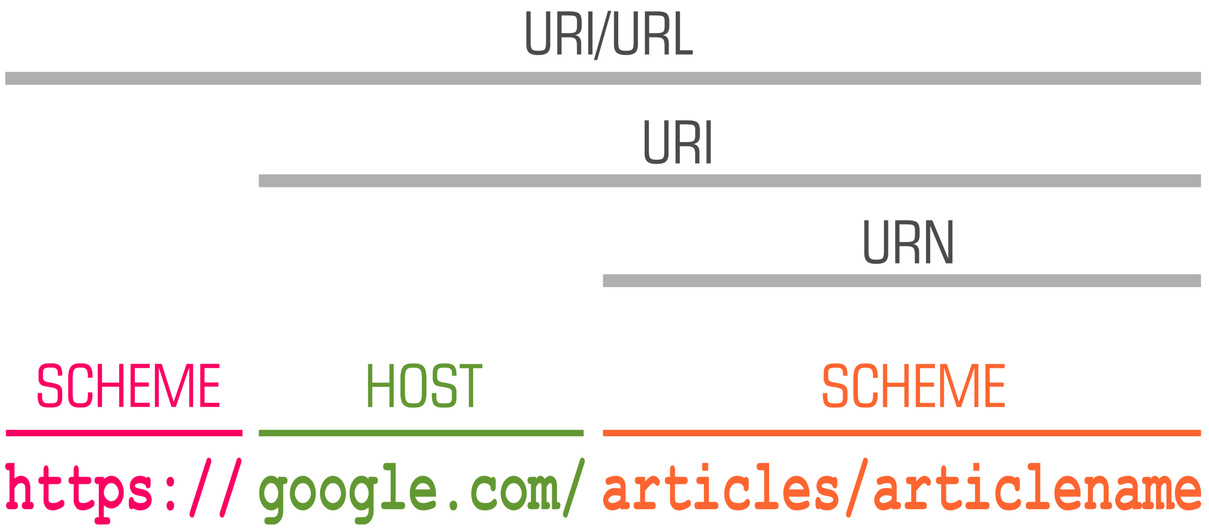
Basic Terms (9)*

RDF

- the Resource Description Framework (RDF) is a general framework for representing interconnected data on the web,
- RDF statements are used for describing and exchanging metadata, which enables a standardized exchange of data based on relationships,
- RDF is used to integrate data from multiple sources,
- the semantic web is based on the use of the RDF framework to organize information,
- the **RDF triple** contains three components: the *subject*, the *predicate*, and the *object*; **each component is an RDF URI reference**

Basic Terms (10)

Universal Resource Identifier / Locator / Number



Internationalized Resource Identifier (IRI)

- is a sequence of characters from the Universal Character Set (Unicode/ISO10646),
- XML notation is using: e.g. 'я stands for CYRILLIC CAPITAL LETTER YA. (Я).

Basic Terms (11)

RDFS

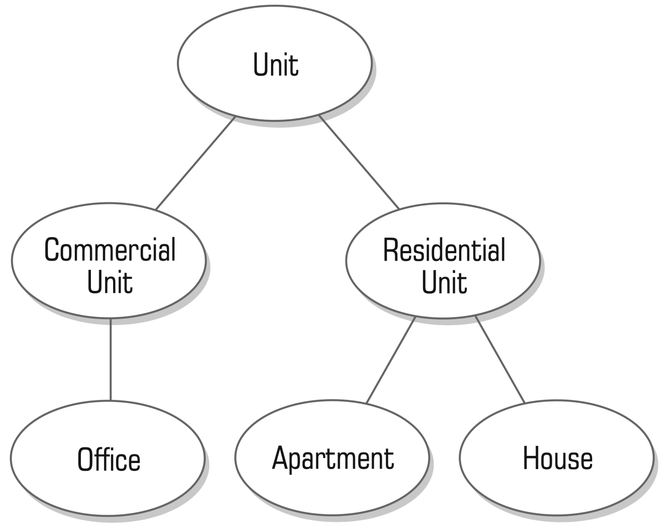
- the Resource Description Framework Schema is a vocabulary for describing properties and classes of RDF resources,
- RDFS is an extensible knowledge representation language, providing basic elements for the definition of ontologies.

RDFS classes

- it corresponds in RDF Schema to the generic concept of a type or category (like the notion of a class in OO languages)
- class C is defined by a triple of the form

```
C rdf:type rdfs:Class.
```

example of classes



RDFS core classes

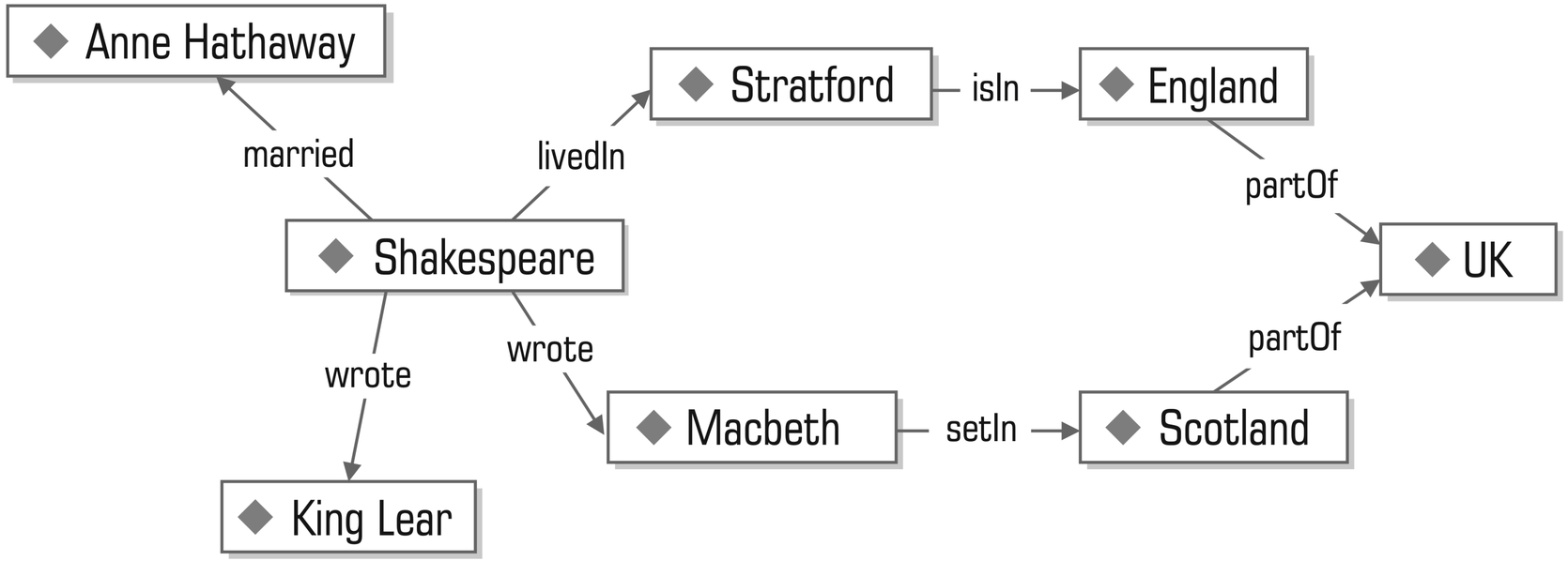
- `rdfs:Resource`, the class of all resources
- `rdfs:Class`, the class of all classes
- `rdfs:Literal`, the class of all literals (strings)
- `rdf:Property`, the class of all properties
- `rdf:Statement`, the class of all reified statements

Simple Ontology expressed in Triples**

Subject	Predicate	Object
Shakespeare	married	Anne Hathaway
Shakespeare	livedIn	Stradford
Stratford	isIn	England
England	partOf	UK

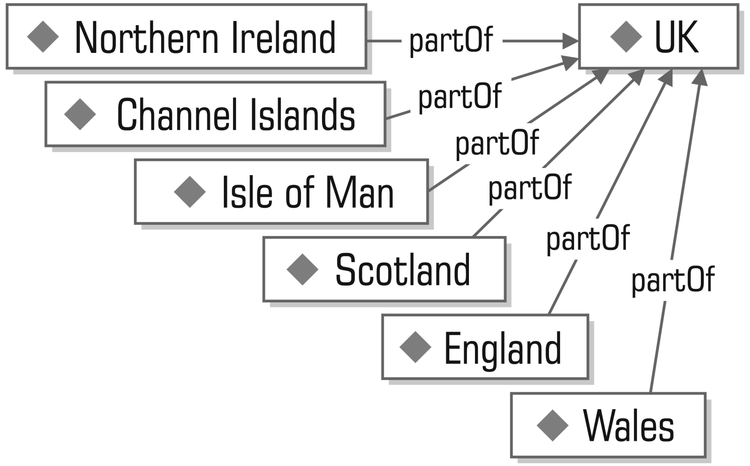
. . .

Modelling Risk

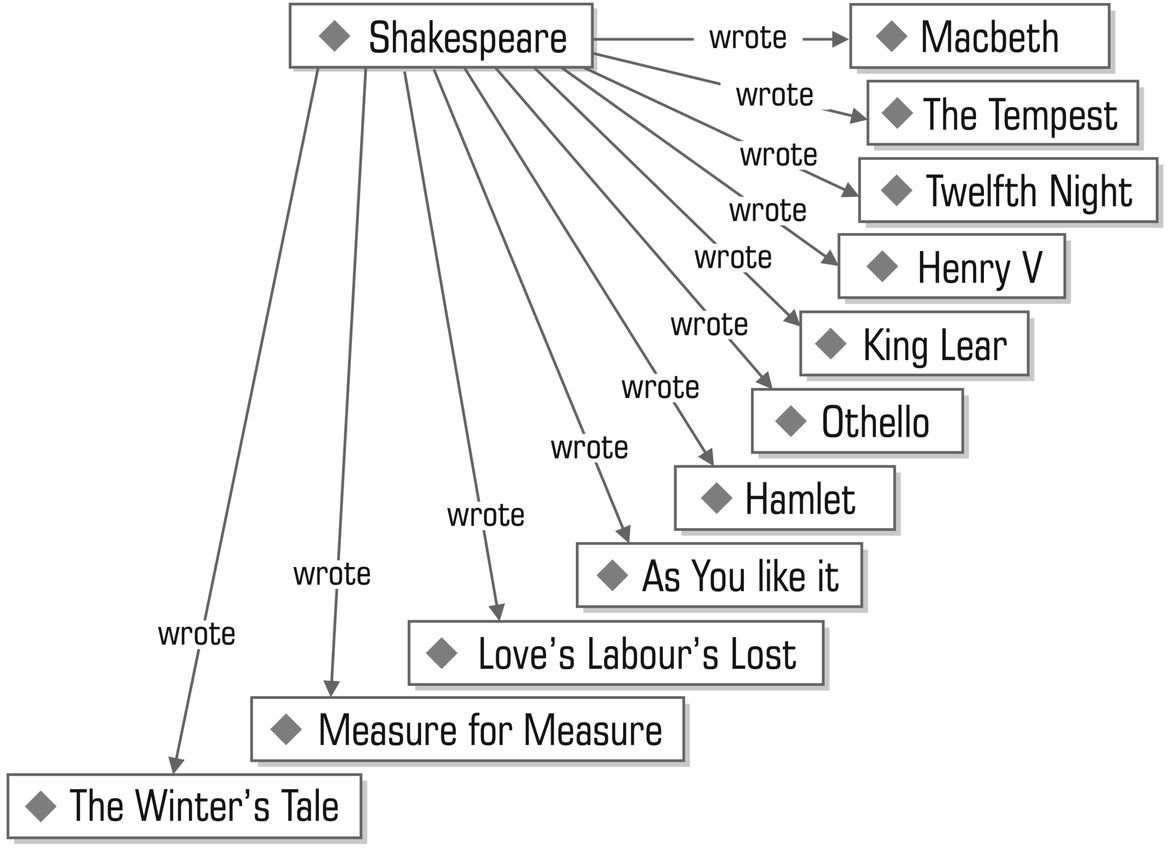


Combined Ontologies (1)

Ontology 1

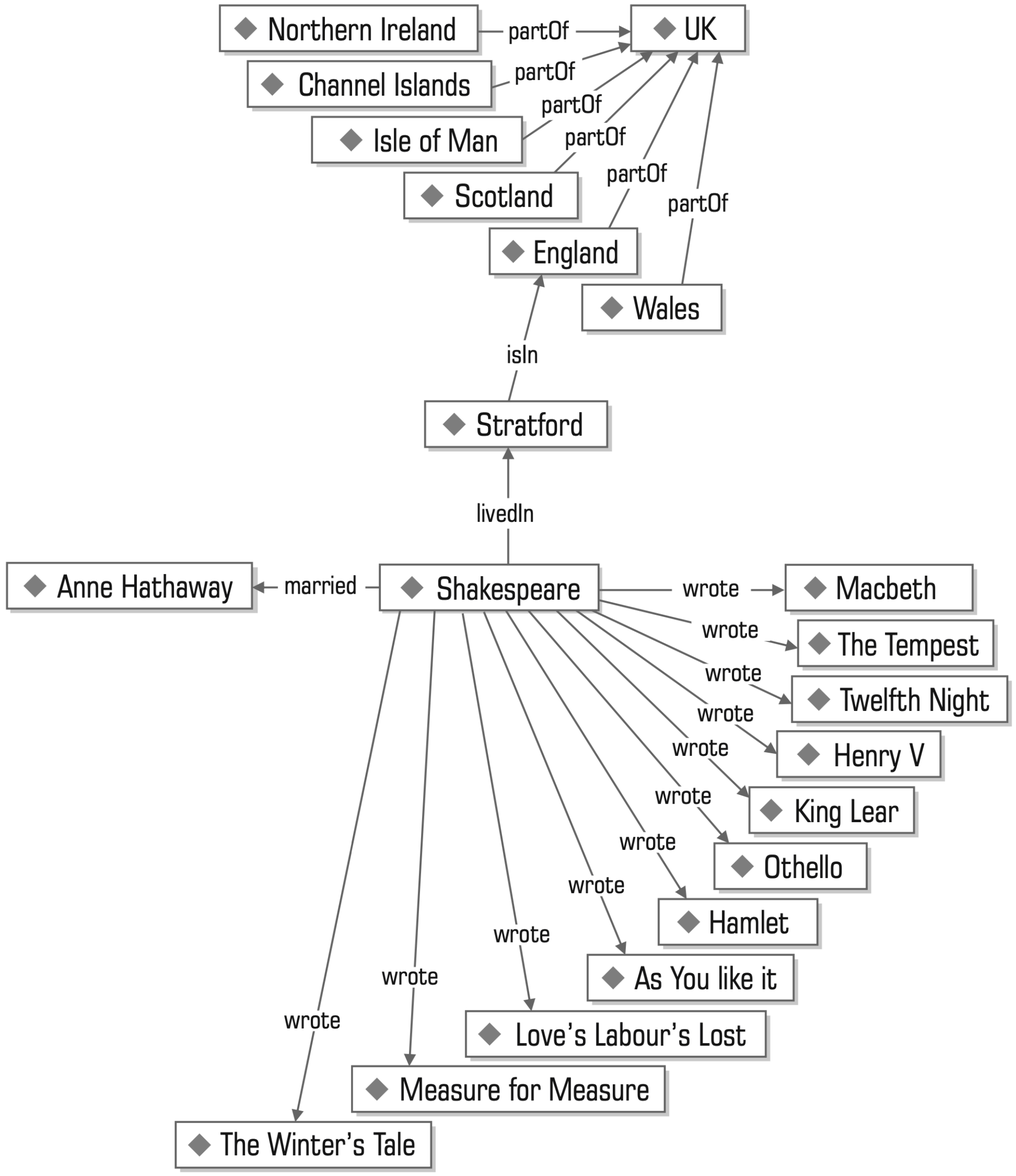


Ontology 2



Combined Ontologies (2)

Ontology 1 and Ontology 2 combined



Example Ontology

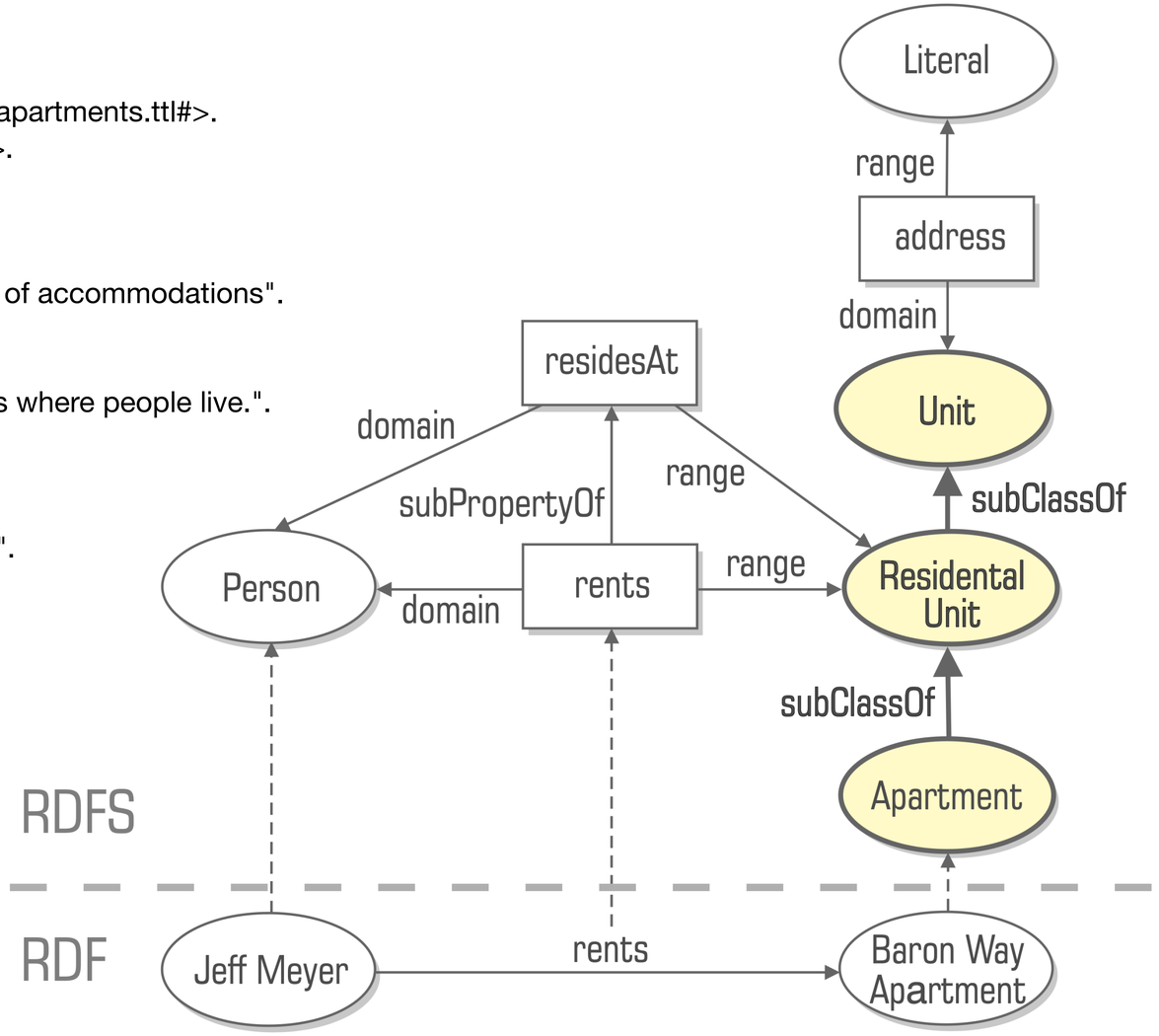
@prefix **swp**: <http://www.semanticwebprimer.org/ontology/apartments.ttl#>.
@prefix **rdf**: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix **rdfs**: <http://www.w3.org/2000/01/rdf-schema#>.

swp:Unit **rdf**:type **rdfs**:Class.
swp:Unit **rdfs**:comment "A self-contained section of accommodations".

swp:ResidentialUnit **rdf**:type **rdfs**:Class.
swp:ResidentialUnit **rdfs**:comment "The class of all units where people live.".
swp:ResidentialUnit **rdfs**:subClassOf **swp**:Unit.

swp:Apartment **rdf**:type **rdfs**:Class.
swp:Apartment **rdfs**:comments "The class of apartments".
swp:Apartment **rdfs**:subClassOf **swp**:ResidentialUnit.

Subject *Predicate* *Object*



RDF Query Language: SPARQL (1)

SPARQL* is an RDF query language: a semantic query language for databases,- able to **retrieve** and **manipulate data** stored in Resource Description Framework (RDF) format.

"*Trying to use the Semantic Web without SPARQL is like trying to use a relational database without SQL*." (Sir Tim Berners-Lee, Director of W3C)

There are several other (far less important) RDF query languages, as well:

GraphQL,
Gremlin,
KGSQL,
RDQL,
SquishQL,
TriQL,
TMQL,
XUL, ...

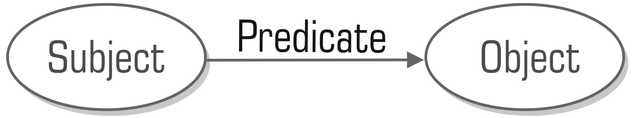
*SPARQL : *S*imple *P*rotocol *a*nd *R*DF *Q*uery *L*anguage.
Version 1.0 was acknowledged by W3C on 15 January 2008

RDF Query Language: SPARQL (2)*

Different representations of the RDF data

RDF is concerned with informational content
XML, Turtle, JSON, ... is concerned with serialization

Graphical form



Triple **subject** **predicate** **object**

Alternative terminology **resource** **property name** **property value**

Relational form **predicate(subject, object)**

RDF/XML encoding

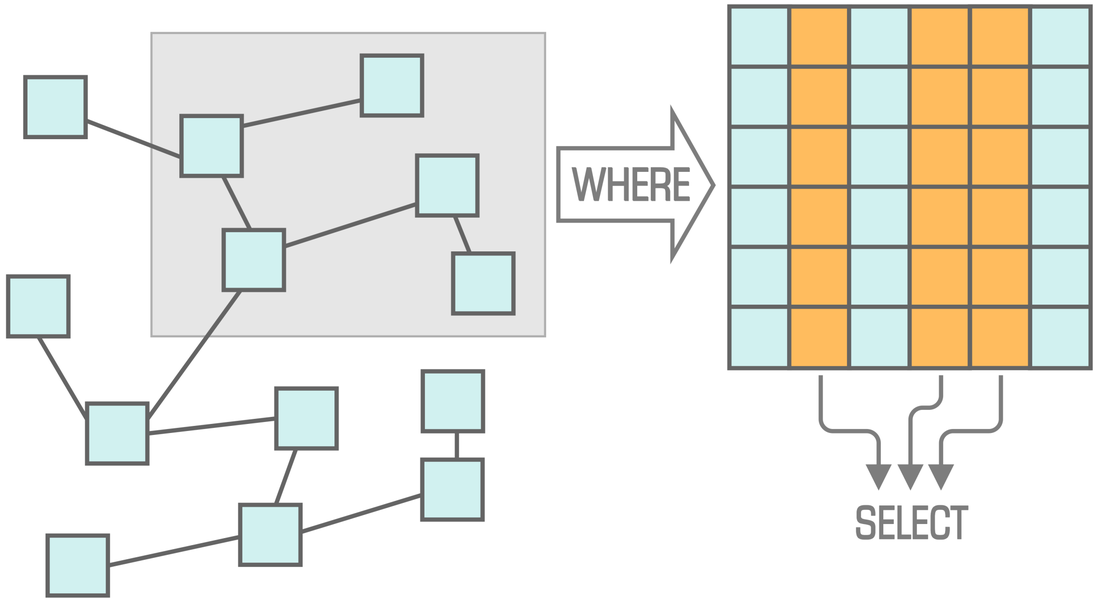
```
<rdf:Description rdf:about="subject">
   <ex:"predicate">
      <rdf:Description rdf:about="object"/>
   </ex:"predicate">
</rdf:Description>
```

*Turtle encoding **subject** **predicate** **object .**

*Turtle : *T*erse *R*DF *T*riple *L*anguage.

RDF Query Language: SPARQL (3)

The SPARQL query's WHERE clause specifies "*pull this data out of the dataset*," and the SELECT part names which parts of that pulled data you actually want to see.



RDF Query Language: SPARQL (4)*

Sample RDF data (*Turtle : *T*erse *R*DF *T*riple *L*anguage encoding)

```
prefix ab: <http://learningsparql.com/ns/addressbook#> .

ab:richard  ab:homeTel  "(209) 276-5135" .
ab:richard  ab:eMail    "richard49@hotmail.com" .

ab:cindy    ab:homeTel  "(245) 646-5488" .
ab:cindy    ab:eMail    "cindym@gmail.com" .

ab:craig    ab:homeTel  "+1 194 966-1505" .
ab:craig    ab:eMail    "craigellis@yahoo.com" .
ab:craig    ab:eMail    "c.ellis@gusairwaysgroup.com" .
```

RDF Query Language: SPARQL (5)*

Sample RDF data fragment (RDF/XML encoding)

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE RDF [
    <!ENTITY ab "http://learningsparql.com/ns/addressbook#">
                ]>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
         xmlns:ab="&ab;">

    <rdf:Description rdf:about="ab:richard">
       <ex:"ab:homeTel">
           <rdf:Description rdf:about="(209) 276-5135"/>
       </ex:"ab:homeTel">
    </rdf:Description>

    <rdf:Description rdf:about="ab:richard">
       <ex:"ab:eMail">
           <rdf:Description rdf:about="richard49@hotmail.com"/>
       </ex:"ab:eMail">
    </rdf:Description>

</rdf:RDF>
```

RDF Query Language: SPARQL (6)

Sample SPARQL query

```
@PREFIX ab: <http://learningsparql.com/ns/addressbook#> .

SELECT ?propertyName ?propertyValue
WHERE
{
     ab:cindy  ?propertyName ?propertyValue .
}
```

SPARQL query result

```
-------------------------------------
| propertyName | propertyValue        |
=====================================
| ab:email     | "cindym@gmail.com"   |
| ab:homeTel   | "(245) 646-5488"     |
-------------------------------------
```

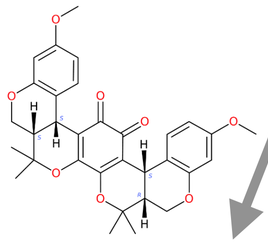
Ontologies in Biology | IDSM*

Integrated Database of Small Molecules

aggregate many different sources of information about small molecules into a

single,
logically coherent,
semantically interconnected

information source using the semantic web technologies.



Sachem GUI

Sachem is a high-performance chemical cartridge for fingerprint-guided substructure and similarity search. Sachem GUI allows quick access to this functionality on our Sachem installation. Indexed databases include up-to-date versions of PubChem and ChEMBL.

Search for compounds »

PubChem is a database of chemical molecules and their activities against biological assays.

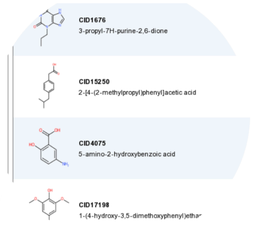
ChEMBL is a manually curated database of bioactive molecules with drug-like properties.

European Molecular Biology Laboratory

SPARQL GUI

We provide an indexing service that allows FAIR-style search in published chemical data. You can easily construct queries that contain chemical substructure and similarity search terms combined with protein or bioassay-related queries.

Search with SPARQL »

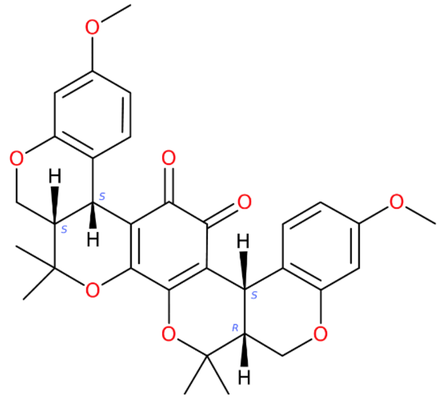


ChemWebRDF

PubChem RDF data exposed and searchable through an interoperable, semantic interface, using a custom high-performance SPARQL endpoint implementation. The service is still under development, but may already be used for processing many complicated queries.

ChemWebRDF app »

Ontologies in Biology | IDSM | Sachem GUI



Biological and Biomedical Ontology (*OBO*) Foundry
Community development of interoperable ontologies f
or the biological sciences

click on to open...

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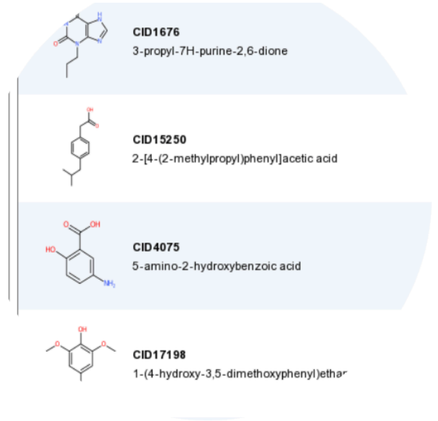
Search for compounds »

Ontologies in Biology | IDSM | Chem Web RDF



click on to open...

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Ontologies in Biology | IDSM | SPARQL GUI

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We provide an indexing service that allows FAIR-style search in published chemical data. You can easily construct queries that contain chemical substructure and similarity search terms combined with protein or bioassay-related queries.

Search with SPARQL »

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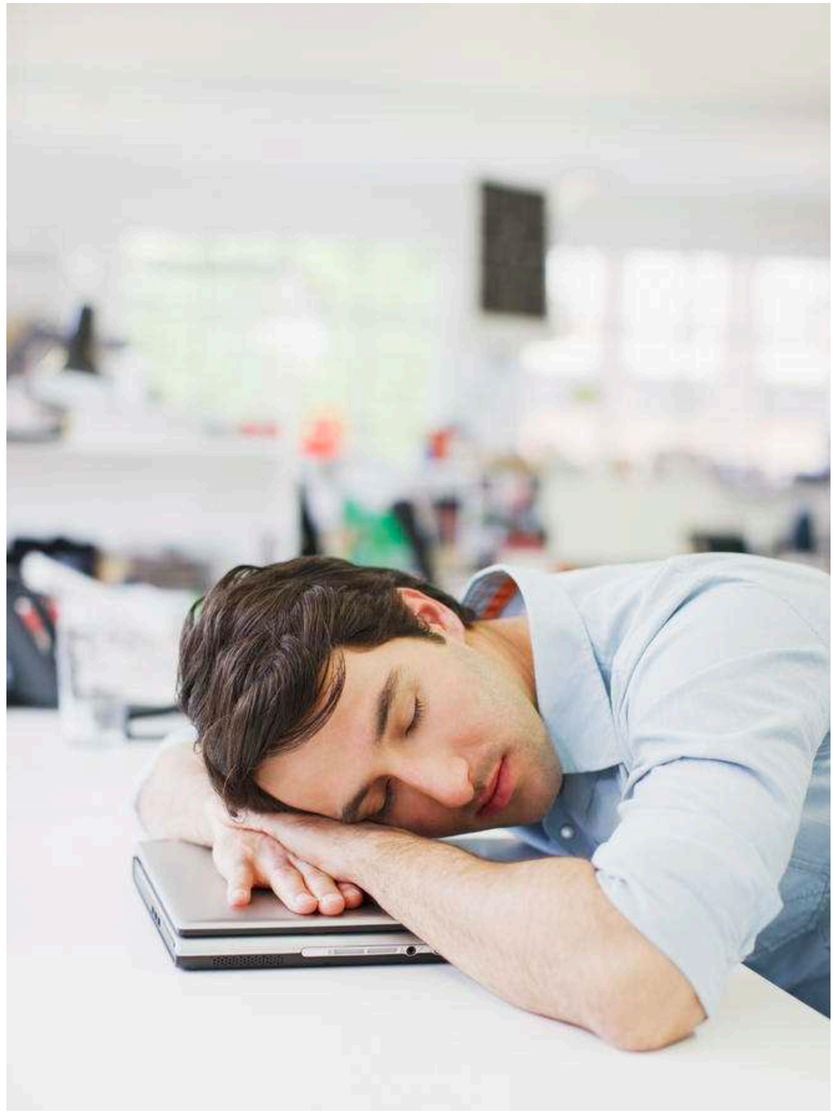
Epistemology, Ontology & Semantic Web

Epistemology is the research field revolving around knowledge and how to reach it. *Ontology* is what reality actually is. *Semantic Web* ameliorates the Web in such a way that it can be read directly by computers.

Questions ?



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