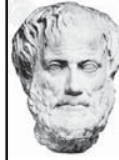# Lecture 1
Ontology as a Branch of Philosophy

A brief history of ontology

Aristotle (384 BC – 322 BC)
Realist theory of categories
Intelligible universals extending across all domains
Central role of organisms

Medieval scholastics: Aquinas, Scotus, Ockham, … (1200 – 1600)
Aristotelianism as *philosophia perennis*
Common panscientific ontology and controlled vocabulary (Latin)

2

A brief history of ontology

Descartes (1596 – 1650)
Sceptical doubt initiates subversion of metaphysics, rise of epistemology
Central role of mind
Dualism of mind and matter
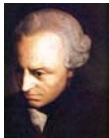
Kant (1724 – 1804)
Reality is unknowable
Metaphysics is impossible
We can only know the quasi-fictional domains which we ourselves create

3
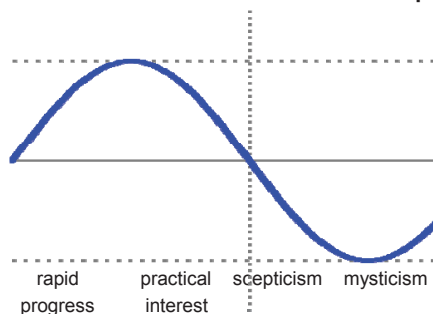

A brief history of ontology

Brentano (1838 – 1917)
Rediscovery of Aristotle
Methods of philosophy and of science are one and the same

Husserl (1859 – 1938)
Inventor of formal ontology as a discipline distinct from formal logic
Showed how philosophy and science had become detached from the 'life world' of ordinary experience
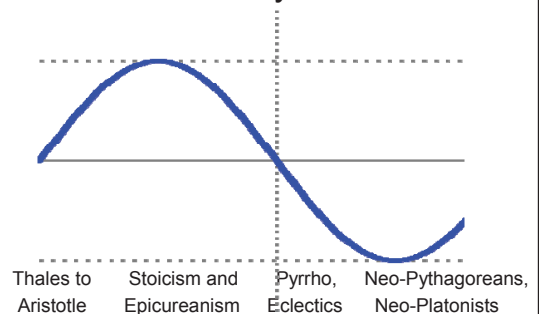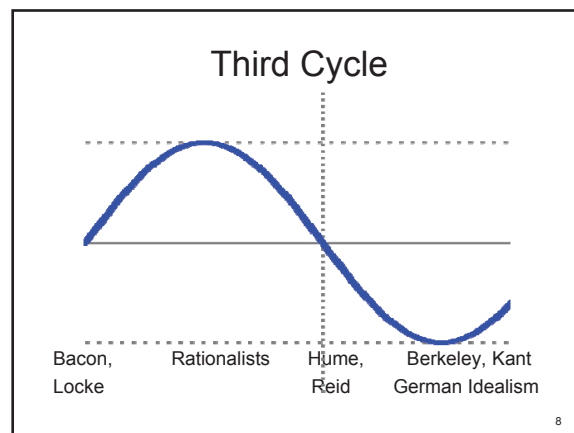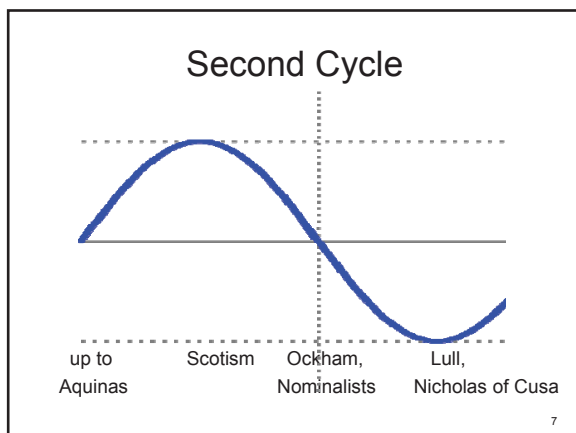
4

The Four Phases of Philosophy

rapid progress   practical interest   scepticism   mysticism

5

First Cycle

Thales to Aristotle   Stoicism and Epicureanism   Pyrrho, Eclectics   Neo-Pythagoreans, Neo-Platonists

6

Second Cycle

| up to Aquinas | Scotism | Ockham, Nominalists | Lull, Nicholas of Cusa |

7

Third Cycle

| Bacon, Locke | Rationalists | Hume, Reid | Berkeley, Kant German Idealism |

8

A brief history of ontology

Wittgenstein 1 (ca. 1910 – 1918)
Author of *Tractatus*
Bases ontology on formal logic in reductionistic atomism

Vienna Circle (1922 – ca. 1938)
Schlick, Neurath, Gödel, Carnap, Gustav Bergmann …
Centrality of logic to philosophy
Construction of philosophy from either physics or sensations as base

9

A brief history of ontology

Wittgenstein 2 (ca. 1930 – 1951)
Centrality of language and of language games
Metaphysics = language goes on holiday

British Ordinary Language philosophy
Philosophical problems to be solved by the study of the workings of language
Speech Act Theory (J. L. Austin, 1911-1960)

10

A brief history of ontology

Quine (ca. 1930 – 1951)
Ontological commitment (study not: *what there is*, but: what sciences believe there is when logically formalized)

Analytical metaphysics (from ca. 1980): Chisholm, Lewis, Armstrong, Fine, Lowe, … beginnings of a rediscovery of metaphysics as first philosophy

What next?

11

Fourth Cycle (Continental)

| Brentano Polish School | Husserl | Heidegger | Derrida and the French |

12

Fourth Cycle (Analytical)

Frege   Vienna Circle   Wittgenstein 2   Rorty
Wittgenstein 1   Quine
Russell

13

Each cycle begins with rediscovery of Aristotle and a new theoretical orientation

From the 3rd cycle marked
by invention of new disciplines
3. Empirical natural science
4. Psychology, logic

14

Fifth Cycle

Analytical Metaphysics   Ontology
Rediscovery of Aristotle

15

An example of a practical problem

Increasingly, publishers are exploring ways to tag scientific literature in ways designed to make their contents more easily accessible to computers

For maximal effect, a single set of terms should be used for tagging all literature published in a given domain

How do we select the set of terms ('ontology') for each domain?

16

---

turn all highlighting on   date | disease | habitat | institution | organism | person | place | protein | taxon

Top | Abstract | Author Summary | Introduction | Methods | Results | Discussion | Supporting Information | Acknowledgements | References | Data Fusion Supplements

SEMANTICALLY ENHANCED VERSION OF A RESEARCH ARTICLE FROM PLOS NEGLECTED TROPICAL DISEASES

Impact of Environment and Social Gradient on *Leptospira* Infection in Urban Slums

document summary

Renato B. Reis [1*], Guilherme S. Ribeiro [1*], Ridalva D. M. Felzemburgh [1], Francisco S. Santana [1,2], Sharif Mohr [1], Astrid X. T. O. Melendez [1], Adriano Queiroz [1], Andréia C. Santos [1], Romy R. Ravines [1], Wagner S. Tassinari [3,4], Marília S. Carvalho [3], Mitermayer G. Reis [1], Albert I. Ko [1,5*]

1 Centro de Pesquisas Gonçalo Moniz, Fundação Oswaldo Cruz, Ministério da Saúde, Salvador, Brazil 2 Secretaria Estadual de Saúde da Bahia, Salvador, Brazil 3 Escola Nacional de Saúde Pública, Fundação Oswaldo Cruz, Ministério da Saúde, Rio de Janeiro, Brazil 4 Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brazil 5 Division of International Medicine and Infectious Diseases, Weill Medical College of Cornell University, New York, New York, United States of America

Abstract

from: http://www.ploscompbiol.org/doi/pcbi.1000361

Background

Leptospirosis has become an urban health problem as slum settlements have expanded worldwide. Efforts to identify interventions for urban leptosprosis have been hampered by the lack of population-based information on Leptospira transmission determinants. The aim of the study was to estimate the prevalence of Leptospira infection and identify risk factors for infection in the urban slum setting.

Methods and Findings

We performed a community-based survey of 3,171 slum residents from Salvador, Brazil. Leptospira agglutinating antibodies were measured as

17

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turn all highlighting off   date | disease | habitat | institution | organism | person | place | protein | taxon

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Abstract

http://www.biocurator.org

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18

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19

Most successful ontology venture thus far

$100 mill. invested in literature and database curation using the Gene Ontology (GO)

over 11 million annotations relating gene products (proteins) described in the UniProt, Ensembl and other databases to terms in the GO

20

GO provides a controlled system of representations for use in annotating data and literature that is

- multi-species
- multi-disciplinary
- multi-granularity, from molecules to population

21
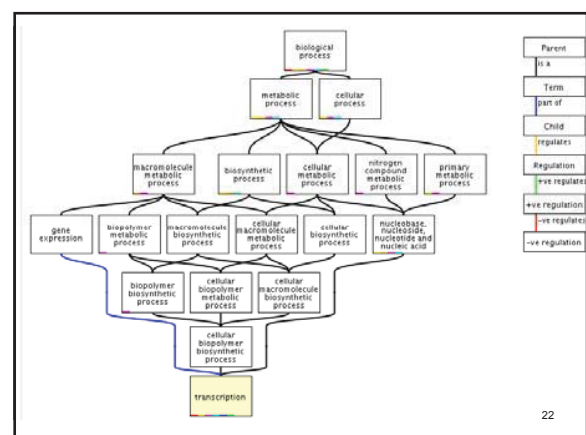
22

The GO and its sister ontologies

are *structured representations of the domains of molecules, cells, diseases ...* which can be used by researchers in many different disciplines who are focused on one and the same biological reality

23

The goal: virtual science

- consistent (non-redundant) annotation
- cumulative (additive) annotation

yielding, by incremental steps, a virtual map of the entirety of reality that is accessible to computational reasoning

24

This goal is realizable if we have a common ontology framework
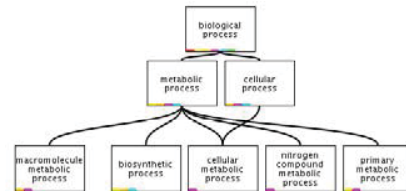
data is retrievable

data is comparable

data is integratable

only to the degree that it is annotated using a common controlled vocabulary

– compare the role of seconds, meters, kilograms … in unifying science

25

To achieve this end we have to engage in something like philosophy

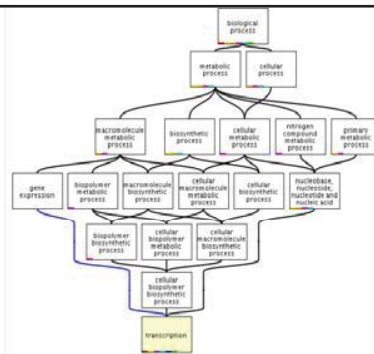is this the right way to organize the top level of this portion of the GO?
how does the top level of this ontology relate to the top levels of other, neighboring ontologies?

26

Aristotle's Metaphysics

The world is organized via types/universals/categories which are hierarchically organized
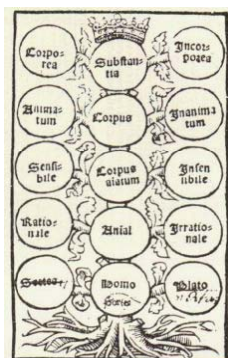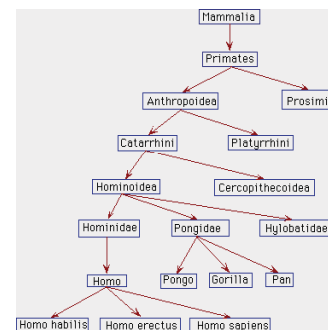
27

This holds, too, of the biological world
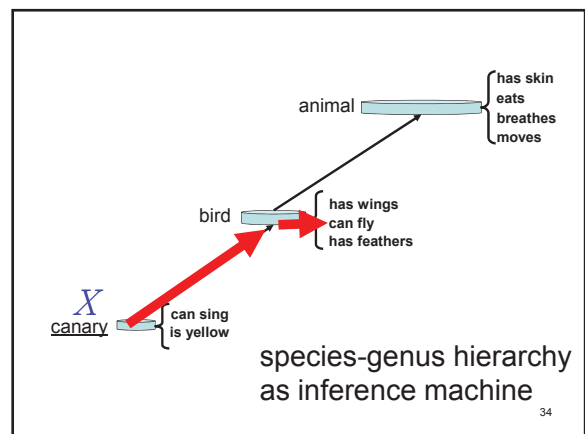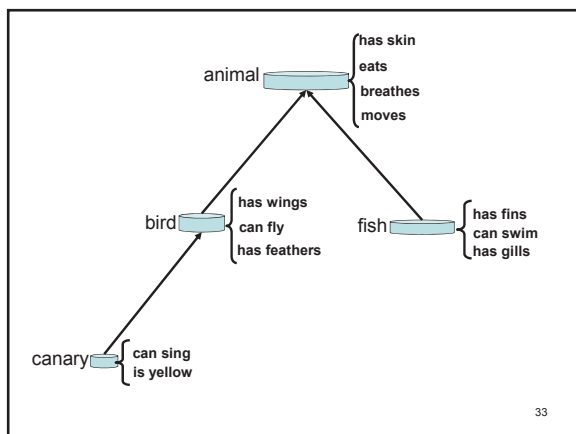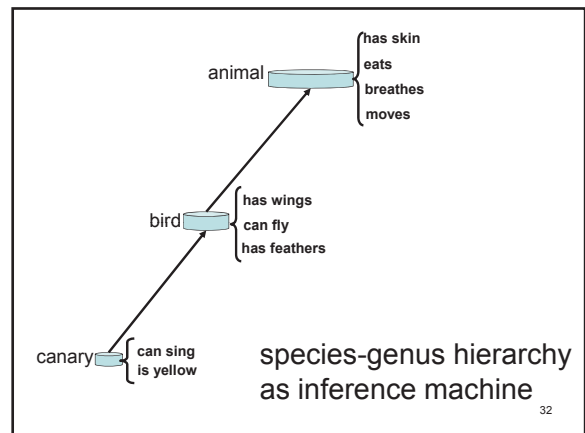
28

Porphyrian Hierarchy

29

Linnaean Hierarchy

30

Slide 31: Hierarchy diagram — animal ← bird ← canary

Slide 32:
- animal: has skin, eats, breathes, moves
- bird: has wings, can fly, has feathers
- canary: can sing, is yellow

species-genus hierarchy as inference machine

Slide 33:
- animal: has skin, eats, breathes, moves
- bird: has wings, can fly, has feathers
- fish: has fins, can swim, has gills
- canary: can sing, is yellow

Slide 34:
- animal: has skin, eats, breathes, moves
- bird: has wings, can fly, has feathers
- X canary: can sing, is yellow

species-genus hierarchy as inference machine
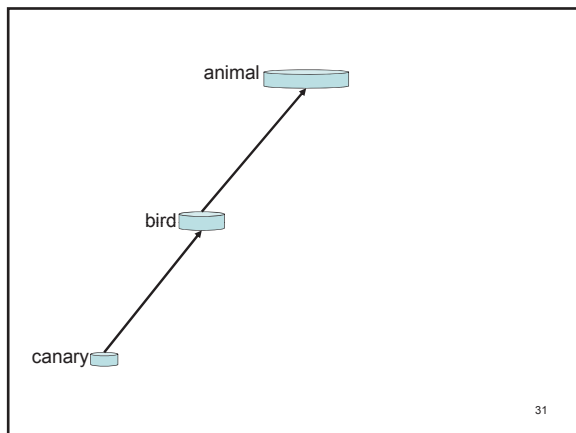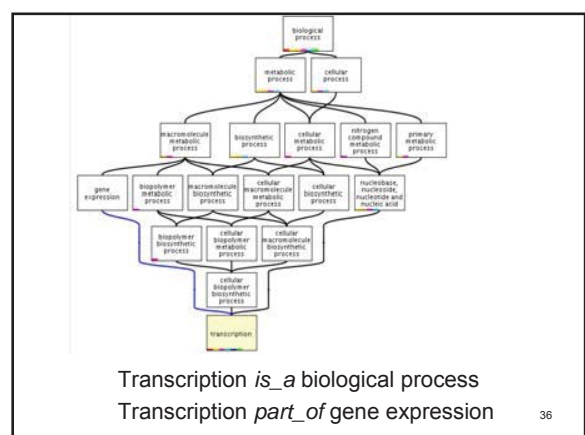
Slide 35:

Question: Why are species-genus hierarchies good ways to represent the world for purposes of reasoning?

Answer: They capture the way the world is (Aristotelian realism)

Slide 36:

Transcription *is_a* biological process
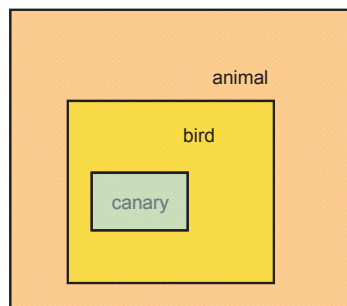Transcription *part_of* gene expression

Species-genus trees can be represented also as map-like *partitions*

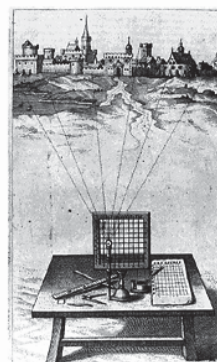If Aristotelian realism is right, then such partitions, when correctly built are *transparent* to the reality beyond

37

animal

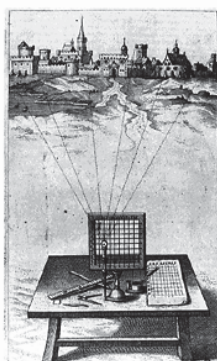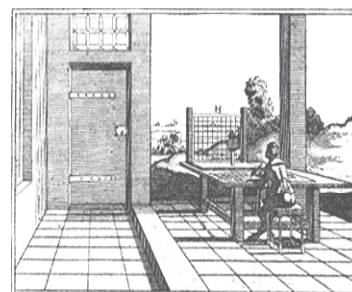bird

canary

38

animal

bird

canary
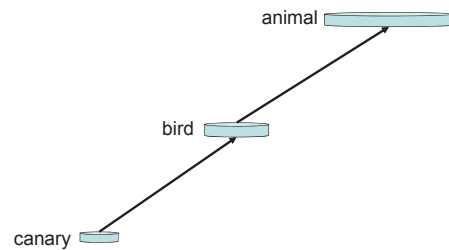
39

Alberti's Grid
c.1450

40

Ontologies:
windows on
the universals
in reality

41

as through a transparent grid

42

species, genera
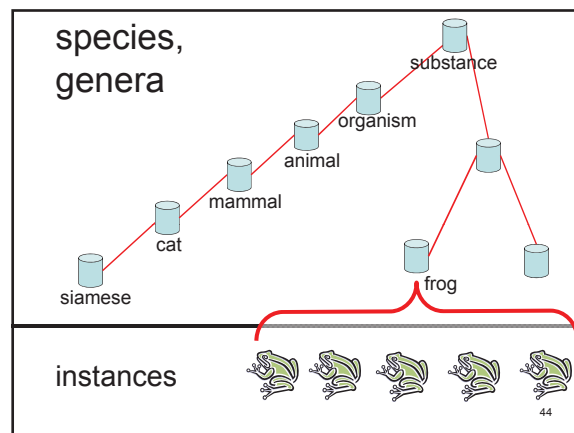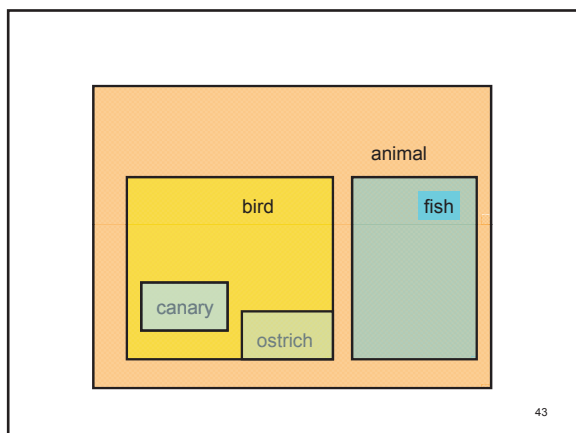
instances

Aristotle's Metaphysics is focused on *objects* (*things, substances, organisms*)

The most important universals in his ontology are _substance_ universals

cow   man   rock   planet

which pertain to *what* a thing is at all times at which it exists

---

For Aristotle, the world contains also _accidents_

which pertain to *how* a thing is at some time at which it exists:

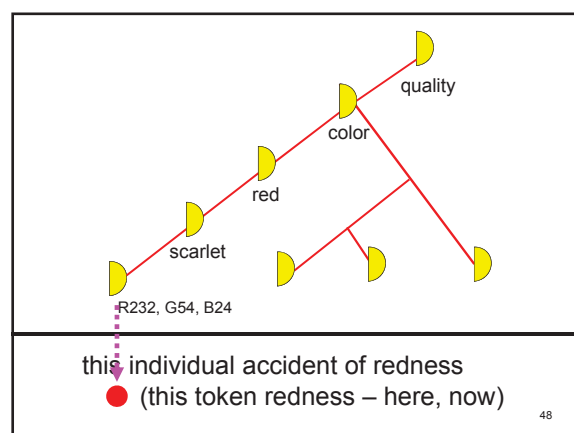*red   hot   suntanned   spinning*

= what holds of a substance *per accidens*

Accidents, too, instantiate genera and species

Thus accidents, too, form trees of greater and lesser generality

---

this individual accident of redness
(this token redness – here, now)

Nine Accidental Categories

quid?	**substance**
quantum?	**quantity**
quale?	**quality**
ad quid?	**relation**
ubi?	**place**
quando?	**time**
in quo situ?	**status/context**
in quo habitu?	**habitus**
quid agit?	**action**
quid patitur?	**passion**

49

Substances are the *bearers* of accidents

hunger

John

⟵ = relations of inherence
(one-sided existential dependence)
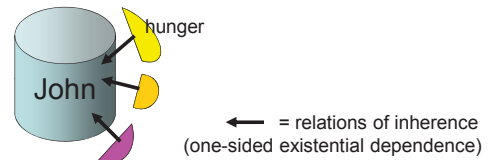
50

Aristotle 1.0

an ontology recognizing:
 substance tokens
 accident tokens
 substance types
 accident types

51

Aristotle's Ontological Square

		Substantial	Accidental
Universal		Second substance *man* *cat* *ox*	Second accident *headache* *sun-tan* *dread*
Particular		First substance *this man* *this cat* *this ox*	First accident *this headache* *this sun-tan* *this dread*

52

Some philosophers accept only part of this four category ontology

53

Standard Predicate Logic – F(a), R(a,b) ...

	Substantial	Accidental
Universal		Attributes F, G, R
Particular	Individuals *a, b, c* *this, that*	

54

Bicategorial Nominalism

	Substantial	Accidental
Universal		
Particular	First substance *this man* *this cat* *this ox*	First accident *this headache* *this sun-tan* *this dread*

55

Process Metaphysics

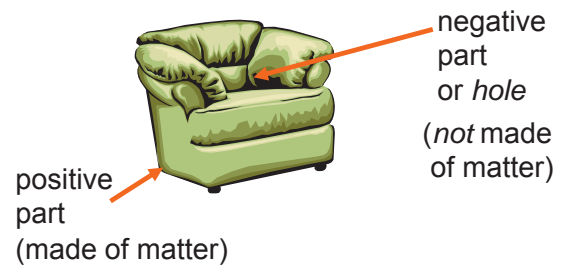|	Substantial	Accidental
Universal		
Particular		Events Processes *"Everything is flux"*

56

In fact however we need more than the ontological square

Not everything in reality is either a substance or an accident

57

Positive and negative parts

negative part or *hole* (*not* made of matter)

positive part (made of matter)

58
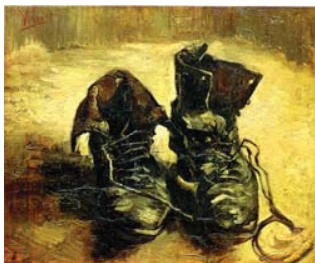
59

60

Niches, environments are holes

61

62

Places are holes

63

Nine Accidental Categories

quid?	substance
quantum?	quantity
quale?	quality
ad quid?	relation
ubi?	place
quando?	time
in quo situ?	status/context
in quo habitu?	habitus
quid agit?	action
quid patitur?	passion

64

For Aristotle the ***place*** of a substance is the interior boundary of the surrounding body

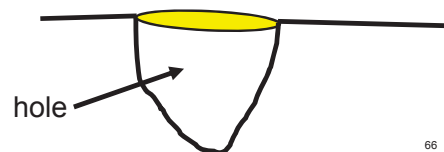(for example the interior boundary of the surrounding water where it meets a fish's skin)

For holes, we need an extension of Aristotle's metaphysics

65

A hole in the ground

Solid physical boundaries at the floor and walls

but with a lid that is not made of matter:

hole

66

Holes involve two kinds of boundaries

bona fide boundaries *which exist independently of our demarcating acts*

fiat boundaries *which exist only because we put them there*

Examples

of bona fide boundaries:
an animal's skin, the surface of the planet

of fiat boundaries:
the boundaries of postal districts and census tracts
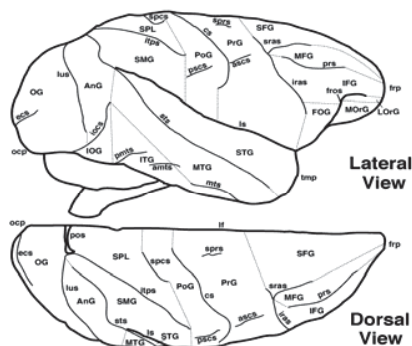
Mountain

bona fide upper boundaries with a fiat base:

where does the mountain start ?

... a mountain is not a substance

Aristotle 1.5

{ an ontology of
substances + accidents
+ holes (and other
entities not made of matter)
+ fiat and bona fide boundaries
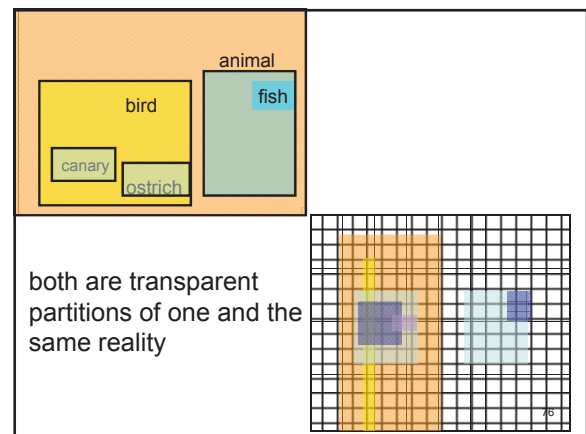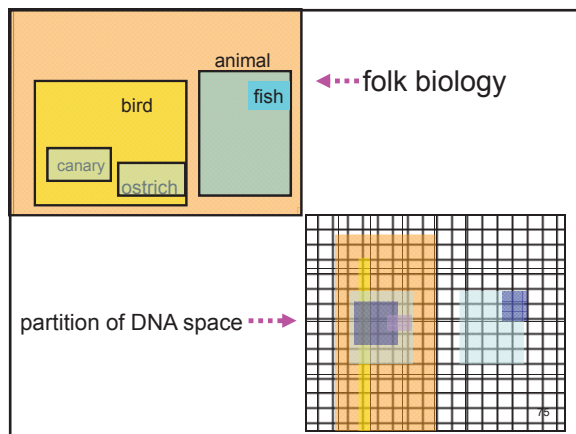+ artefacts and environments }

Question

How do those parts and dimensions of reality which we encounter in our everyday experience relate to those parts and dimensions of reality which are studied by science?

Aristotle 2010

scientific realism coupled with realism about the everyday world

animal
fish
bird
canary
ostrich

◄···folk biology

partition of DNA space ···►

animal
fish
bird
canary
ostrich

both are transparent partitions of one and the same reality

An organism is a totality of atoms

An organism is a totality of molecules

An organism is a totality of cells

An organism is a single unitary substance

... all of these express **veridical partitions**

Multiple transparent partitions

at different levels of granularity

operating with species-genus hierarchies and with an ontology of substances and accidents along the lines described by Aristotle

substances and accidents reappear in the microscopic and macroscopic worlds of e.g. of chemistry and evolutionary biology

we do not assert

that every level of granularity is structured in substance-accident form -- perhaps there are pure process levels, perhaps there are levels structured as fields

Perspectivalism

Different partitions may represent cuts through the same reality which are skew to each other

Not all need be structured in substance-accident terms – perhaps there are pure process levels, perhaps there are levels structured as fields
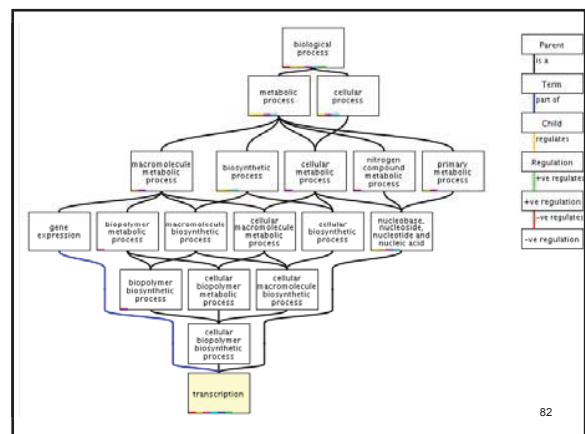
Scientific partitions like the Periodic Table or the Gene Ontology

are transparent to the hierarchical order of an associated domain of objects

they capture reality at different levels of granularity

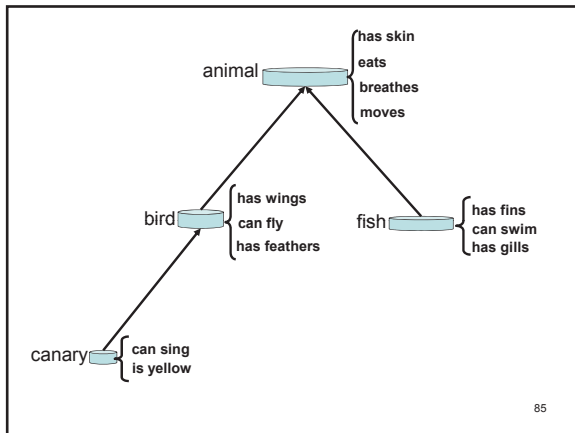cellular constituents are visible to the GO, molecular constituents not
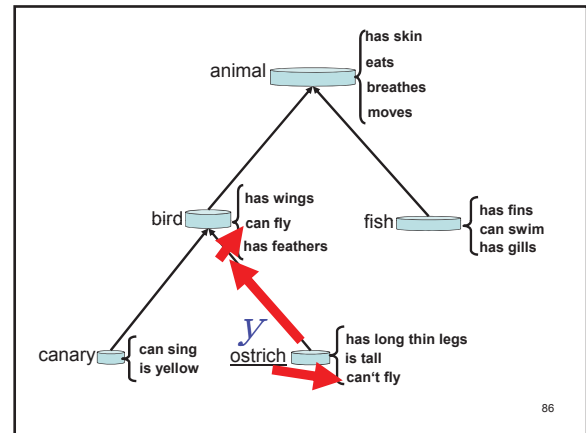
Perspectivalism

Different partitions may represent cuts through the same reality which are skew to each other

Different partitions may capture reality in ways which involve different degrees of vagueness
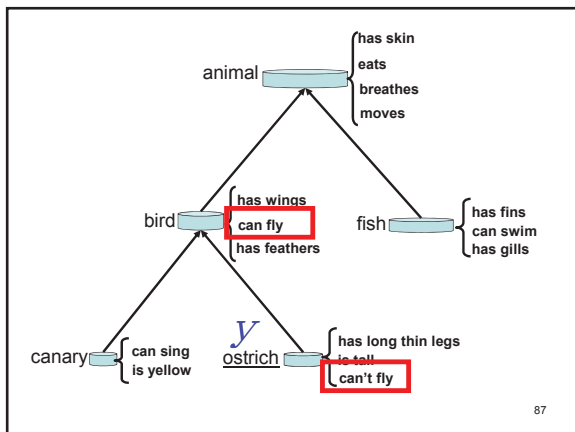
Slide 85

animal — has skin / eats / breathes / moves

bird — has wings / can fly / has feathers

fish — has fins / can swim / has gills

canary — can sing / is yellow

85

Slide 86

animal — has skin / eats / breathes / moves

bird — has wings / can fly / has feathers

fish — has fins / can swim / has gills

canary — can sing / is yellow

y ostrich — has long thin legs / is tall / can't fly

86

Slide 87

animal — has skin / eats / breathes / moves

bird — has wings / can fly / has feathers

fish — has fins / can swim / has gills

canary — can sing / is yellow

y ostrich — has long thin legs / is tall / can't fly

87

Slide 88

How can ▮▮▮▮-based conceptualizations be transparent, if the world is shaped like this
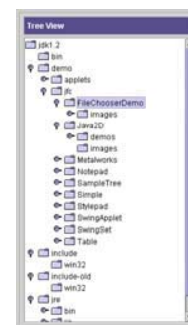
?

88

Slide 89

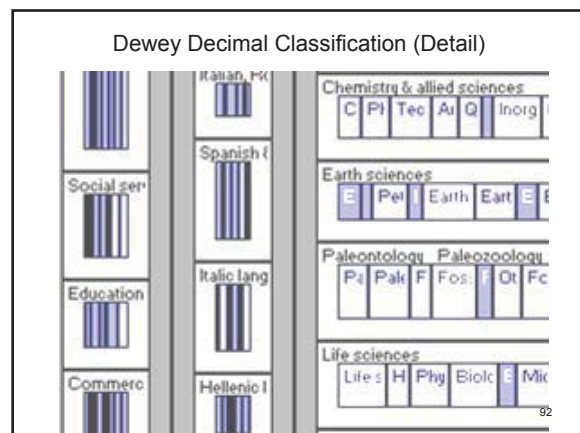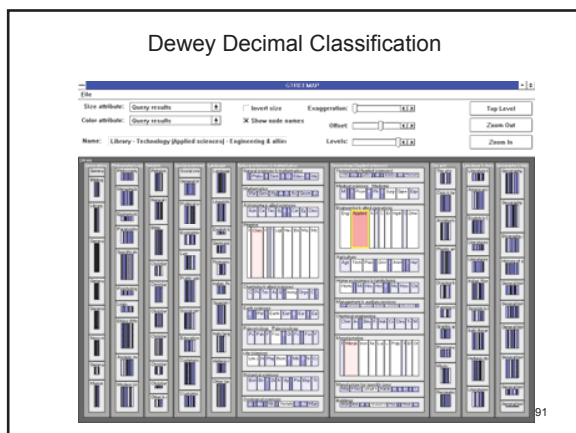# Observe that no such problems arise for the closed worlds constructed in information systems

hierarchies as reasoning tools work very well for the closed worlds of database engineers

89

Slide 90

whether a file is in a given folder on your hard-drive is completely determinate:

Tree View
jdk1.2
  bin
  demo
    applets
    jfc
      FileChooserDemo
      Java2D
        images
        demos
          images
      Metalworks
      Notepad
      SampleTree
      Simple
      Stylepad
      SwingApplet
      SwingSet
      Table
  include
    win32
  include-old
    win32
  jre
    bin

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Dewey Decimal Classification

Dewey Decimal Classification (Detail)

No borderline cases in the closed world of a database

Every book is assigned a determinate Dewey Classification Number at birth

111.560xxx

this yields a classification that is completely *crisp*

... and always up-to-date

To be a book = to have a reference number in the Catalogue System

Each of the ontologies produced by ontological engineers deals with objects which are constructed (Kant would say "constituted") by the database itself

Kant

Sharpness of database reality vs. vagueness of flesh and blood reality

How to deal with the problem of vagueness of our representations?

How to create adequate representations beyond the quasi-Kantian realm of database engineers

Kantian Constructivism

There are no species-genus hierarchies in reality *unless we put them there*

The world – insofar as it is accessible to us through our concepts at all – is a *closed system* tailored by us to fit those concepts

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Kantianism seems to work very well for the closed worlds of database environments

There Midas-touch epistemology is appropriate

If our database recognizes only two genders, then the world represented in the database is a world in which there are only two genders

---

Kantianism: we constitute/shape (empirical) reality in such a way that it corresponds to our categories

Aristotelianism: reality in itself is messy, but our categories fit nonetheless
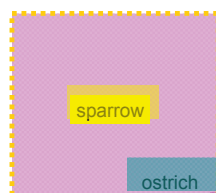

For Aristotelians

when we apply general terms to reality we are aware that we may have to deal with an opposition

... between standard or focal or **prototypical** instances of the corresponding universals
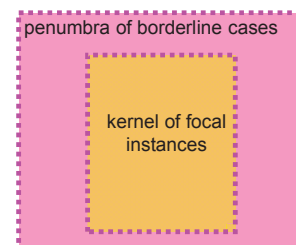
... and non-standard or **'fringe'** instances

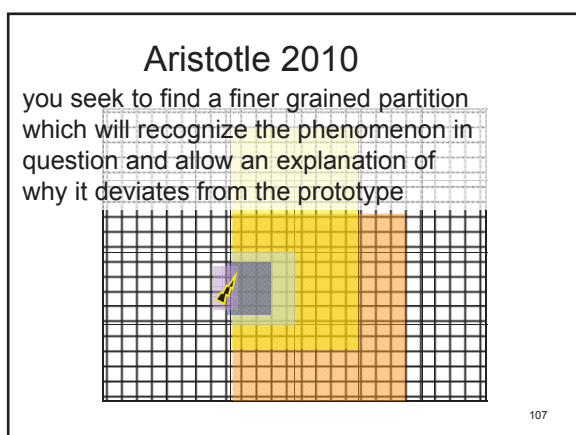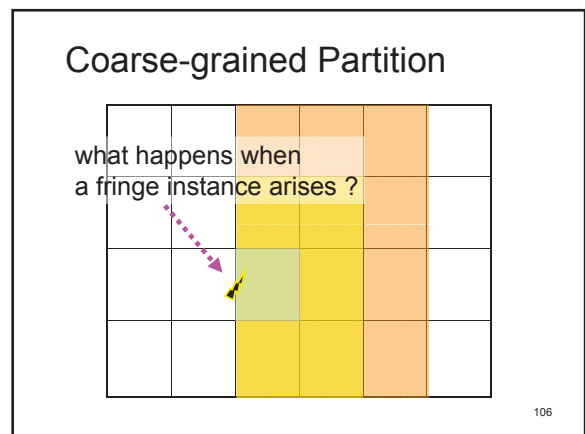
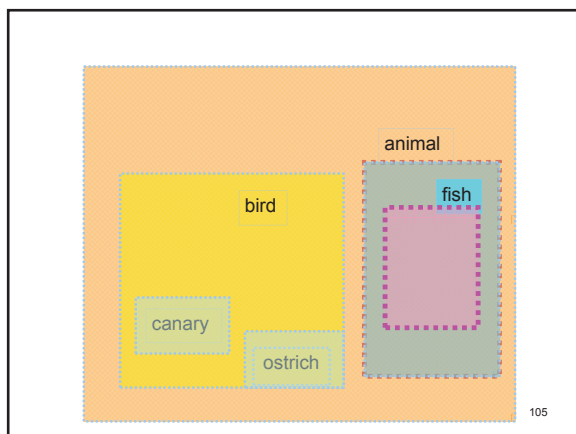Natural categories have *borderline cases*

sparrow

ostrich

birds

... they have a kernel/penumbra structure

penumbra of borderline cases

kernel of focal instances

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Coarse-grained Partition

what happens when
a fringe instance arises ?

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Aristotle 2010

you seek to find a finer grained partition
which will recognize the phenomenon in
question and allow an explanation of
why it deviates from the prototype

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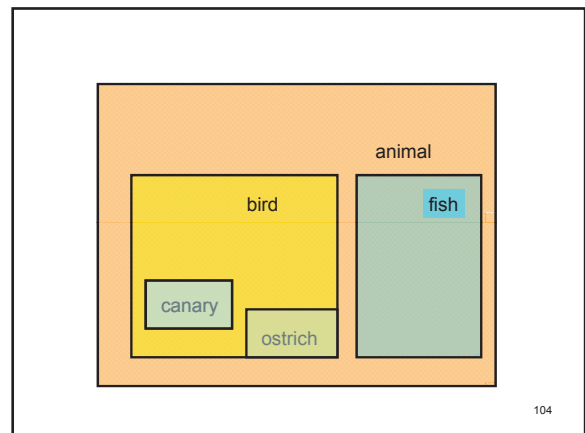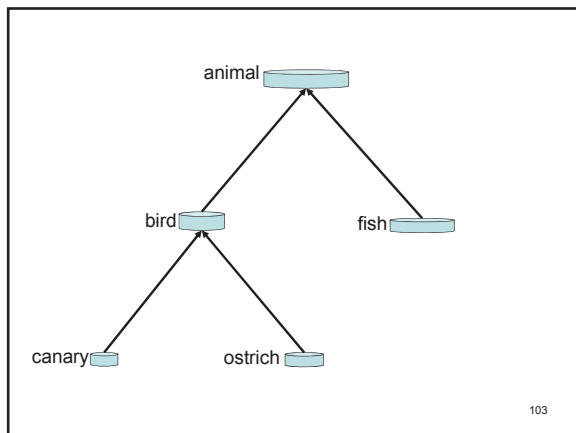
The advance of science

is not an advance away from Aristotle
towards something better.

Provided Aristotle is interpreted aright, it
is a rigorous demonstration of the
correctness of his ontological approach

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