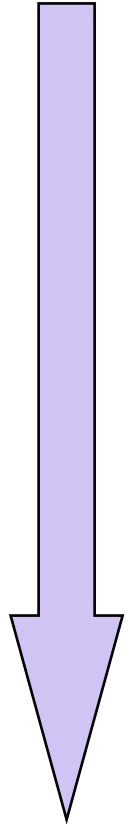


Logic and Ontology

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Presentation Outline

- What is Ontology? What are ontological categories?
- Ontological schemes through categorical analysis
- Logic and Ontology: Any Connection? Overlapping concerns?
- Formal Ontologies and Logic



Many Ways to Approach 'What is Logic?'

- Study of certain mathematical properties of artificial, languages, formal systems: predicate calculus
- Study of formal validity of inferences (valid by virtue of 'logical form') or of '**Logical consequence**': proofs and models
- Study of logical truths
- Study of the structure or the **most general forms of our thoughts** (Kantian Idea): subject-predicate structure in our judgments

Two Ways to look at Logic: Tradition

- **Aristotle**, early dialectical *logoi* of the *Topics* : Art of thought, closely connected to natural language and grammar
- **Aristotle**, later Syllogistic Logic of *Prior Analytics*: Closer to an abstract calculus, dissociated from Dialectics

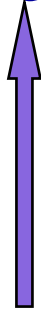
Two Approaches to Logic

- Logic as a calculus Connection to ontology is thin
- Logic as a language: Interesting links between logic and ontology
 - Lingua philosophica, lingua universalis underlying all natural languages : Descartes, Leibniz, Frege

Cocchiarella, 2001..

But What is Ontology?

- Traditionally, Ontology is a *metaphysical scheme about the world*



What is metaphysics?

Metaphysics

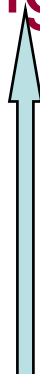
- Metaphysics :
- Aristotle's conception: metaphysics has dual character¹
- (a) As the study that seeks knowledge of 'first causes' (e.g. the Unmoved Mover)

A narrower study on basic causes, e.g, God

¹ M J Loux


Metaphysics

- (b) Metaphysics is the study of being *qua* being



Existents,
existing things

The diagram shows a light blue rectangular box containing the text 'Existents, existing things'. A light blue arrow points vertically upwards from the top center of this box towards the word 'being' in the bullet point above.



Entity, thing,
item in the world

The diagram shows a light blue rectangular box containing the text 'Entity, thing, item in the world'. A light blue arrow points vertically upwards from the top center of this box towards the word 'being' in the bullet point above.

Study of things (their properties or features) *in so far* as they are existents: a special perspective on things

Metaphysics

- It is (b) that is more general and comprehensive: Metaphysics is the study of *being qua being*

Study of Table qua being?



A thing / object

What properties/features does it exhibit just as an existent? In terms of them, what would be its most general, yet fundamental, categorical description?

Metaphysics and Ontology

- **Metaphysics:** Coming up with a theory or a description of the world in terms of a list of most basic 'kinds'

Metaphysics and Ontology

- Metaphysics is that branch of study which tries to come up with the most general description of the reality / world in terms of 'ontological categories'
 - Some aim further for the minimalist description (sparseness, **Occam's Razor**)



Entities are not to be multiplied without necessity

Ontology

- **Ontology (traditional conception):** The study of common properties of all entities, and representation of that analysis in terms of a list of **basic kinds or categories**
- Its method is categorical analysis or categorization

Categorization

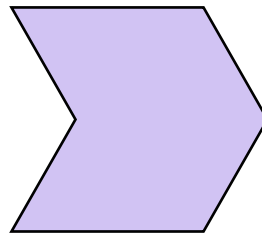
- Carving up of reality in our thoughts, speeches, experiences in terms of kinds of things : a common human cognitive act
- Examples: people, chairs, trees, colors
- As a part of a cognitive act, we routinely employ categories





Not all Categories are Ontological Categories

- Spoons and forks
- Running and laughing



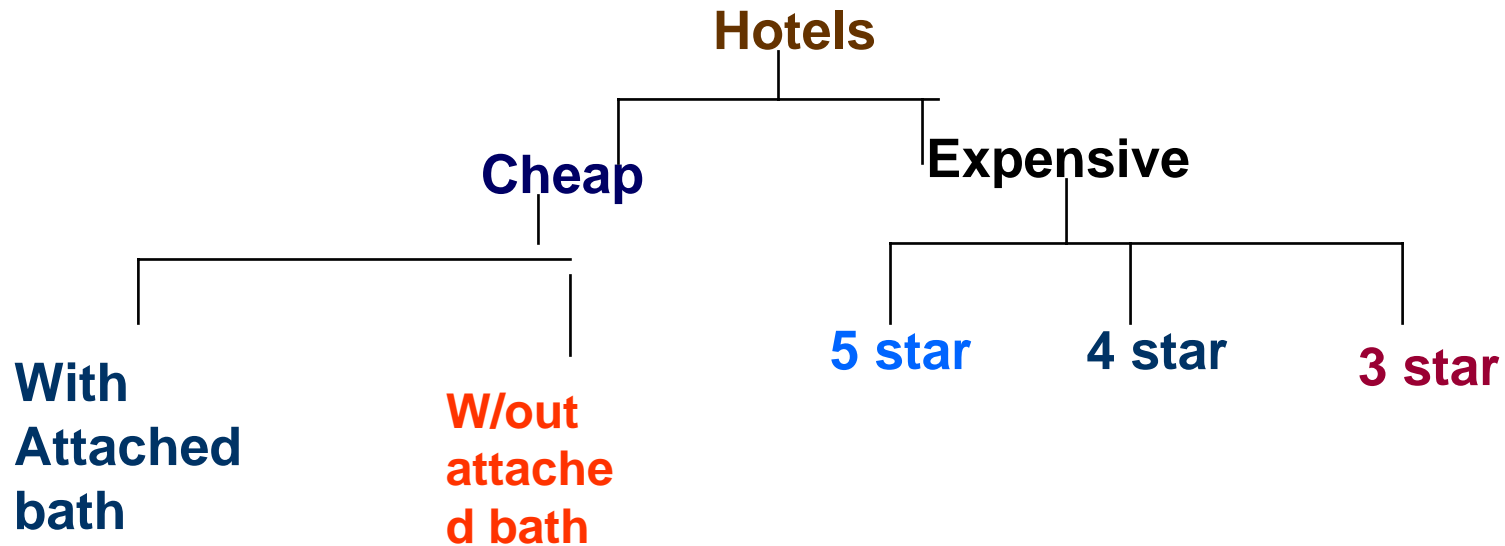
Are categories but
are NOT ontological
categories

Ontological Categories and Ontology

- Ontological Categories are supposed to be very general, basic in nature,
- Ontologies are windows made out of these categories through which we view reality
- Ontologies are supposed to be a list or map or catalogue of hierarchy (may be related in terms of class inclusion) ¹ or a taxonomy of real things

1 Westerhoff 2004

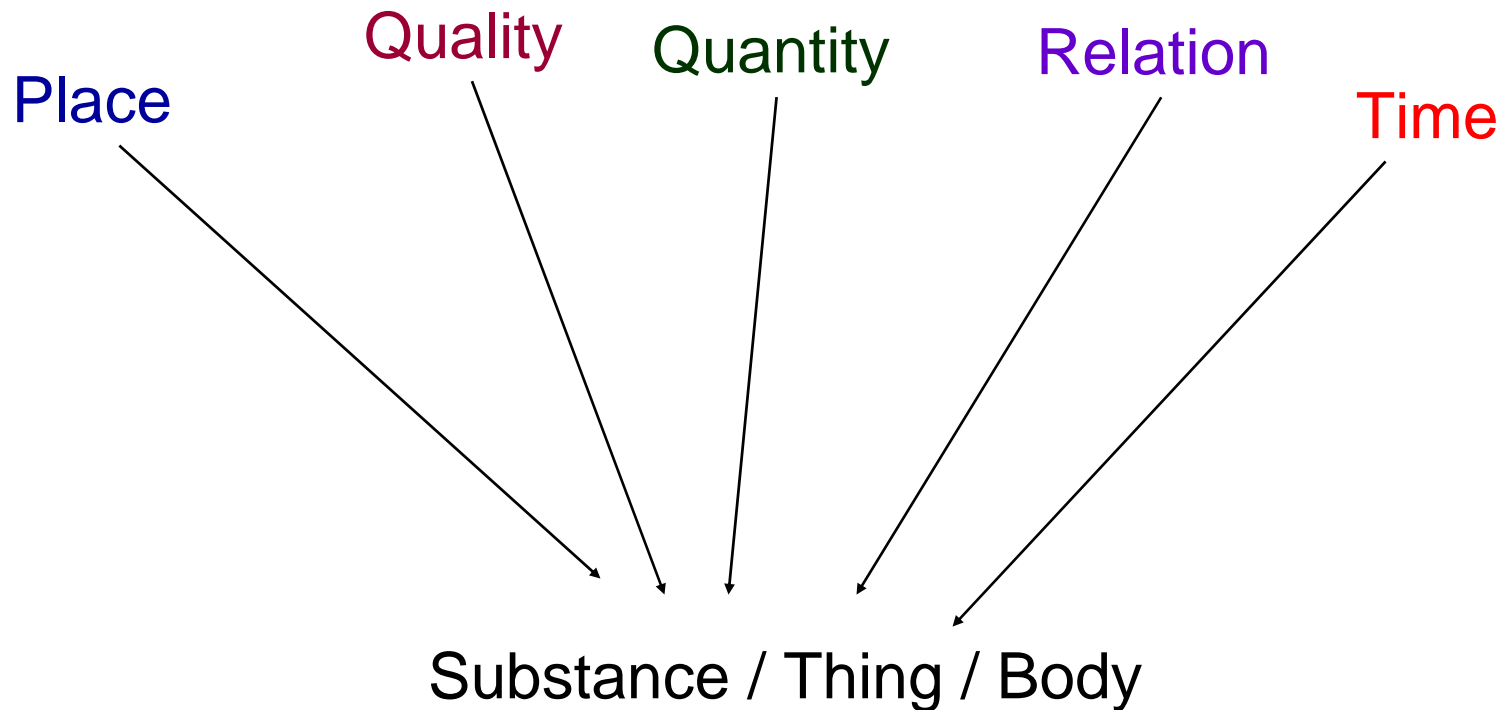
Every Taxonomy is not an Ontology



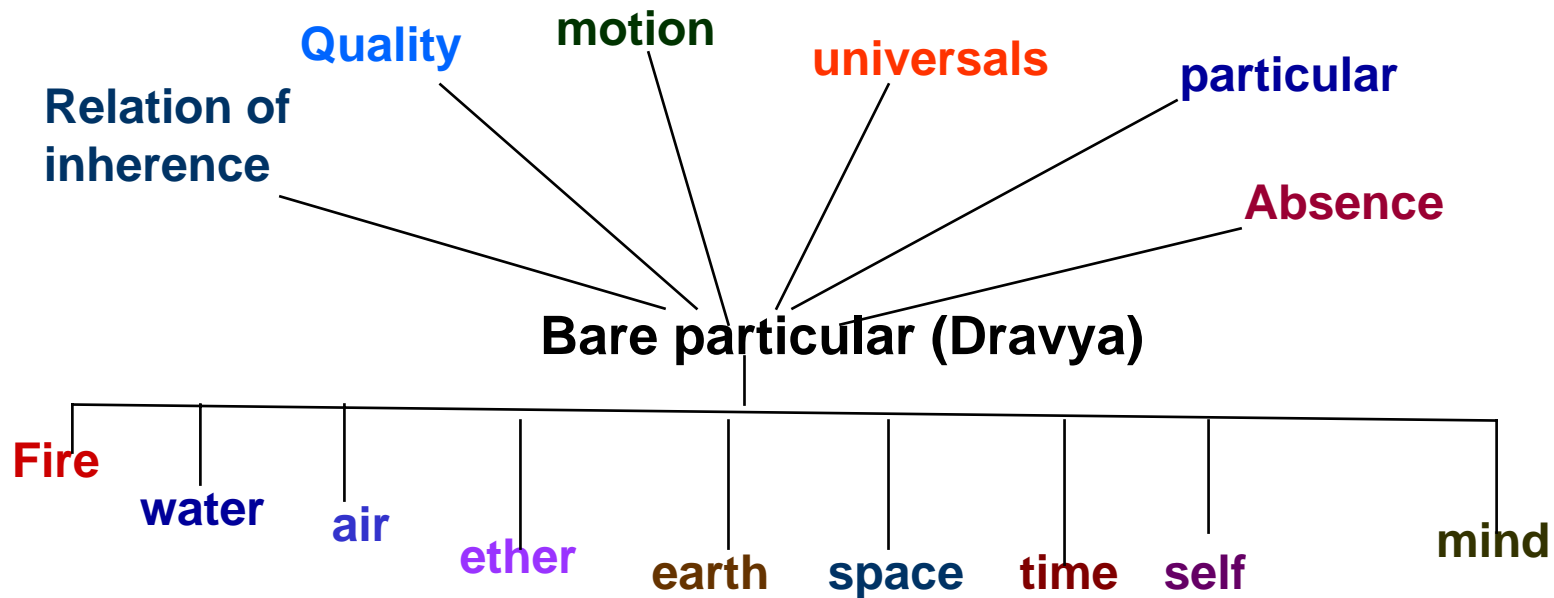
Which can be the Ontological Categories?

- Their identification is interest-dependent,
- Their choice is the result of the conceptual scheme that we wish to choose
- Metaphysics-driven Ontology

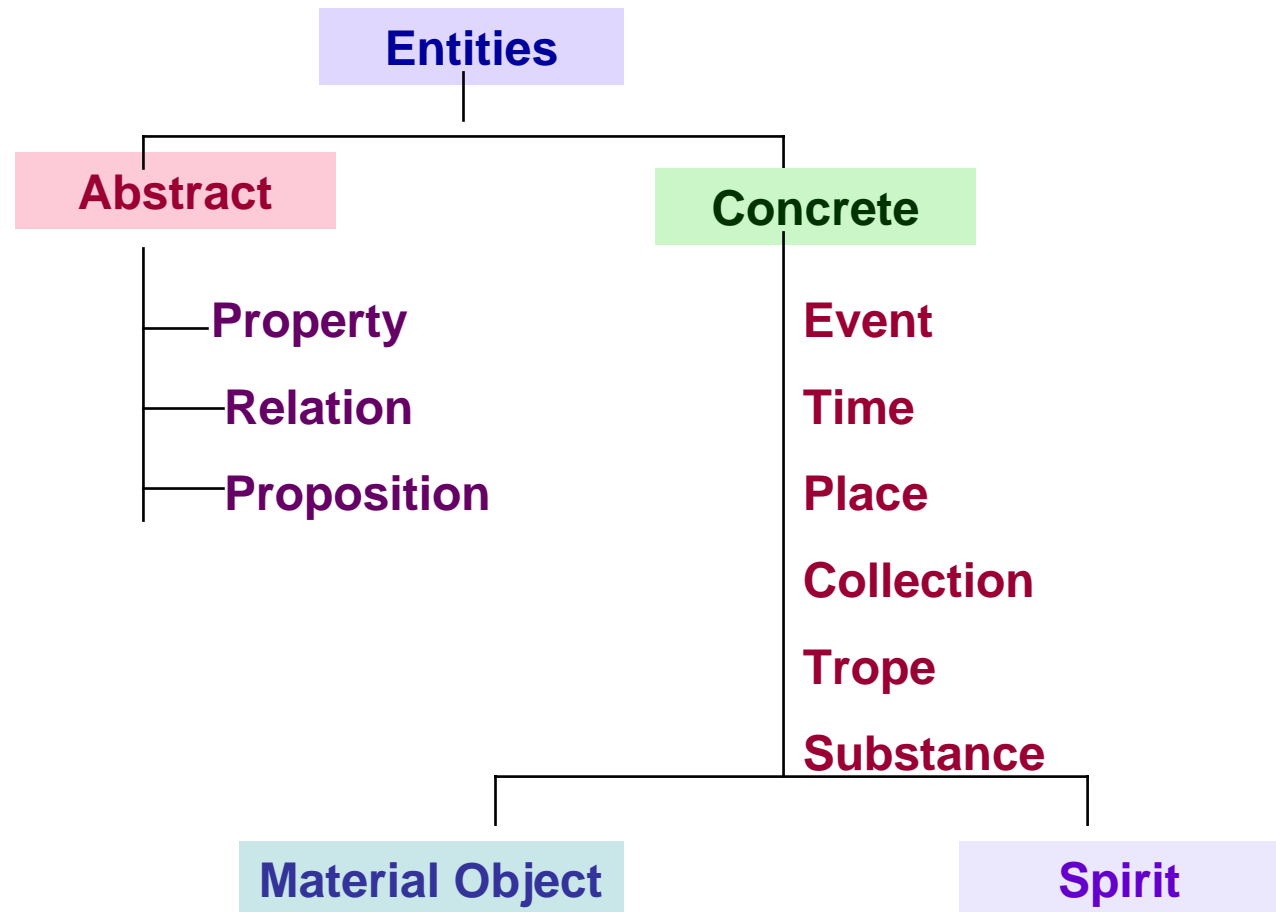
Aristotle's Ontology: Structure of Reality



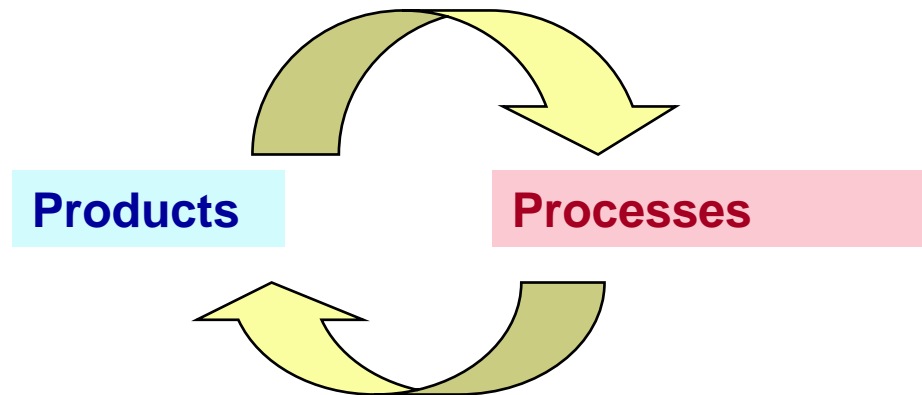
The Nyaya- Vaisesika Ontology



Hoffman-Rosenkrantz Ontology



Ontology of Process Metaphysics



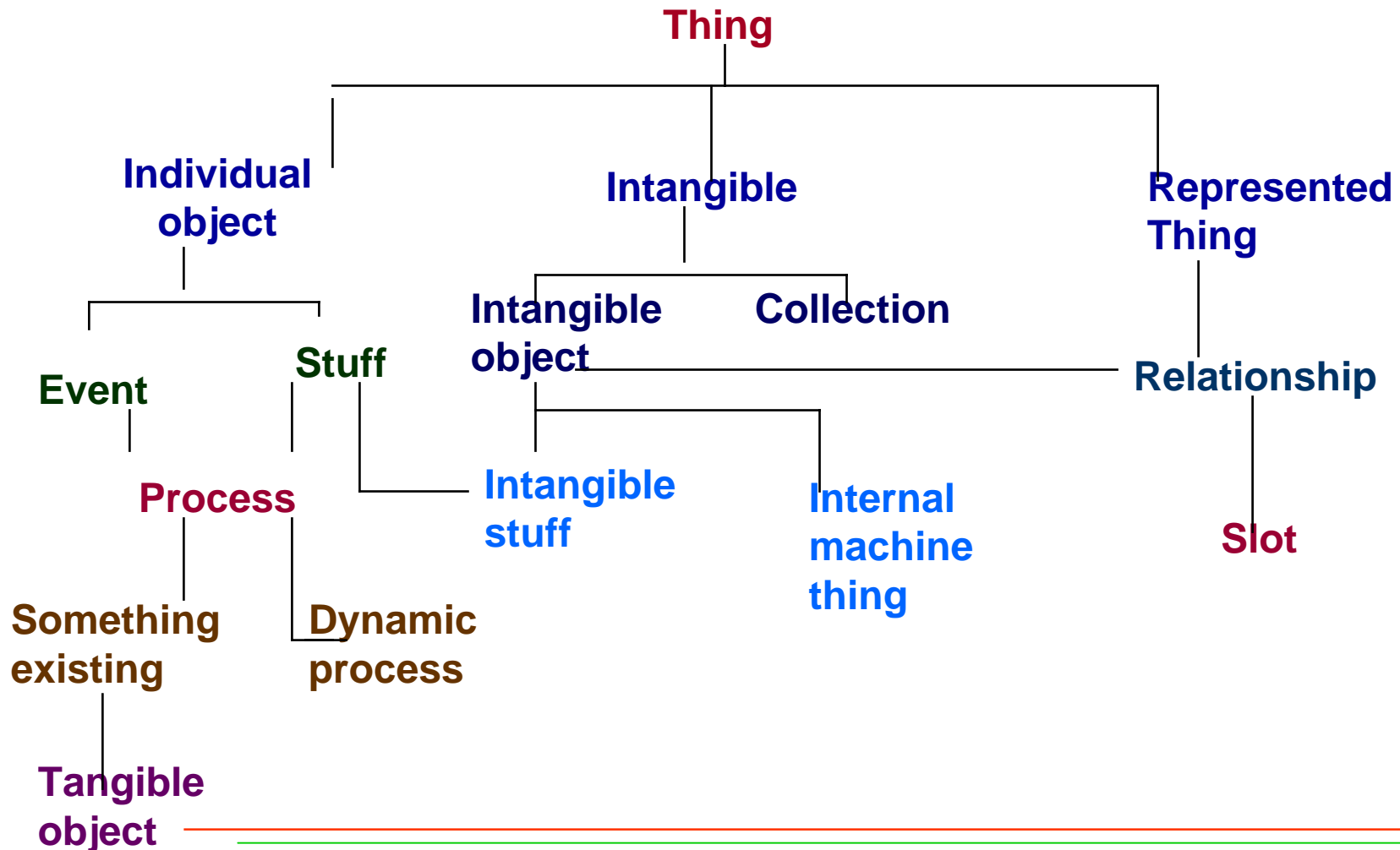
Ontology is...View 1

- A conceptual framework arrived at by categorical analysis.
- A catalogue of reality in terms of most general categories : philosophy

Ontology is...View 2

- Ontology, in the applied sense, is a tool to represent knowledge through categorical analysis: Applied Ontology
- Product is often an engineering artifact made for a specific vocabulary
- Used mostly in AI research, Knowledge representation in cognitive science, NLP, Semantic Web etc.

CYC Project Ontology



Applied Ontology To represent Knowledge

- Application of Formal Ontology to represent knowledge in a specific domain
- Example: Barry Smith (SUNY Buffalo) and ontology for the *world* of common sense

Example : Biomedical Ontology

- Biomedical ontology: Developed Ontology for structured representation of medical information (clinical trials)
 - First capture the basic scientific entities: cells? Organs? Molecules? (subject-specific)
 - Developers have to believe that these terms refer to some existing ‘entities’ on best current evidence

Formal Ontologies

- Ontologies committed exclusively to the semantics of formal languages like that of Modal logic, predicate logic, etc.
- A Formal ontology may be viewed also as a mathematical theory of some entities.
- Sufficiently rich axiomatized systems whose job is to *organize* knowledge

Logic & Ontology: Formal Ontology

- Logical features of Predication and Basic ontological commitment : Task of Formal Ontology

- Husserl's idea: 

Logic	Ontology
Proposition Concept Subject term predicate term	Individuals Properties Relations State of affairs

While Building Formal Ontology

- Traditional tools such as taxonomic structure, graph and lattice theories are used
- **Plus Logic**
- Theory of Logical Form is used to make a theory about the ontological structure of the world
- Different ontological categories are represented by different logico-grammatical categories

Example: Conceptual Space

- A framework in cognitive robotics: a metric space whose dimensions are related to the 'objects' perceived by the agent sensor: sort of Ontology
- It is a presupposition of any symbolic-propositional characterization of cognitive phenomena
- Peter Gardenfors (LUCS, Sweden), 'Conceptual Space' theory, a framework for representing information, and for locating a concept in that space

Logic and Pure Ontology: Any relation?

- Logic as such does not appear to have anything to say about 'being', which is the main topic of Ontology
 - Historically, Stoics, Scholastic logicians: No common ground:

Logic and Ontology: View 1

- Logic when viewed as an abstract calculus, devoid of content of its own, 'topic neutral'
- Domains and interpretations are part of Set Theory
- So, ontology as 'a general theory of objects' applies to only that part of logic
- So, at best a partial connection between the two

Logic and Ontology: View 2

- Ontology is connected to Logic

Logic and Ontology: View 2

- Ontology: a general framework to represent our commonsensical & scientific understanding of the world
- Link to logic: Through efforts to capture truth conditions of sentences, and efforts to locate them ontologically within the general conceptual framework

Logic and Ontology: View 2

- Ontology is sort of like a prolegomenon to logic¹
- Ontology is intuitive, informal inquiry into categorical aspects of entities
- Logic is more formal, axiomatic elaboration of the same

¹Bochenski, I. M.: 1974, 'Logic and Ontology', *Philosophy East and West* **24**, 275–292.

Logic and Ontology: Intersecting points of interest

1. Through semantics: truth and ontological commitment
2. Through theoretical presuppositions
3. Through interpretation of predication

1. Logic & Ontology: Ontological Commitment through semantics

- Parmenides (5th BCE): to be discussable, i.e. an object of discussion, is already to be a matter of being
- Object of any cognitive act is real: 'I can imagine a mountain of gold'



1. Logic & Ontology: Ontological Commitment through semantics

- Alexius Meinong's theory of 'objects': correspondence between mental states and 'objects'
- In std. logic: $Fa \equiv (\exists x) ((x = a) \bullet Fx)$

Existential Presupposition in Logic of Categories

- Pervasive ontological presupposition in Aristotelian logic of categories:
- A: All As are Bs
- E: No As are Bs
- I: Some As are Bs
- O: Some As are not Bs



Basic
assumption
about **non-
empty** domains

Problem with blanket Existential Presupposition

- Then what to do about propositions about non-existent entities such as 'Pegasus the flying horse', 'the largest natural number' ?

Problem with blanket Existential Presupposition

- Modern logicians (e.g. George Boole, Bertrand Russell) objected against such unwarranted and blanket existential commitment:
- ‘existence is not a predicate’,
- Russell’s point: From ‘something is a p’ it does not follow that there exists a p
- Theory of Descriptions (Russell): Every description need not contain ontological claim or a reference

Russell's Theory of Descriptions

- A statement containing an **indefinite description** ‘An F is G’ [is understood to have the logical form:
Some F is G
- But a statement with **definite description** ‘The F is G’ has the logical form:
 - There is something that is F: $(\exists x) Fx$
 - There is at most one thing that is F: $(\forall y) (Fy \rightarrow (x=y))$
 - Something that is F is also G

Modern Revision of Aristotelian Logic of Categories

- Existential claim restricted only to particular statements: ' $(\exists x) (Fx \bullet Gx)$ ', ' $(\exists x) (Fx \bullet \sim Gx)$ '
- **No existential claim for universal statements :**
 - ' $(\forall x) (Fx \rightarrow Gx)$ ',
 - ' $(\forall x) (Fx \rightarrow \sim Gx)$ '

For any x , IF x is
f then...

Does not imply that
the x exists

- Propositions do not require ontological presupposition
- **Existential Fallacy: To assume existence in an unwarranted manner**

W V O Quine on Reference to Ontology

- Pervasive ontological claims with every judgment is a case of faulty reasoning
- ‘Pegasus does not exist’ need not imply there is a Pegasus which has the property of non-existence



To be is to be the value of a bound individual variable : W V O Quine

- We only commit ourselves to ontology by claims about bound individual variable
- ' $(\exists x) Fx$ ' : what value would 'x' have to have in order for this expression to be true?
- 'There is some property that blue pens and blue flowers have in common'
- Whatever entity can serve as that value, (e.g. numbers, humans) we are committed to include that as an existent in our ontology

Quine: To be is to be the value of a variable

- No entity without identity, no need for 'bloated ontology'
- Quine does not tell us which ontology should be accepted, only tells in making logical claims how we commit ourselves to certain ontology

W V O Quine on Reference to Ontology

- Replace named individuals (Pegasus) with predicated object description 'the thing that answers the description of being Pegasus'
- 'Pegasus is a winged horse' \equiv ' Whatever answers the description of being Pegasus is a winged horse'



Nothing in the ontology

1. Logic & Ontology: Ontological Commitment through semantics

- *Objectual semantics: truth requirement to ontology*
 - Include only that which is necessary to posit from a logical point of view
- An expression ' $(\exists x) Fx$ ' is true if and only if there is an object in the domain which when assigned as the value of the variable 'x', satisfies the open expression 'Fx'.

Problem with Quine's Proposal

- Replacement of substantives by adjectival descriptions does not really eliminate the objects to whom uninstantiated predicates are attributed
- They stay on as values of variables, only certain terms get discarded

Alternative approach to semantics

- *Substitutional semantics:*
- No need to assume entities as values of variables
- ‘ $(\exists x) Fx$ ’ is true if and only if there is a term in language which when substituted for ‘x’ in ‘Fx’ yields a true statement.
- Use of existential quantifier may be ontologically innocent.

2. Logic & Ontology: Ontological Commitment through theoretical commitment

- Does logic as a theory imply the existence of certain entities?
- **Logic as a Language View:** Yes, through the content of logic
- **Logic as a calculus View:** No, logic is topic-neutral. So, it has to be neutral about what there is.

2. Logic & Ontology: Ontological Commitment through theoretical commitment

- Frege: The verb 'to be' or 'is' has at least three meanings:
 - The 'is' of identity (Morning star is evening star)
 - The 'is' as copula of predication (India is large)
 - The 'is' of class inclusion (goat is mammal)
 - **The 'is' of existence (There are humans): indicates ontological claim**

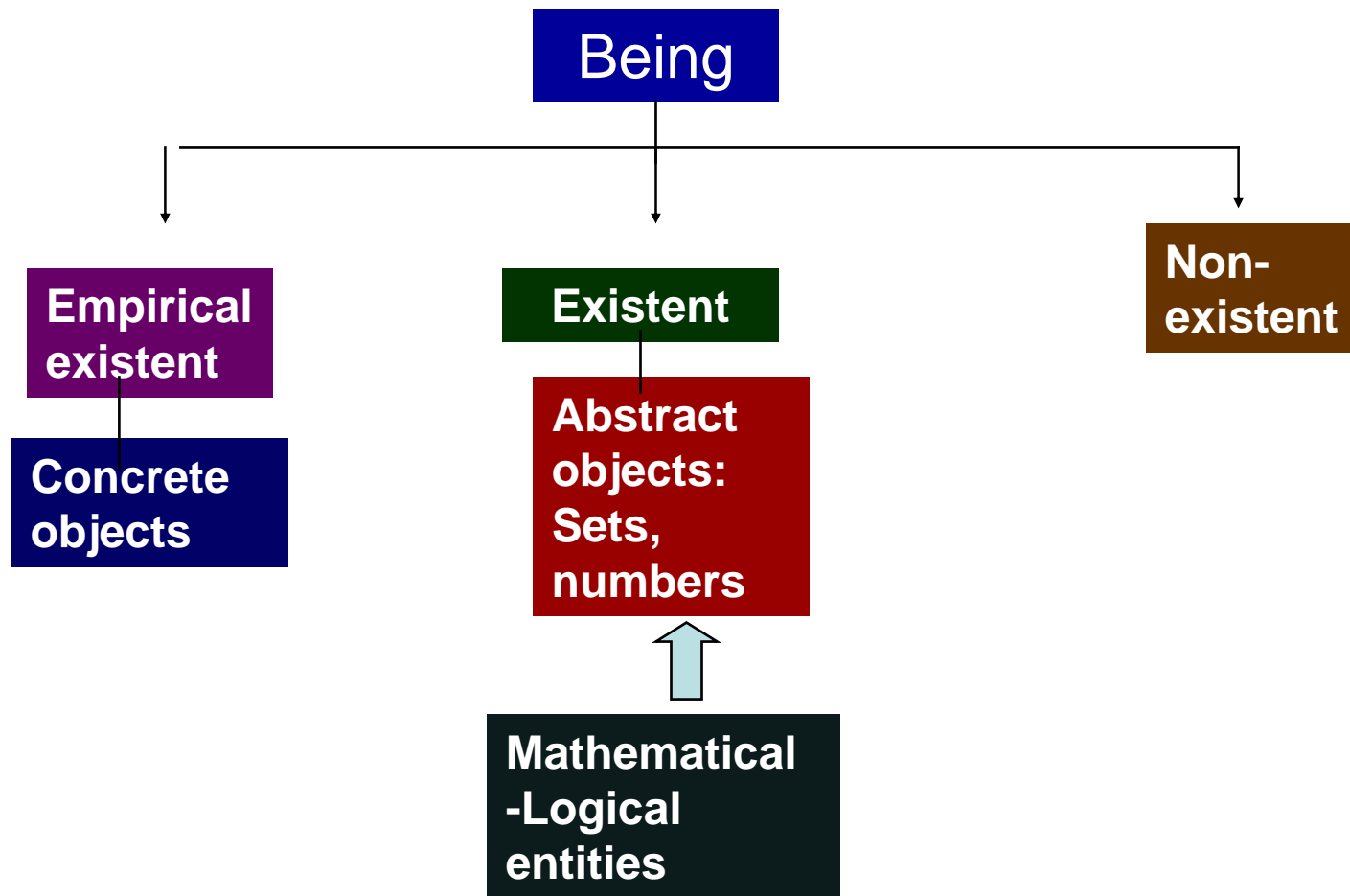
Frege: Logic as a language of concepts

- Thesis of **Logicism**: Arithmetic is logic
- Numbers are objects whose existence is implied by Arithmetic
- So, Logic implies the existence of certain objects, including that of the numbers, sets.
- Frege's Logic needs certain kind of entities to exist: a special ontology

Problem

- Objective existence of mathematical entities on grounds analogous to that for existence of physical objects
- Naïve set theory and Russell's paradox: what about the set of all sets? Is that a set? Is that a member of itself?
- What about a set of all those sets that are not members of themselves? Is that a member of itself?

Early Russell's Realist Ontology in Principles of Mathematics



Ontology of Early Wittgenstein: Tractatus

- The world is a totality of facts (states of affairs), not of things: abstract objects
- There is an isomorphic relation between what represents (thought, logic/language) and what is represented (reality)
- Names refer directly to objects, and propositions refer to state of affairs

Quine's separation of Set Theory and Logic

- In set theory ontological questions are relevant: Russell's paradox
- Set theory is to be separated from logic
- Logic has no ontology of its own, its predicate letters are just dummy letters.
- Only when the predicates from a branch of science are given, one can use logical connectors and quantifiers to characterize the ontology of that branch


Alternative View: Ontology has no role in Logic

- Others: Pure logic is ontology neutral
- From theoretical posits in logic or language, no inference possible to the existence in the ontology and in the world
- Logical truths are true regardless of domains, so they cannot imply that anything exists.

Tarski and others

- Development of formal, model-theoretic semantics
- With varying interpretations over various set-theoretic domains

3. Logic and Ontology: Through different theories of Predication

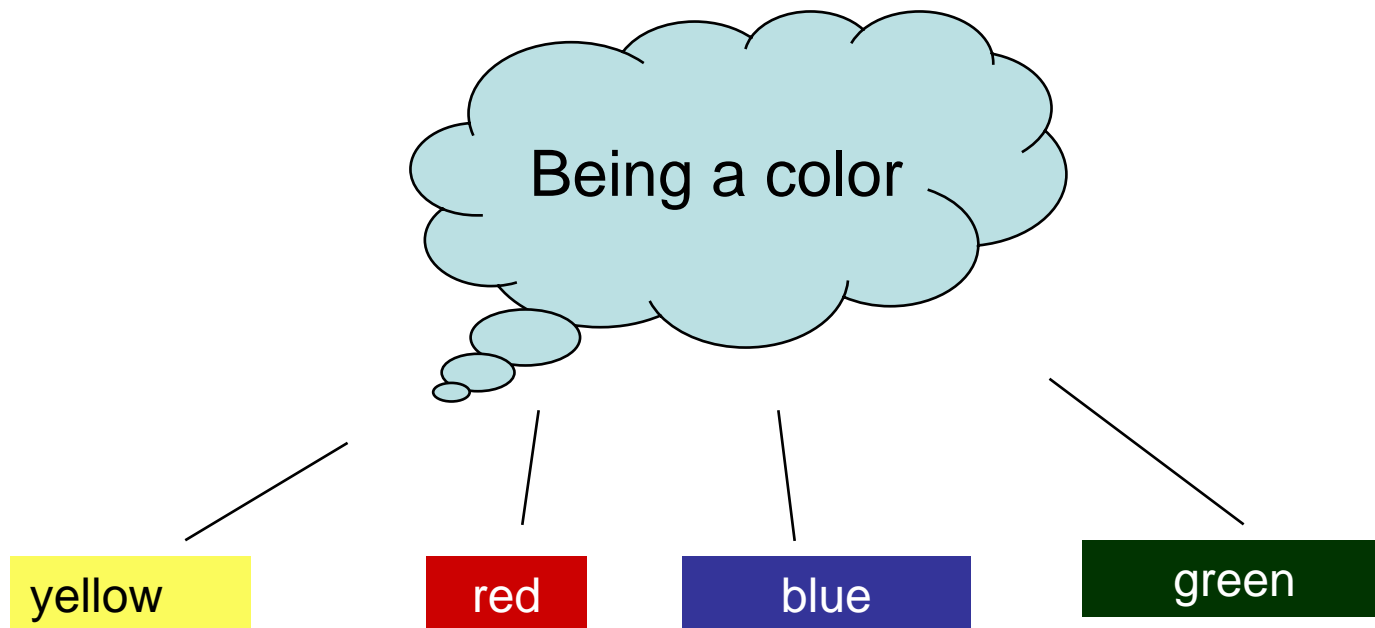
- 'X is F' 'Kolkata is populated' 'Roses are red'
 - The property of 'being F' is predicated to x
 - Property: a feature of an object, 'in the world'
 - Predicate: a linguistic expression, part of language
- 

Logical Predication and Ontology

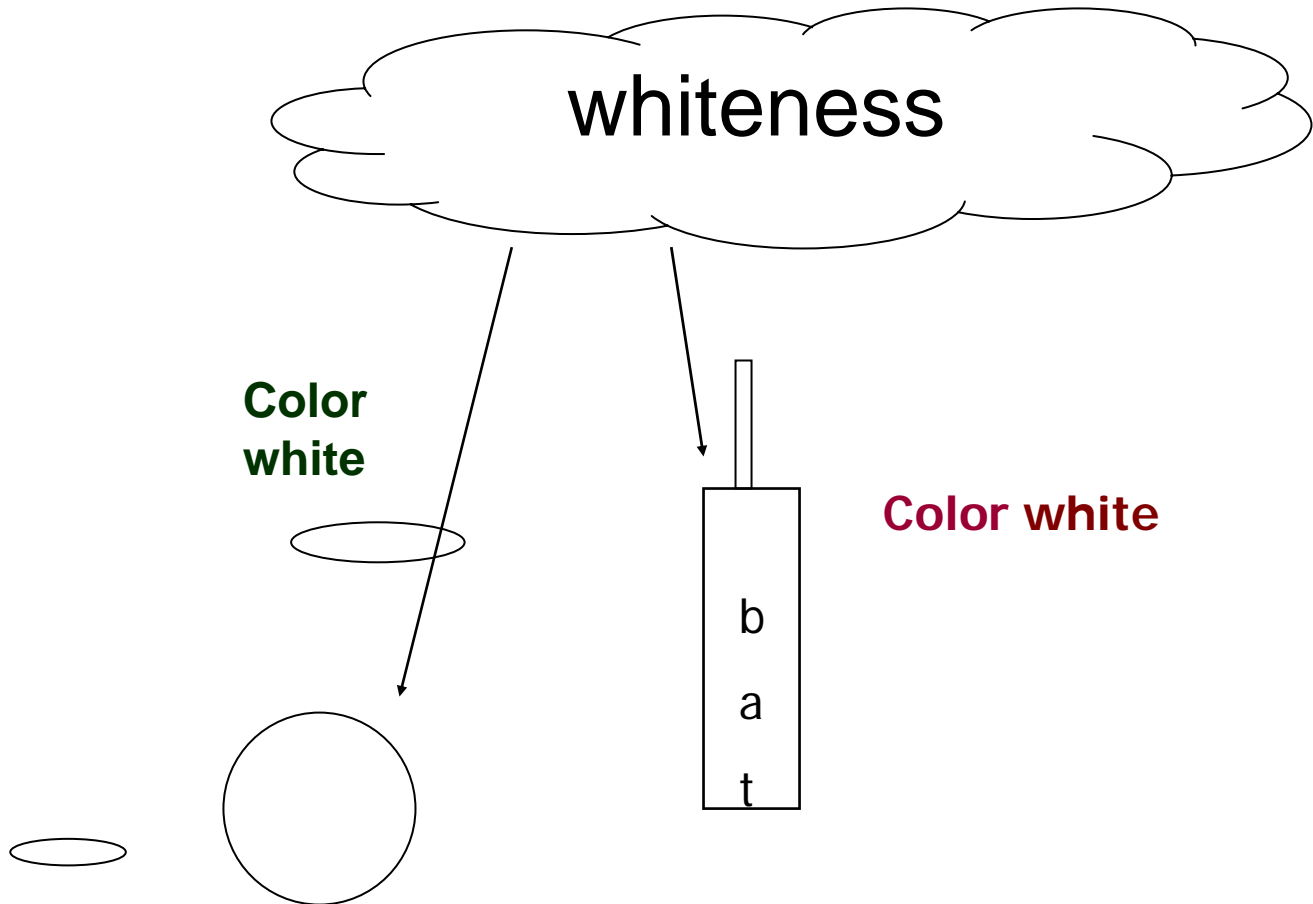
- The property of being F: What is it? How does it stand in the overall scheme of reality?
 - Only as an expression in language? As predicates?
 - Does it exist in reality?
 - If so, it exists as what? As Universal i.e. an entity that can be predicated to many things?

Property as Universal

- Abstract entity
- Multiply instantiable



2 things, 1 property



Logic and Ontology

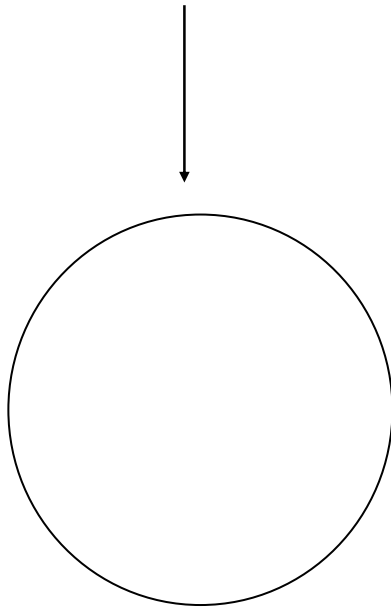
- If properties are understood as universals, then one set of consequences
- For example : multiple instantiation is possible and rule of Universal Instantiation holds good:
- $(\forall x)Fx$
- -----
- therefore, $Fa \bullet Fb \bullet Fc \dots\dots$

Property as a Trope: 2 things, 2 distinct properties

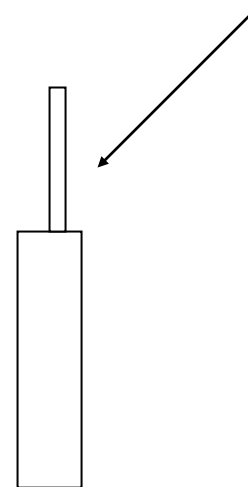
Properties: concrete particulars, uniquely characterize

No two things can share the same property

Ballwhite trope



Batwhite trope



Logic and Ontology

- If trope ontology is followed to understand properties, then another set of consequences for predication
- For example, Universal instantiation will be a questionable rule
- The claim ' $(\forall x)Fx$ ' may be interpreted as about a resemblance set: all members of which resemble each other in varying degrees in the 'F' aspect

Ontological nominalism

- There are no properties.
- Predication is just using predicates in language. Predication is true when a certain predicate expression is true of the mentioned things. There are only individuals, no abstract entities.

Ontological nominalism

- Quine: The word 'red' is true every sundry individual entities such as red houses, red rose, red sunsets, but there is no, in addition, any entity which is named by 'redness'
- Nelson Goodman: Whatever is admitted as entity has to be counted as an individual.

Effect of Nominalism on Logic

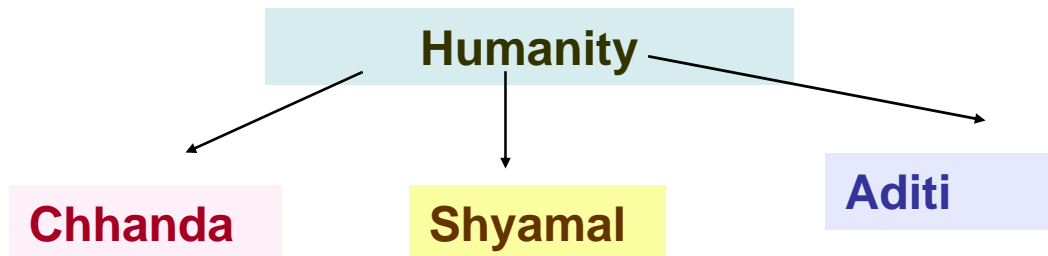
- Second order quantifiers need NOT be construed as ranging over 'abstract objects' such as properties


$$(\exists F) (\exists y) Fy$$

- Use ontologically unloaded metalanguage to explain
- E.g. 'Rimi is kind' \longleftrightarrow Rimi is something that all and only kind things are

Ontological Realism

- **Platonism:** There are properties as universals (and there are also predicates). Abstract entities as well as concrete individuals exist



Logical realism

- Universals (properties, relations) exist and provide the semantic ground for the truth or falsity of predicate expressions

Logical realism

- Frege:
- Propositions posited to exist as individual objects
- Sets posited to exist just as individual objects
 - For, predicates refer to certain classes / sets as their extensions in the world
- Russell till 1913 took properties and relations as objects
- Zermelo's set theory

Ontological Conceptualism

- Abstract concepts exist, e.g. Society, though no abstract objects exist
- There are universals, but they are mind-made, connected to the capacities of thought and language: **no ontological commitment**
- Concepts are intersubjectively realizable, hence 'objective' in that sense
- Leibniz is read as an ontological conceptualist: Only abstract concepts exist

Ontological Conceptualism

- Modern version: Intersubjective cognitive structures exist as capacities (e.g. Lorenz: biologically evolved) for characterizing or relating objects, and concepts cannot exist independently of these structures.
- Predication is joint application of referential and predicable concepts

Understanding Predication through Conceptualist's eyes

- Referential concepts: cognitive capacities that underlie our ability to refer to objects
- Predicable concepts: cognitive capacities that enable us to predicate
- Predication: when both kinds are applied jointly in a mental or speech act

All swans are white

Referential concept

Predicable concept

Concluding remarks

- Though may seem unconnected on cursory view, there may be a deep connection between Logic and Ontology
- Ontological categories as “modes of being” surface as the background as we do logic
- Ontology as “ explicit specification of conceptualization” (Gruber, 1995) requires logic