

# Knowledge Graphs

## Lecture 4 - Knowledge Representation with Ontologies

### 4.1 A Brief History of Ontologies

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# Knowledge Graphs

## Lecture 4: Knowledge Representation with Ontologies

### 4.1 A Brief History of Ontologies

### 4.2 Why we do need Logic

### Excursion 4: A Brief Recap of Essential Logics

### Excursion 5: Description Logics

### 4.3 First Steps in OWL

### 4.4 More OWL

### 4.5 OWL and beyond

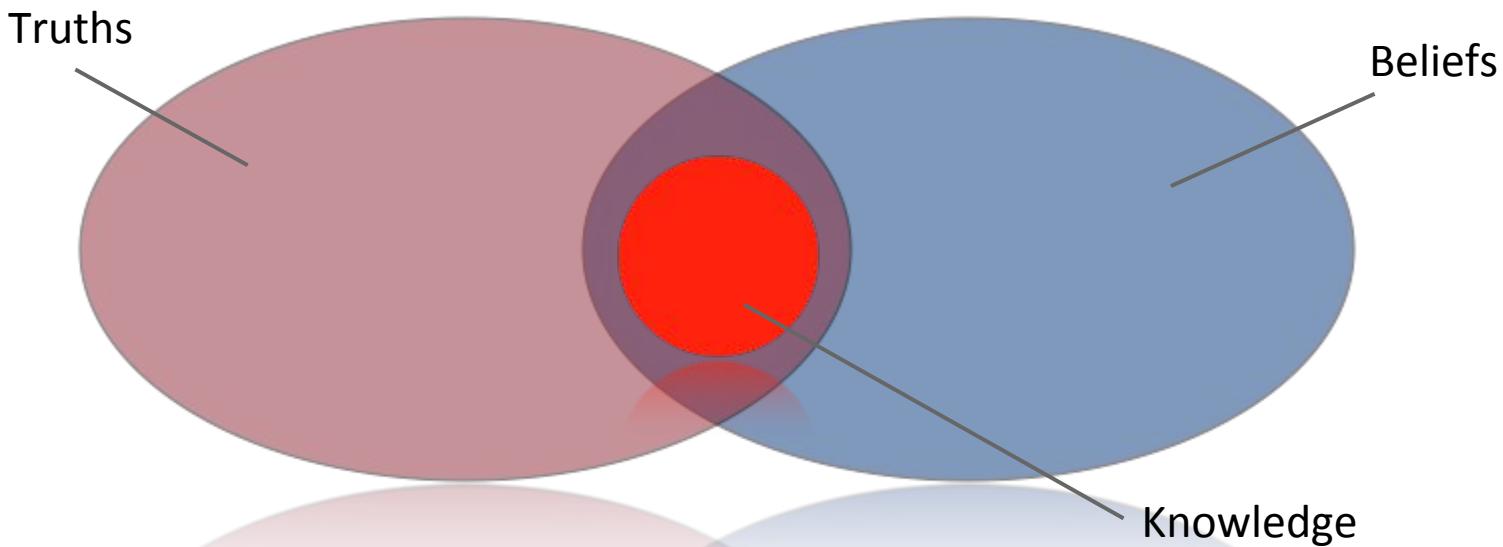
### 4.6 How to Design your own Ontology



„People can't share knowledge if they don't speak a common language“

Thomas Davenport (1997)

# What is Knowledge?

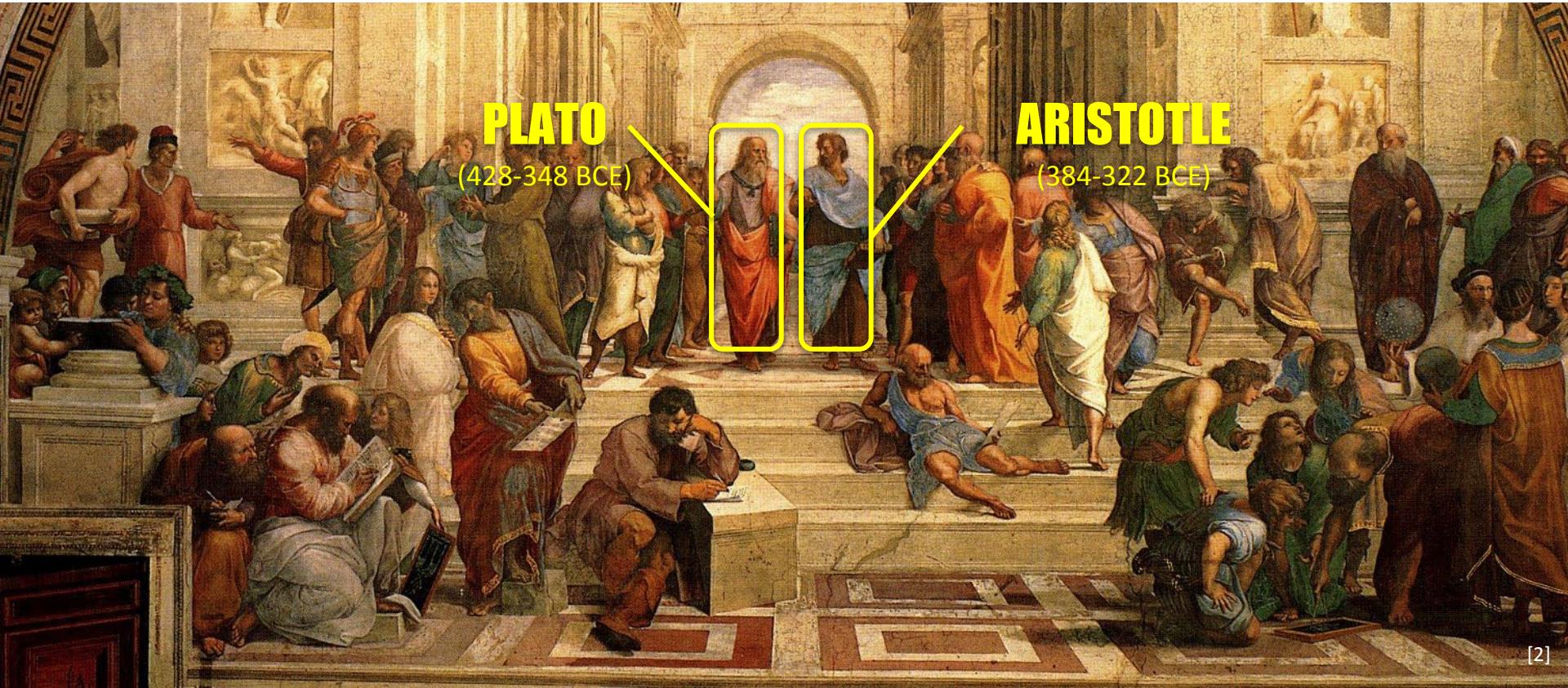


Traditional Definition: „Knowledge is a subset of all true beliefs.“

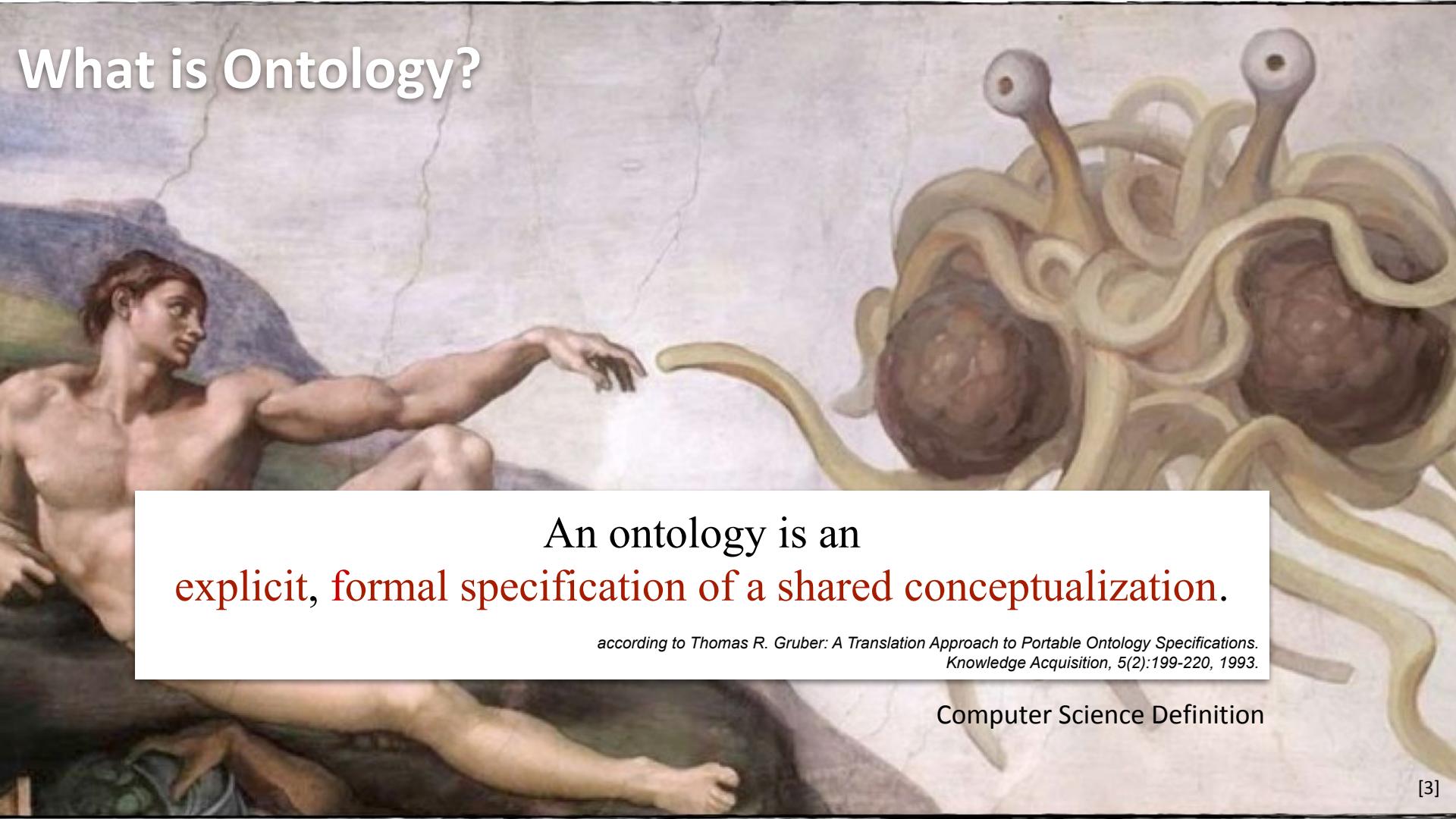
## ...to speak a common Language:

- common symbols and concepts (**Syntax**)
- agreement about their meaning (**Semantics**)
- classification of concepts (**Taxonomy**)
- associations and relations of concepts (**Thesauri**)
- rules and knowledge about which relations are allowed and make sense (**Ontologies**)

**ONTOLOGY** is the philosophical study of the nature of being, existence, or reality, as well as the basic categories of being and their relations...



# What is Ontology?

A reproduction of Michelangelo's 'The Creation of Adam' fresco from the Sistine Chapel. It depicts the moment when God, represented by a large, muscular male figure on the left, reaches out his right hand towards the finger of Adam, a smaller male figure on the right. The background is a light-colored stone wall with visible cracks.

An ontology is an  
explicit, formal specification of a shared conceptualization.

*according to Thomas R. Gruber: A Translation Approach to Portable Ontology Specifications.  
Knowledge Acquisition, 5(2):199-220, 1993.*

Computer Science Definition

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- |                           |   |
|---------------------------|---|
| <b>conceptualization:</b> | abstract model<br>(domain, identified relevant concepts, relations) |
| <b>explicit:</b>          | meaning of all concepts must be defined                             |
| <b>formal:</b>            | machine understandable  |
| <b>shared:</b>            | consensus about ontology  |

# How to Represent Ontologies

- Ontologies can be represented via **Classes, Relations and Instances**
- **Classes** are abstract groups, sets, or collections of objects and represent **ontology concepts**
- Classes are characterised via **attributes**
- **Attributes** are name-value pairs

**„Carbon dioxide** is a colorless gas with a density about 60% higher than that of dry air. Carbon dioxide consists of a carbon atom covalently double bonded to two oxygen atoms.“

informal description

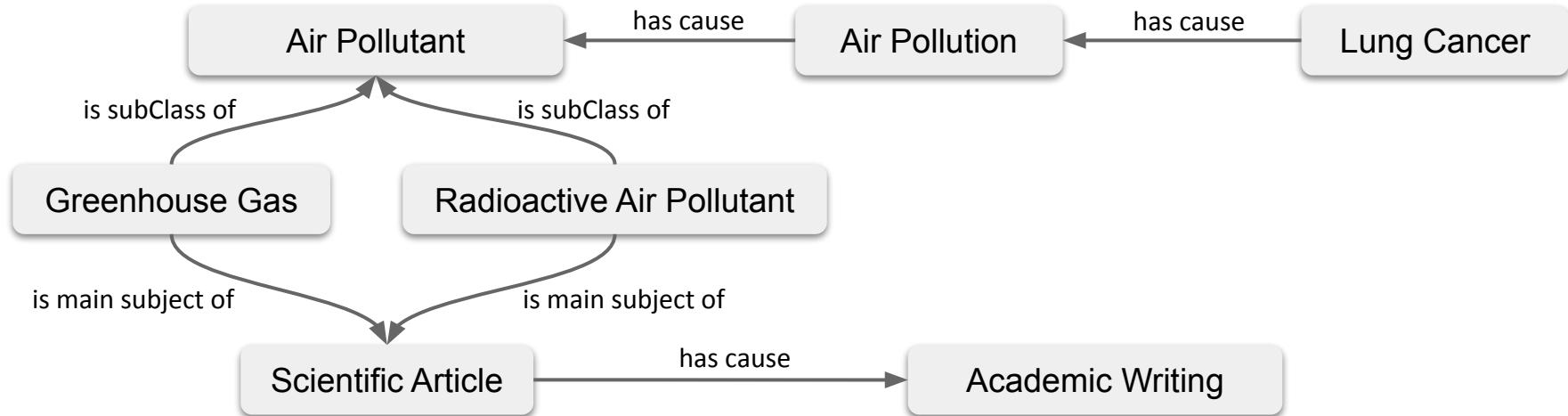
## **Carbon dioxide**

- *name <string>*
- *chemical formula <string>*
- *mass <float>*
- *density <float>*
- *sublimation temperature <string>*
- ...

semi-formal description

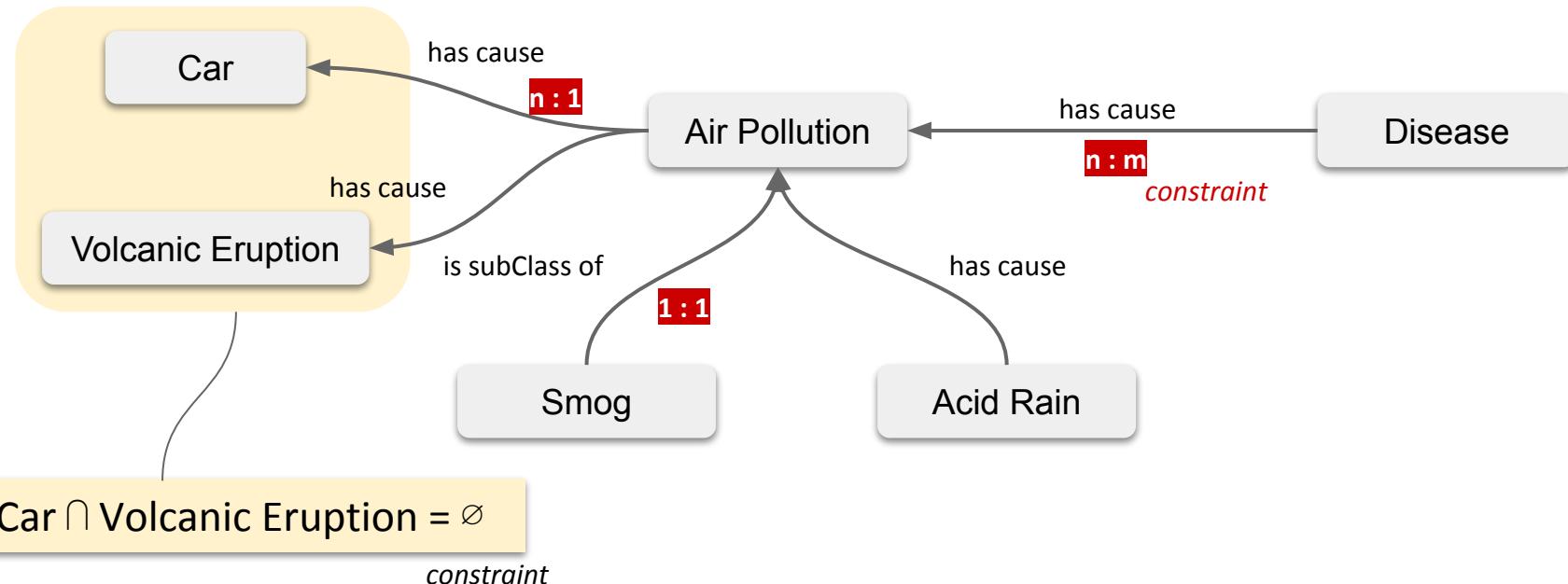
# How to Represent Ontologies

- Classes can be **related** to other classes
- **Relations** are special attributes, whose values are objects of (other) classes



# How to Represent Ontologies

- For Relations and Attributes **Rules (Constraints)** can be defined that determine allowed/valid values



*constraint*

# How to Represent Ontologies

- Classes, relations, and constraints can be combined to form (complex) **Statements / Assertions**
- Special Case: **formal Axioms**

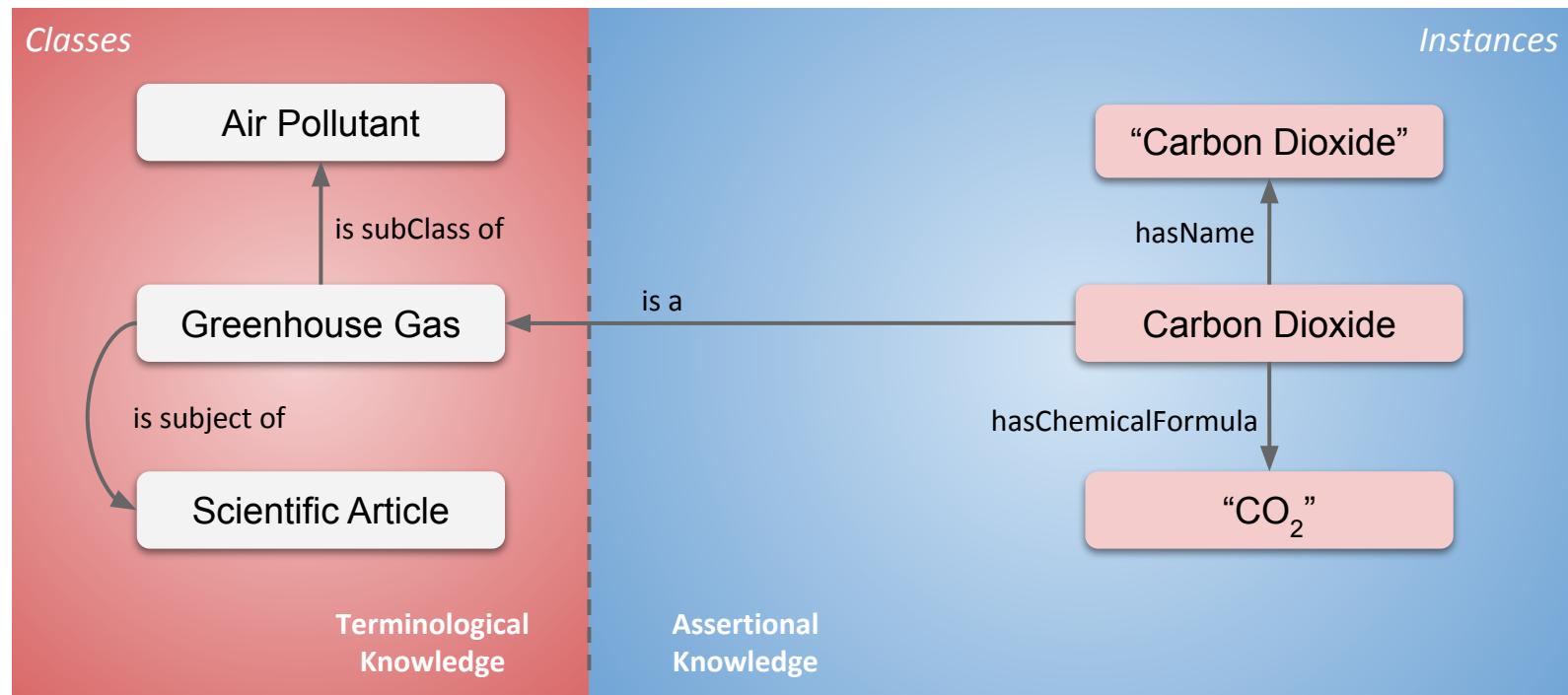
Example:

- „*It is not possible to disprove climate change*“

- **Axioms** describe knowledge that cannot be expressed simply with the help of other existing components.

# How to Represent Ontologies

- Instances describe individuals of an ontology





Why we do need Logic

### Picture References:

- [1] Pieter Bruegel the Elder, The Tower of Babel (1563)  
[https://commons.wikimedia.org/wiki/File:Pieter\\_Bruegel\\_the\\_Elder\\_-\\_The\\_Tower\\_of\\_Babel\\_\(Vienna\)\\_-\\_Google\\_Art\\_Project.jpg](https://commons.wikimedia.org/wiki/File:Pieter_Bruegel_the_Elder_-_The_Tower_of_Babel_(Vienna)_-_Google_Art_Project.jpg)
- [2] Raphael, School of Athens, 1511, [Public Domain]  
[https://commons.wikimedia.org/wiki/File:%22The\\_School\\_of\\_Athens%22\\_by\\_Raffaello\\_Sanzio\\_da\\_Urbino.jpg](https://commons.wikimedia.org/wiki/File:%22The_School_of_Athens%22_by_Raffaello_Sanzio_da_Urbino.jpg)
- [3] Niklas Jansson, Touched by His Noodly Appendage, the parody of Michelangelo's Creation of Adam has become an iconic image of the Flying Spaghetti Monster. 2015, [Public Domain]  
[https://commons.wikimedia.org/wiki/File:Touched\\_by\\_His\\_Noodly\\_Appendage\\_HD.jpg](https://commons.wikimedia.org/wiki/File:Touched_by_His_Noodly_Appendage_HD.jpg)
- [4] Melancholia I, Albrecht Dürer, 1511 [Public Domain]  
[https://commons.wikimedia.org/wiki/File:Albrecht\\_D%C3%9CRer\\_-\\_Melencolia\\_I\\_-\\_Google\\_Art\\_Project.jpg](https://commons.wikimedia.org/wiki/File:Albrecht_D%C3%9CRer_-_Melencolia_I_-_Google_Art_Project.jpg)