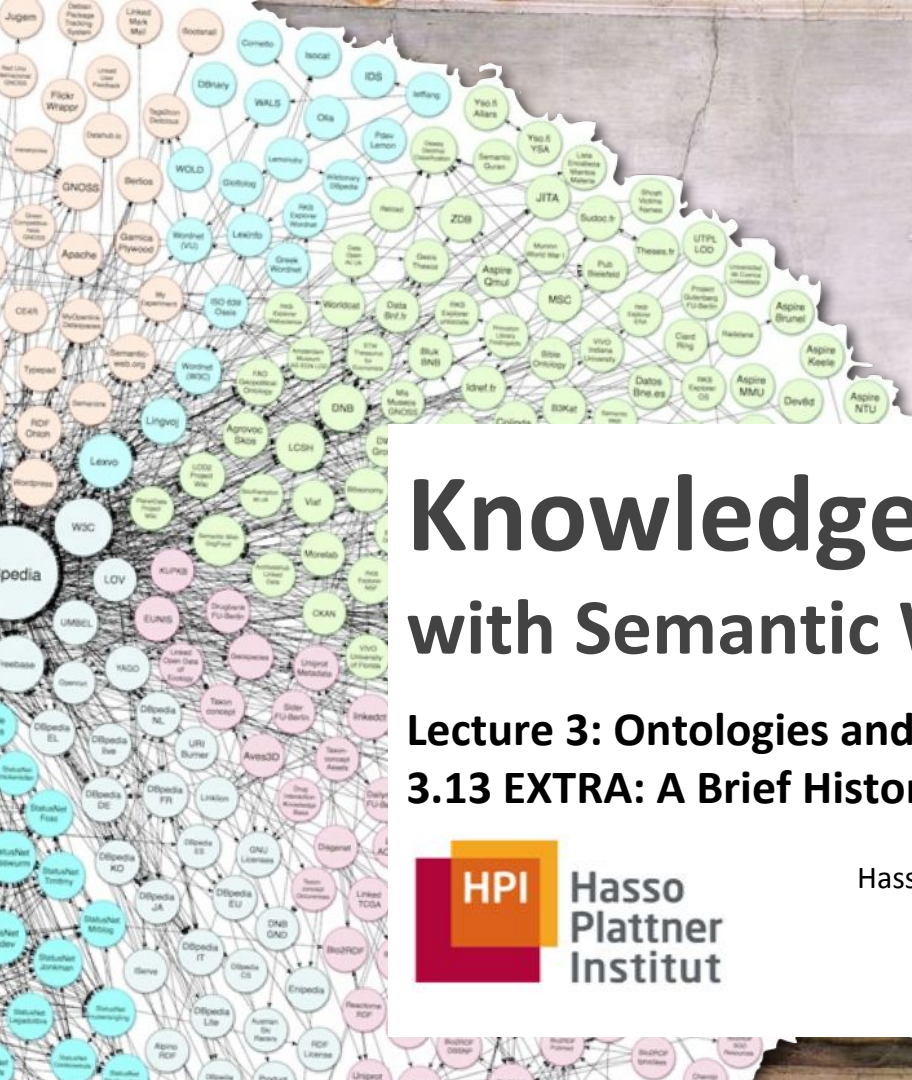




Knowledge Engineering with Semantic Web Technologies

Lecture 3: Ontologies and Logic

3.13 EXTRA: A Brief History of Ontology

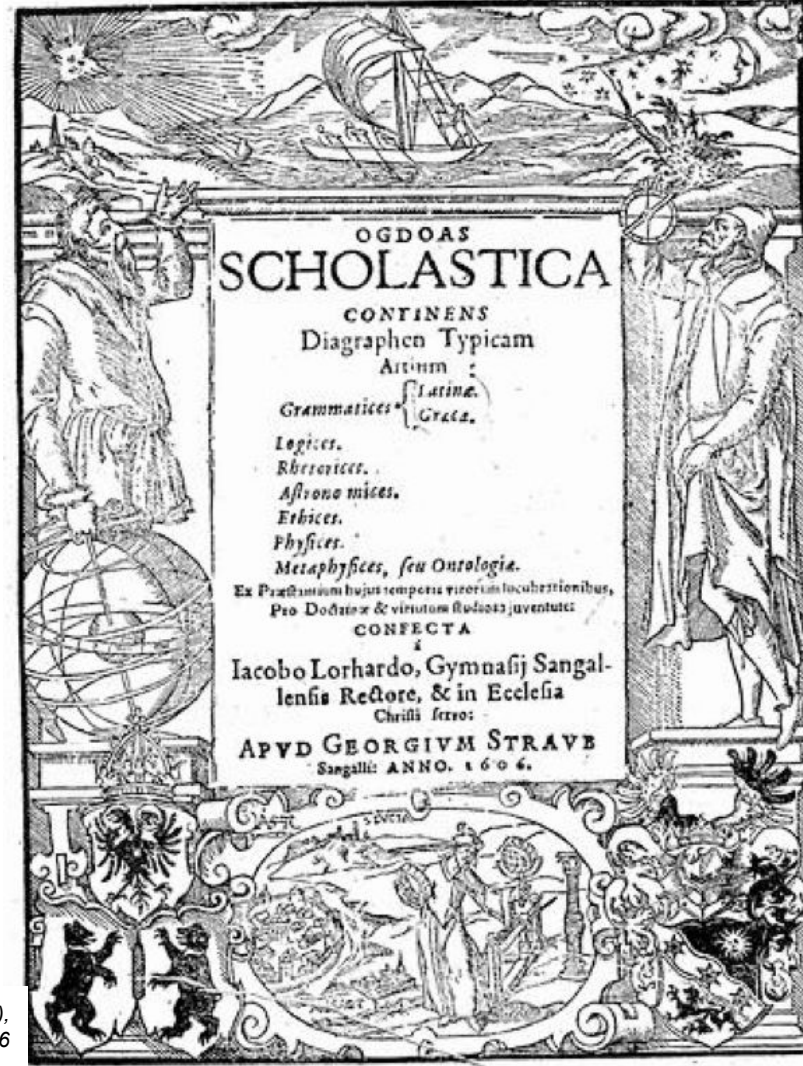


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Autumn 2015



What is Ontology?

- **Etymology:**
 - ον [greek] participle of „to be“
 - λογια [greek] science
- **(simplified) Definition:**
 - „philosophical study of the nature of being, existence, or reality, as well as the basic categories of being and their relations....“
(wikipedia)
- **General Question:**
 - „what does exist or can be said to exist?“
- General Metaphysics vs. Epistemology



Fundamental Questions of Ontology

1. What does it mean for a being to be?

- When are two things identical?
- Is everything that exists also real?
- Does something exist, if it is only possible?
- Are there non-existing things?

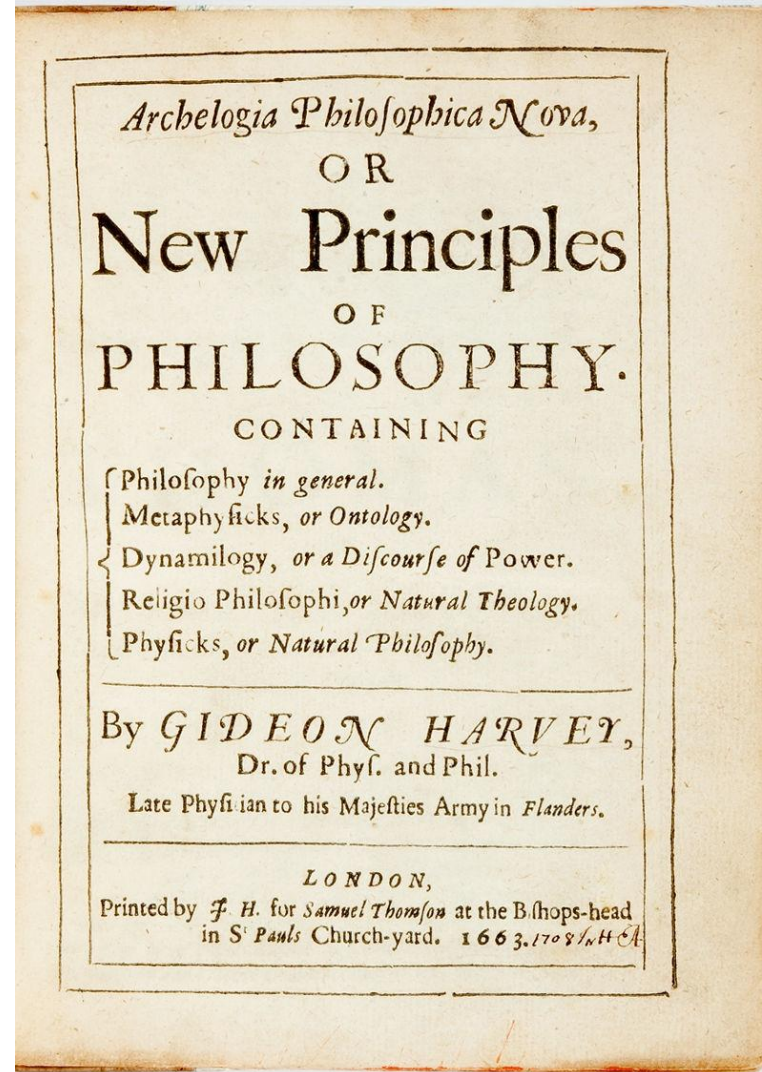
2. What categories of objects do exist?

- Do things exist that are only unique or only multiple (Universalia)?
- Do things exist that are unilaterally dependent of others (Substances)?
- Of which sort is this dependency (Causality)?
- Do necessary properties exist (Essences)?
- How do composed things relate to their components?



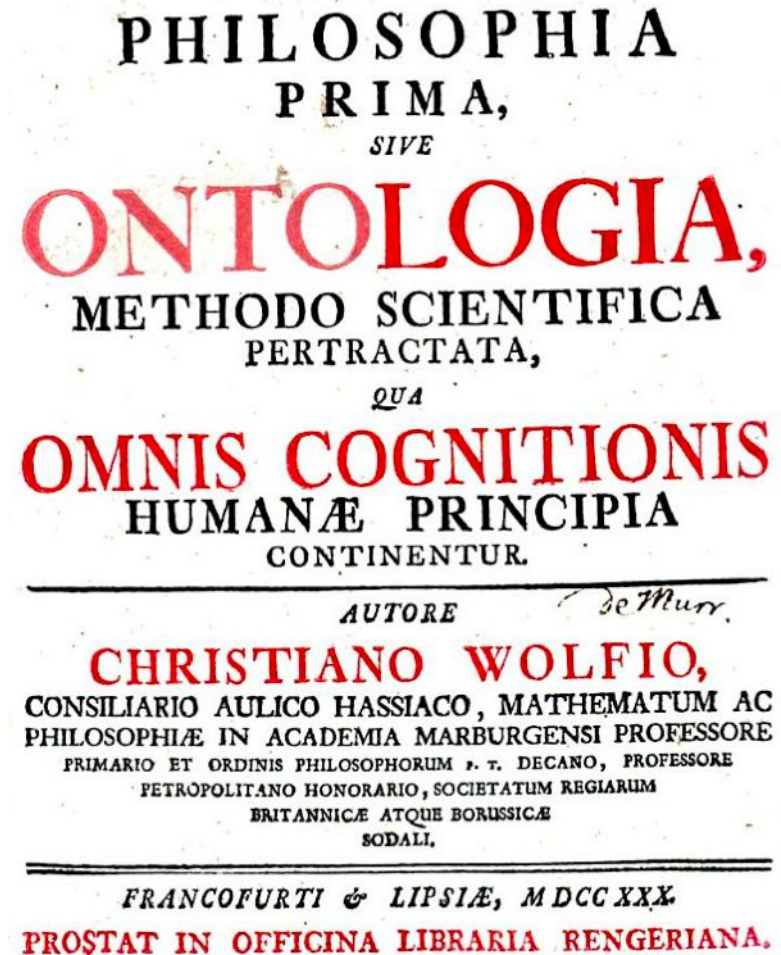
Etymology

- „Ontology“ first turned up in 1606 („*ontologia*“ in Latin) by **Jacob Lorhard** in his book „*Ogdoas Scholastica*“
- In German the term „*Ontologie*“ first turns up in 1613 in **Rudolf Göckel's** „*Lexicon philosophicum*“
- In English the term „*Ontology*“ first turns up 1663 in **Gideon Harvey's** „*Archelogia philosophica nova*“



Categorization of Ontology

- **Christian Wolff** categorizes the philosophical discipline '**ontology**' as being a part of **metaphysics**, in particular of general metaphysics (*metaphysica generalis*)
- Classical ontology deals with the relation of **being** and **existence**
 - cf. **ontological difference** according to Martin Heidegger
= separation of *categoriality* and *existentiality*



Ontology in Classical Greek Philosophy



Ontology in Classical Greek Philosophy

- **Parmenides** (6th-5th Century BC)
- Fundamental Question:
„What are the fundamental categories of existence?“
- ontological argument against nothingness, essentially denying the possible existence of a void

“For this view, that That Which Is Not exists, can never predominate. You must debar your thought from this way of search, nor let ordinary experience in its variety force you along this way, (namely, that of allowing) the eye, sightless as it is, and the ear, full of sound, and the tongue, to rule; but (you must) judge by means of the Reason (Logos) the much-contested proof which is expounded by me.”

(Parmenides, On Nature, The Way of Truth, B 7.1–8.2)



Parmenides
(ca. 535-470 BC)

Ontology in Classical Greek Philosophy

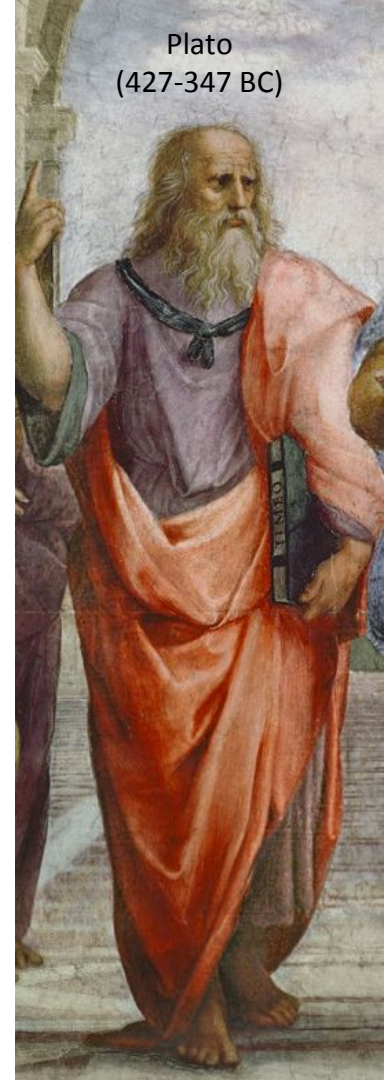
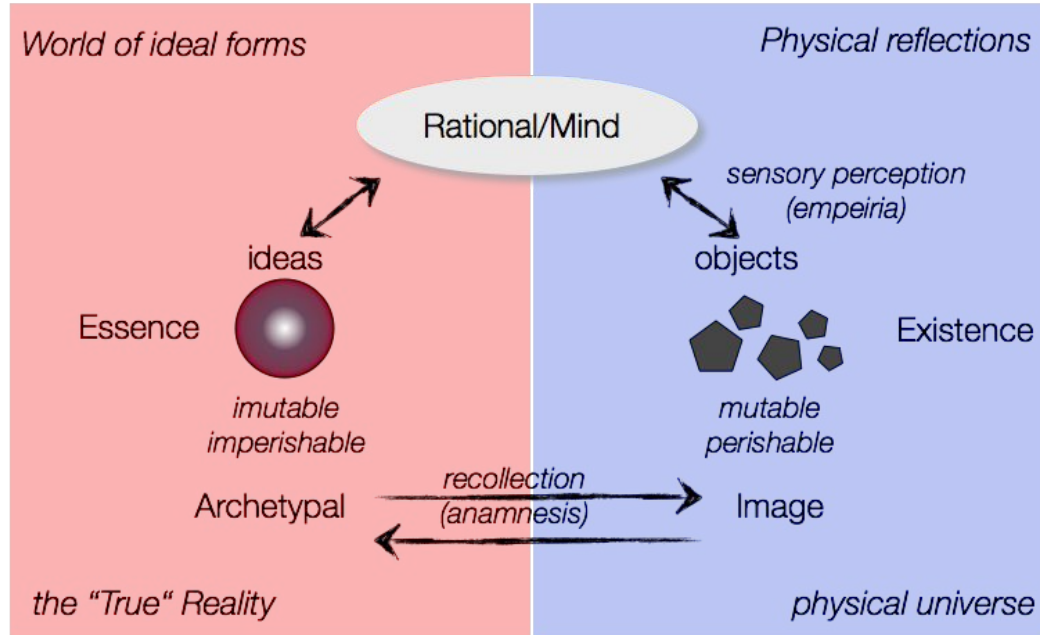
- **Socrates** (469-399 BC)
- **Socratic Question/Problem**
 - There are only secondary sources about Socrates available, esp. from his disciples Plato and Xenophon
 - It is not clear whether Plato refers only to Socrates' ideas in his 'Dialogues' or if he adds his own contributions
- **Socratic Method**
 - structured dialog (Maieutics)
 - to solve a problem,
break it down into a series of questions



Socrates
(469-399 BC)

Ontology in Classical Greek Philosophy

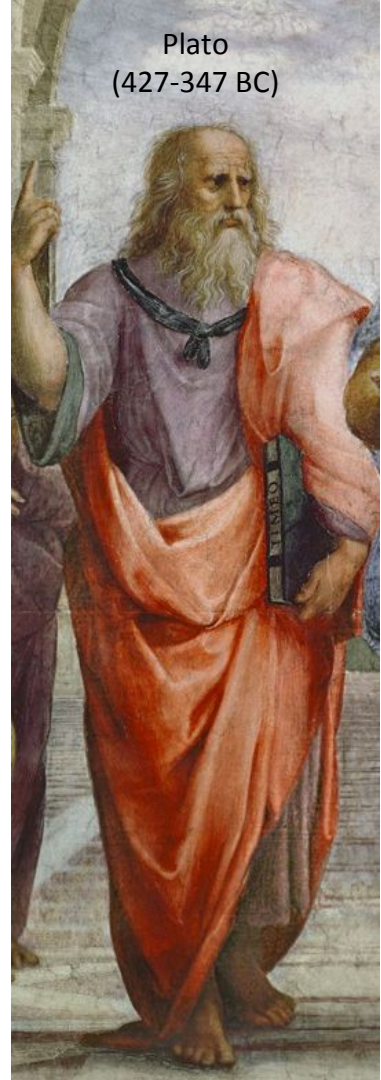
- **Plato (427-347 BC)**



Ontology in Classical Greek Philosophy

- **Plato** (427-347 BC)
- Division between
 - concept / class
(idea, ‚Noosphere‘, word of idea)
and
 - entity (instance)
(real world objects, merely „shadows“ of ideas)
- defines a hierarchy of ideas

Plato
(427-347 BC)



Ontology in Classical Greek Philosophy

- **Aristotle** (384-322 BC)
 - Metaphysics = first philosophy
 - Organon (ὄργανον) = logic as a tool(set) for science
 - **Categories** = general and exhaustive account of the things there are

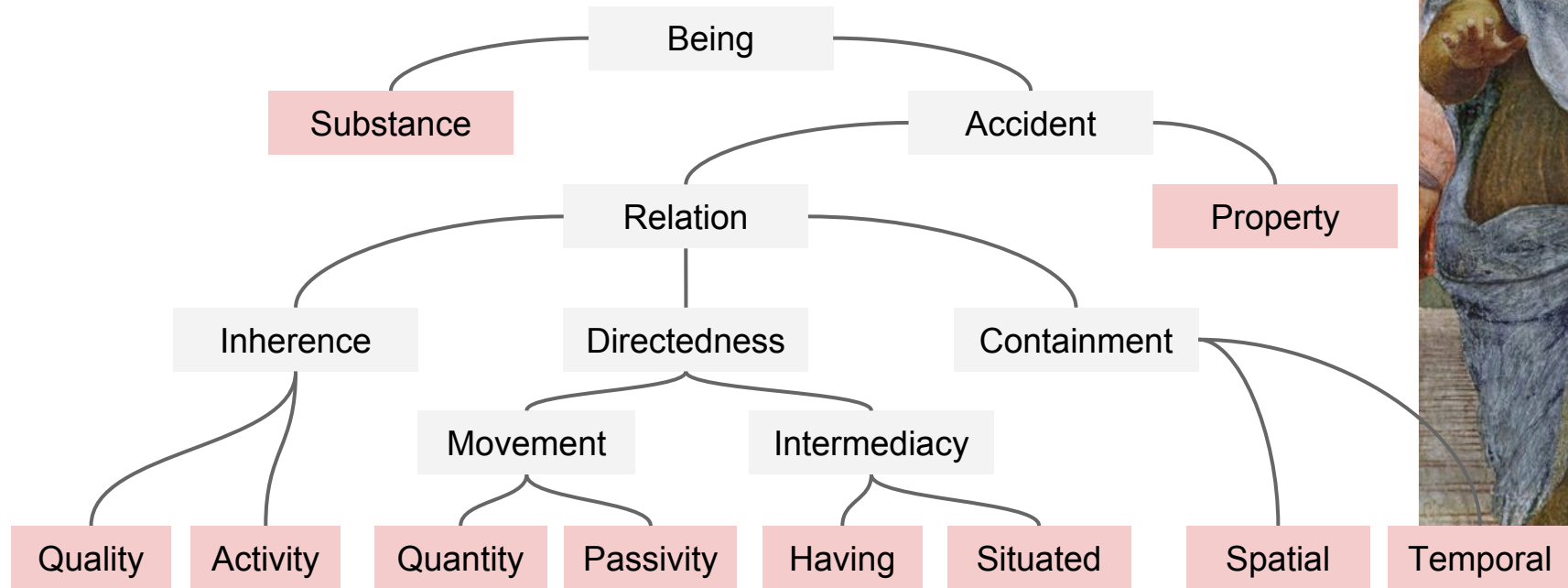
“Those things therefore which are in the voice, are symbols of the passions of the soul, and when written, are symbols of the (passions) in the voice, and as there are not the same letters among all men, so neither have all the same voices, yet those passions of the soul, of which these are primarily the signs, are the same among all, the things also, of which these are the similitudes, are the same. “

Aristotle, De Interpretatione, I. 16



Aristotle's Categories

- Aristotle defines a system of **general categories** for classification of all things about which statements can be made



Aristotle
(384-322 BC)



Aristotle's categories as arranged by Franz Brentano

Johng F. Sowa, Applications of Ontology, <http://www.jfsowa.com/talks/ontology.htm>

Aristotle's Categories

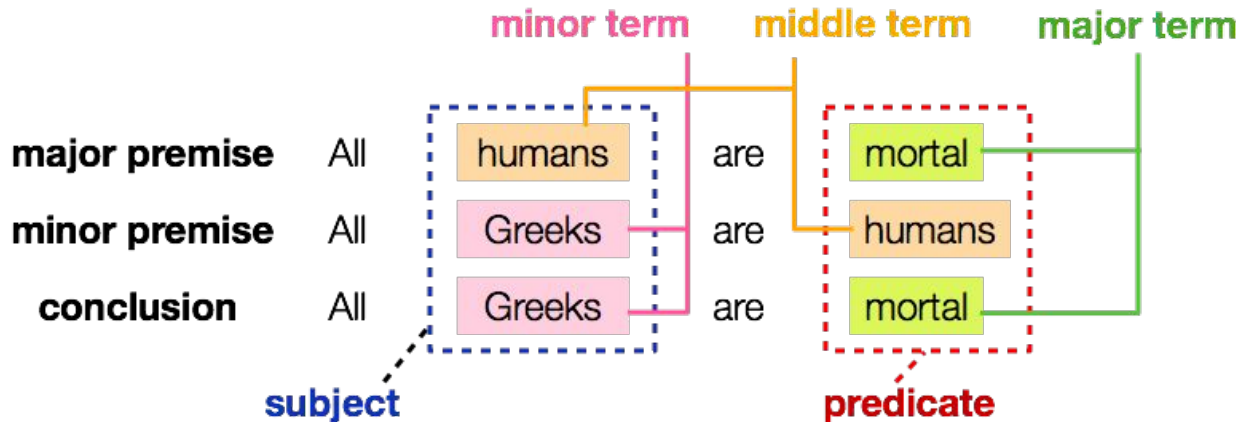
Substance	examples of primary substance and secondary substance (species, genera)	this man, this horse man, horse
Quantity	how much? discrete or continuous	two meters long, three pieces
Quality	of what kind or description	black, white, hot, sweet
Relation	toward something	double, half, larger
Place	where?	in the marketplace, at home
Time	when?	yesterday, last year, now
Position	posture, attitude	sitting, lying, standing
State	condition, to have or to be	armed, shod
Action	to make or to do	to lance, to heat, to cool
Affection	passion, to suffer or to undergo	to be lanced, to be heated, to be cooled

Aristotle
(384-322 BC)



Aristotle's Syllogisms

- συλ-λογισμός [griech.] *add up, gather, logical conclusion*
- Core of Aristotelian logic
- (*Organon*, **Prior Analytics**)
- Set of Inference rules (deductions), all built according to the same pattern



Aristotle
(384-322 BC)



Aristotle's Categories Revisited

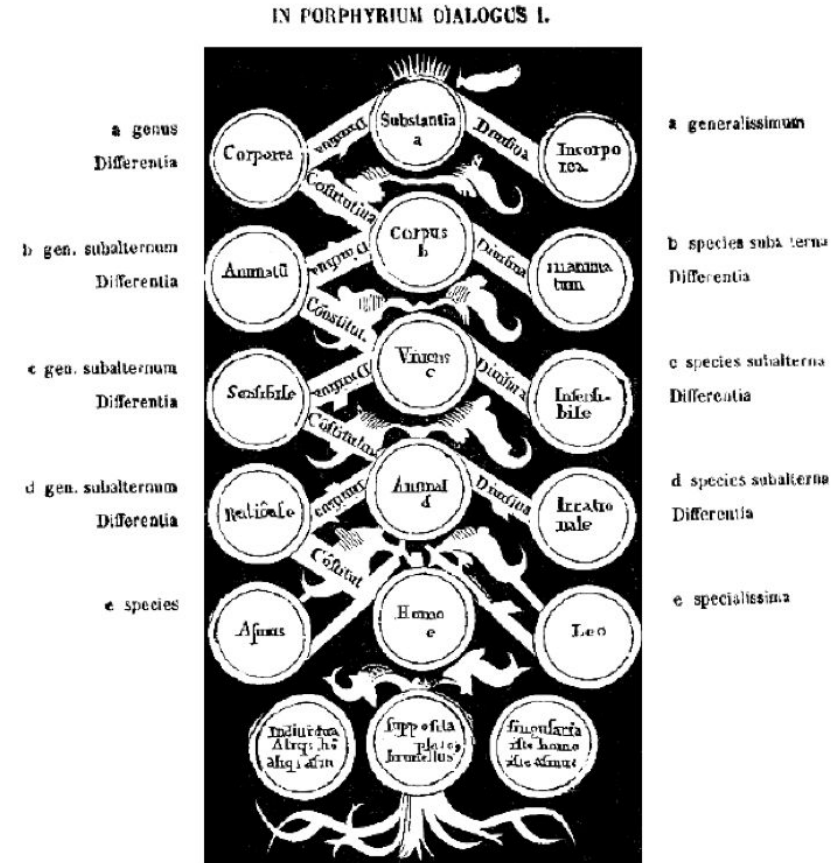
- **Porphyry of Tyros** (234-301/5 AD)
explains in his textbook „*Isagoge*“ the Aristotelian categories for beginners
- he extends Aristotelian categories by breaking down the philosophical concept of *substance* into the five components *genus, species, difference, property, accident*



Porphyry of Tyros
(234-301/305 AD)

Aristotle's Categories Revisited

- In the Middle Ages the so-called „**arbor porphyriana**“
(*Tree of Porphyry* or *Tree of Knowledge*)
is created as visualization of the
Aristotelian categories



Ontology in the Middle Ages

- **Medieval Scholasticism (12th-14th century)**

- Anselm of Canterbury (*“credo ut intellegam”*)
- Thomas Aquinas (On Being and Essence)
- William of Ockham

- **Problem of Universals:**

Do Universals (Ideas) possess an ontological (real) existency?

- Realism *„Universals are real!”*

vs

- Nominalism *„Universals are nothing but words and symbols!”*



Anselm of Canterbury
(1033-1109)

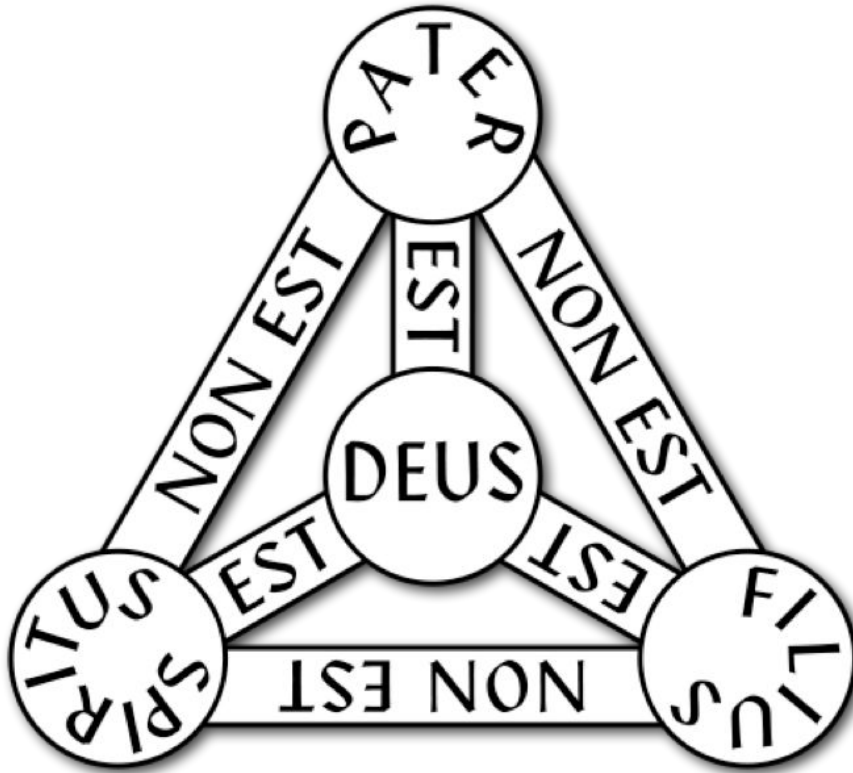


Thomas Aquinas
(1225-1274)



William of Ockham
(1288-1349)

Ontology in the Middle Ages



- Christian doctrine of trinity as example for a medieval ontology

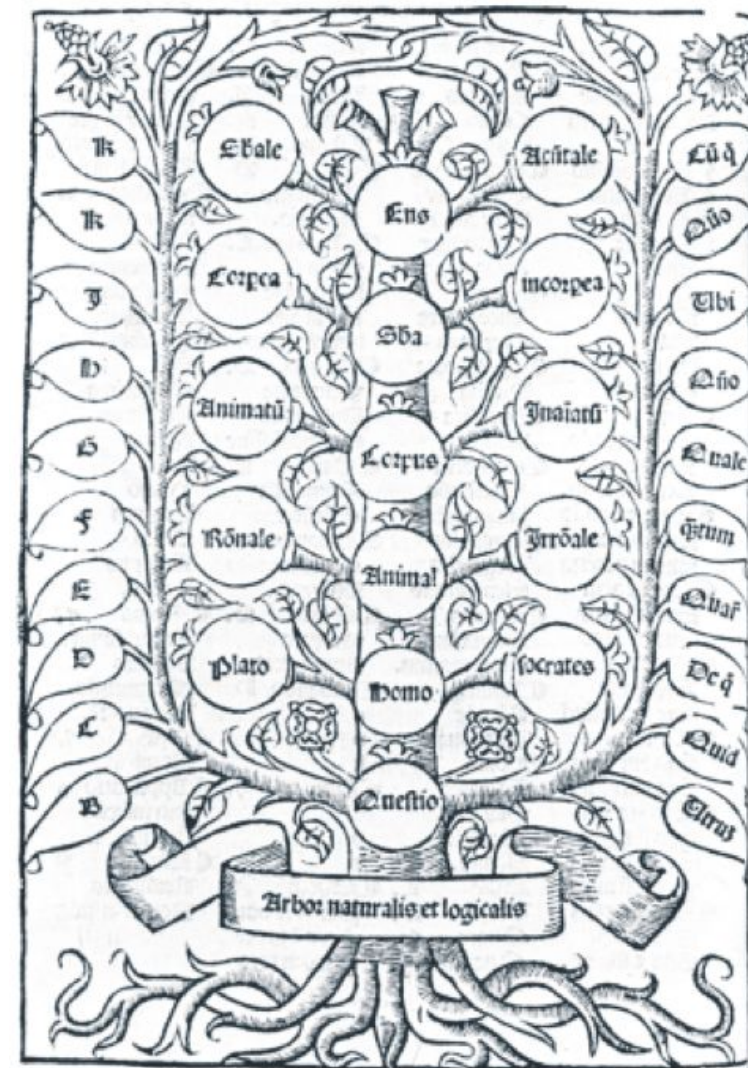
Ontology in the Middle Ages

- **Ramon Lull** (1232-1316)
applies ontology in the sense of the Aristotelian system of categories within his „*Tree of Nature and Logic*“ as first predecessor of a logical machine
- **Logic** according to Ramon Lull is „*the art and the science to distinguish between truth or lie with the help of reason, to accept truth and to reject lie.*“



Ramon Lull
(Raimundus Lullus)
(1232-1316)

Arbor naturalis et logicalis, aus „Ars Magna“, um 1275



Ontology and Enlightenment

- **John Wilkins** (1614-1672)
finds out, that the inaccuracy of natural language impedes scientific progress
- He developed the idea of a **universal philosophical language** with the goal to represent the entire knowledge of the universe.

AN ESSAY
Towards a
REAL CHARACTER,
And a
PHILOSOPHICAL
LANGUAGE.

By JOHN WILKINS D.D. *Dean of RIFON,
And Fellow of the ROTAL SOCIETT.*



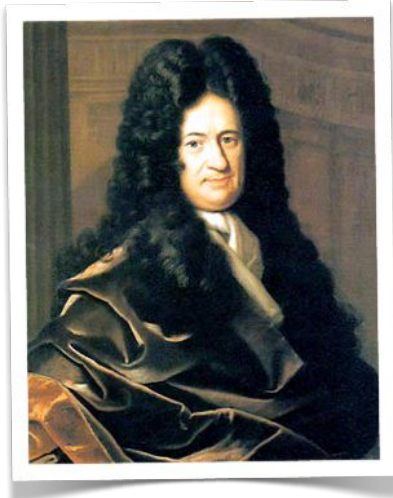
LONDON,
Printed for SA: GELLIBRAND, and for
JOHN MARTIN Printer to the ROTAL
SOCIETT, 1668.

Ontology and Enlightenment

- **Gottfried Wilhelm Leibniz (1646-1716)**
develops the idea of „characteristic numbers“
as a model for Aristotelian Logic, in the hope to
solve logical problems with the help of a
calculus.

“It is obvious that if we could find characters or signs suited for expressing all our thoughts as clearly and as exactly as arithmetic expresses numbers or geometry expresses lines, we could do in all matters insofar as they are subject to reasoning all that we can do in arithmetic and geometry. For all investigations which depend on reasoning would be carried out by transposing these characters and by a species of calculus.”

Leibniz, Preface to the General Science, 1677



Gottfried Wilhelm Leibniz
(1646 – 1716)

Ontology and Enlightenment

- **Immanuel Kant** turns himself towards Epistemology (Kritik an der „reinen Vernunft“)
- Fundamental Question:
„How can our mind perceive the world?“

*“In his **Critique of Pure Reason**, Kant arrives at his list of categories by first enumerating the forms of possible judgment. On this view, objective empirical judgments are endowed with their objectivity and generality in virtue of the a priori concepts embodied in the relevant forms of judgment. If we can identify all of the possible forms of objective empirical judgment, we can then hope to use them as the basis to discover all of the most general concepts or categories that are employed in making such judgments, and thus that are employed in any cognition of objects.”*

Körner 1955, 48–49



Immanuel Kant
(1724-1804)

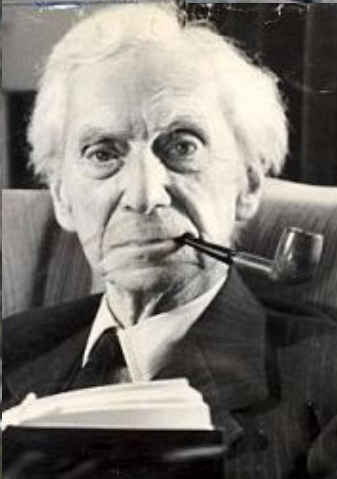
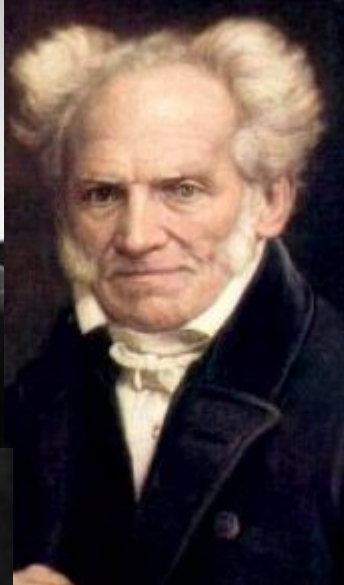
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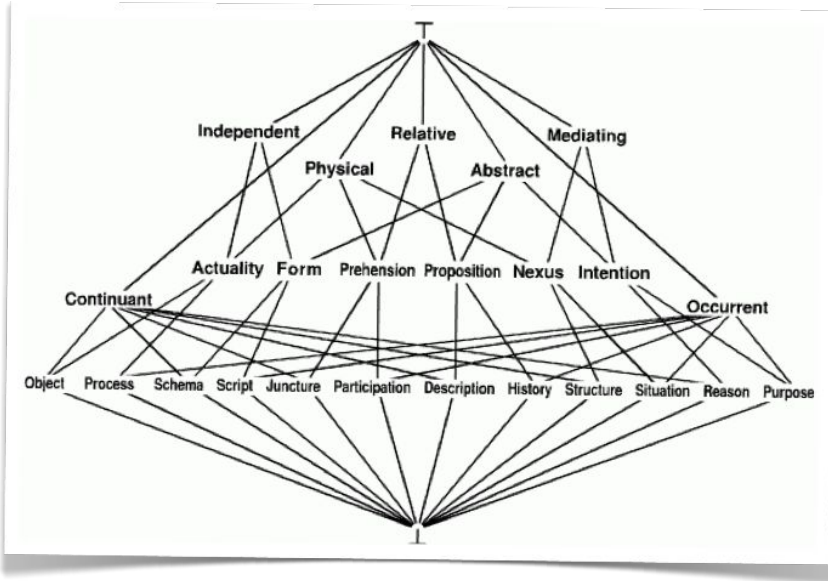
Quantity	Quality	Relation	Modality
Unity	Reality	Substance & Accident	Possibility
Plurality	Negation	Cause & Effect	Existence
Totality	Limitation	Reciprocity	Necessity



Immanuel Kant
(1724-1804)



KR Ontology

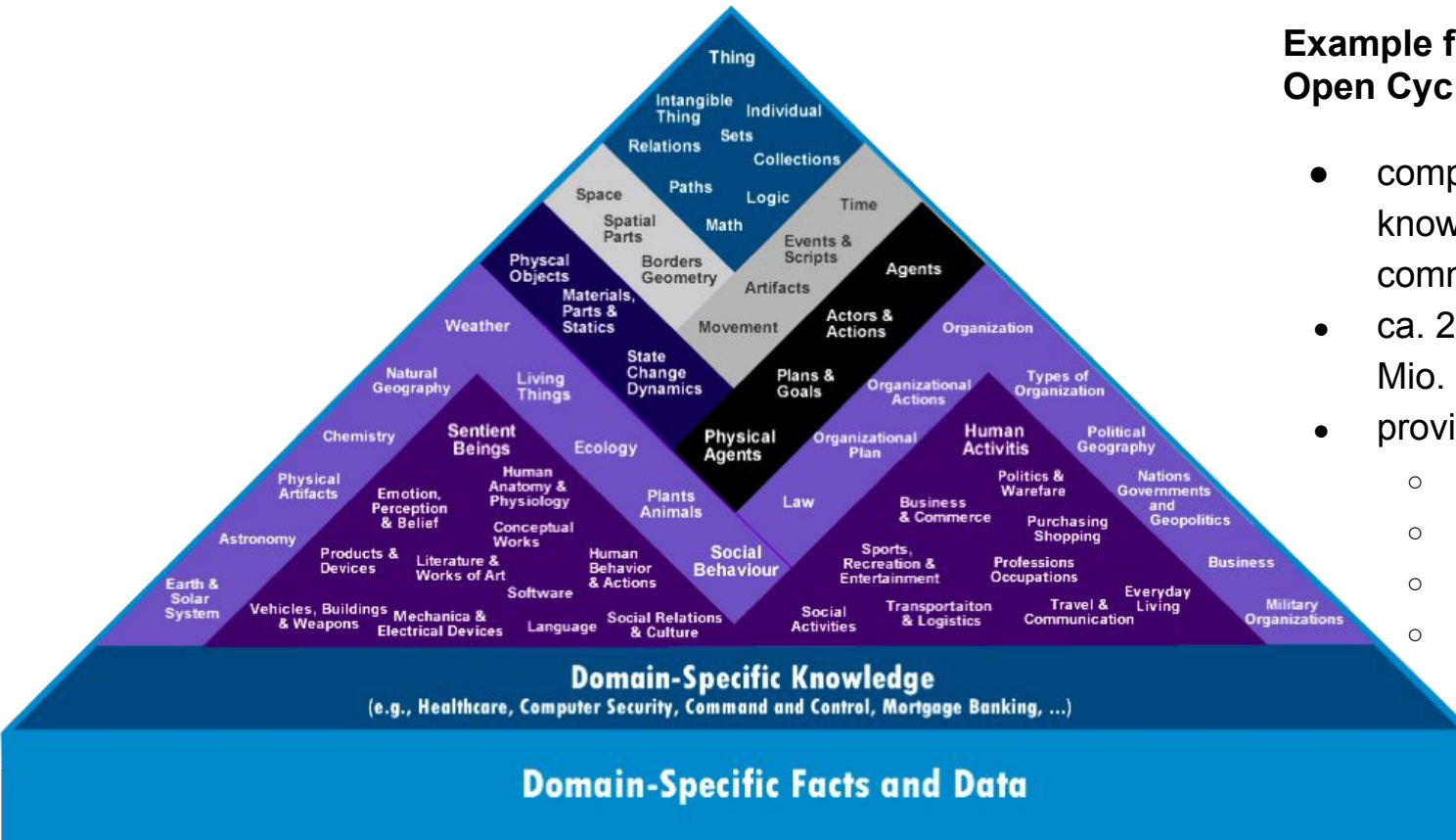


<http://www.jfsowa.com/ontology/kronto.htm>

Example for a Top-Level Ontology: KR Ontology (John F. Sowa)

- based on Alfred North Whithead's **process philosophy** and Charles Sanders Peirce's **semiotic**
- provides a foundation for a systematic characterization of the universe and its expression in human language
- contains 27 concepts
- organized as lattice

Open Cyc



Example for a Knowledge Base: Open Cyc (Douglass Lenat, 1984)

- comprehensive ontology and knowledge base of everyday common sense knowledge
- ca. 240,000 entities and 2 Mio. axioms
- provides links to
 - DBpedia
 - FOAF
 - WordNet
 - and many more

<http://www.opencyc.org/>

DBpedia Ontology

DBpedia Ontology

- shallow, manually created cross-domain ontology
- based on most commonly used infoboxes within Wikipedia
- 685 classes and 2,795 properties
- category system for 4,233,000 DBpedia instances

<http://wiki.dbpedia.org/services-resources/ontology>



OpenHPI - Course Knowledge Engineering with Semantic Web Technologies
Lecture 4: OWL, Rules, and Reasoning