

Analytic Metaphysics

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Lecture 10

April 12, 2016

Organisms and Environments

How to do biology across the genome?

VMVGKKNVKKFLTFVEDEPDFQGGPISKYLIPKKINLMVY
TLFQVHTLKFNRKDYDTLSLFYLNRGYYNELSFRVLER
CHEIASARPNDSSSTMRTFTDFVSGAPIVRSLQKSTIRKY
GYNLAPYMFLLLHVDELSIFSAYQASLPGEKKVDTERL
KRDLCPRKPIEIKYFSQICNDMMNKKDRLGDILHILRAC
ALNFGAGPRGGAGDEEDRSITNEEPIIPSVDEHGLKVC
KLRSPNTPRRLRKTLDVAVKALLVSSCACTARDLDIFDD
NNGVAMWKWIKILYHEVAQETTLKDSYRITLVPSSDGI
SLLAFAGPQRNVYVDDTTRRIQLYTDYNKNGSSEPRLK
TLDGLTSDYVFYFVTVLRQMQICALGNSYDAFNHDPW
MDVVGFEDPNQVTNRDISRIVLYSYMFLNTAKGCLVEY
ATFRQYMREL PKNAPQKLN FREMRQGLIALGRHCVGS
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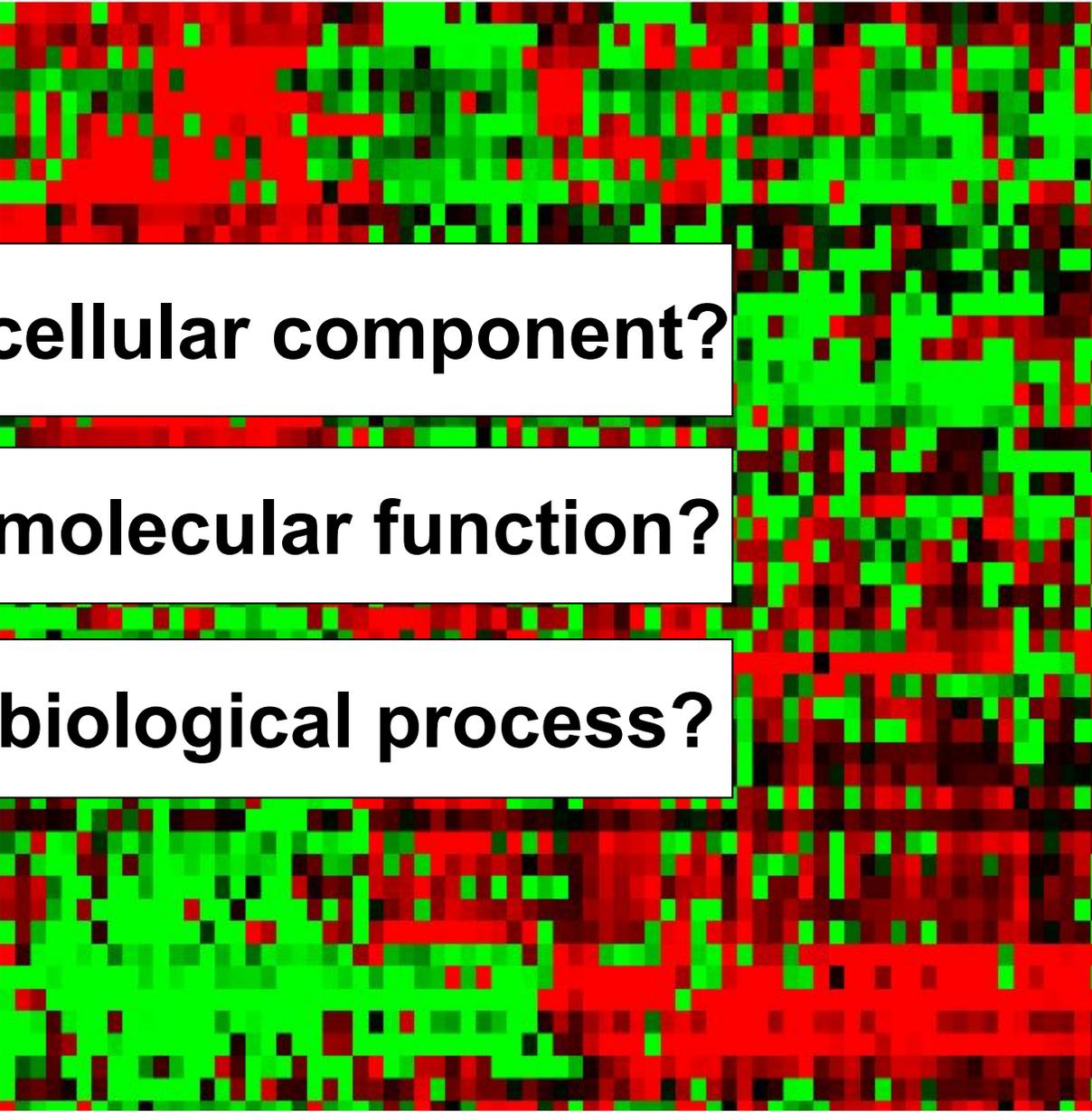
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SLFYLNRYGYYNELSFRVLERCHEIASARPNDSSSTMRTFTDFVSGAPIVRSLQKSTIRKYGYNLAPYM
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RIQLYTDYNKNGSSEPRLKTLTGLTSDYVFYFVTVLRQMICALGNSYDAFNHDPWMDVVGFEDEP
NQVTNRDISRIVLYSYMFLNTAKGCLVEYATFRQYMRELKPNAPQKLNFRMRQGLIALGRHCVGS
RFETDLYESATSELMANHSVQTGRNIYGVDSFSLTSVSGTTATLLQERASERWIQWLGLESYHCS
FSSTRNAEDVVAGEAASSNHHQKISRVRTRKPREPKSTNDILVAGQKLFSSFEFRDLHQLRLCYEI
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NVRTNATTNASTNATTNASTNASTNATTNASTNATTNSSTNATTTASTNVRTSATTTASINVRTSATT
TESTNSSTNATTTESTNSSTNATTTESTNSNTSATTTASINVRTSATTTESTNSSTASATTTASINVRTS
ATTTKSINSSTNATTTESTNSNTNATTTESTNSSTNATTTESTNSSTNATTTESTNSNTSAATTESTN
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LIGLFYNKTRQKLEYLLEQISEVWLLPHWLDLANVEVLAADDTRVPLYMLMVAVHKELDSDDVPDG
RFDILLCRDSSREVGE

The GO idea: through annotation of data

what cellular component?

what molecular function?

what biological process?



GLUL Glutamate-ammonia ligase
HMOX2 Heme oxygenase (decycling)
Ahnak-A Nucleoprotein Ahnak-A
Erythrocyte membrane 50kd glycc
CA2 Carbonic anhydrase II
NFIX Nuclear factor I/X
HOMEBOX PROTEIN HOX-A5
Homeotic Protein C6, Class I
KIAA0246 gene, partial cds
ELA2 Elastatse 2, neutrophil
MPO Myeloperoxidase
CST3 Cystatin C
ARHG Ras homolog, member G (rhc)
ANX1 Annexin I (lipocortin I)
CSF3R
SPI1 integration oncogene
D component of complement
NF-IL6-beta
Ahnak-Related Sequence
MANA2 Alpha mannosidase II isoz
GRO2 oncogene
Homolog suppressor-of-white-apr
CD2 antigen (p50)
Myosin VIIA (USH1B)
SPRR1B Small proline-rich prote
ACTN2 Actinin alpha 2
KIAA0080 gene, partial cds
DTYMK Deoxythymidylate kinase
Carcinoembryonic antigen precur
LTB Lymphotoxin-beta
GATA3 GATA-binding protein 3
GB DEF = Escherichia coli unknc
GUANYLATE CYCLASE, BETA-1
Spinal Muscular Atrophy 4
KIAA0239 gene, partial cds
Butyrophilin (BTF4)
MHC-encoded proteasome LAMP7-E1
RPA1 Replication protein A1
Clone 22 mRNA
CTPS CTP synthetase
UBIQUITIN-LIKE PROTEIN GDX
(AF1q) mRNA
S100 calcium-binding protein A1
BLK Protein-tyrosine kinase blk
IGB (B29)
OBF-1
TCL1
CD19 antigen
Skeletal muscle abundant protei

Benefits of GO

1. rooted in experimental biology
2. links people to data and to literature
3. links data to data (comparability)
 - across species (human, mouse, yeast, fly ...)
 - across granularities (molecule, cell, organ, organism, population)
4. links medicine to biological science
5. serves cumulation of scientific knowledge in algorithmically tractable form

How to extend the GO methodology to other areas of the life sciences?

OBO (Open Biomedical Ontologies)

created 2001 in Ashburner and Lewis

a shared portal for (so far) 60 ontologies

<http://obo.sourceforge.net>

with a common OBO flatfile format

Animal natural history and life history	ADW	protege source
Arabidopsis development	TAIR	arabidopsis development.obo
Arabidopsis gross anatomy	TAIR	po anatomy.obo
Biological imaging methods	FBbi	image.obo
Biological process	GO	gene ontology.obo
BRENDA tissue / enzyme source	BTO	BrendaTissue.obo
C. elegans development	WBls	worm development.obo
C. elegans gross anatomy	[none]	[none]
Cell type	CL	cell.obo
Cellular component	GO	gene ontology.obo
Cereal plant development	GRO	cereals development.obo
Cereal plant gross anatomy	GRO	po anatomy.obo
Cereal plant trait	TO	plant trait.obo
Chemical entities of biological interest	CHEBI	chebi.obo
Dictyostelium discoideum anatomy	DDANAT	dictyostelium anatomy.obo
Drosophila development	FBdv	fly development.obo
Drosophila gross anatomy	FBbt	fly anatomy.obo
Event (INOH pathway ontology)	IEV	event.obo
Evidence codes	ECO	evidence code.obo
eVOC (Expressed Sequence Annotation for Humans)	EV	evoc.obo.tar (v2.7)

In 2004 reform efforts initiated linking GO to other ontologies and data sources via formal relations

GO term: **osteoblast differentiation**
Synonym: **osteoblast cell differentiation**
GO id: **GO:0001649**
Definition: **Processes whereby a relatively unspecialized cell acquires the specialized features of an osteoblast, the mesodermal cell that gives rise to bone.**

id: CL:0000062
name: osteoblast
def: "A bone-forming cell which secretes an extracellular matrix. Hydroxyapatite crystals are then deposited into the matrix to form bone."
is_a: CL:0000055
relationship: develops_from CL:0000008
relationship: develops_from CL:0000375

Osteoblast differentiation: Processes whereby an osteoprogenitor cell or a cranial neural crest cell acquires the specialized features of an osteoblast, a bone-forming cell which secretes extracellular matrix.

GO
+
Cell type
=
New Definition

RELATION TO TIME	CONTINUANT				OCCURRENT
	INDEPENDENT		DEPENDENT		
GRANULARITY					
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	Anatomical Entity (FMA, CARO)	Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)	Biological Process (GO)
CELL AND CELLULAR COMPONENT	Cell (CL)	Cellular Component (FMA, GO)	Cellular Function (GO)		
MOLECULE	Molecule (ChEBI, SO, RnaO, PrO)		Molecular Function (GO)		Molecular Process (GO)

OBO Foundry
<http://obofoundry.org>

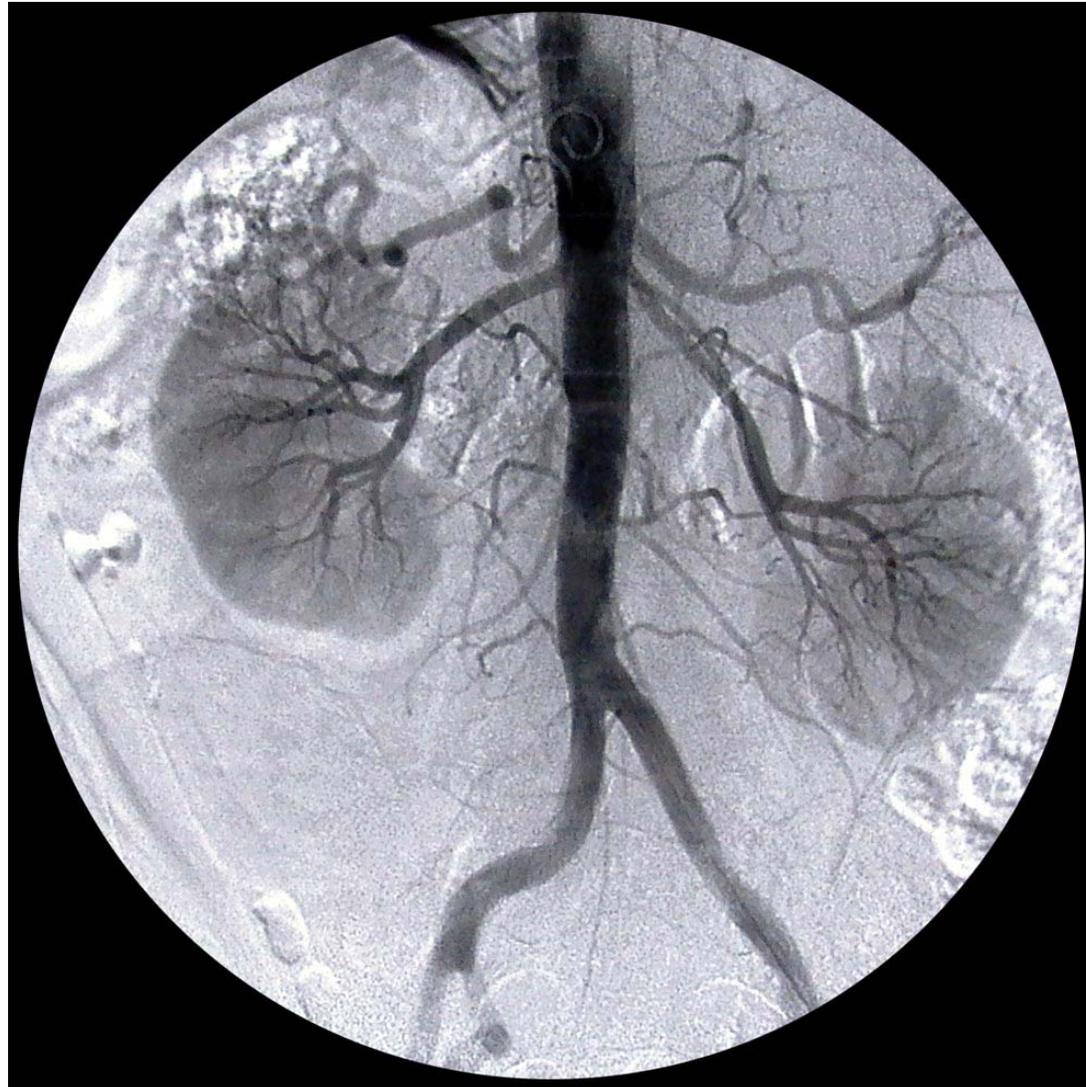
Ontology	Scope	URL	Custodians
Cell Ontology (CL)	cell types from prokaryotes to mammals	obo.sourceforge.net/cgi-bin/detail.cgi?cell	Jonathan Bard, Michael Ashburner, Oliver Hofman
Chemical Entities of Biological Interest (ChEBI)	molecular entities	ebi.ac.uk/chebi	Paula Dematos, Rafael Alcantara
Common Anatomy Reference Ontology (CARO)	anatomical structures in human and model organisms	(under development)	Melissa Haendel, Terry Hayamizu, Cornelius Rosse, David Sutherland,
Foundational Model of Anatomy (FMA)	structure of the human body	fma.biostr.washington.edu	JLV Mejino Jr., Cornelius Rosse
Functional Genomics Investigation Ontology (FuGO)	design, protocol, data instrumentation, and analysis	fugo.sf.net	FuGO Working Group
Gene Ontology (GO)	cellular components, molecular functions, biological processes	www.geneontology.org	Gene Ontology Consortium
Phenotypic Quality Ontology (PaTO)	qualities of anatomical structures	obo.sourceforge.net/cgi-bin/detail.cgi?attribute_and_value	Michael Ashburner, Suzanna Lewis, Georgios Gkoutos
Protein Ontology (PrO)	protein types and modifications	(under development)	Protein Ontology Consortium
Relation Ontology (RO)	relations	obo.sf.net/relationship	Barry Smith, Chris Mungall
RNA Ontology (RnaO)	three-dimensional RNA structures	(under development)	RNA Ontology Consortium
Sequence Ontology (SO)	properties and features of nucleic sequences	song.sf.net	12 Karen Eilbeck

Ontologies are representations of what is general in reality

aka universals, kinds, types, categories, species, genera, ...

instances in reality are linked to universals via the **instance_of** relation

A photographic image is a representation of an instance



The distinction between universals and instances

allows us to provide clear logical definitions of the relations which connect ontology terms

A is_a B =def. every instance of A is an instance of B

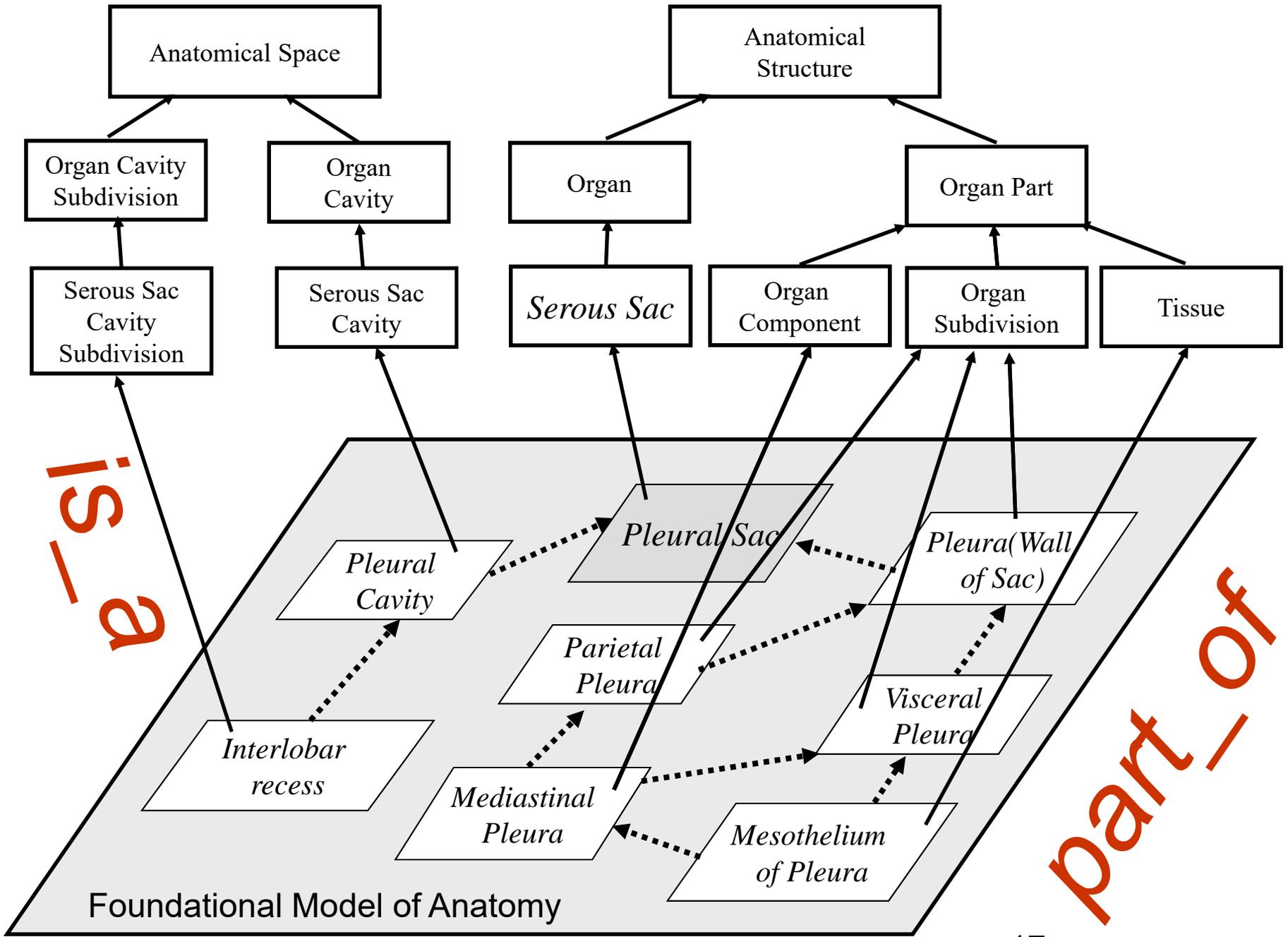
and this holds as a matter of scientific law

part_of

A part_of B =def. every instance of *A* is an **instance-level part** of some instance of *B*

Mary's heart **instance-level part** of Mary

cell nucleus part_of cell



How to do anatomy ontology

Functional: cardiovascular system,
nervous system

Spatial: head, trunk, limb

Developmental: endoderm, germ ring,
lens placode

Structural: tissue, organ, cell

Stage: developmental staging series

OBO Relation Ontology 1.0

<u>Foundational</u>	<i>is_a</i> <i>part_of</i>
<u>Spatial</u>	<i>located_in</i> <i>contained_in</i> <i>adjacent_to</i>
<u>Temporal</u>	<i>transformation_of</i> <i>derives_from</i> <i>preceded_by</i>
<u>Participation</u>	<i>has_participant</i> <i>has_agent</i>

Kinds of relations

<universal, universal>: *is_a, part_of, ...*

<instance, universal>: this cell **instance_of**
the universal *cell*

<instance, instance>: Mary's heart **part_of**
Mary

Foundry principle for definitions

Definitions of terms should be of the following form

an A =def. a B which Cs

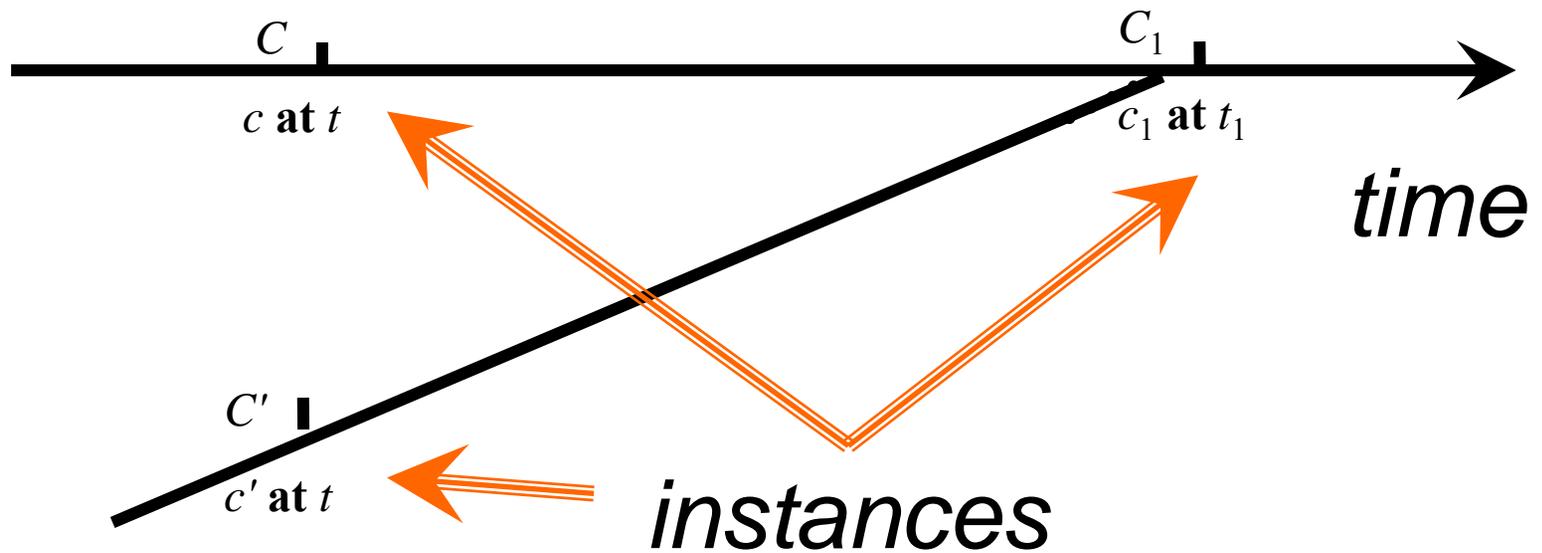
where B is the *is_a* parent of A and C is some differentia

Definitions are rooted in the *is_a* hierarchy

OBO Relation Ontology 1.0

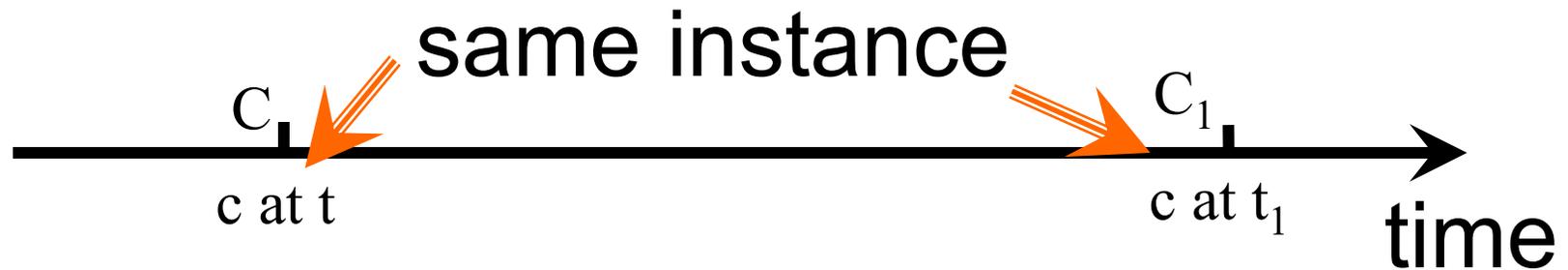
<u>Foundational</u>	<i>is_a</i> <i>part_of</i>
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<u>Temporal</u>	<i>transformation_of</i> <i>derives_from</i> <i>preceded_by</i>
<u>Participation</u>	<i>has_participant</i> <i>has_agent</i>

derives_from



zygote derives_from *ovum*
sperm

transformation_of



pre-RNA → mature RNA

child → adult

pupa → larva

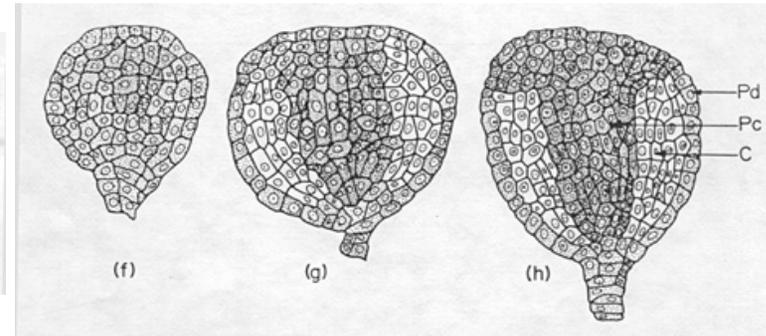
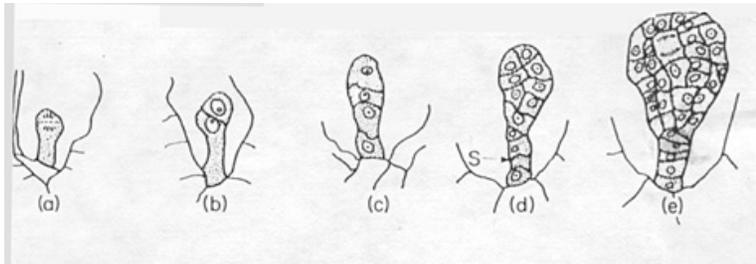
transformation_of

C_2 *transformation_of* C_1 =def. any instance of C_2 was at some earlier time an instance of C_1

fetus *transformation_of* embryo

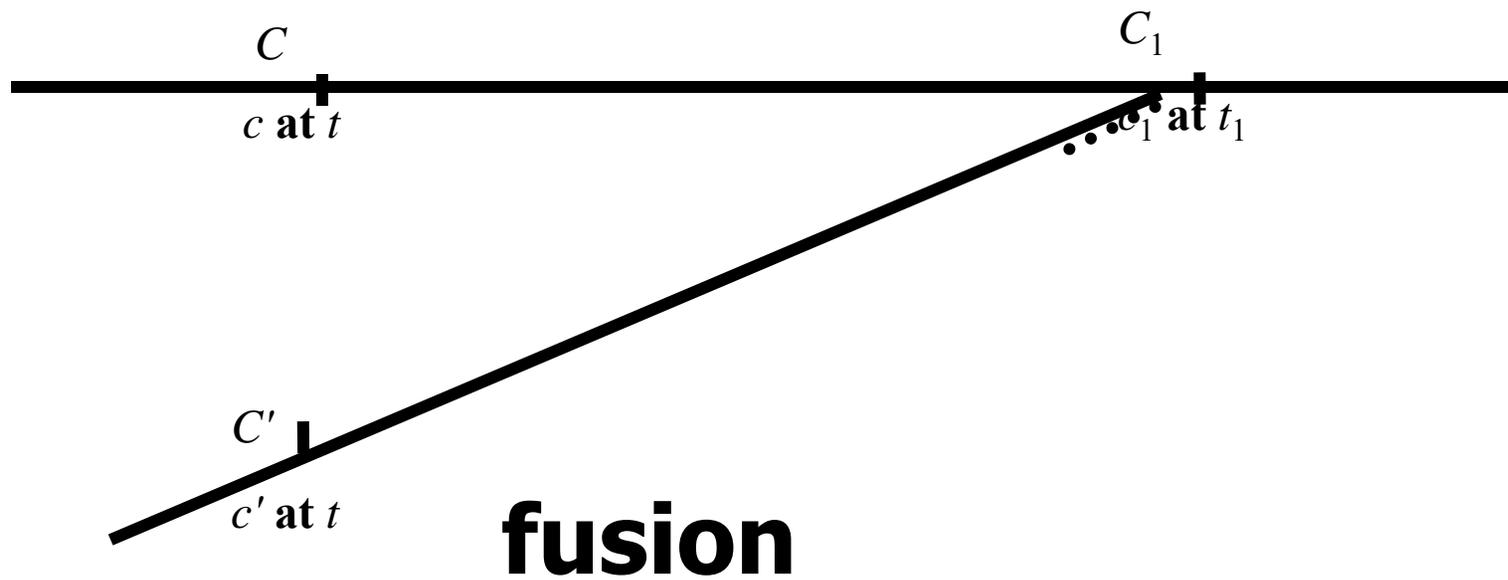
larva *transformation_of* pupa

adult *transformation_of* child

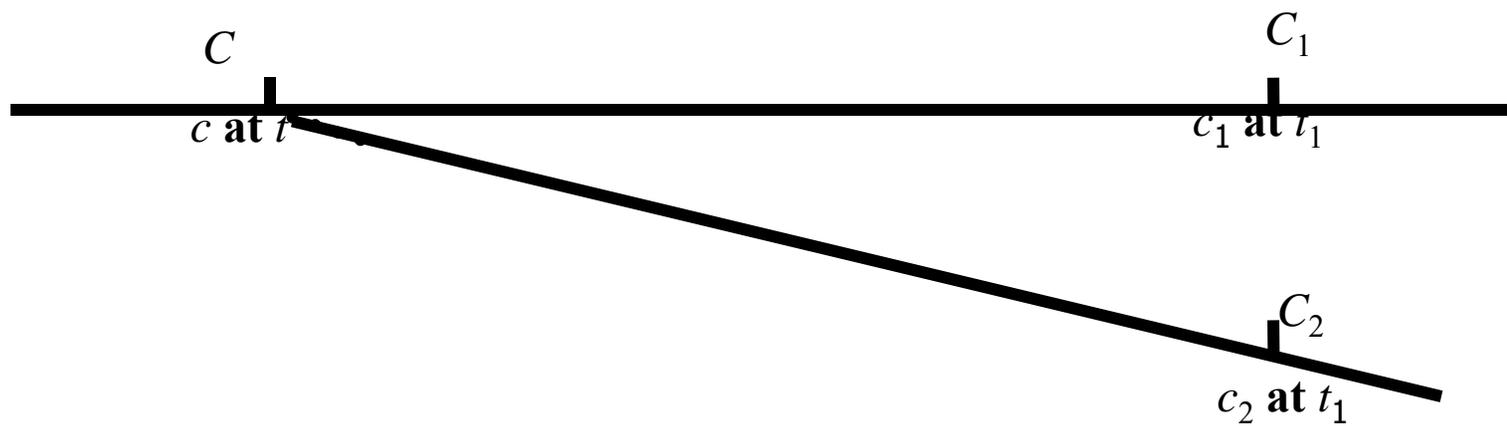


embryological development

two continuants fuse to form a new continuant

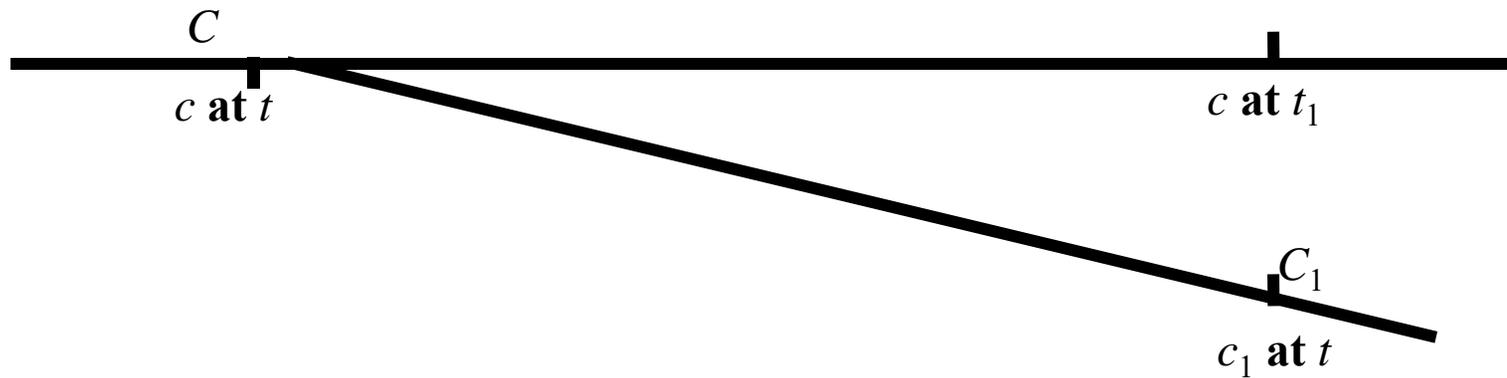


**one initial continuant is replaced by two
successor continuants**



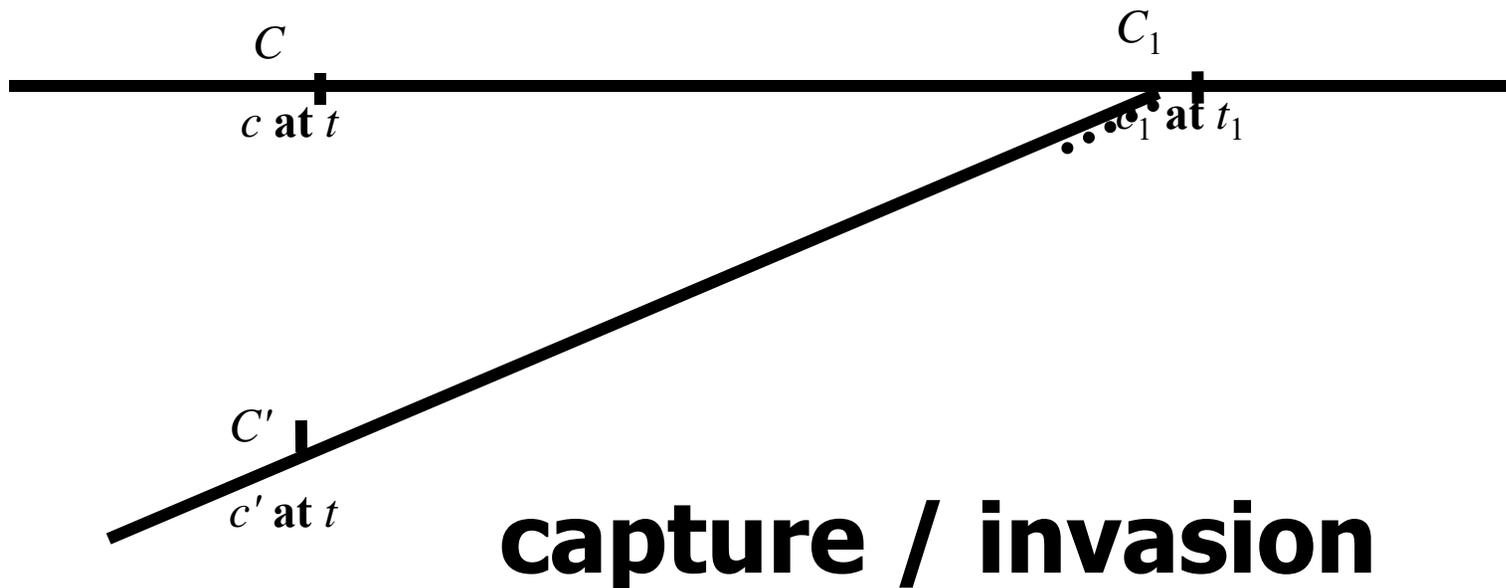
fission

one continuant detaches itself from an initial continuant, which itself continues to exist



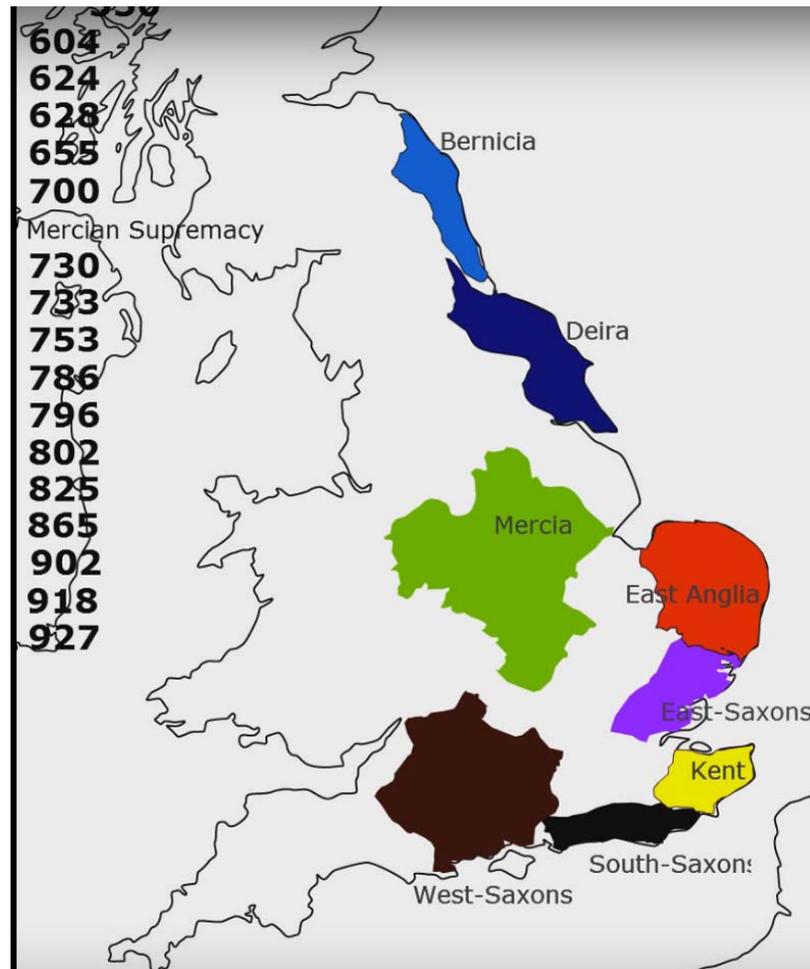
budding

**one continuant is absorbed by
a second continuant**



Not just for organisms

<https://www.youtube.com/watch?v=4eDU543tjoc>



How to understand biological
universals / classes / types ?

Classes vs. Sums

Classes are marked by *granularity*:

they divide up the domain into whole units, whose interior parts are traced over.

The **class** of human beings is instantiated only by human beings as single, whole units.

A **mereological sum** is not granular in this sense (molecules are parts of the mereological sum of human beings)

Sets in the mathematical sense are marked by granularity

Granularity = each class or set is laid across reality like a grid consisting

(1) of a number of slots or pigeonholes
each (2) occupied by some member.

Each set is (1) associated with a specific number of slots, each of which (2) must be occupied by some specific member.

A class survives the turnover in its instances:
both (1) the number of slots and (2) the individuals occupying these slots *may vary with time*

But sets are timeless

A set is an abstract structure, existing outside time and space. The set of human beings existing at t is (timelessly) a different entity from the set of human beings existing at t' because of births and deaths.

Biological classes *exist in time*

Sets are mathematical entities

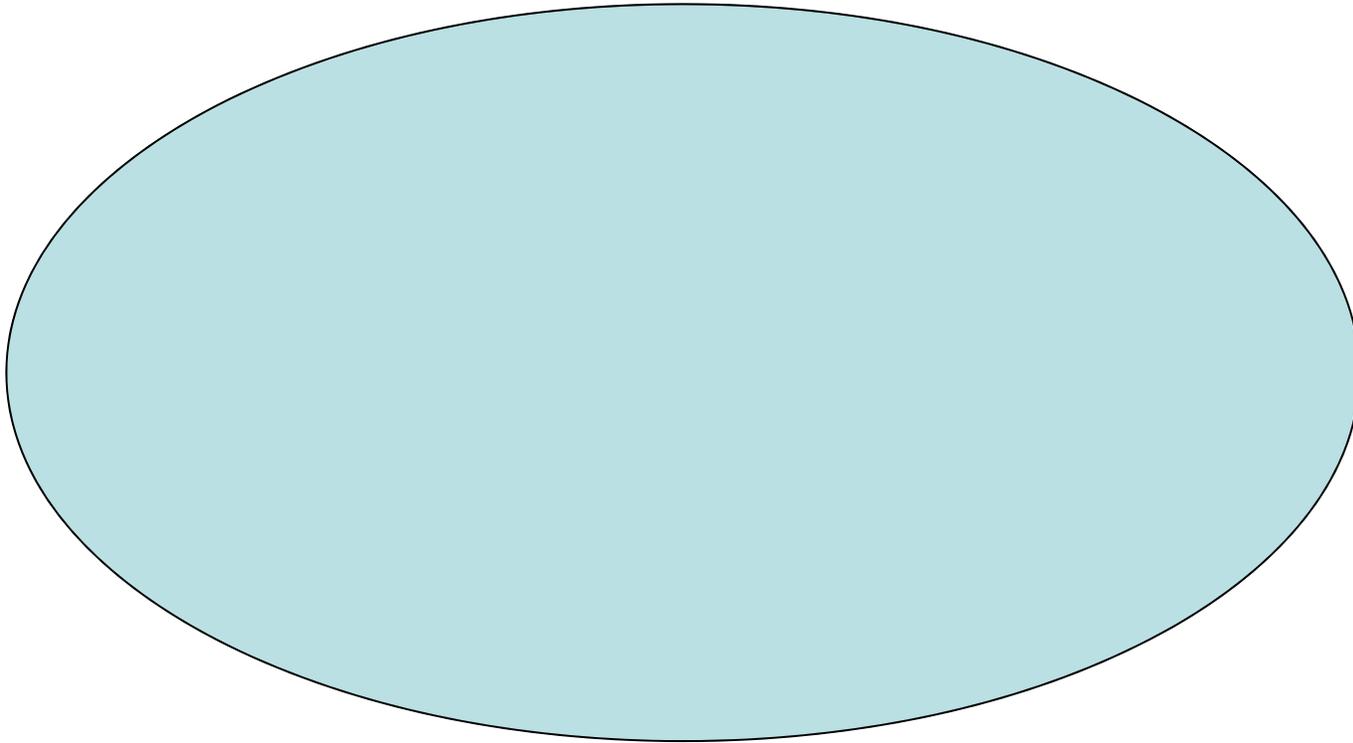
A set with n members has in every case exactly 2^n subsets

The subclasses of a class are limited in number

(which classes are subsumed by a larger class is a matter for empirical science to determine)

Classes reflect a sparse ontology à la David Lewis / David Armstrong

Entities



Entities

universals (classes, types, taxa, ...)

particulars (individuals, tokens, instances ...)

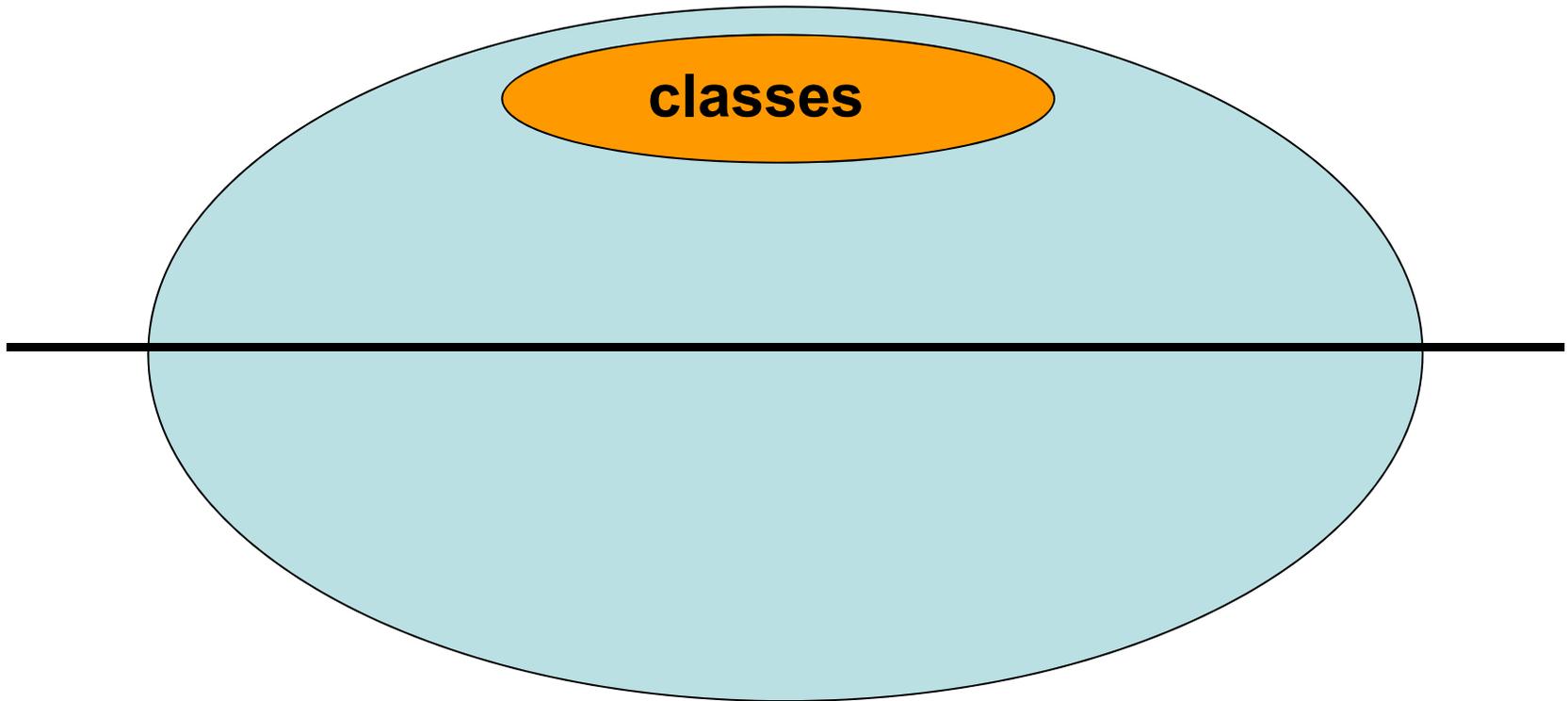
Axiom: Nothing is both a universal and a particular

Two Kinds of Elite Entities

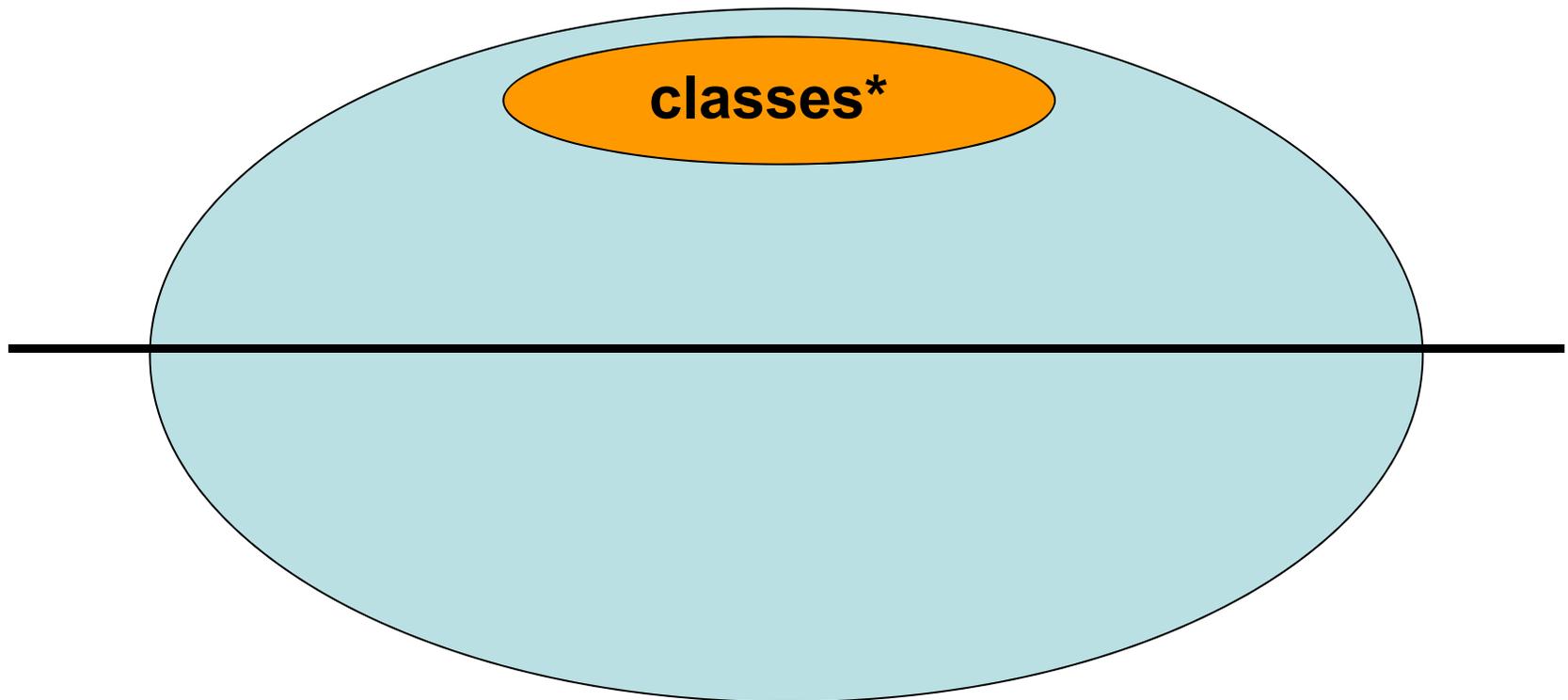
classes, within the realm of universals

instances within the realm of particulars

Entities

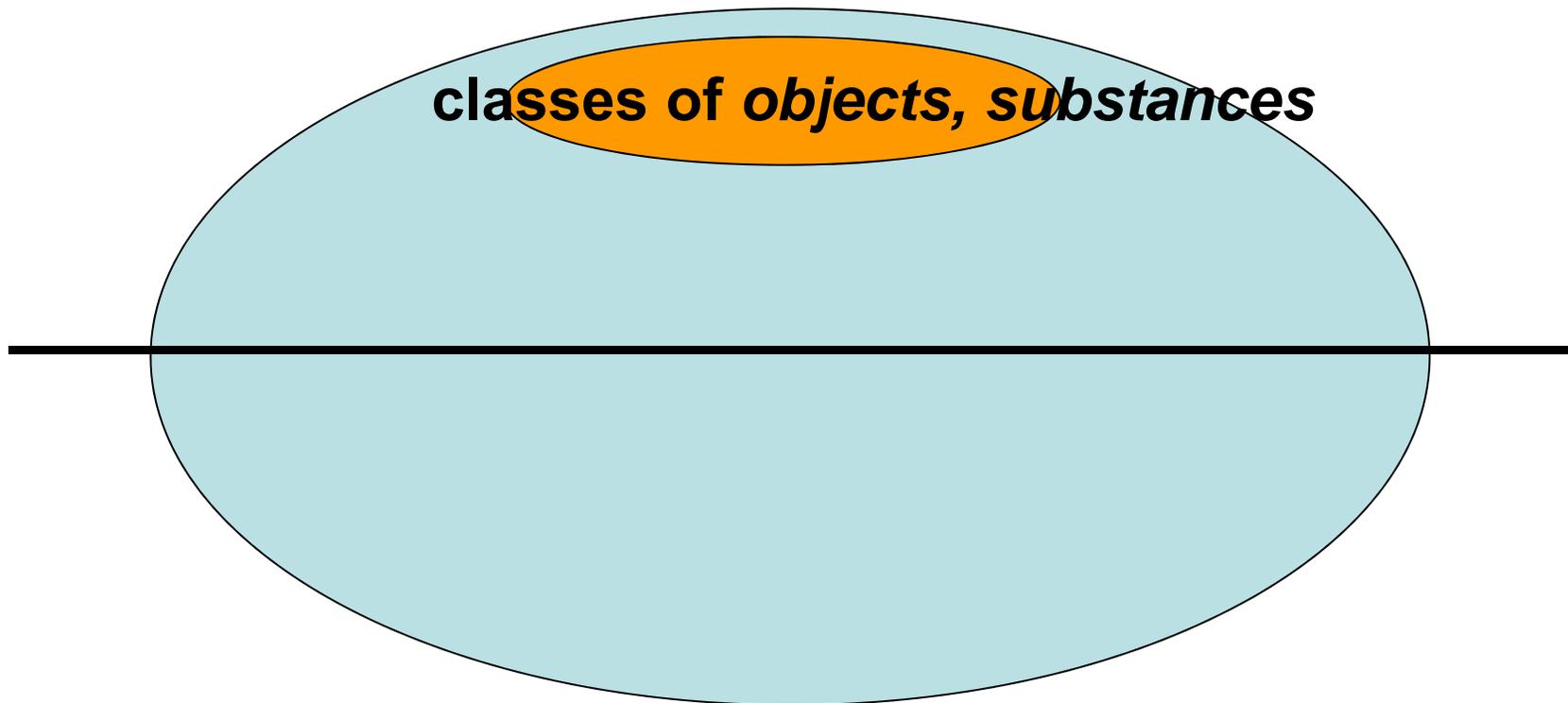


Entities



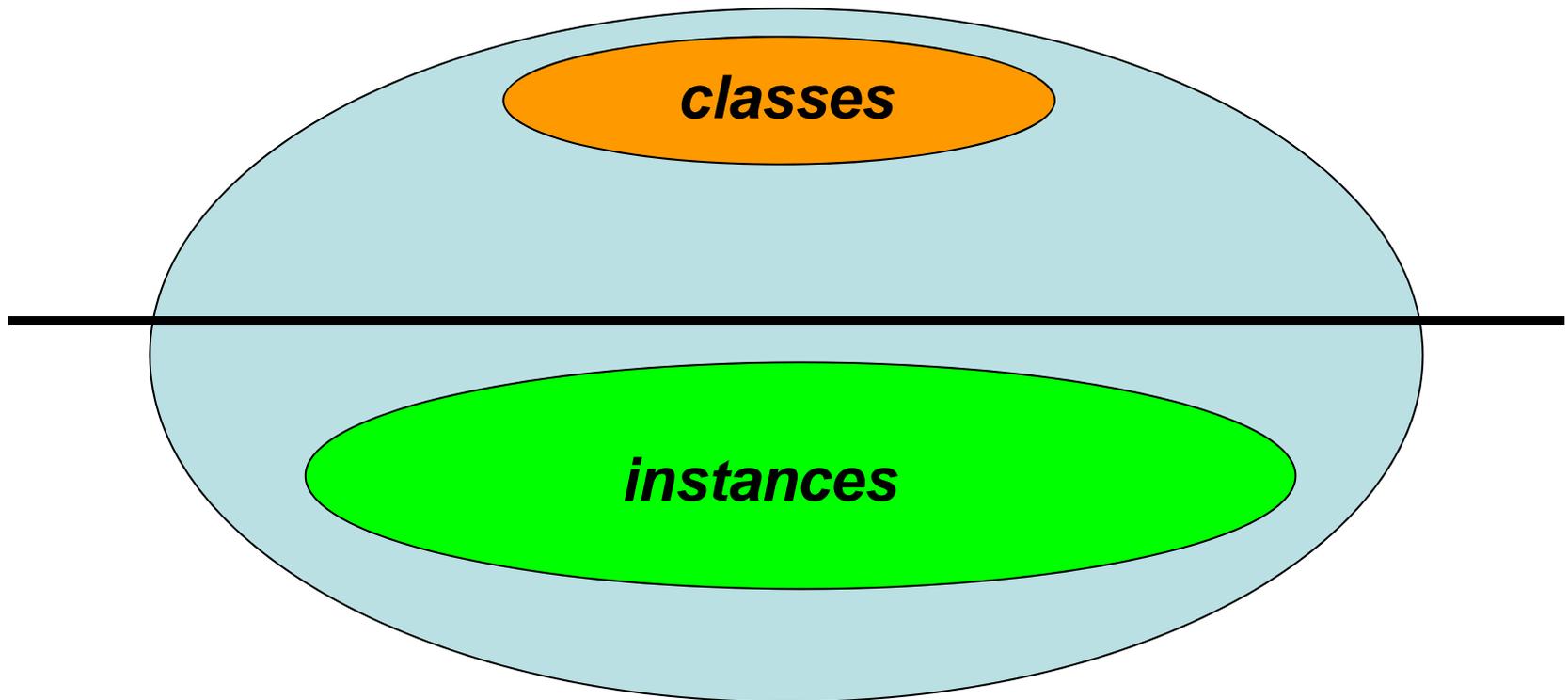
***natural, biological**

Entities



need modified axioms for classes of functions, processes, pathways, reactions, etc.

Entities



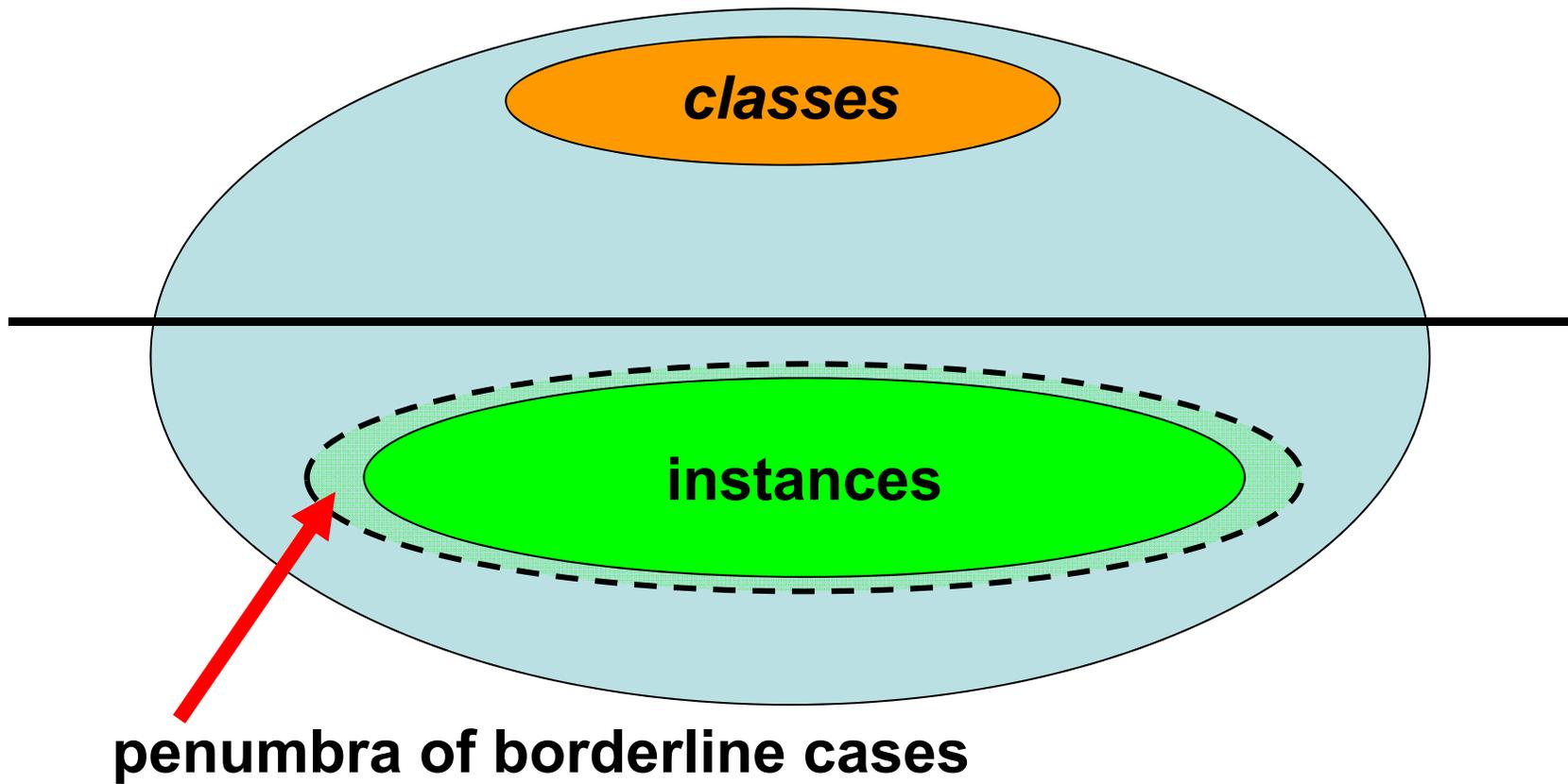
Classes are *natural* kinds

Instances are *natural* exemplars of *natural* kinds

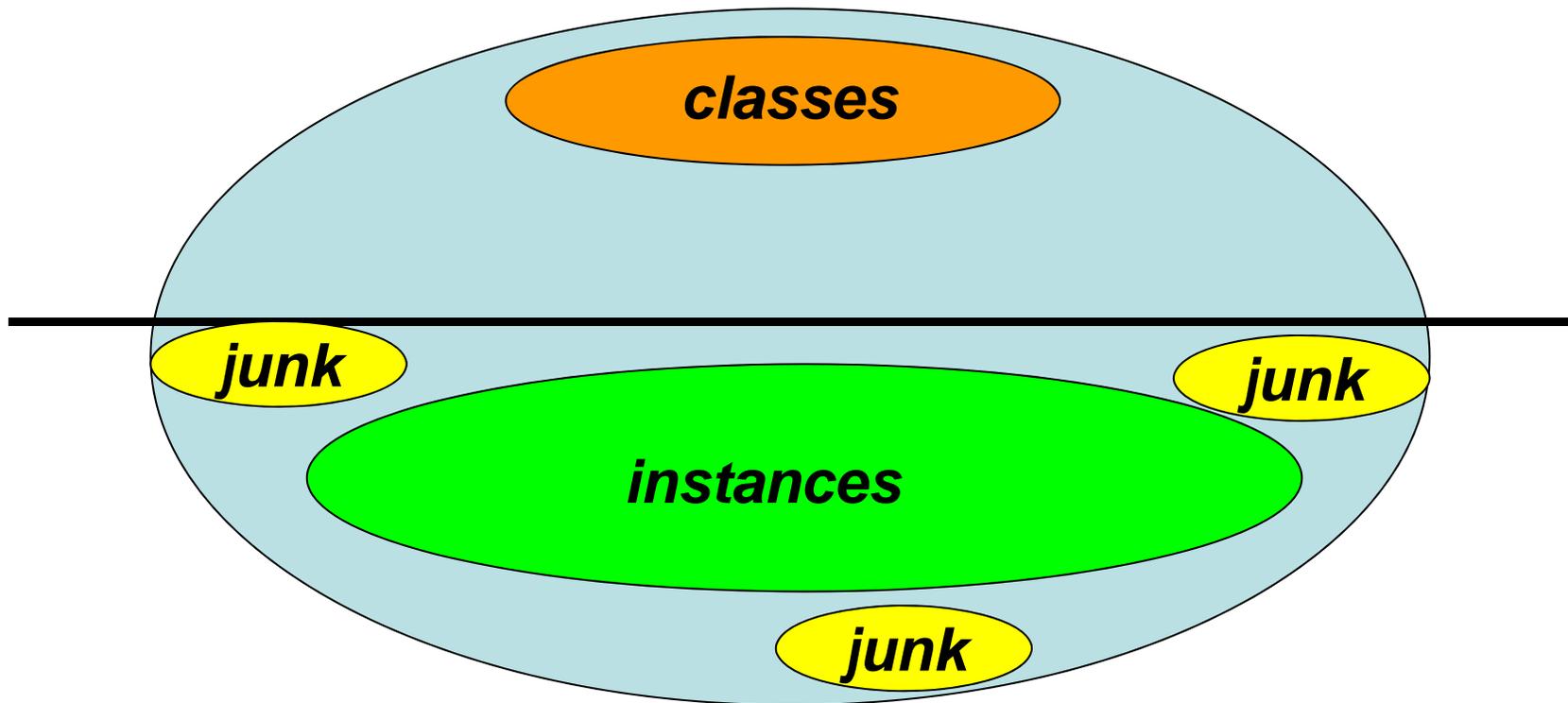
(problem of non-standard instances)

Not all individuals are instances of classes

Entities



Entities



example of junk: beachball-desk

Primitive relations:
inst and *part*

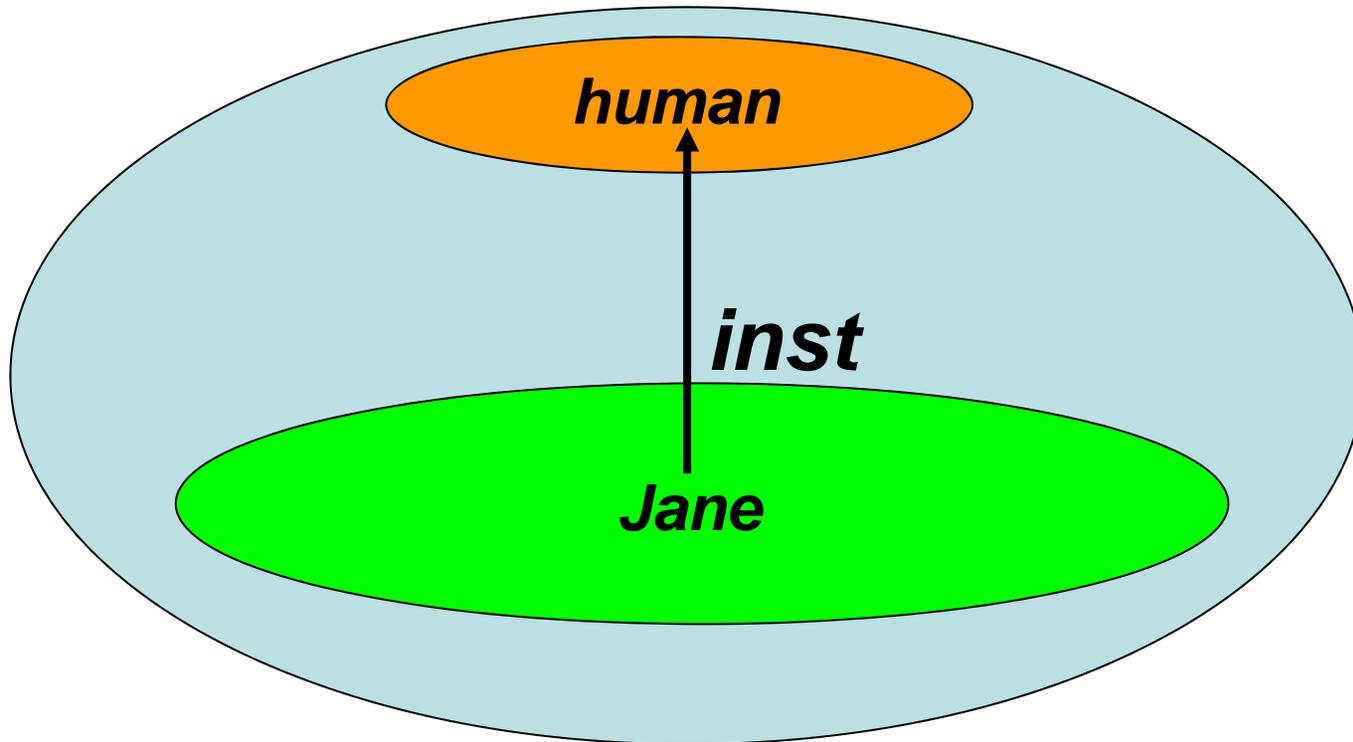
inst(Jane, human being)

part(Jane's heart, Jane's body)

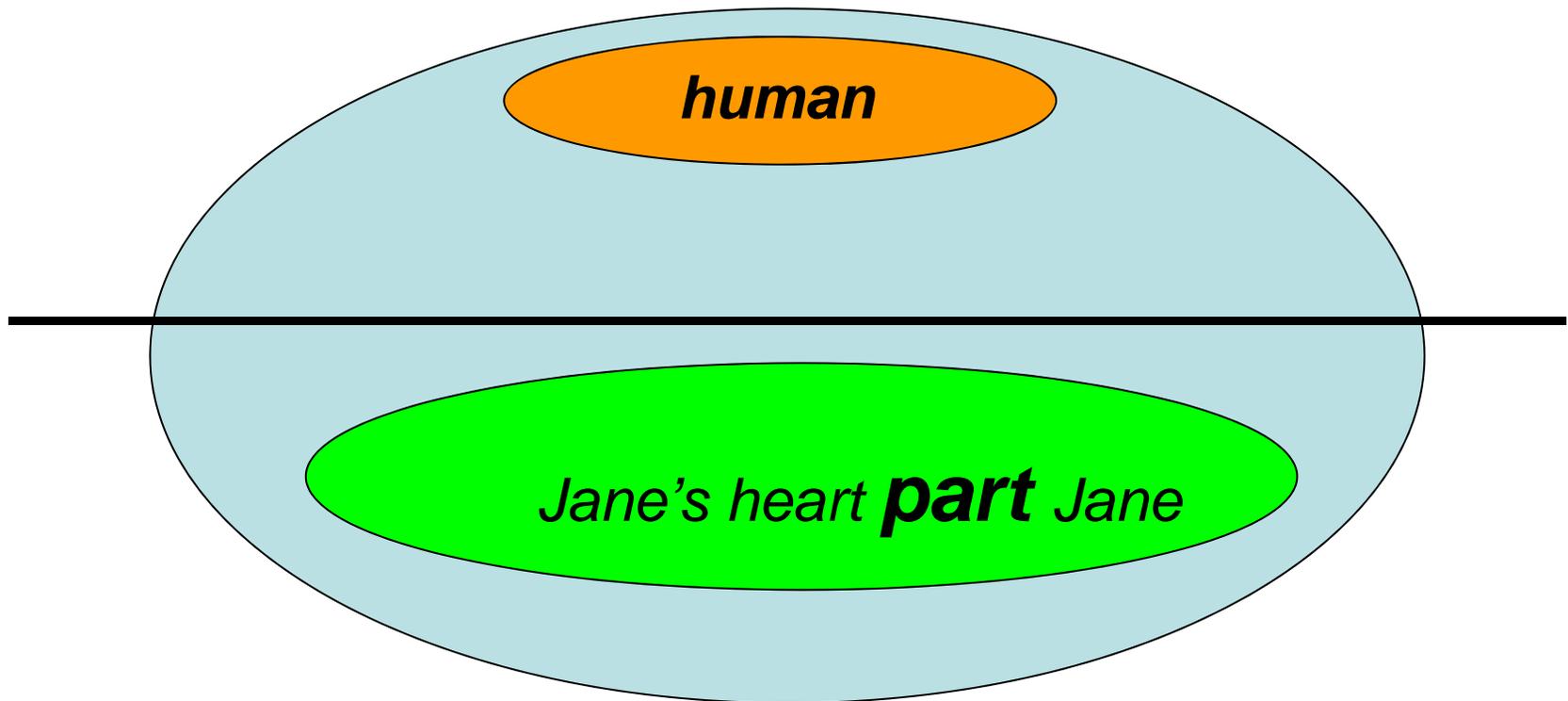
A class is anything that is instantiated

An instance is anything (any individual) that
instantiates some class

Entities



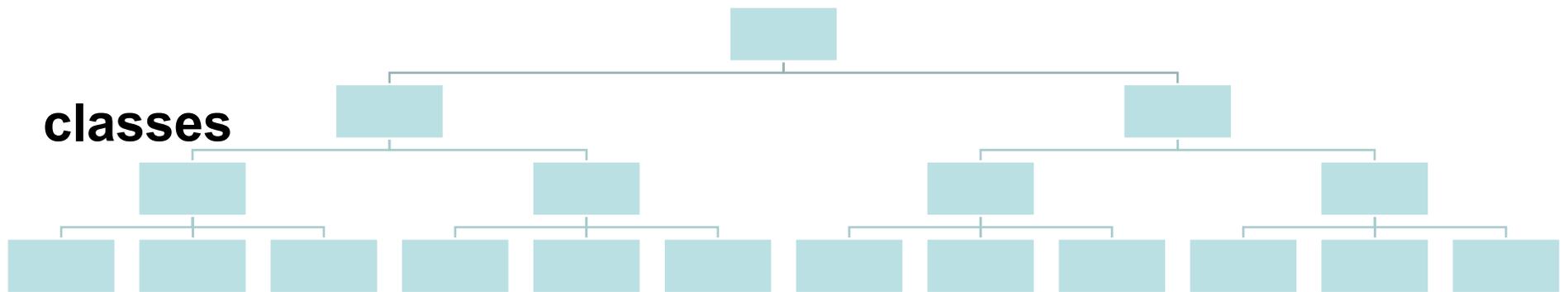
Entities



*part as a relation between
individuals*

subject to the **usual axioms of
mereology**

A is_a B
genus(A)
species(A)



... instances

is-a

D3* $e \text{ is a } f = \text{def } \text{class}(e) \wedge \text{class}(f) \wedge \forall x$
 $(\textit{inst}(x, e) \rightarrow \textit{inst}(x, f)).$

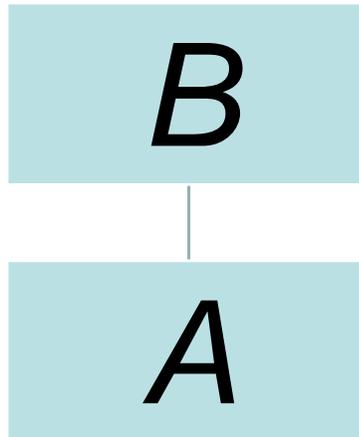
$\text{genus}(A) = \text{def } \text{class}(A) \wedge \exists B (B \text{ is a } A \wedge B \neq$
 $A)$

$\text{species}(A) = \text{def } \text{class}(A) \wedge \exists B (A \text{ is a } B \wedge B \neq$
 $A)$

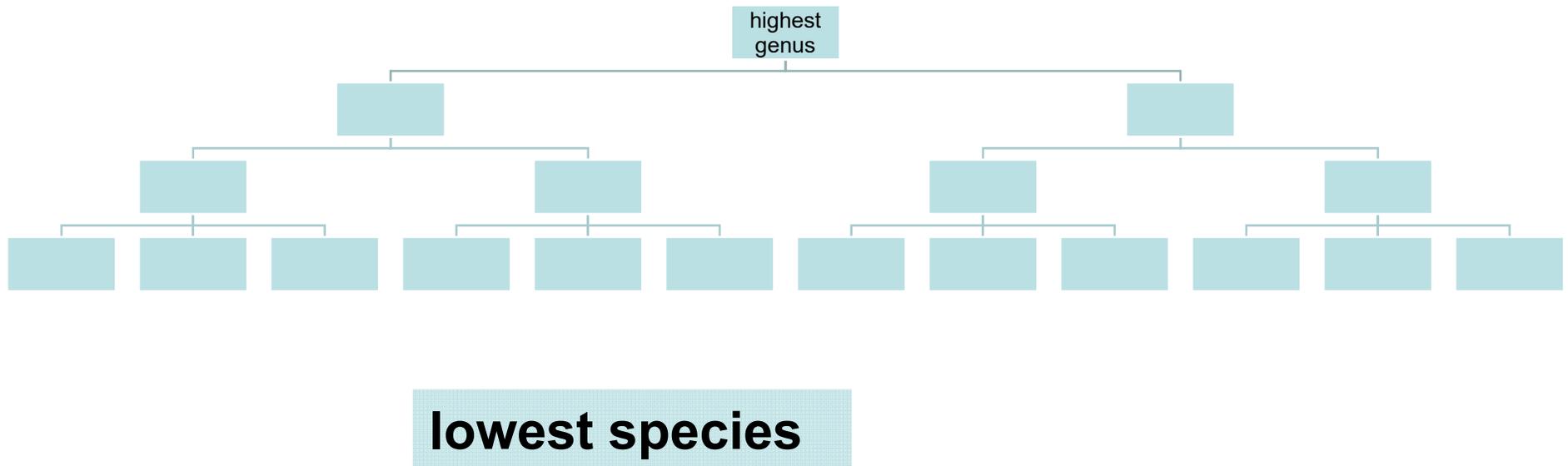
nearest species

$\text{nearestspecies}(A, B) =_{\text{def}} A \text{ is_a } B \ \&$

$\forall C ((A \text{ is_a } C \ \& \ C \text{ is_a } B) \rightarrow (C = A \text{ or } C = B))$



Definitions



... instances

Lowest Species and Highest Genus

$\text{lowestspecies}(A) =_{\text{def}}$
 $\text{species}(A) \ \& \ \text{not-genus}(A)$

$\text{highestgenus}(A) =_{\text{def}}$
 $\text{genus}(A) \ \& \ \text{not-species}(A)$

Theorem:

$\text{class}(A) \rightarrow (\text{genus}(A) \ \text{or} \ \text{lowestspecies}(A))$

Axioms

Every class has at least one instance

Distinct lowest species never share instances

SINGLE INHERITANCE:

Every species is the nearest species to exactly one genus

Axioms governing *inst*

$\text{genus}(A) \ \& \ \text{inst}(x, A) \rightarrow$

$\exists B \text{ nearestspecies}(B, A) \ \& \ \text{inst}(x, B)$

EVERY GENUS HAS AN INSTANTIATED SPECIES

$\text{nearestspecies}(A, B) \rightarrow A$'s instances are properly included in B 's instances

EACH SPECIES HAS A SMALLER CLASS OF INSTANCES THAN ITS GENUS

Axioms

nearestspecies(B, A)

$\rightarrow \exists C$ (nearestspecies(C, A) & $B \neq C$)

EVERY GENUS HAS AT LEAST TWO CHILDREN

nearestspecies(B, A) & nearestspecies(C, A) & $B \neq C$ \rightarrow not- $\exists x$ (inst(x, B) & inst(x, C))

SPECIES OF A COMMON GENUS NEVER SHARE INSTANCES

Theorems

$(\text{genus}(A) \ \& \ \text{inst}(x, A)) \rightarrow \exists B (\text{lowestspecies}(B) \ \& \ B \text{ is_a } A \ \& \ \text{inst}(x, B))$

EVERY INSTANCE IS ALSO AN INSTANCE OF SOME LOWEST SPECIES

$(\text{genus}(A) \ \& \ \text{lowestspecies}(B) \ \& \ \exists x(\text{inst}(x, A) \ \& \ \text{inst}(x, B))) \rightarrow B \text{ is_a } A$

IF AN INSTANCE OF A LOWEST SPECIES IS AN INSTANCE OF A GENUS THEN THE LOWEST SPECIES IS A CHILD OF THE GENUS

Theorems

$\text{class}(A) \ \& \ \text{class}(B) \rightarrow (A = B \text{ or } A \text{ is_a } B \text{ or } B \text{ is_a } A \text{ or not-}\exists x(\text{inst}(x, A) \ \& \ \text{inst}(x, B)))$

**DISTINCT CLASSES EITHER STAND IN
A PARENT-CHILD RELATIONSHIP OR
THEY HAVE NO INSTANCES IN
COMMON**

Finiteness Axiom

To prove further interesting theorems we need to add an axiom to the effect that the universe is finite

Theorems

A is_a B & A is_a C

→ (B = C or B is_a C or C is_a B)

**CLASSES WHICH SHARE A CHILD IN
COMMON ARE EITHER IDENTICAL OR
ONE IS SUBORDINATED TO THE
OTHER**

Theorems

$(\text{genus}(A) \ \& \ \text{genus}(B) \ \& \ \exists x(\text{inst}(x, A) \ \& \ \text{inst}(x, B))) \rightarrow \exists C(C \text{ is_a } A \ \& \ C \text{ is_a } B)$

**IF TWO GENERA HAVE A COMMON
INSTANCE THEN THEY HAVE A
COMMON CHILD**

Model

P = any finite set.

I = any non-empty proper subset of P

C = any non-empty subset of $\wp(I)$ with the following properties:

i) $\emptyset \notin C$

ii) $\cup C = I$

iii) if $X, Y \in C$ and $X \cap Y \neq \emptyset$, then $X \subseteq Y$ or $Y \subseteq X$

iv) if $X \in C$, then there is some $Y \in C$ such that either $X \subset Y$ or $Y \subset X$

v) if $X, Y \in C$ and $X \subset Y$, then there are $Z_1, \dots, Z_n \in C$ disjoint from X such that $X \cup Z_1 \cup \dots \cup Z_n = Y$.

Model

Particulars = the members of P

Classes = the members of C

Instantiation = set-membership relation.

Instances = members of I

A highest genus is a member of C that is not a proper subset of any member of C and a lowest species is a member of C that is not a proper superset of any member of C.

Because I is finite, there must be at least one highest genus and more than one (but only finitely many) lowest species.

Temporalize the Model

P = a sequence P_1, P_2, \dots, P_k of finite sets, such that P_i, P_{i+1} have members in common

I = a sequence I_1, I_2, \dots, I_k of non-empty proper subsets of P_1, P_2, \dots, P_k such that I_i, I_{i+1} have members in common

C = a sequence C_1, C_2, \dots, C_k of non-empty subsets of $\wp(I_1), \wp(I_2), \dots, \wp(I_k)$

What is a function?

Millikan: function = that disposition of an organism part in you whose exercise on behalf of your ancestors was responsible for the fact that you exist

Simple forward-looking view: function = that disposition of an organism part in you whose exercise is beneficial to your existence/survival

Canonical anatomy and canonical physiology

development

growth

physiology

aging

death

What is a function

Refined forward-looking view: function = that disposition of an organism part in you whose exercise is such as to contribute to a canonical life-plan

The Logic of Biological Classification

Barry Smith

<http://ontologist.com>

How to understand biological classes?

Classes are not concepts but universals *in re*

Class hierarchies reflect invariants in reality
(cf. the Periodic Table of the Elements)

Classes vs. Sums

Classes are marked by *granularity*:

they divide up the domain into whole units, whose interior parts are traced over.

The **class** of human beings is instantiated only by human beings as single, whole units.

A **mereological sum** is not granular in this sense (molecules are parts of the mereological sum of human beings)

Sets in the mathematical sense are also marked by granularity

Granularity = each class or set is laid across reality like a grid consisting

(1) of a number of slots or pigeonholes
each (2) occupied by some member.

Each set is (1) associated with a specific number of slots, each of which (2) must be occupied by some specific member.

A class survives the turnover in its instances:
both (1) the number of slots and (2) the individuals occupying these slots *may vary with time*

But sets are timeless

A set is an abstract structure, existing outside time and space. The set of human beings existing at t is (timelessly) a different entity from the set of human beings existing at t' because of births and deaths.

Biological classes *exist in time*

Sets are mathematical entities

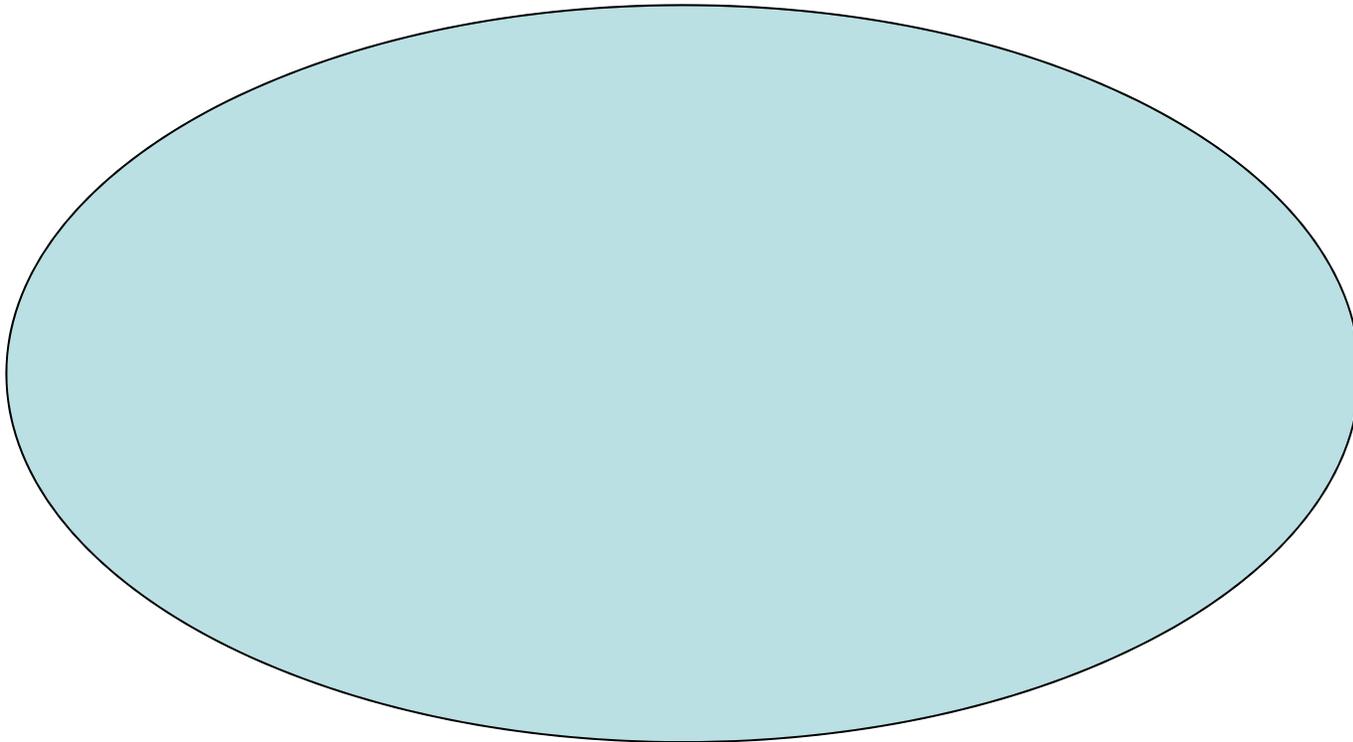
A set with n members has in every case exactly 2^n subsets

The subclasses of a class are limited in number

(which classes are subsumed by a larger class is a matter for empirical science to determine)

Classes reflect a sparse ontology à la David Lewis / David Armstrong

Entities



Entities

universals (classes, types, taxa, ...)

particulars (individuals, tokens, instances ...)

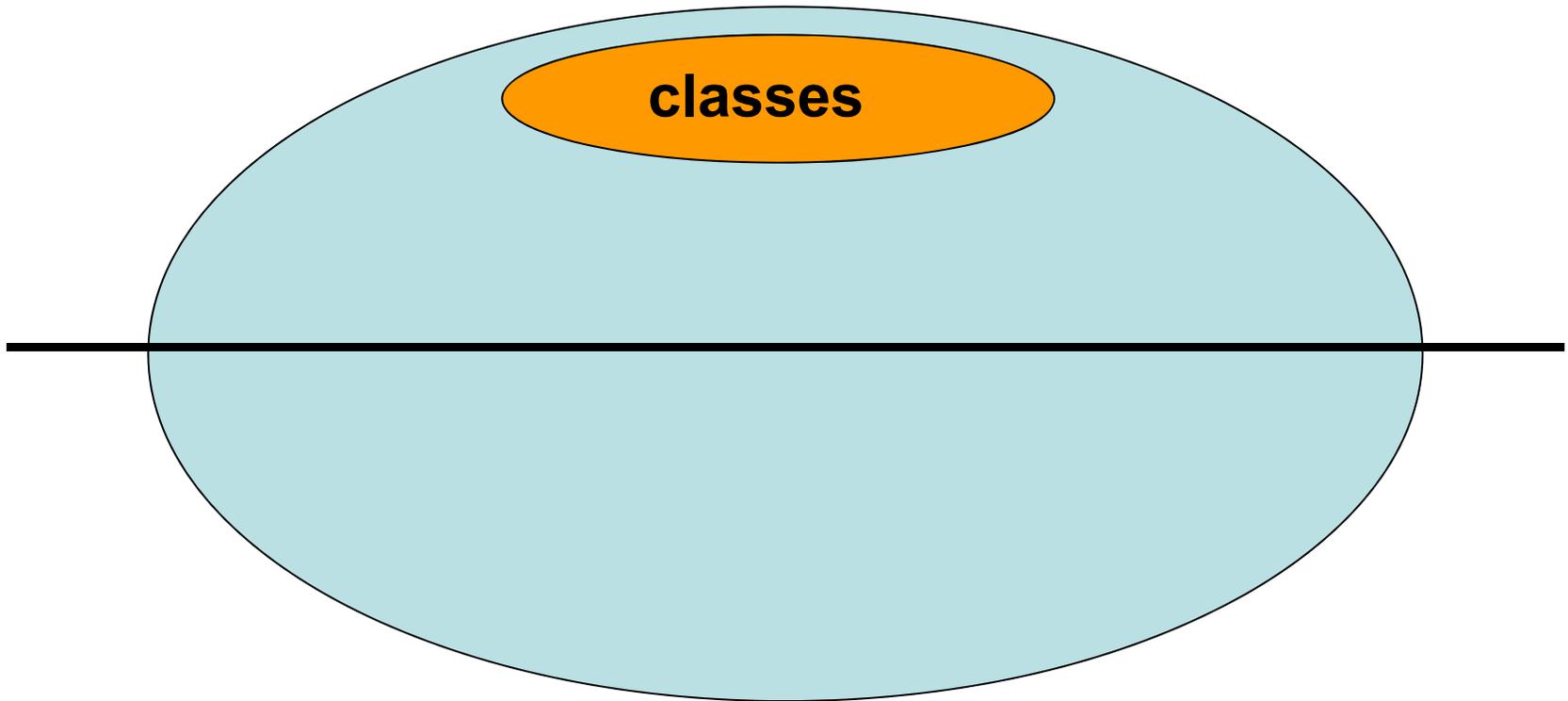
Axiom: Nothing is both a universal and a particular

Two Kinds of Elite Entities

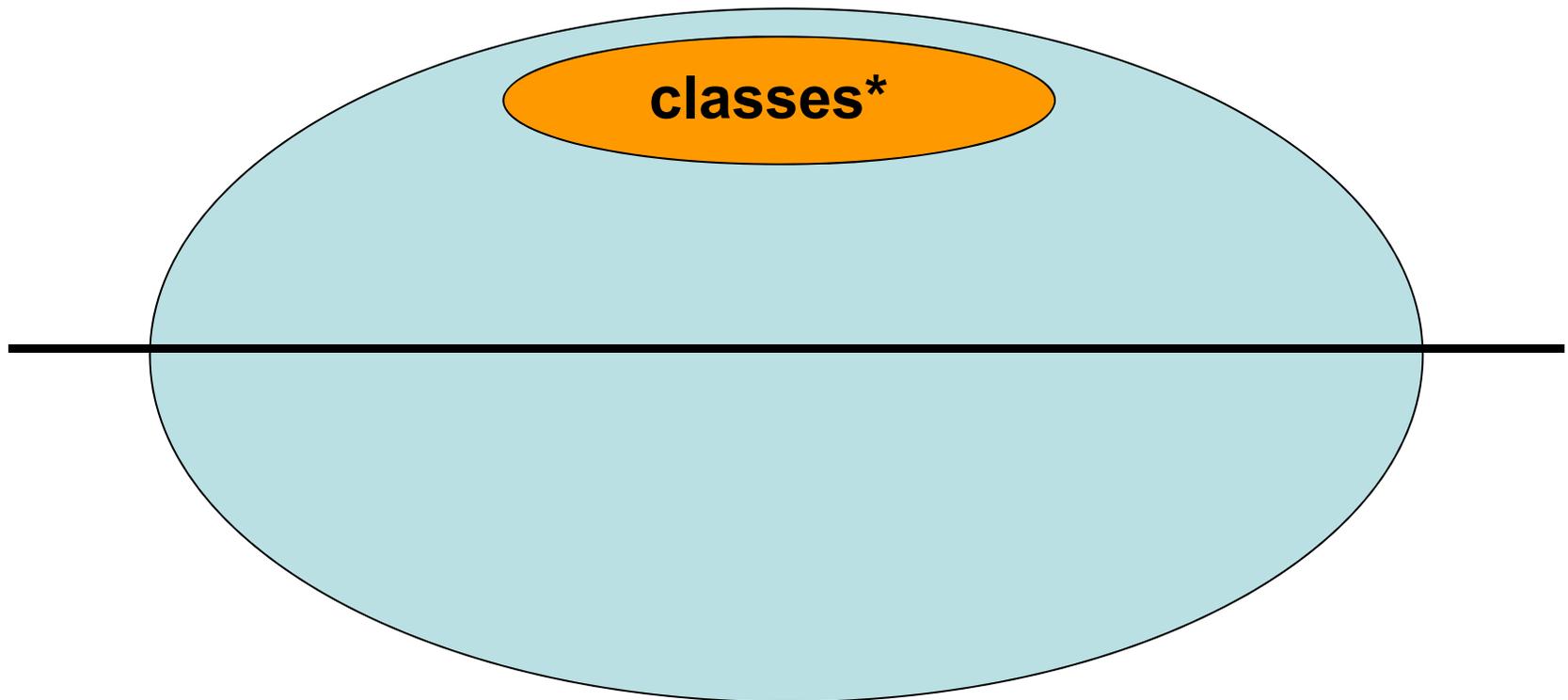
classes, within the realm of universals

instances within the realm of particulars

Entities

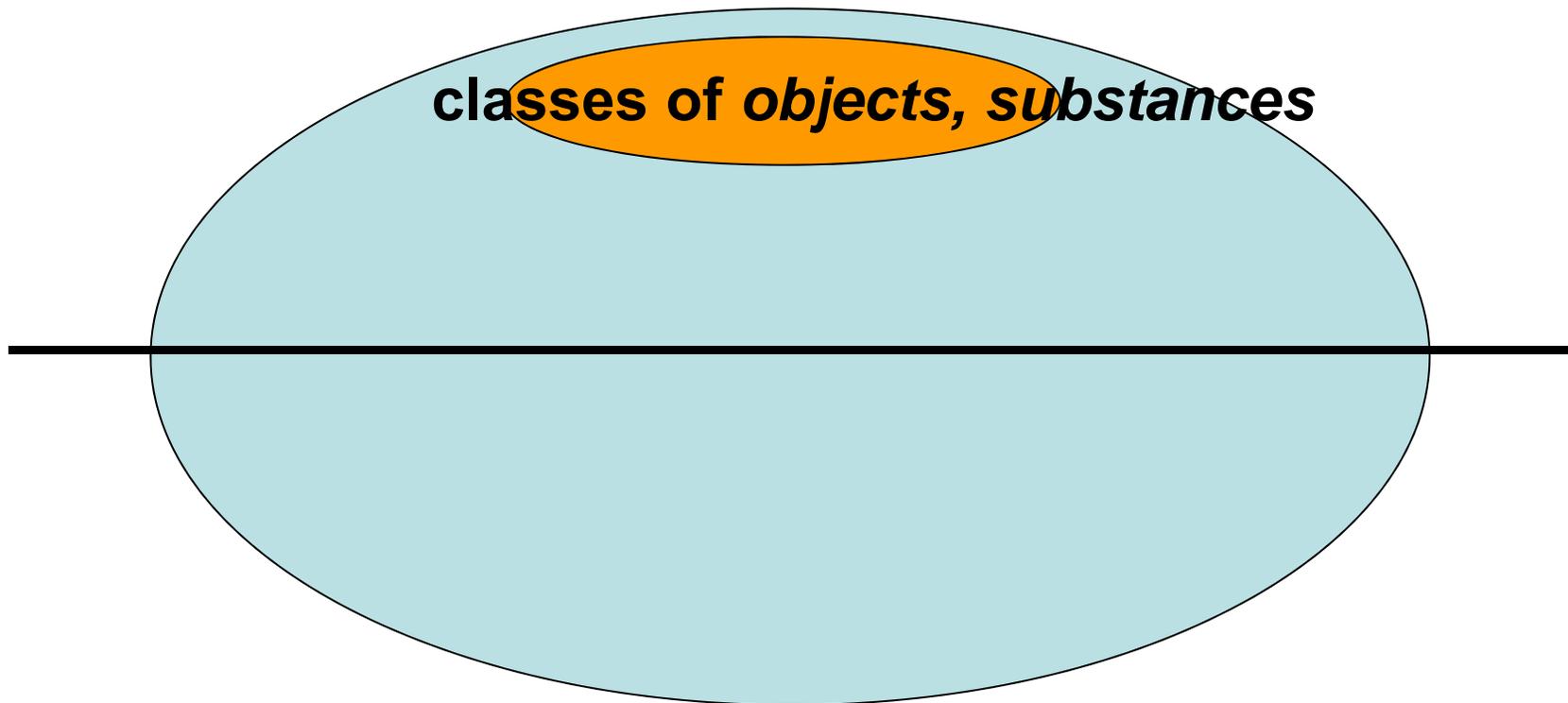


Entities



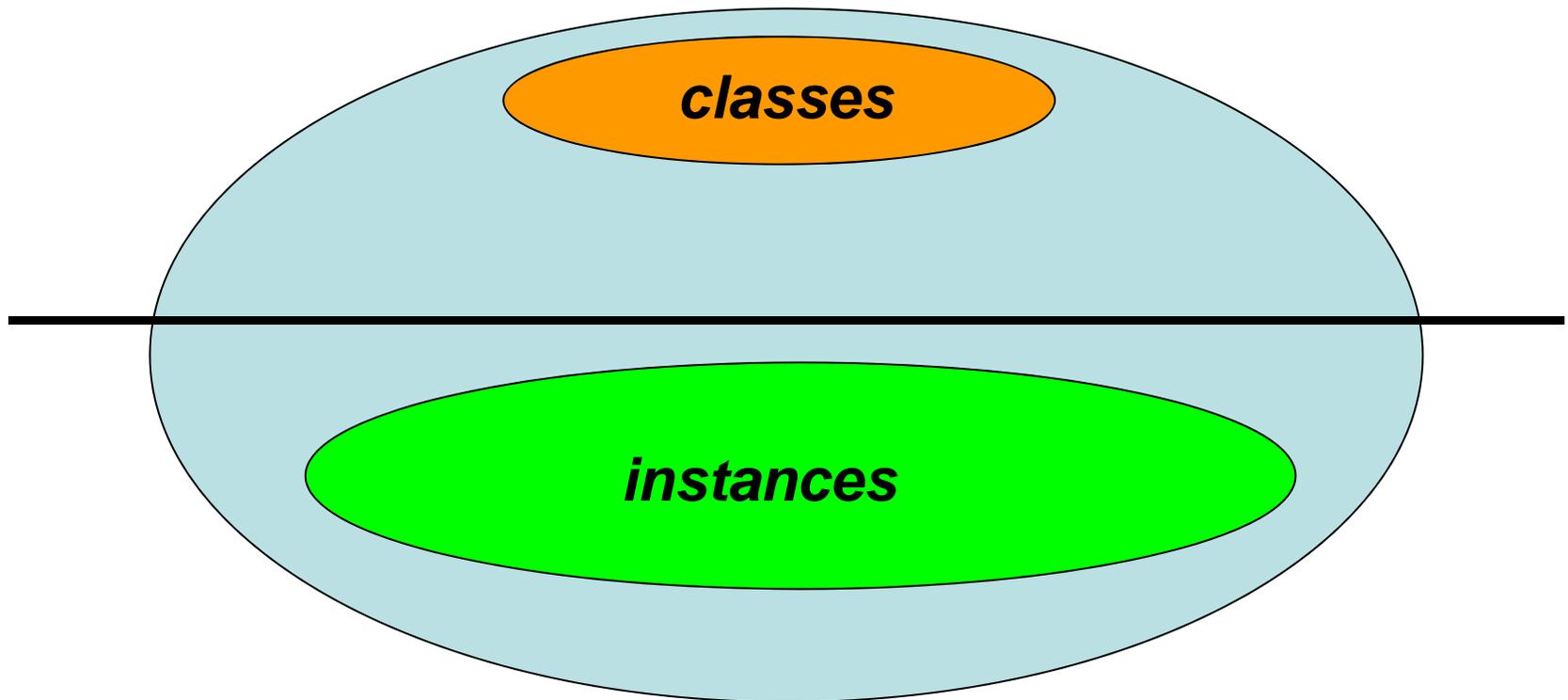
***natural, biological**

Entities



need modified axioms for classes of functions, processes, pathways, reactions, etc.

Entities



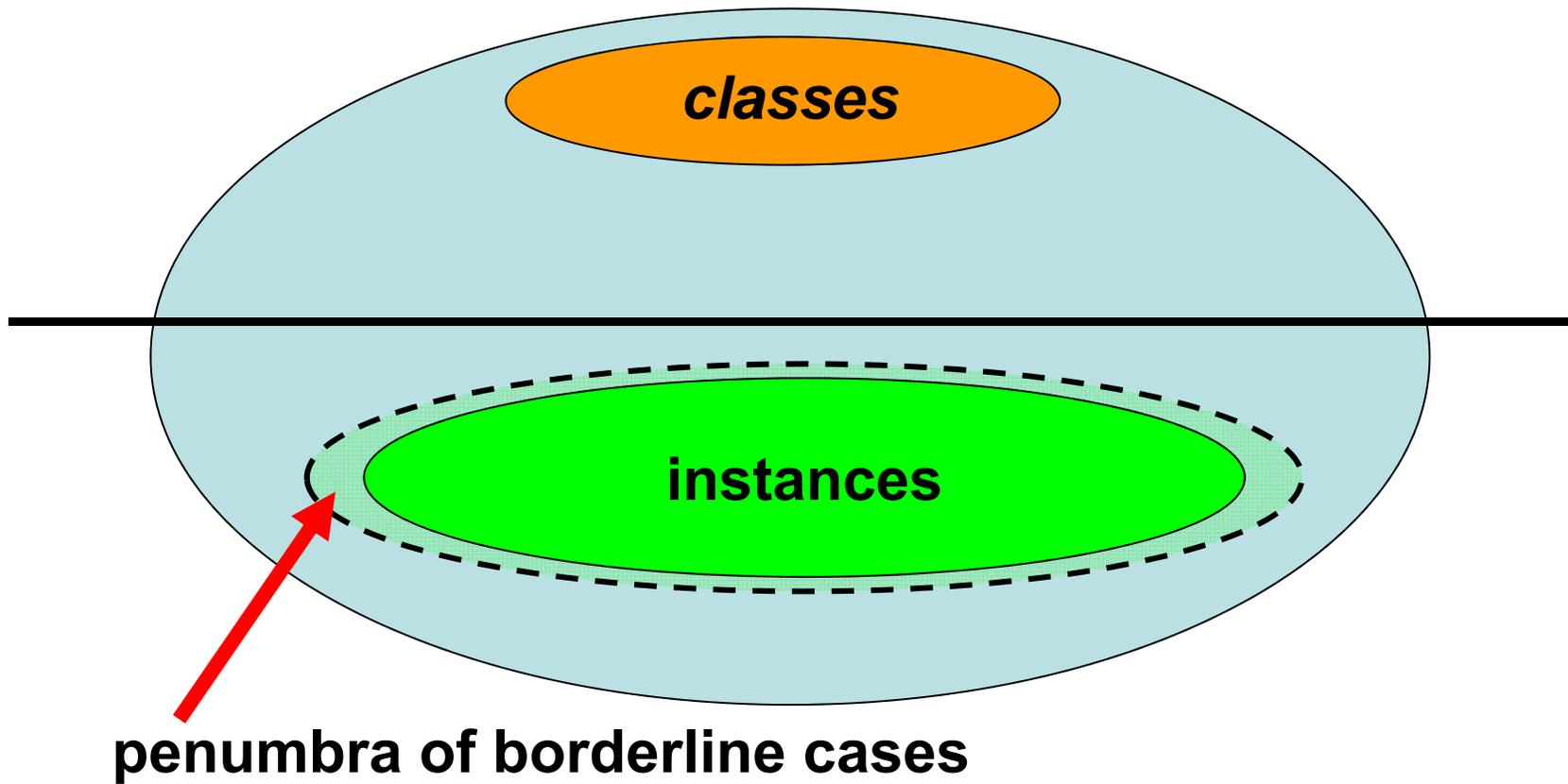
Classes are *natural* kinds

Instances are *natural* exemplars of *natural* kinds

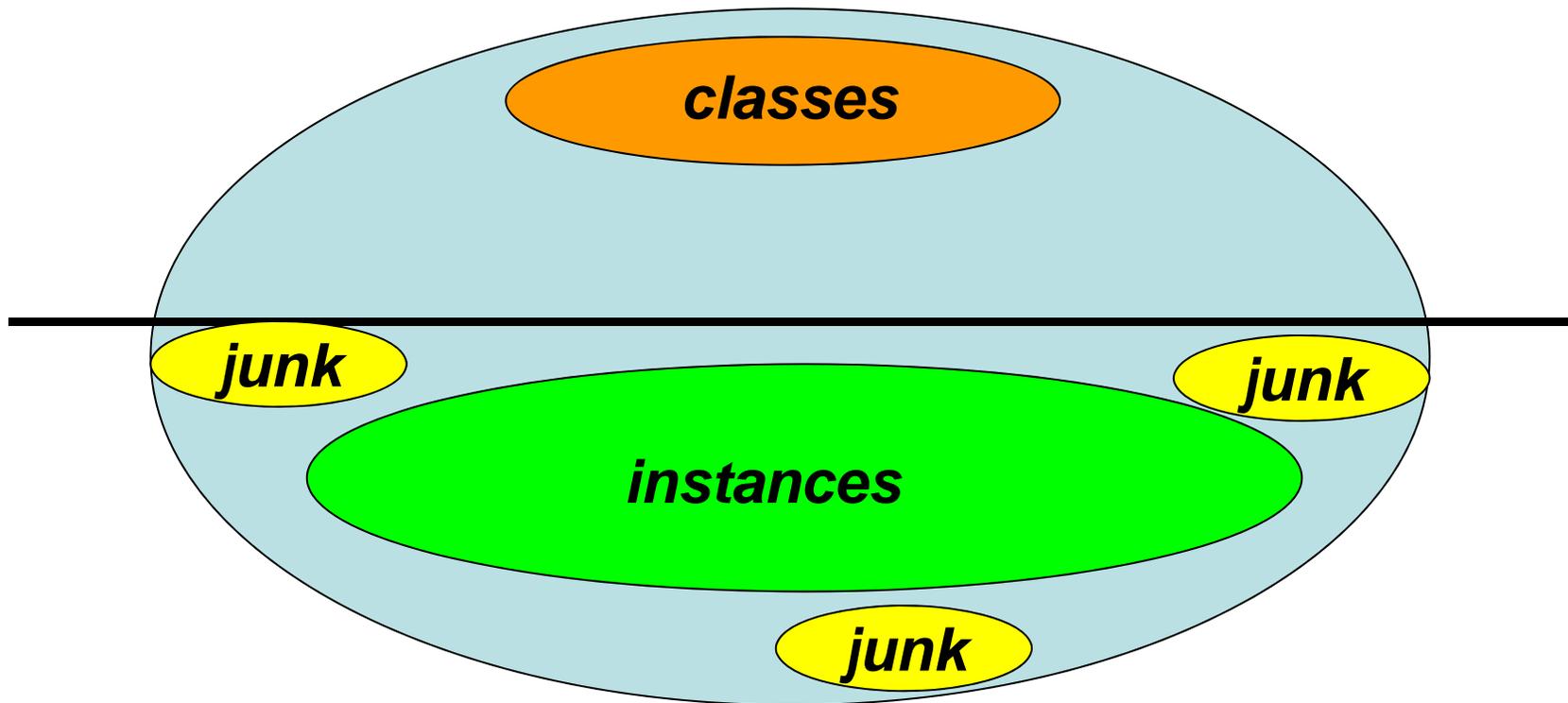
(problem of non-standard instances)

Not all individuals are instances of classes

Entities



Entities



example of junk: beachball-desk

Primitive relations:
inst and ***part***

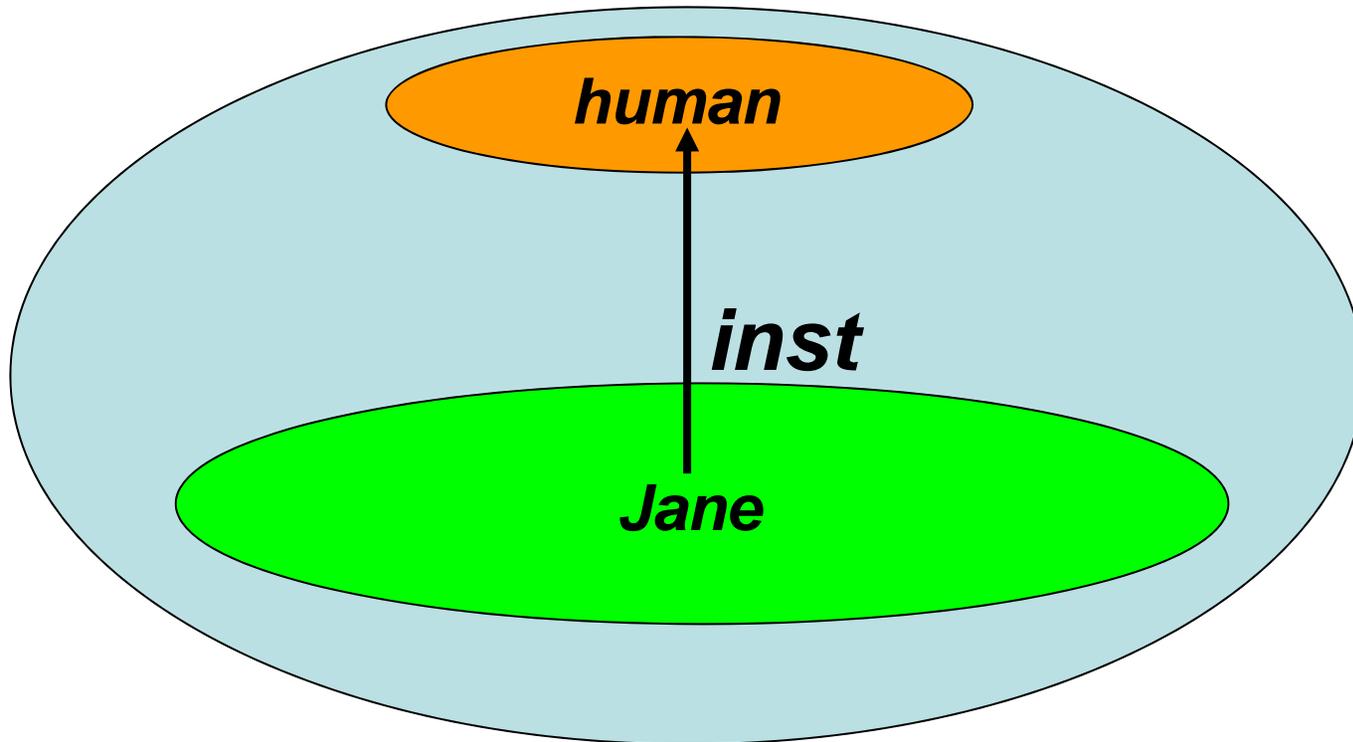
inst(Jane, human being)

part(Jane's heart, Jane's body)

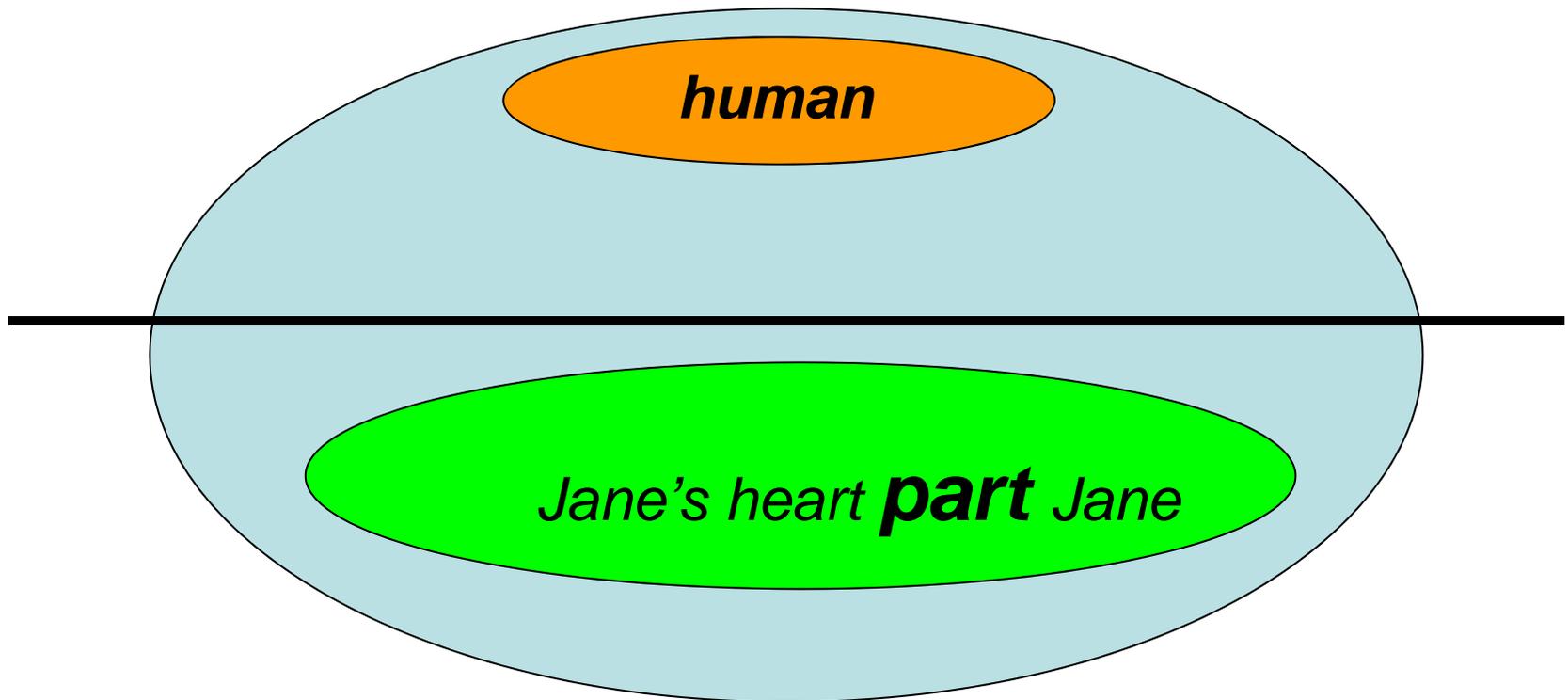
A class is anything that is instantiated

An instance is anything (any individual) that
instantiates some class

Entities



Entities



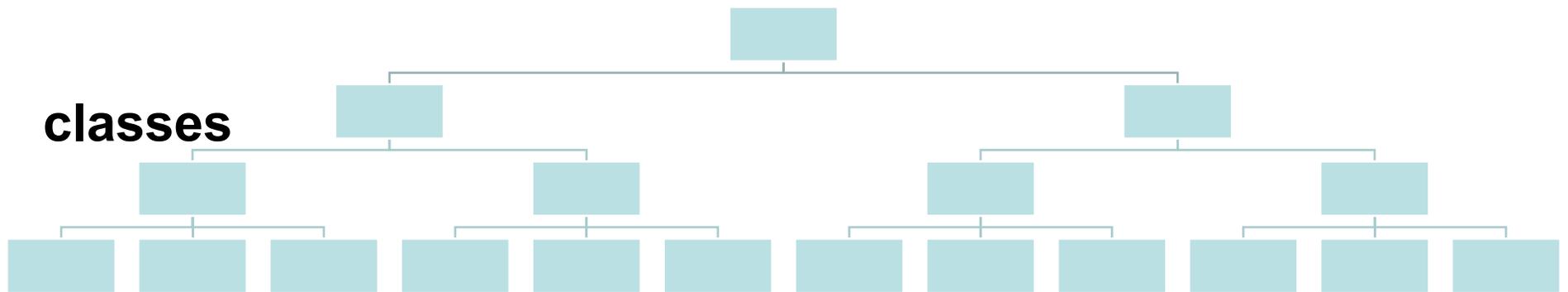
*part as a relation between
individuals*

subject to the usual axioms of
mereology

Axiom of Extensionality

Classes which share identical instances at the same times are identical

A is_a B
genus(A)
species(A)



... instances

is-a

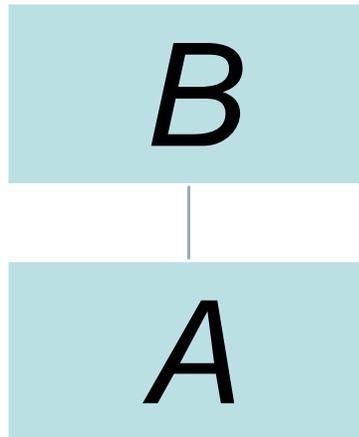
D3* $e \text{ is a } f = \text{def } \text{class}(e) \wedge \text{class}(f) \wedge \forall x$
 $(\textit{inst}(x, e) \rightarrow \textit{inst}(x, f)).$

$\text{genus}(A) = \text{def } \text{class}(A) \wedge \exists B (B \text{ is a } A \wedge B \neq$
 $A)$

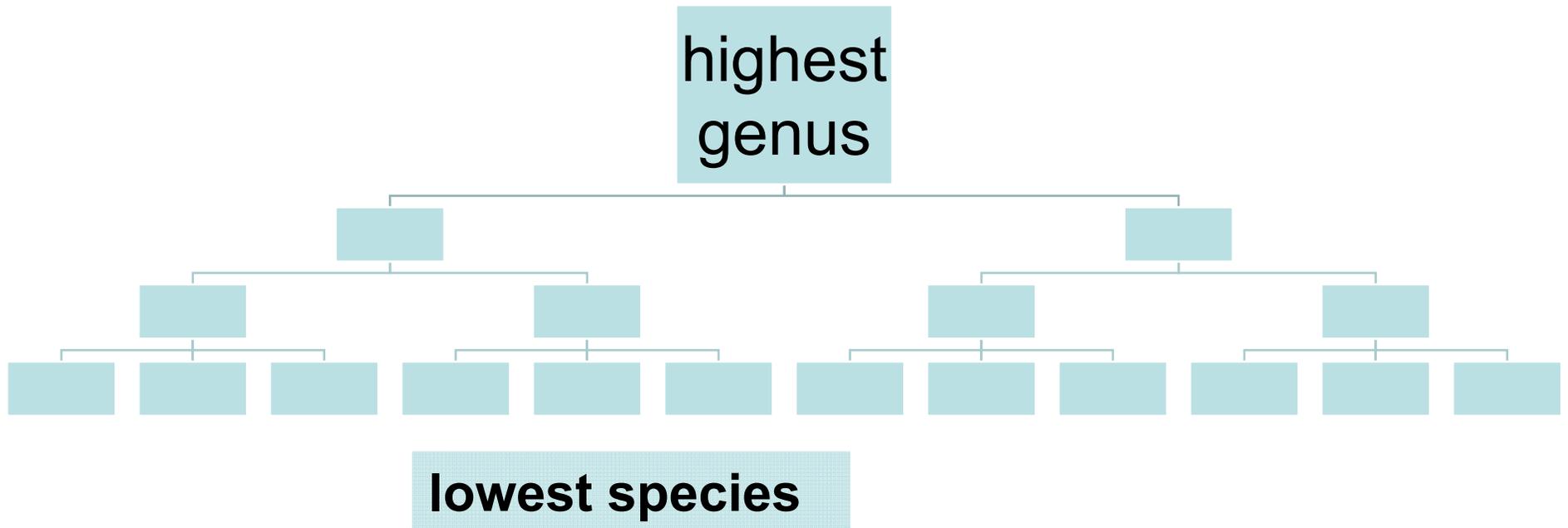
$\text{species}(A) = \text{def } \text{class}(A) \wedge \exists B (A \text{ is a } B \wedge B \neq$
 $A)$

nearest species

$\text{nearestspecies}(A, B) =_{\text{def}} A \text{ is_a } B \ \& \ \forall C ((A \text{ is_a } C \ \& \ C \text{ is_a } B) \rightarrow (C = A \text{ or } C = B))$



Definitions



... instances ...

Lowest Species and Highest Genus

$\text{lowestspecies}(A) =_{\text{def}}$
 $\text{species}(A) \ \& \ \text{not-genus}(A)$

$\text{highestgenus}(A) =_{\text{def}}$
 $\text{genus}(A) \ \& \ \text{not-species}(A)$

Theorem:

$\text{class}(A) \rightarrow (\text{genus}(A) \ \text{or} \ \text{lowestspecies}(A))$

Axioms

Every class has at least one instance

Distinct lowest species never share instances

SINGLE INHERITANCE:

Every species is the nearest species to exactly one genus

Axioms governing *inst*

$\text{genus}(A) \ \& \ \text{inst}(x, A) \rightarrow$

$\exists B \text{ nearestspecies}(B, A) \ \& \ \text{inst}(x, B)$

EVERY GENUS HAS AN INSTANTIATED SPECIES

$\text{nearestspecies}(A, B) \rightarrow A$'s instances are properly included in B 's instances

EACH SPECIES HAS A SMALLER CLASS OF INSTANCES THAN ITS GENUS

Axioms

nearestspecies(B, A)

$\rightarrow \exists C$ (nearestspecies(C, A) & $B \neq C$)

EVERY GENUS HAS AT LEAST TWO CHILDREN

nearestspecies(B, A) & nearestspecies(C, A) & $B \neq C$ \rightarrow not- $\exists x$ (inst(x, B) & inst(x, C))

SPECIES OF A COMMON GENUS NEVER SHARE INSTANCES

Theorems

$(\text{genus}(A) \ \& \ \text{inst}(x, A)) \rightarrow \exists B (\text{lowestspecies}(B) \ \& \ B \text{ is_a } A \ \& \ \text{inst}(x, B))$

EVERY INSTANCE IS ALSO AN INSTANCE OF SOME LOWEST SPECIES

$(\text{genus}(A) \ \& \ \text{lowestspecies}(B) \ \& \ \exists x(\text{inst}(x, A) \ \& \ \text{inst}(x, B))) \rightarrow B \text{ is_a } A$

IF AN INSTANCE OF A LOWEST SPECIES IS AN INSTANCE OF A GENUS THEN THE LOWEST SPECIES IS A CHILD OF THE GENUS

Theorems

$\text{class}(A) \ \& \ \text{class}(B) \rightarrow (A = B \text{ or } A \text{ is_a } B \text{ or } B \text{ is_a } A \text{ or not-}\exists x(\text{inst}(x, A) \ \& \ \text{inst}(x, B)))$

**DISTINCT CLASSES EITHER STAND IN
A PARENT-CHILD RELATIONSHIP OR
THEY HAVE NO INSTANCES IN
COMMON**

Finiteness Axiom

To prove further interesting theorems we need to add an axiom to the effect that the universe is finite

Theorems

A is_a B & A is_a C

→ (B = C or B is_a C or C is_a B)

**CLASSES WHICH SHARE A CHILD IN
COMMON ARE EITHER IDENTICAL OR
ONE IS SUBORDINATED TO THE
OTHER**

Theorems

$(\text{genus}(A) \ \& \ \text{genus}(B) \ \& \ \exists x(\text{inst}(x, A) \ \& \ \text{inst}(x, B))) \rightarrow \exists C(C \text{ is_a } A \ \& \ C \text{ is_a } B)$

**IF TWO GENERA HAVE A COMMON
INSTANCE THEN THEY HAVE A
COMMON CHILD**

Model

P = any finite set.

I = any non-empty proper subset of P

C = any non-empty subset of $\wp(I)$ with the following properties:

i) $\emptyset \notin C$

ii) $\cup C = I$

iii) if $X, Y \in C$ and $X \cap Y \neq \emptyset$, then $X \subseteq Y$ or $Y \subseteq X$

iv) if $X \in C$, then there is some $Y \in C$ such that either $X \subset Y$ or $Y \subset X$

v) if $X, Y \in C$ and $X \subset Y$, then there are $Z_1, \dots, Z_n \in C$ disjoint from X such that $X \cup Z_1 \cup \dots \cup Z_n = Y$.

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C = a sequence C_1, C_2, \dots, C_k of non-empty subsets of $\wp(I_1), \wp(I_2), \dots, \wp(I_k)$

Aristotelian Definitions

An A is a B which exemplifies S

New primitive: ***exemp***

$$\mathbf{inst}(x, A) \leftrightarrow \mathbf{inst}(x, B) \wedge \mathbf{exemp}(x, S)$$

e.g. a man is an animal which exemplifies
rationality

Differentia

$\text{differentia}(S) = \text{def } \exists B \exists C (\text{nearestspecies}(B, C) \wedge \forall x(\mathbf{inst}(x, B) \leftrightarrow (\mathbf{inst}(x, C) \wedge \mathbf{exemp}(x, S))))$

Problem: propria = properties peculiar to all the members of a given species which yet do not belong to the essence of the species – for example *capable of laughing* as possessed by humans.

For Aristotle

differentia include potencies, tendencies,
powers ...

Axioms for differentia

Axiom:

$\text{differentia}(S) \rightarrow \neg \text{class}(S)$

Theorem:

$\text{differentia}(S) \rightarrow \exists x \text{ **exemp**}(x, S)$

Jan Berg, "Aristotle's Theory of Definition", *ATTI del Convegno Internazionale di Storia della Logica*, Bologna: CLUEB, 1983, 19–30:
<http://ontology.buffalo.edu/bio/berg.pdf>.

Testing the theory

Sexually reproducing organisms

Organisms in general

Cladistic classification

Biological *processes*

Biological *functions*

Non-biological natural kinds (chemical elements, minerals ...)

Artefact kinds

16th Annual International Conference on Intelligent Systems for Molecular Biology

The Ontology of Biological Taxa

Stefan Schulz
Holger Stenzhorn
Martin Boeker

University Medical Center
Freiburg (Germany)
Institute of Medical Biometry
and Medical Informatics



Examples for Taxa

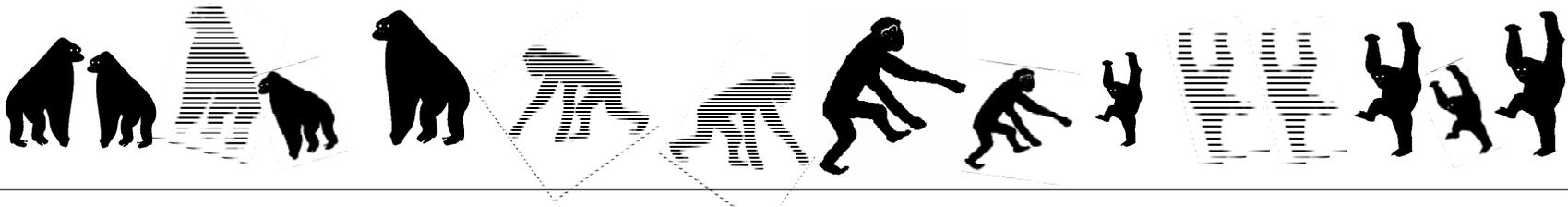
Taxon (Rank)	Chimpanzee 	Asian Elephant 	Drosophila 
<i>Kingdom</i>	Animalia	Animalia	Animalia
<i>Phylum</i>	Chordata	Chordata	Arthropoda
<i>Subphylum</i>	Vertebrata	Vertebrata	
<i>Class</i>	Mammalia	Mammalia	Insecta
<i>Order</i>	Primates	Proboscidea	Diptera
<i>Superfamily</i>		Elephantoidea	
<i>Family</i>	Hominides	Elephantidae	Drosophilidae
<i>Subfamily</i>			Drosophilinae
<i>Genus</i>	Pan	Elephas	Drosophila
<i>Species</i>	Simia troglodytes	Elephas maximus	Drosophila melanogaster

Basic stipulations on ontologies

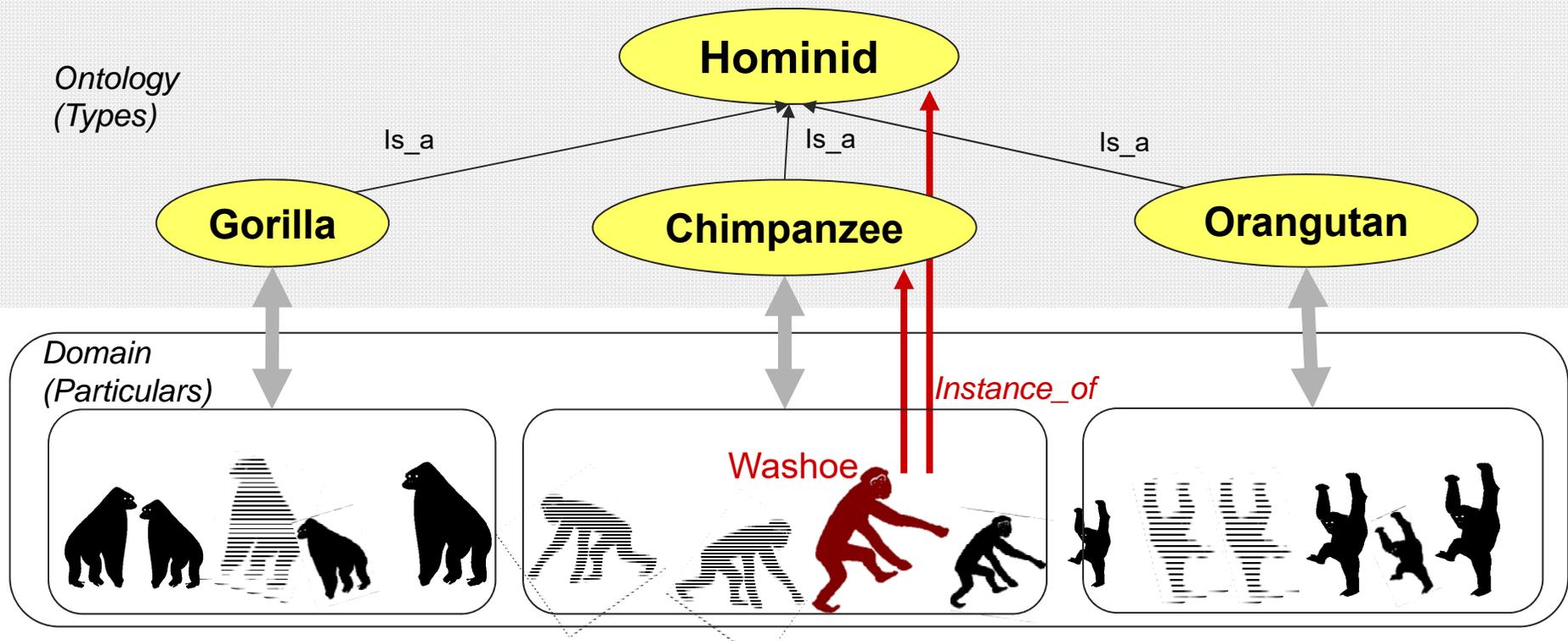
Ontology
(Types)

Hominid

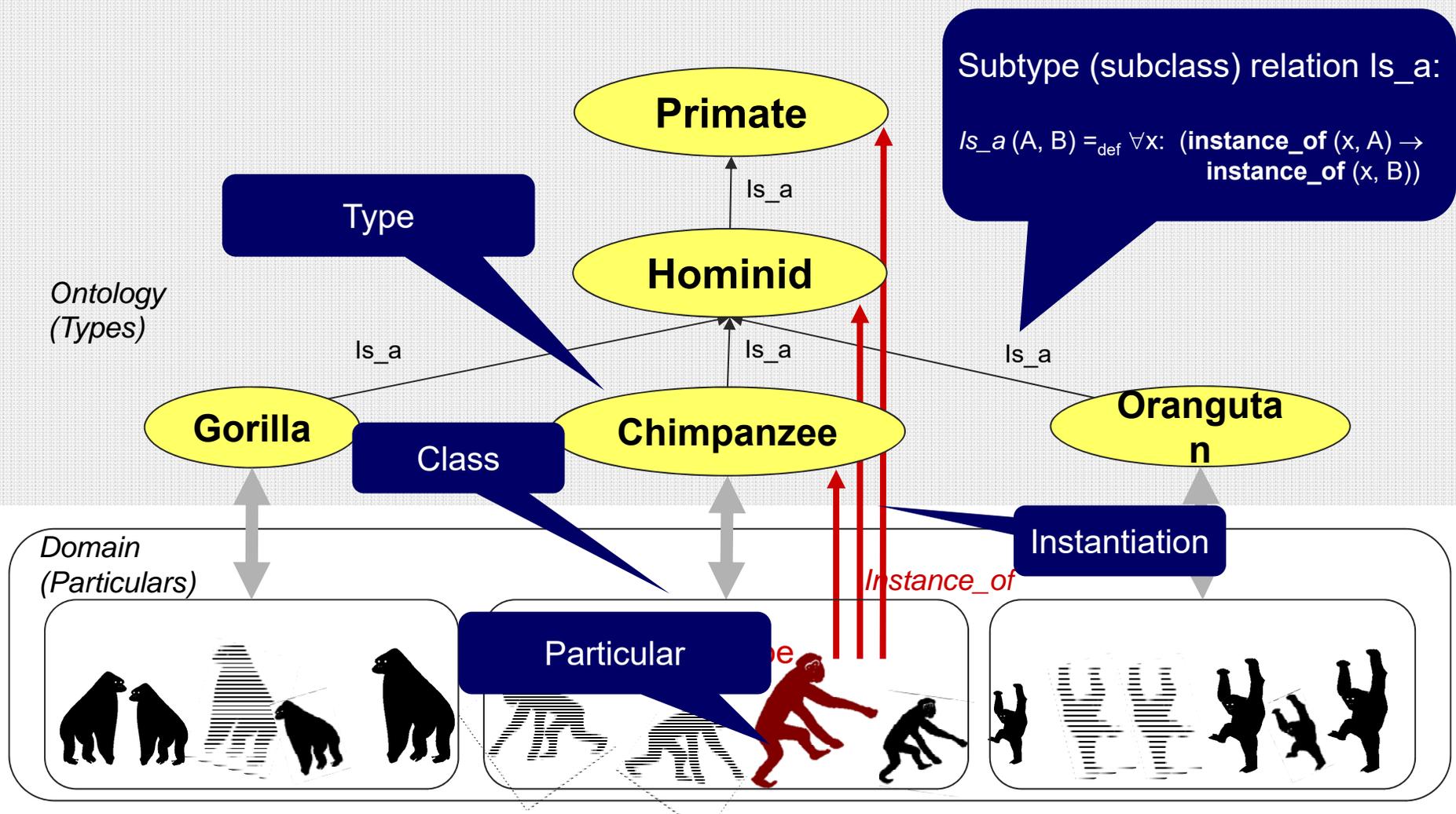
Domain
(Particulars)



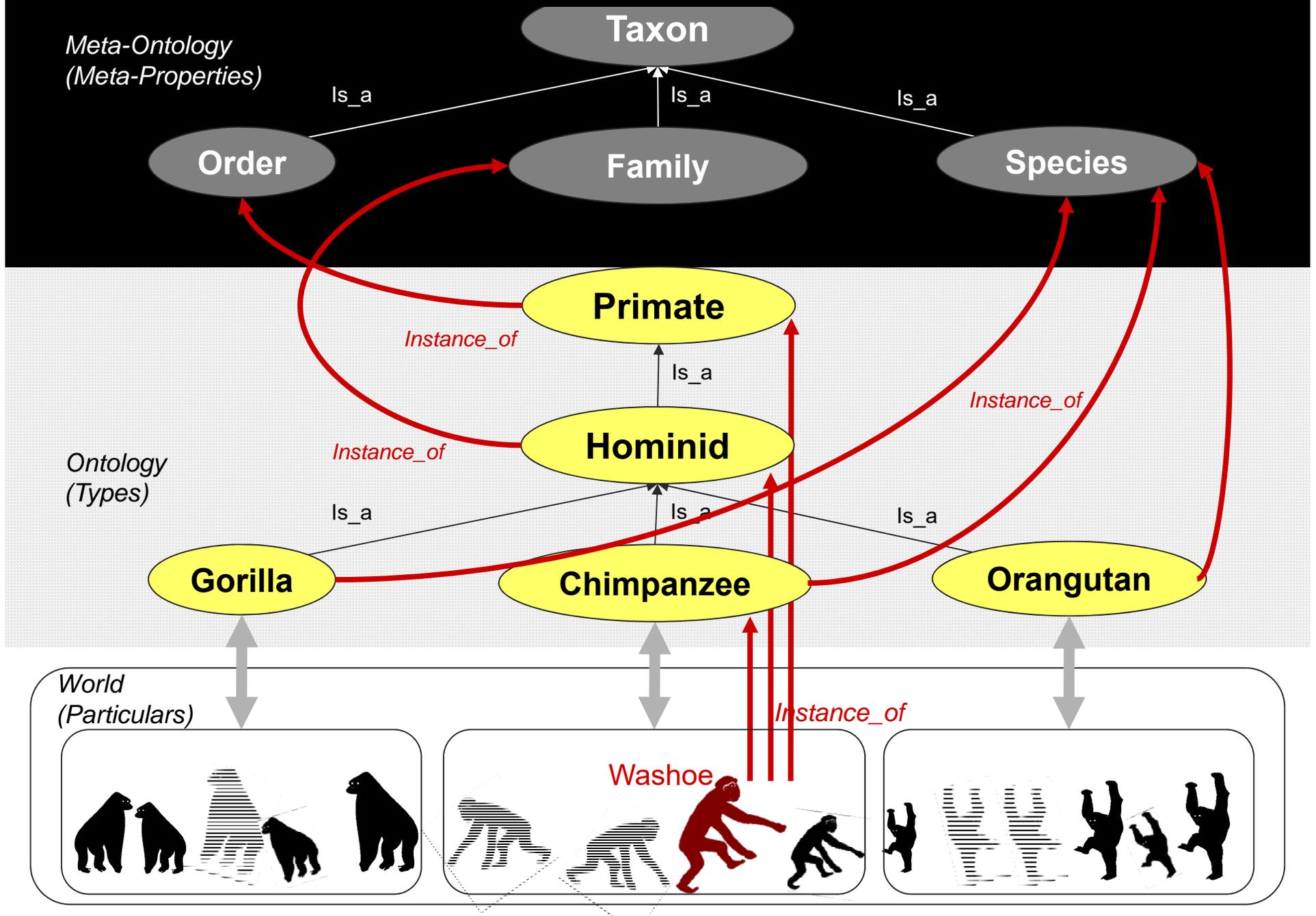
Basic stipulations on ontologies



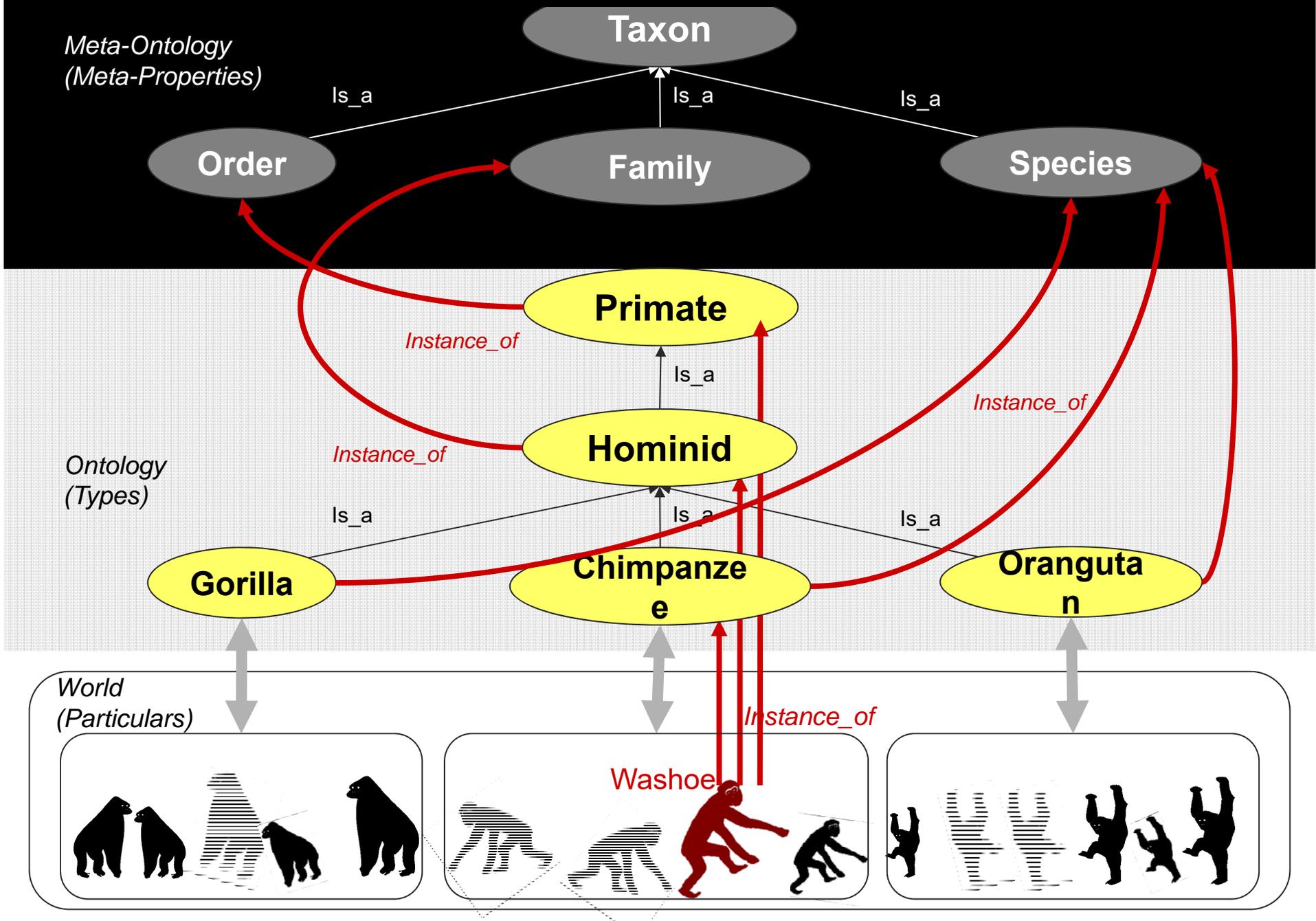
Basic stipulations on ontologies

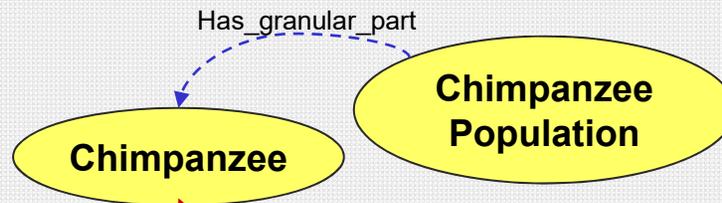
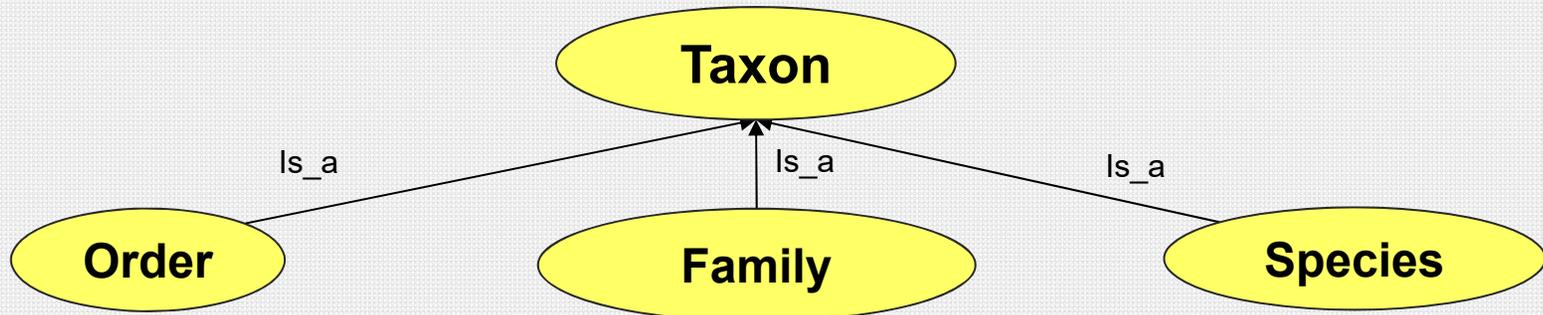


Definition Ontologies Representation [1] 2 3 4 5 Conclusion



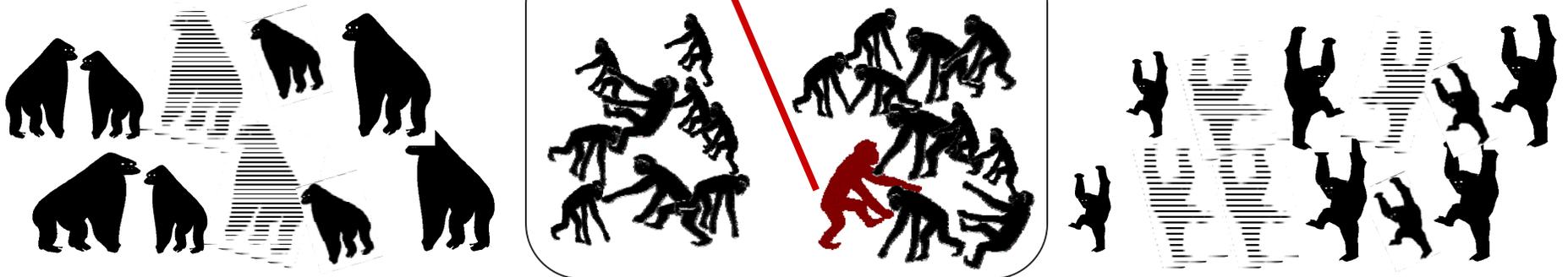
Definition Ontologies Representation 1 [2] 3 4 5 Conclusion

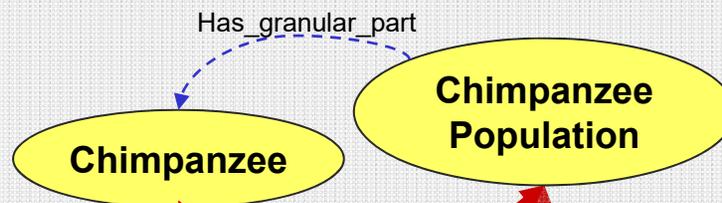
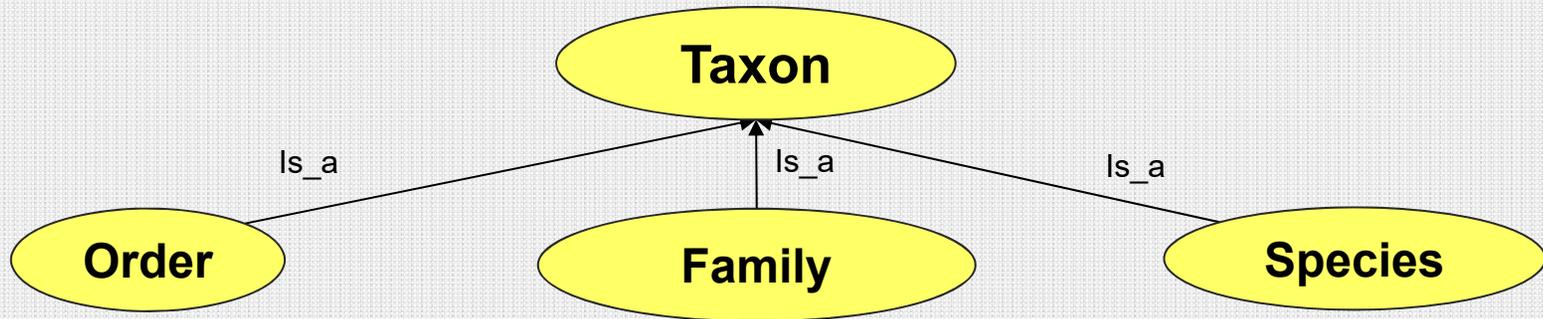




World
(Particulars)

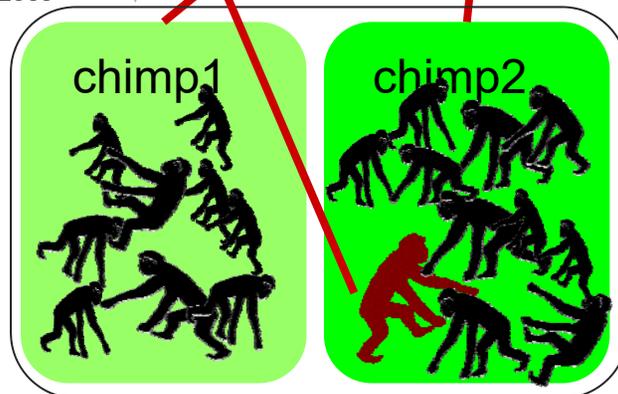
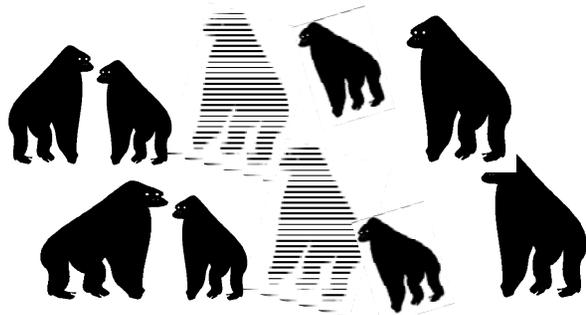
Class
of
Chimpanzees

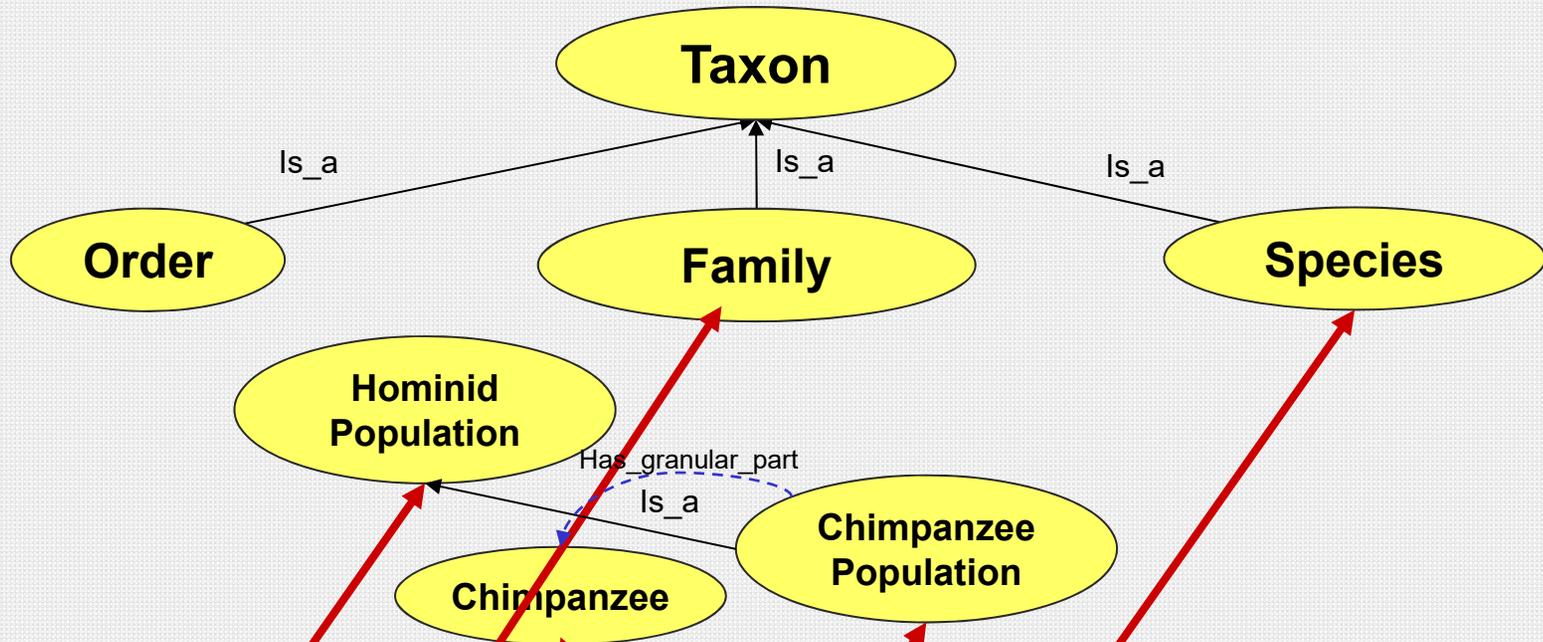




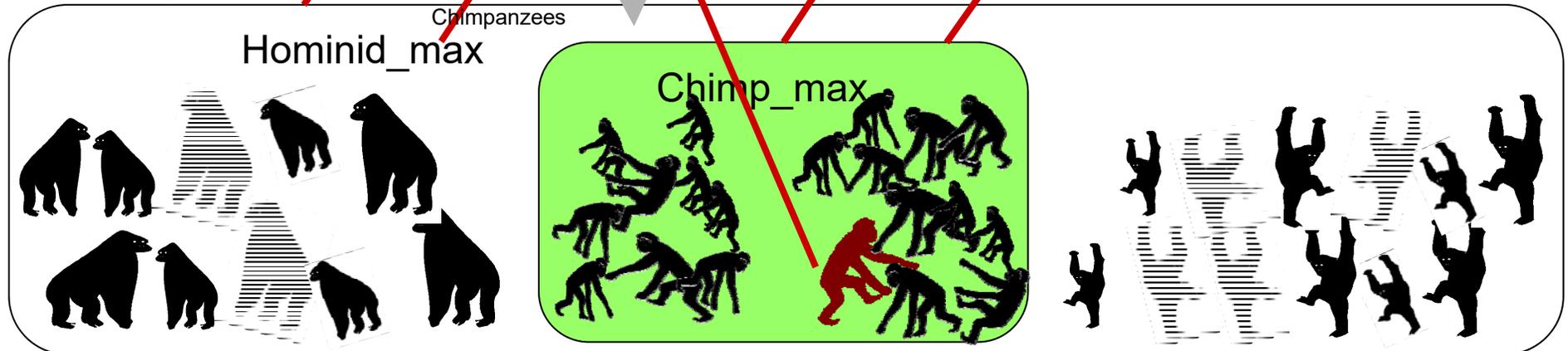
World
(Particulars)

Class
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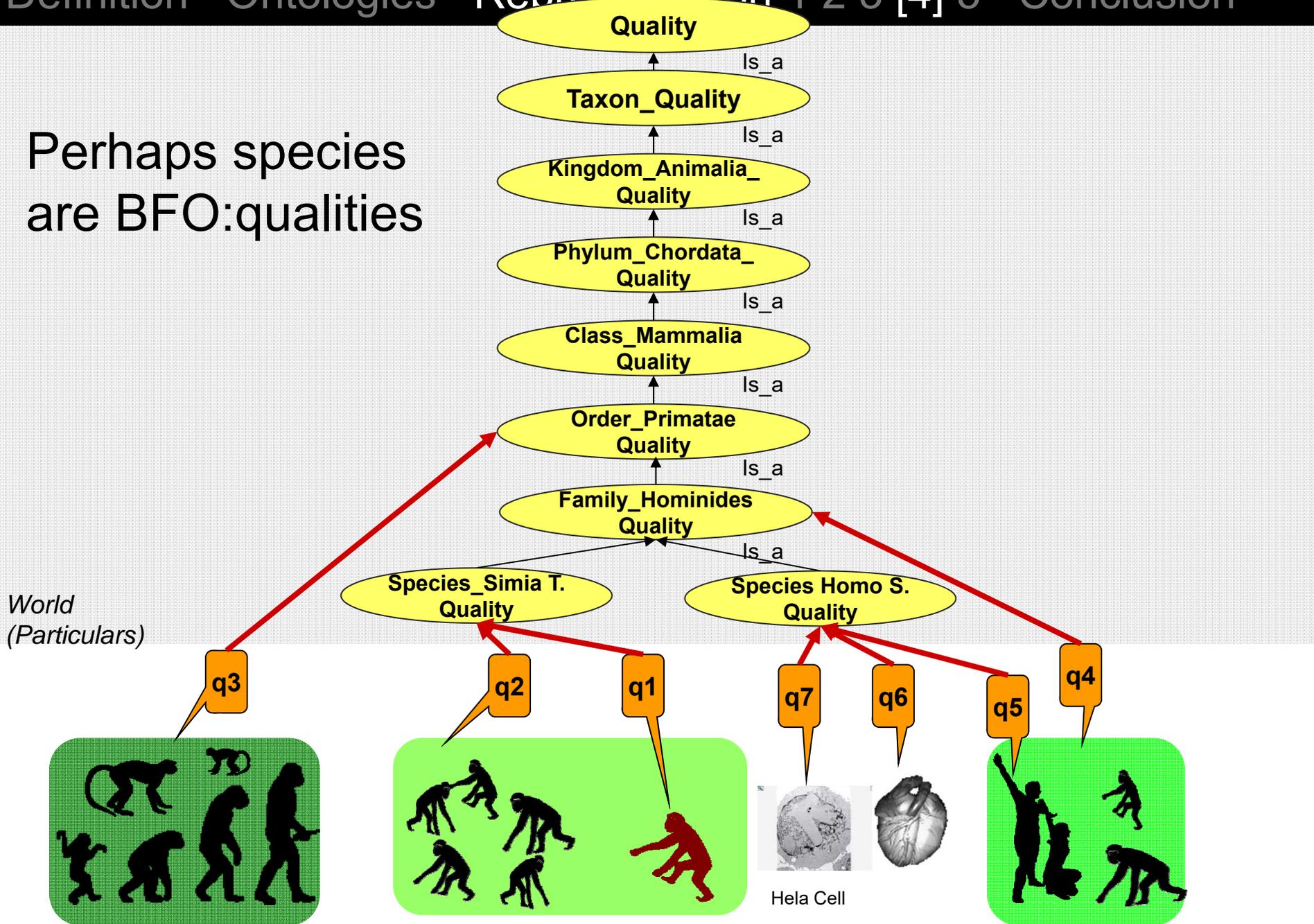


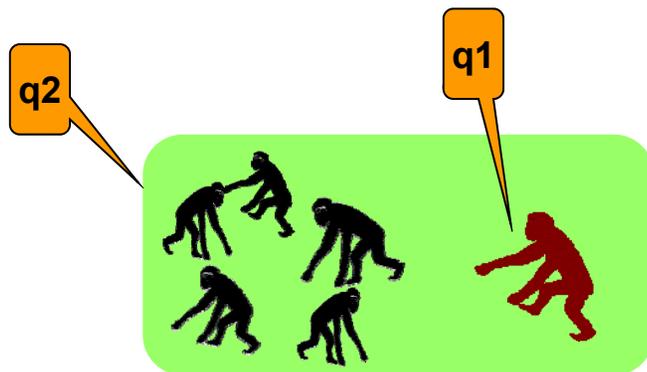
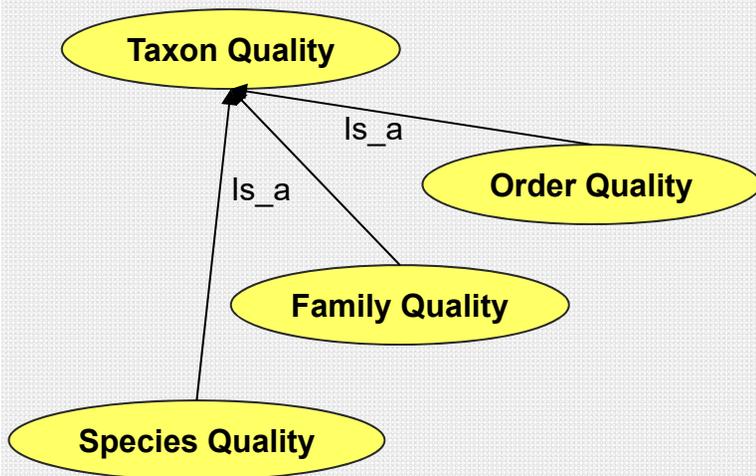


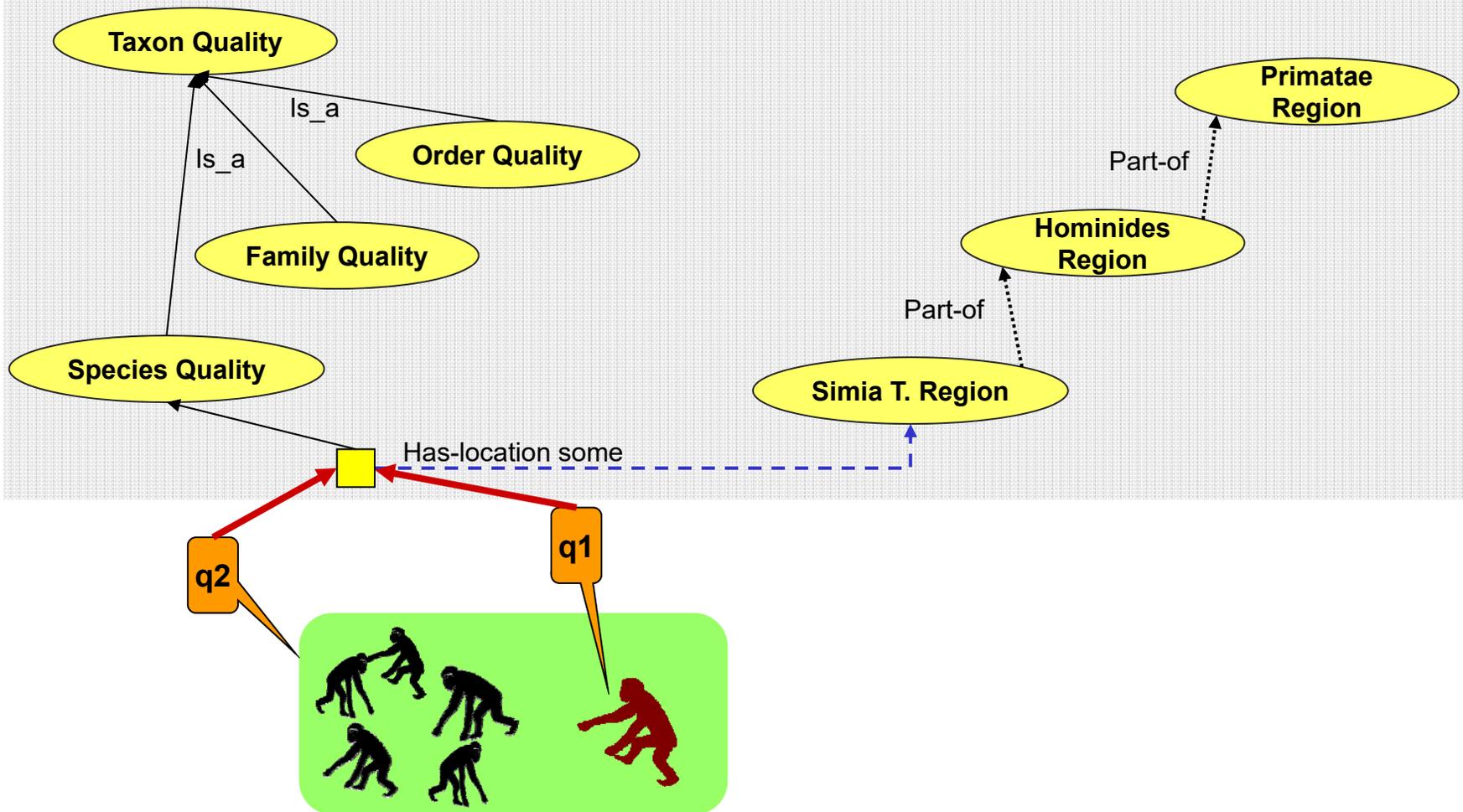
World (Particulars)



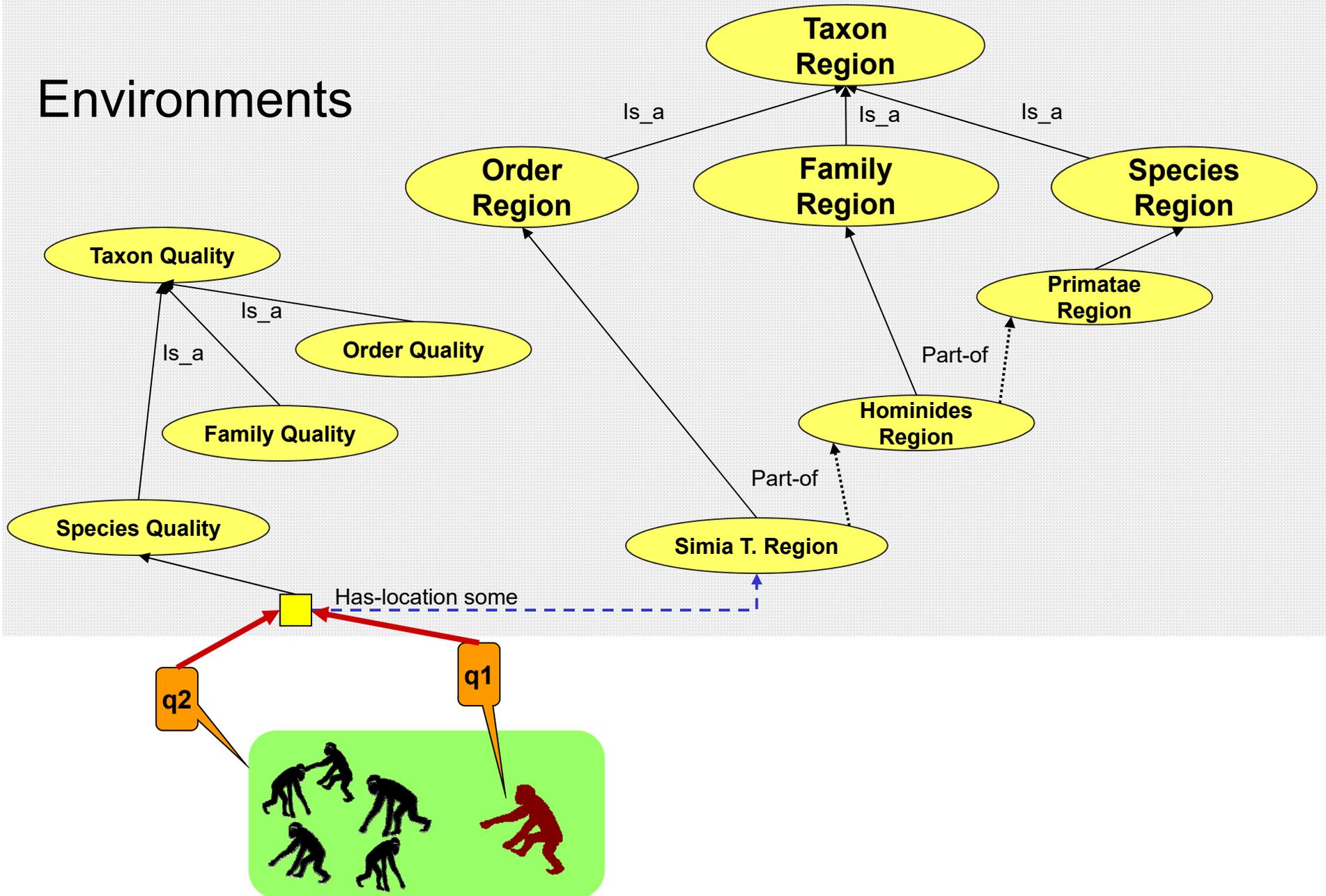
Perhaps species are BFO:qualities







Environments





The Environment Ontology

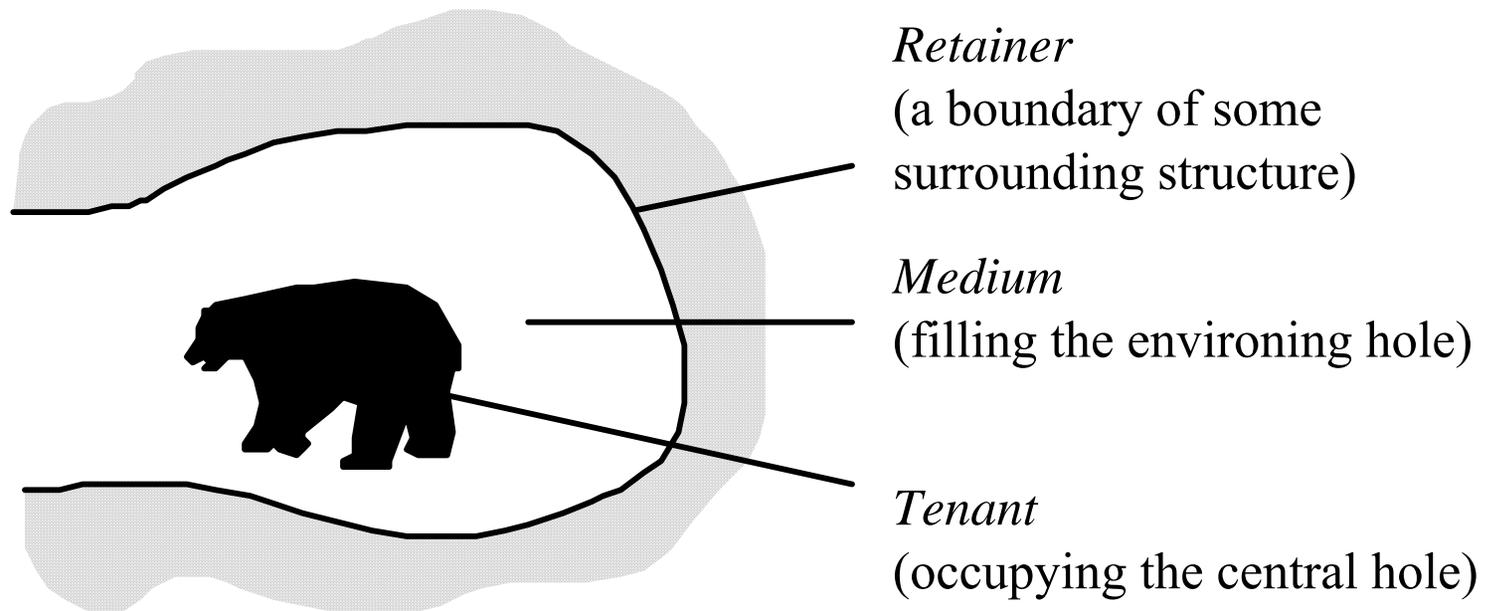
The Hole Story







Double Hole Structure of the Occupied Niche

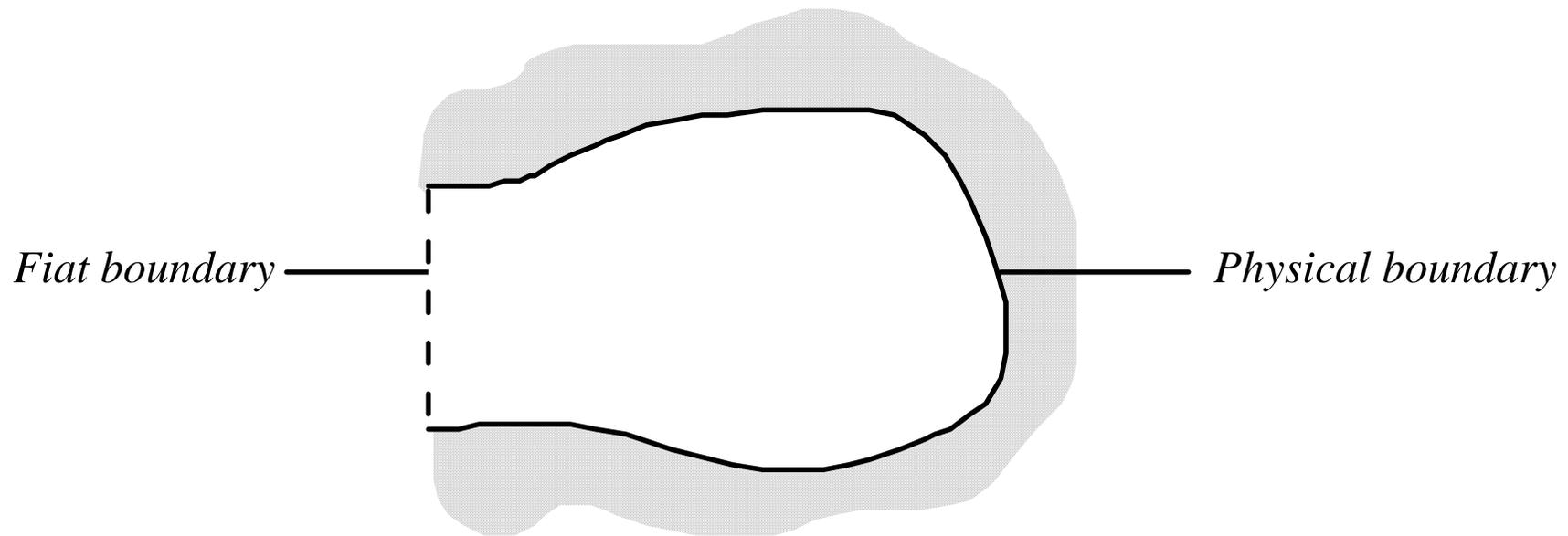


Tenant, medium and retainer

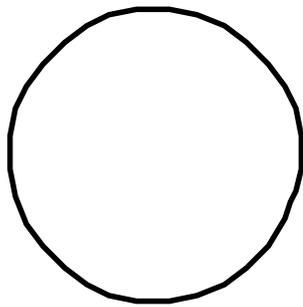
the medium of the bear's niche is a
circumscribed body of air

medium might be body of water, cytosol,
nasal mucosa, epithelium, endocardium,
synovial tissue ...

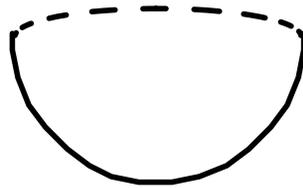
The Empty Niche



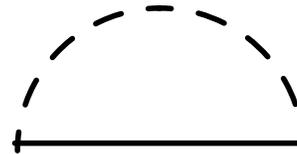
Four Basic Niche Types (Niche as *generalized* hole)



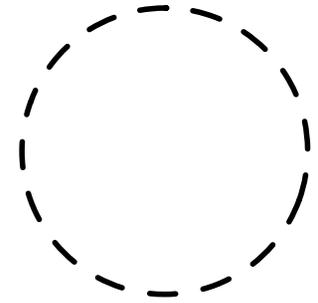
1



2



3



4

- 1: a womb; an egg; a house (better: the interior thereof)
- 2: a snail's shell;
- 3: the niche of a pasturing cow;
- 4: the niche around a circling buzzard (fiat boundary)

Elton – niche as role

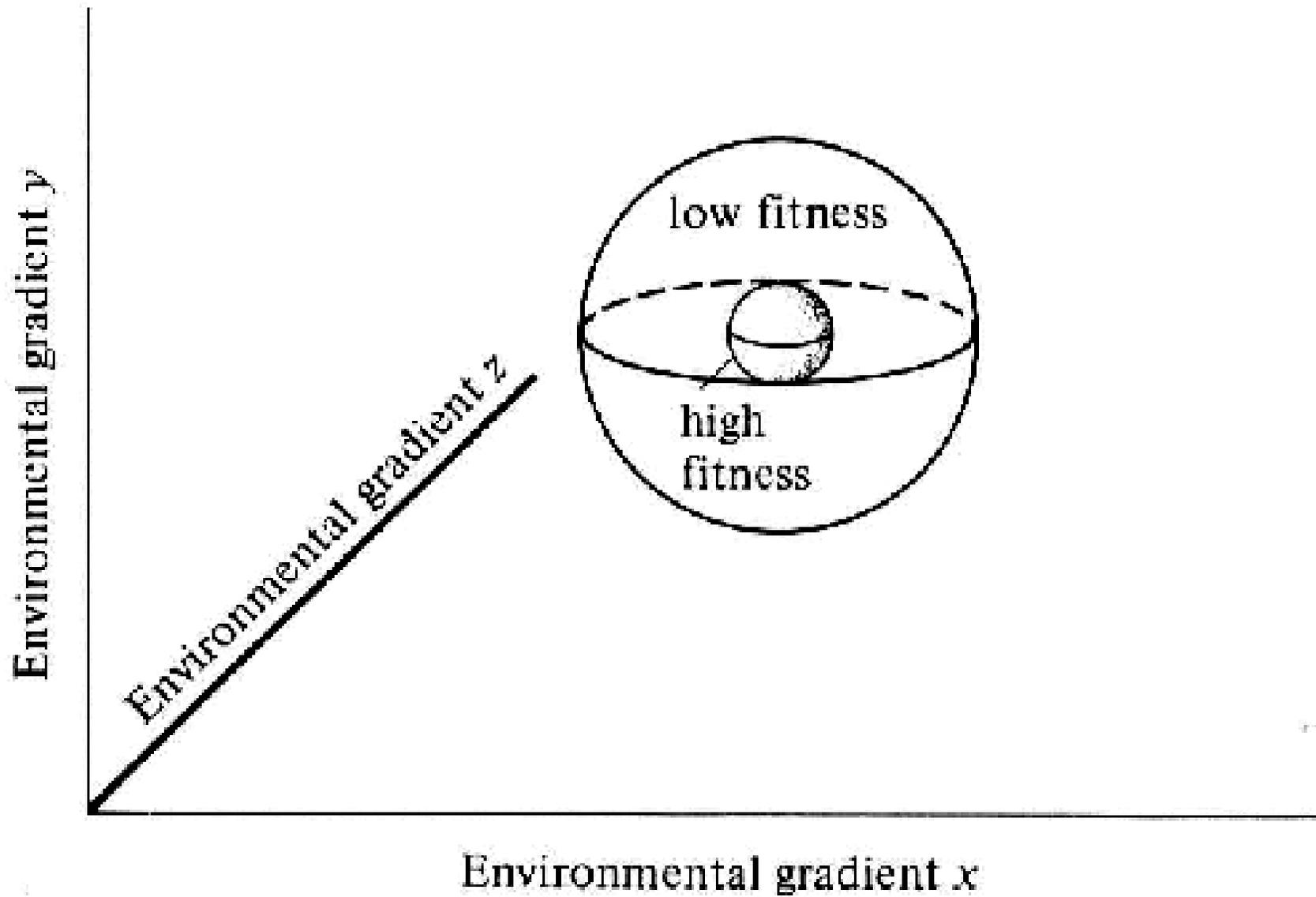
the 'niche' of an animal means its place in the biotic environment, its relations to food and enemies. [...]

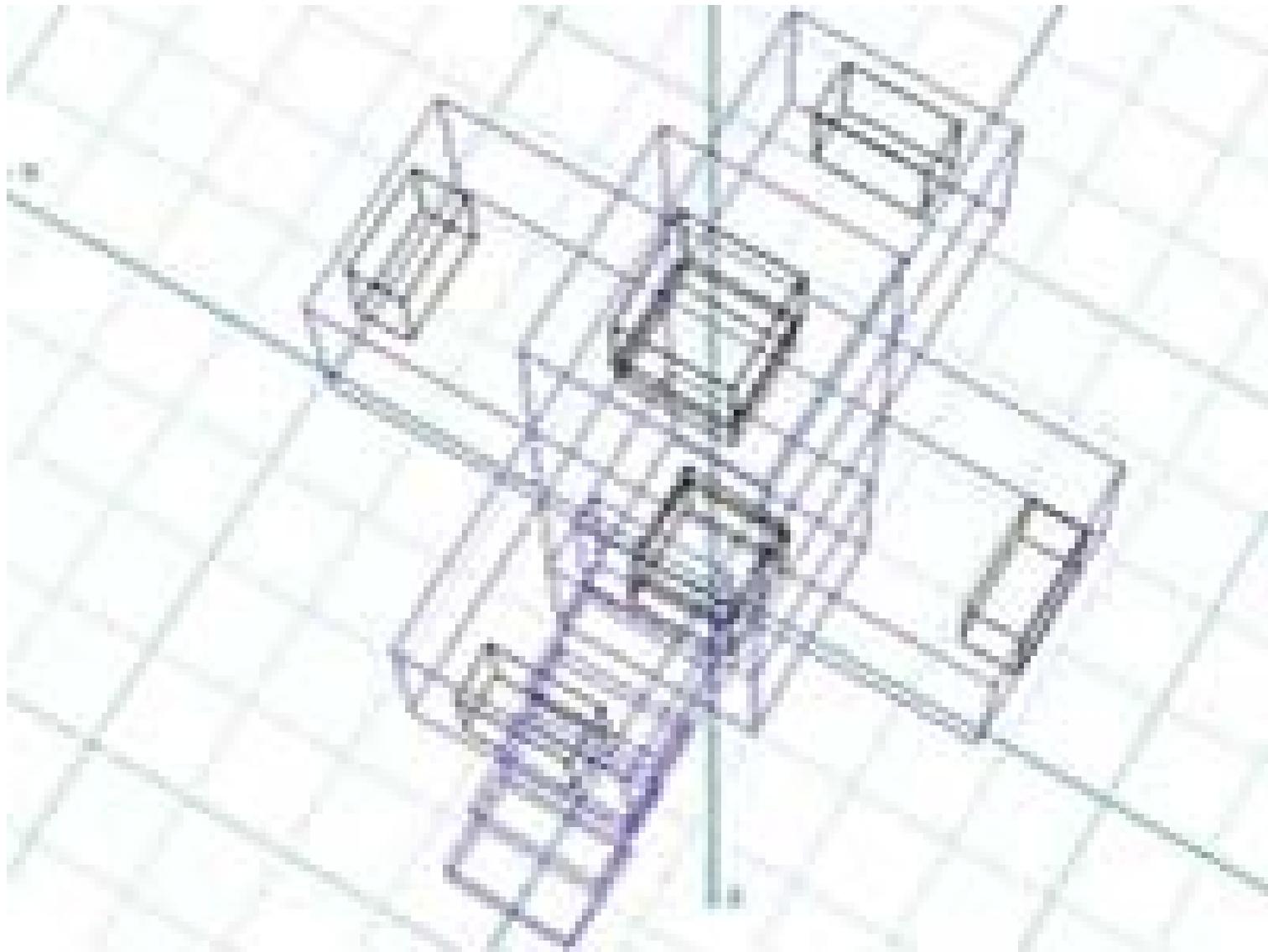
When an ecologist says 'there goes a badger' he should include in his thoughts some definite idea of the animal's place in the community to which it belongs, just as if he had said 'there goes the vicar' (Elton 1927, pp. 63f.)

G.E. Hutchinson: niche as volume in a functionally defined space

the niche = an n-dimensional hyper-volume whose dimensions correspond to resource gradients over which species are distributed

G.E. Hutchinson (1957, 1965)





Hypervolume niche = a location
in an attribute space

defined by a specific constellation of
environmental variables such as degree of
slope, exposure to sunlight, soil fertility,
foliage density, salinity...

EnvO

combines the spatial and
Hutchinsonian perspectives to create
a consensus controlled vocabulary for
representing

macroscopic (geographical)

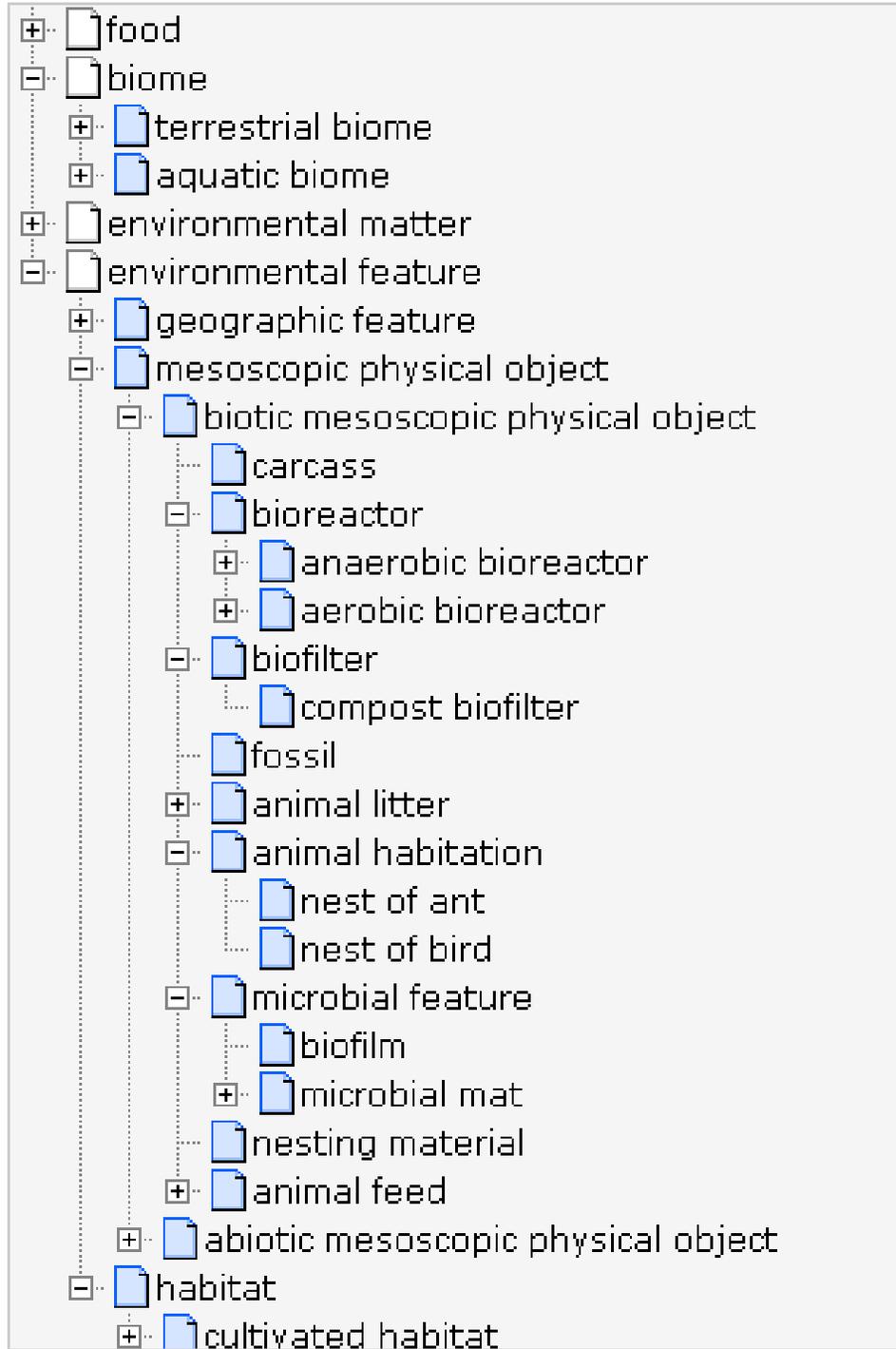
mesoscopic (behavioral)

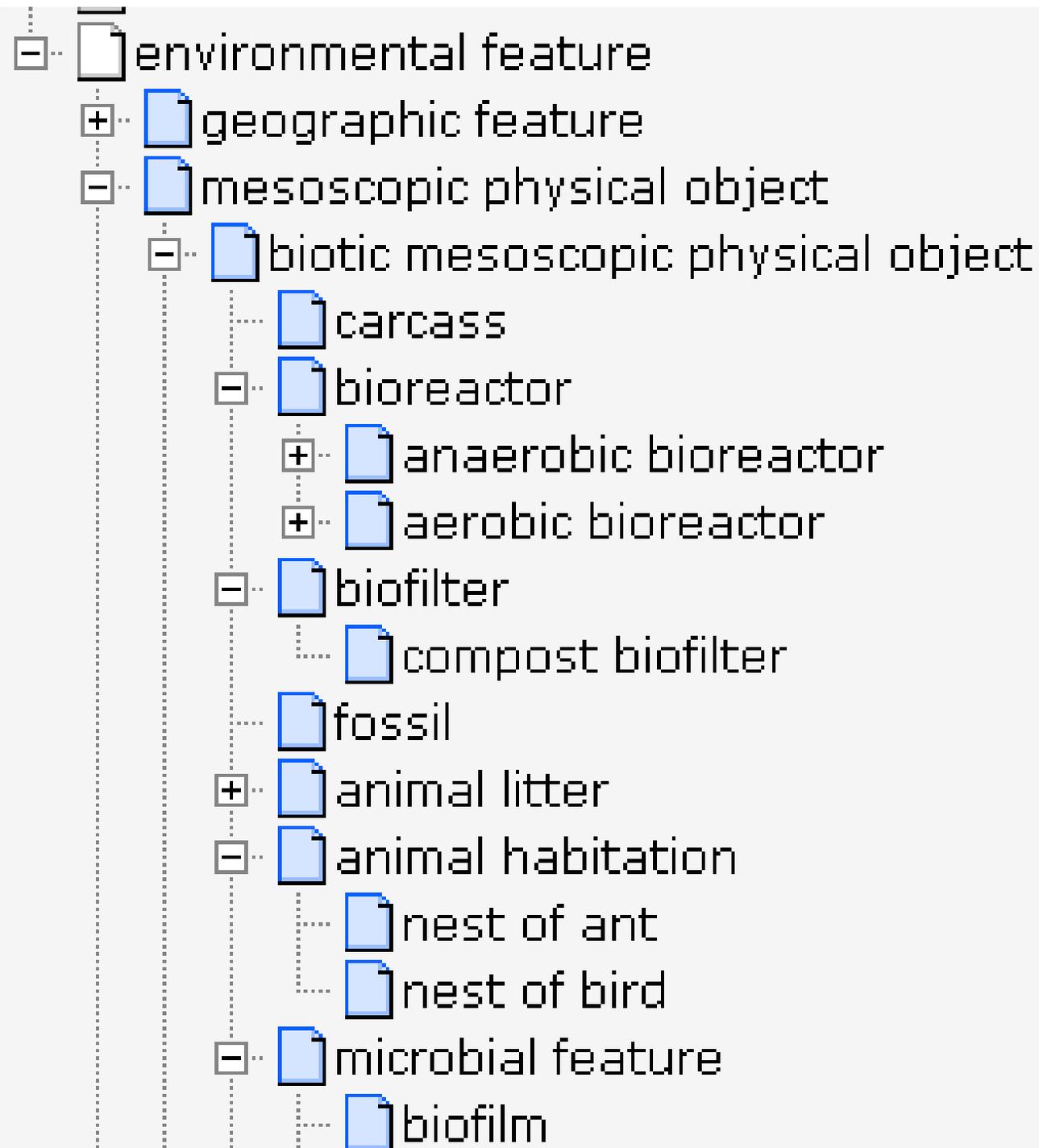
microscopic (cellular, molecular ...)

environments

Applications of EnvO in biology

- Support the annotation of meta-data related to:
 - Data about biological samples produced from various technologies
 - Metagenomics, Metabolomics, Proteomics, Transcriptomics, Genomics...
 - Data produced from remote sensing equipment
 - Images
 - Web 2.0, tagging
 - Physical holdings
 - Museum artifacts, (preserved) biological samples / organisms
 - ...anything that has an ***environment***

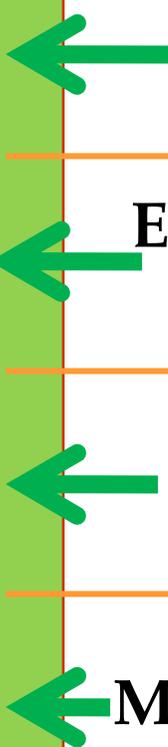




RELATION TO TIME GRANULARITY	CONTINUANT			OCCURRENT		
	INDEPENDENT		DEPENDENT			
COMPLEX OF ORGANISMS	Family, Community, Deme, Population		E N V I R O N M E N T	Population Phenotype	Population Process	
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	(FMA, CARO)		Organ Function (FMP, CPRO)	Phenotypic Quality (PaTO)	Biological Process (GO)
CELL AND CELLULAR COMPONENT	Cell (CL)	Cell Component (FMA, GO)		Cellular Function (GO)		
MOLECULE	Molecule (ChEBI, SO, RnaO, PrO)			Molecular Function (GO)		

RELATION TO TIME	CONTINUANT	
	INDEPENDENT	
GRANULARITY		
COMPLEX OF ORGANISMS	Family, Community, Deme, Population	
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	(FMA, CARO)
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MOLECULE	Molecule (ChEBI, SO, RnaO, PrO)	

ENVIRONMENT

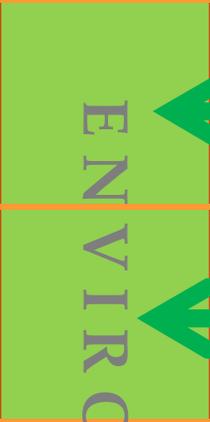


Environment of population

Environment of single organism

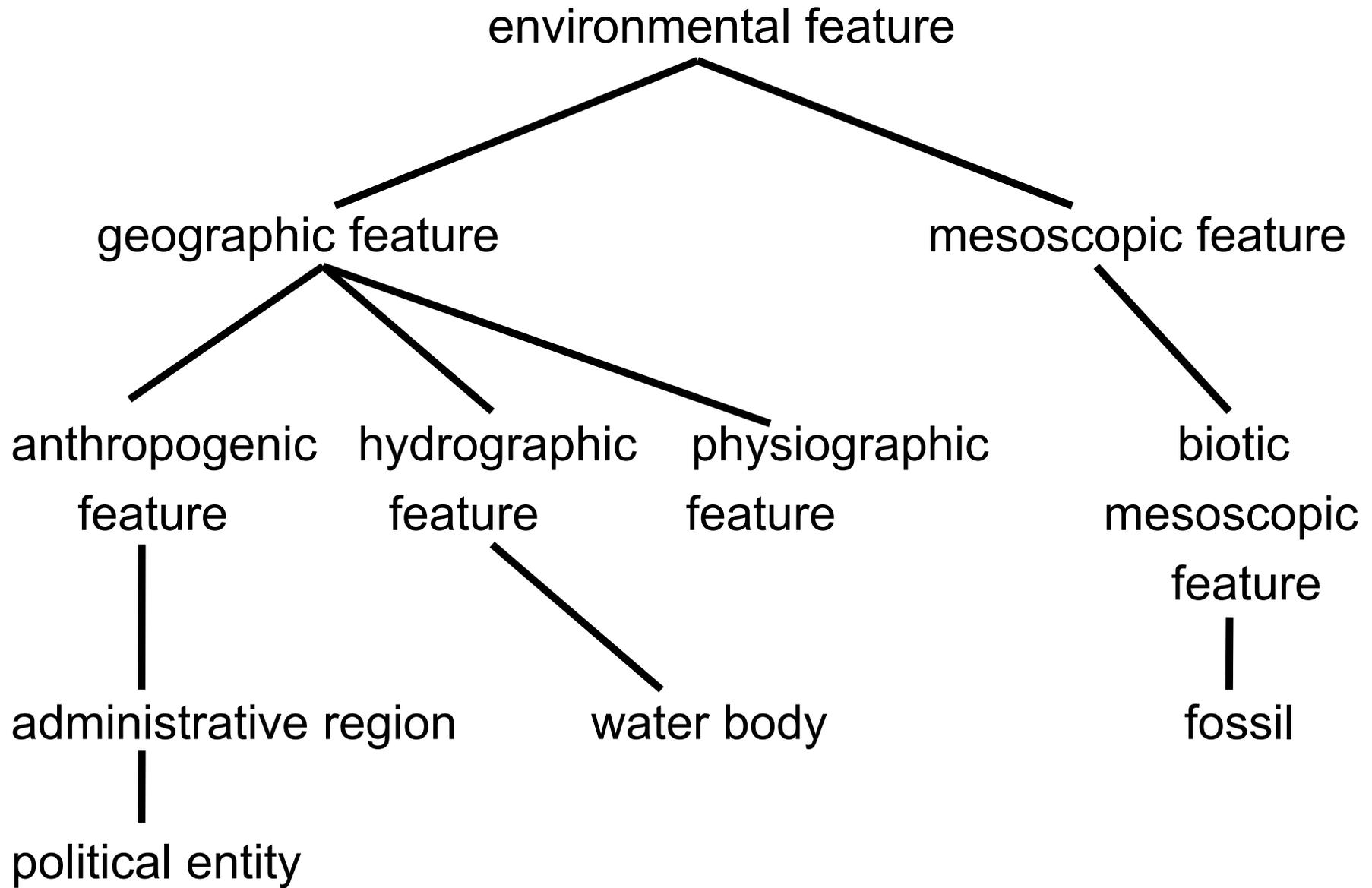
Environment of cell

Molecular environment

RELATION TO TIME	CONTINUANT	
	INDEPENDENT	
GRANULARITY		
COMPLEX OF ORGANISMS	Family, Community, Deme, Population	 Environment of population
ORGAN AND ORGANISM	Organism (NCBI Taxonomy)	(FMA, CARO) Environment of single organism*

* The sum total of the conditions and elements that make up the surroundings and influence the development and actions of an individual.

RELATION TO TIME GRANULARITY	CONTINUANT	
	INDEPENDENT	
COMPLEX OF ORGANISMS	ENVIRONMENT	biome / biotope, territory, habitat, neighborhood, ...
ORGAN AND ORGANISM		work environment, home environment; host/symbiont environment; ...
CELL AND CELLULAR COMPONENT		extracellular matrix; chemokine gradient; ...
MOLECULE		hydrophobic surface; virus localized to cellular substructure; active site on protein; pharmacophore ...



environmental feature

habitat

*def: a spatial region having environmental qualities
which may sustain an organism or a community of
organisms*

cultivated
habitat

terrestrial
habitat

anthropogenic
habitat

environmental feature



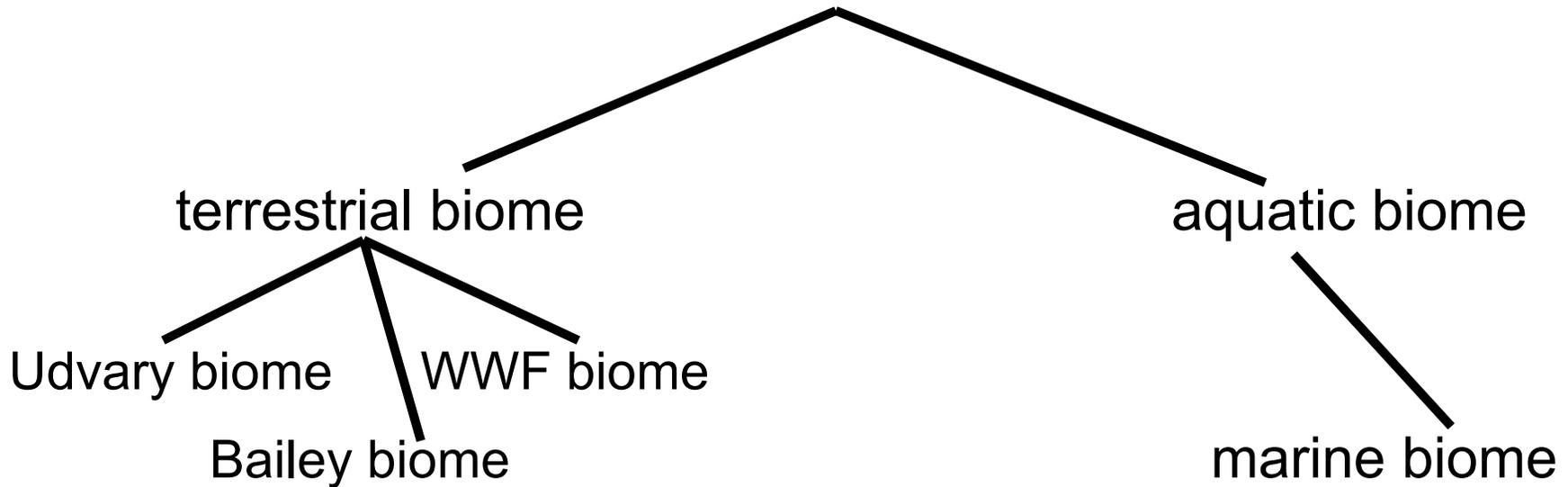
habitat

def: a spatial region having environmental qualities which may sustain an organism or a community of organisms

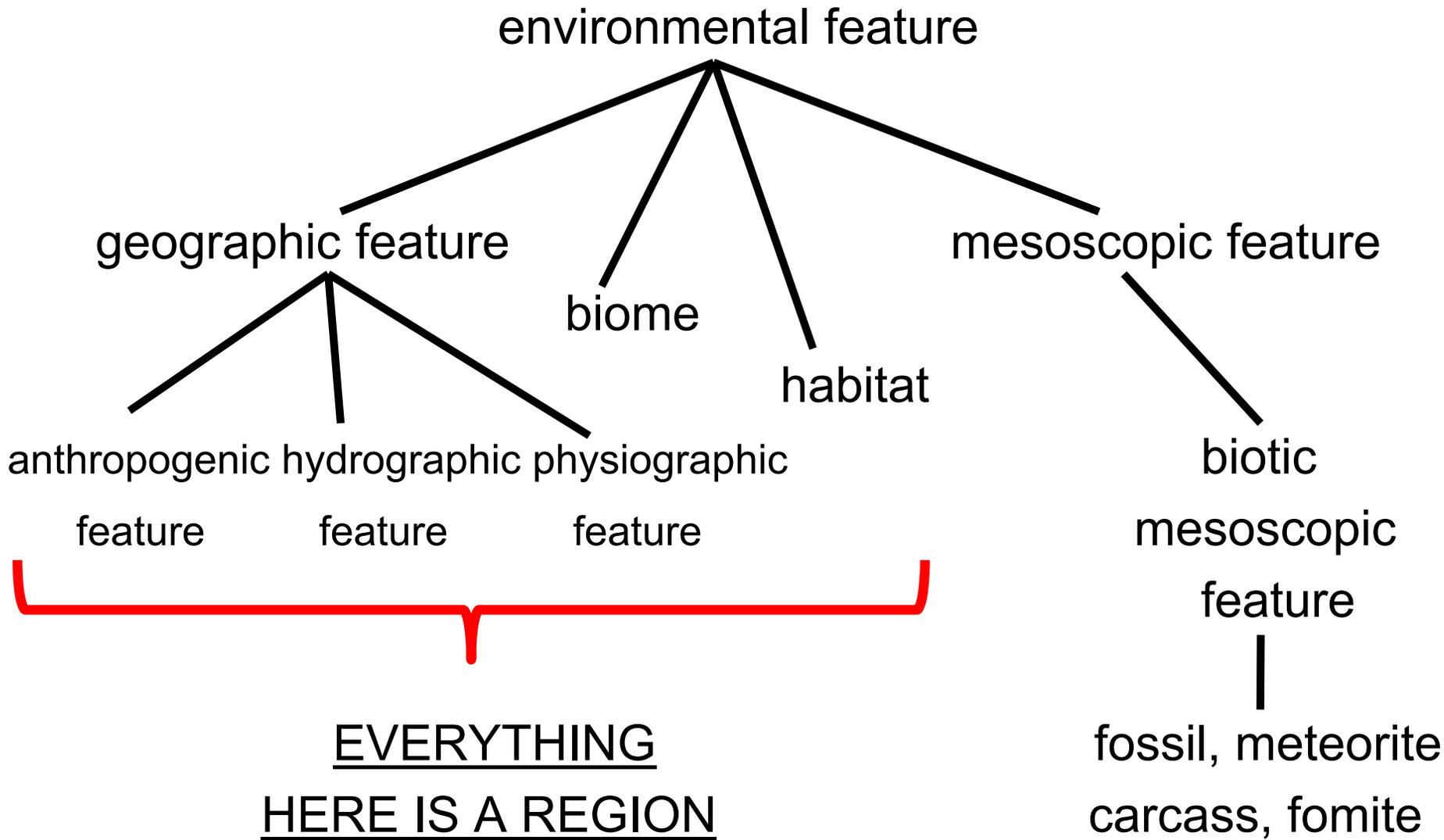
Two aspects:
spatial
qualities

biome

(region defined by the types of organisms which inhabit it)



Udvardy: A Classification of the Biogeographical Provinces of the World

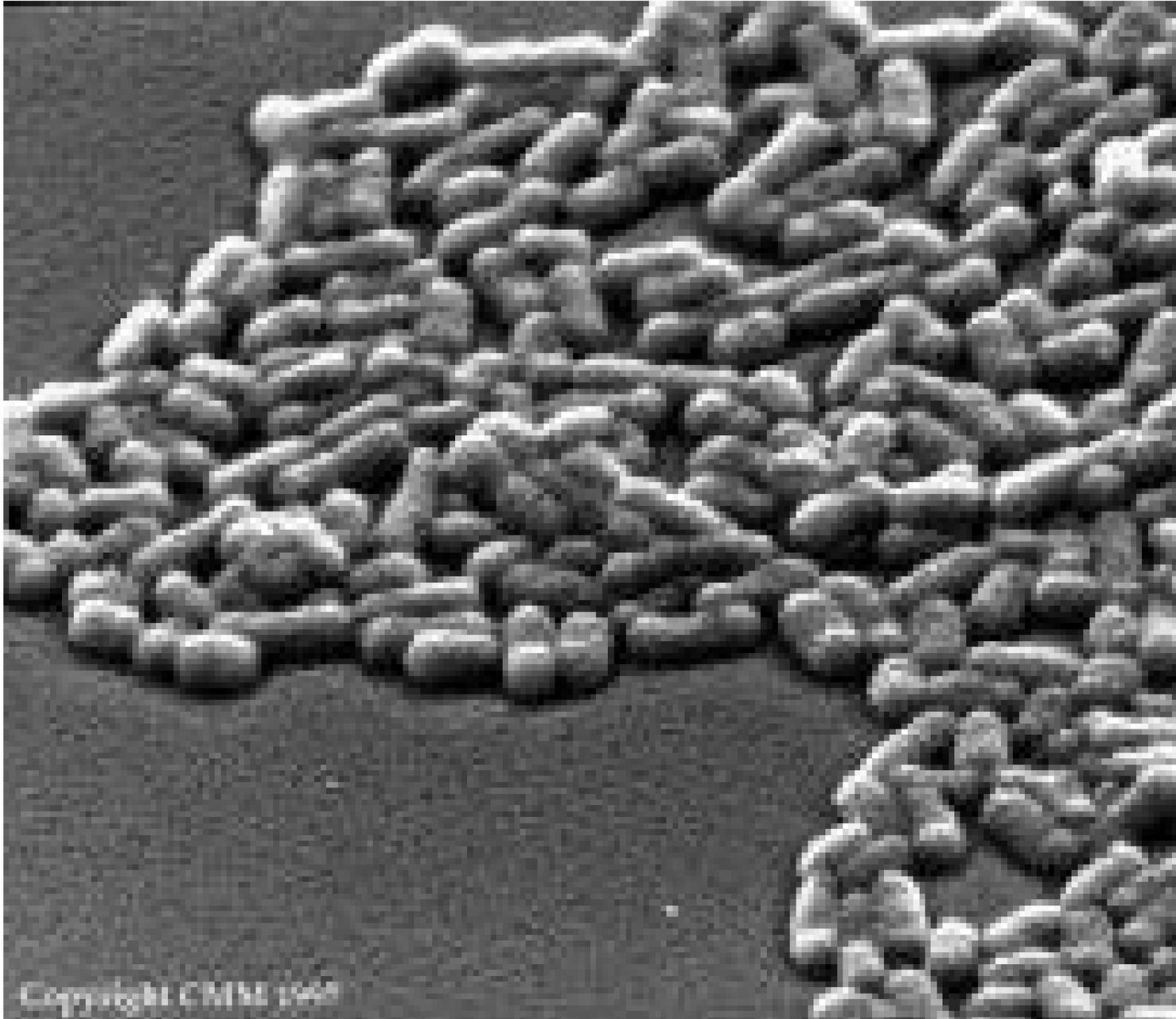


HERE ALSO THINGS

two principal types of regions

1. holes, cavities
2. surface regions





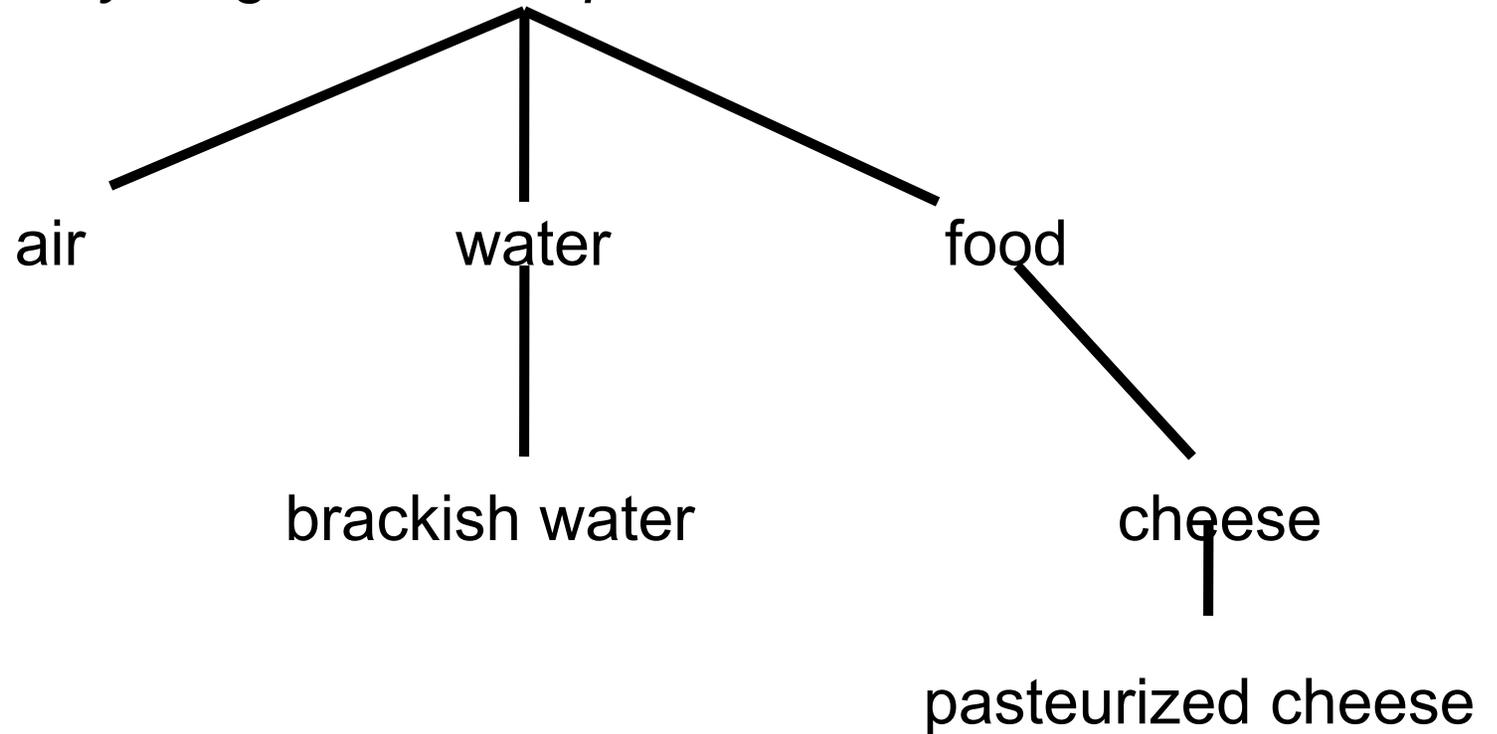


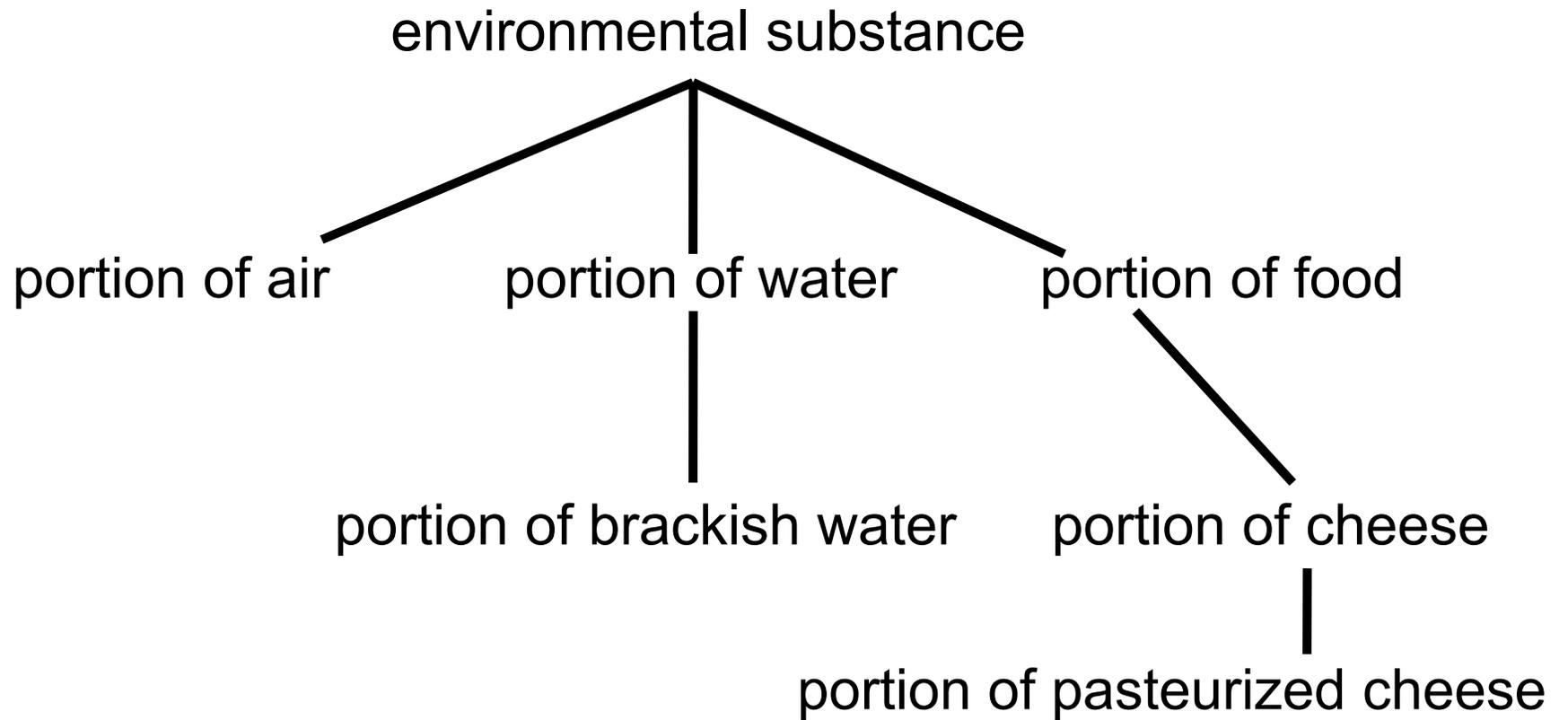


environmental substance

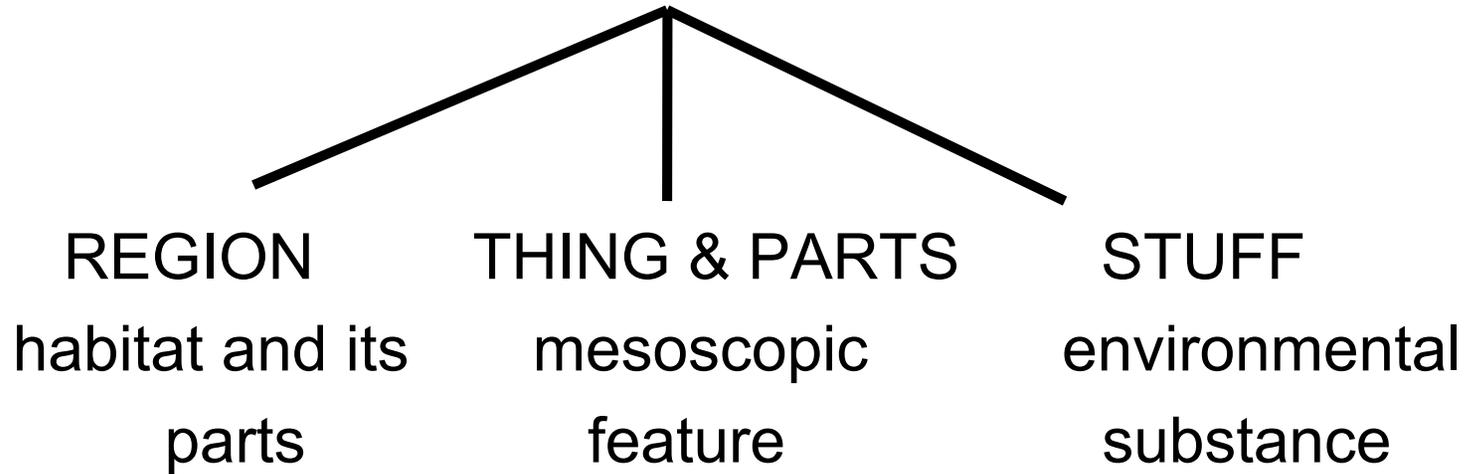
def: A body of stuff in or on which organisms may live.

comment: Everything under this parent must be a mass noun.





three branches of EnvO



Biomes, too, are regions

(with thanks to Tom Bittner)

Ecoregion
classification

What are
ecoregions?
How to
differentiate
ecoregion
types ?

Ecoregion
delineation

How to draw
boundaries
that separate
ecoregion
instances ?

↑
single level
of granularity

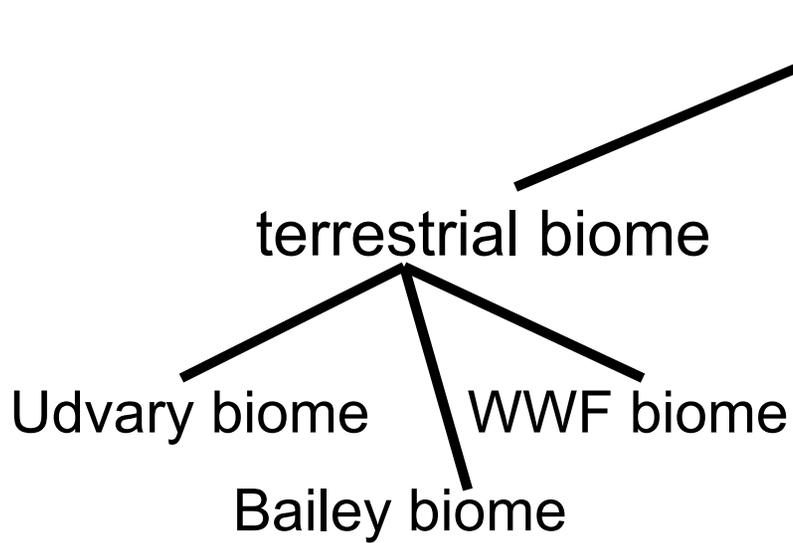
Hierarchical
nesting of
ecoregions

How are ecoregion
instances
nested
hierarchically ?

↑
multiple levels
of granularity

biome

(region defined by the types of organisms which inhabit it)



biome

(region defined by the types of organisms which inhabit it)

terrestrial biome

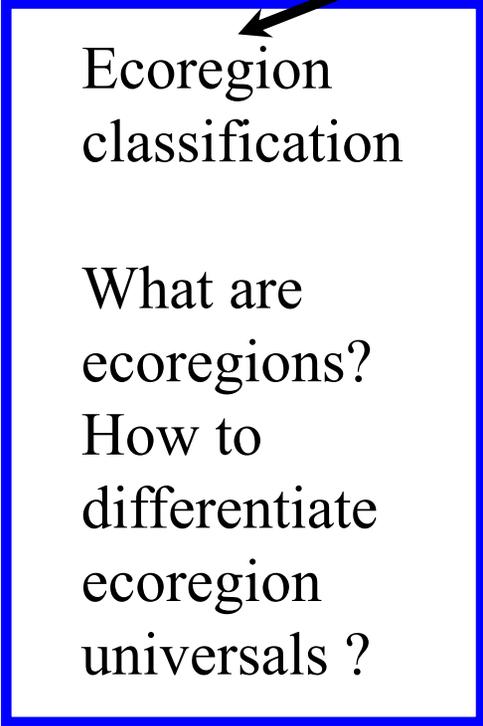
Udvary biome

Bailey biome

WWF biome

Omernik (EPA) biome

Bailey's system



Ecoregion
classification

What are
ecoregions?
How to
differentiate
ecoregion
universals ?

Ecoregion
delineation

How to draw
boundaries
that separate
ecoregion
individuals ?

Hierarchical
nesting of
ecoregions

How are ecoregion
individuals
nested
hierarchically ?

Clarifying Bailey's definitions

(BL1) "Ecoregions are large ecosystems of regional extent that contain a number of smaller ecosystems. They are geographical zones that represent geographical groups of similarly functioning ecosystems"

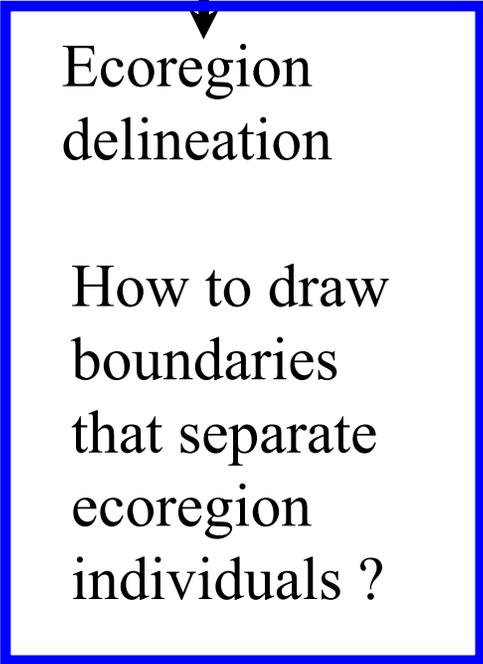
Ecoregion instances are instance-level parts of the biosphere on the surface of the Earth (another instance)

Bailey ecoregion types are instantiated by ecoregions that are of geographic scale or larger.

Classification of ecoregions according to specific climatic and vegetational affinities

<i>Humid Temperate Ecosystem</i>	<i>=_{df}</i>	<i>Geographic Ecosystem with humid temperate climate.</i>
<i>Prairie Ecosystem</i>	<i>=_{df}</i>	<i>Humid Temperate Ecosystem with prairie climate.</i>
<i>Prairie Bushland Ecosystem</i>	<i>=_{df}</i>	<i>Prairie Ecosystem with climax vegetation type Bushland.</i>

Ecoregion delineation



Ecoregion classification

How to differentiate ecoregion universals ?

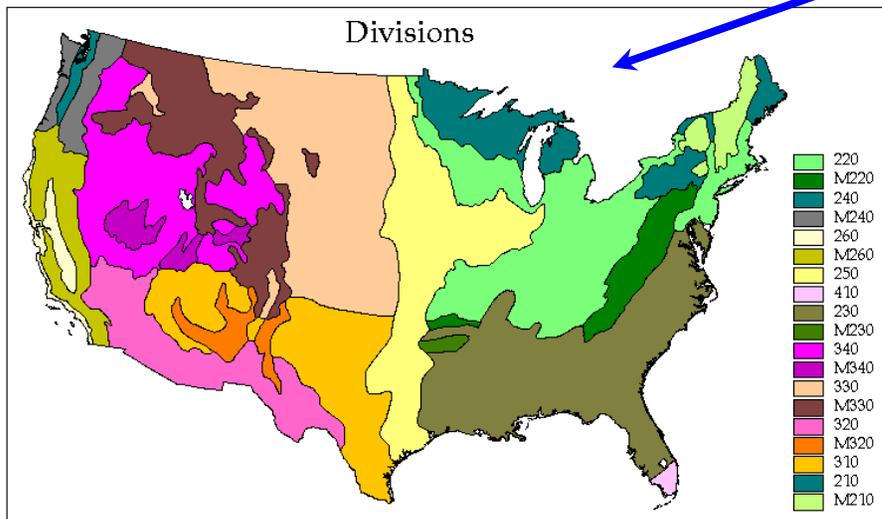
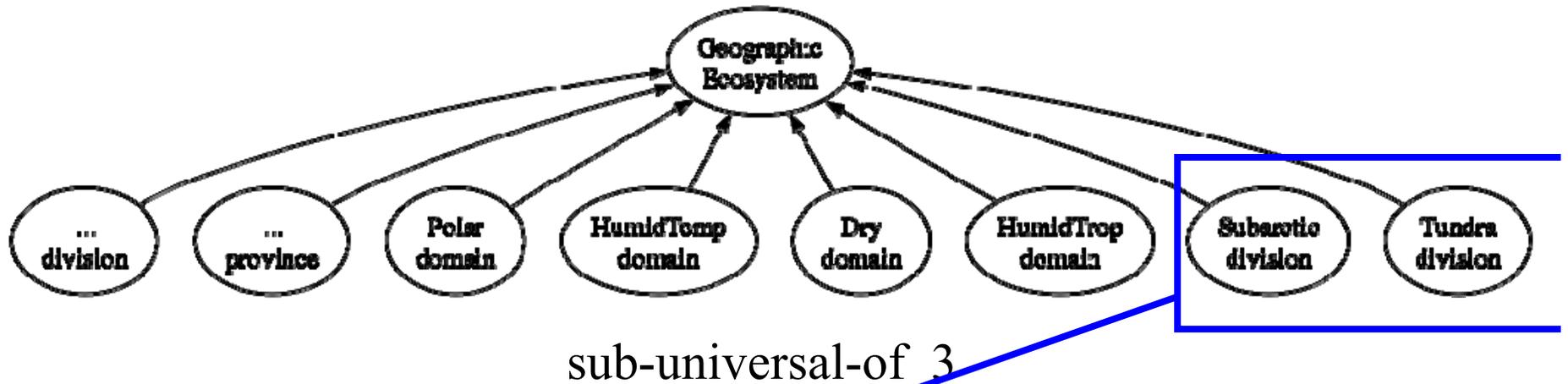
Hierarchical nesting of ecoregions

How are ecoregion individuals nested hierarchically ?

most entities in the domain of
EnvO are fiat entities

they are regions demarcated not on the
basis of physical discontinuities

Ecoregion delineation



spatial partition at the level of instances

types generate maximal instances

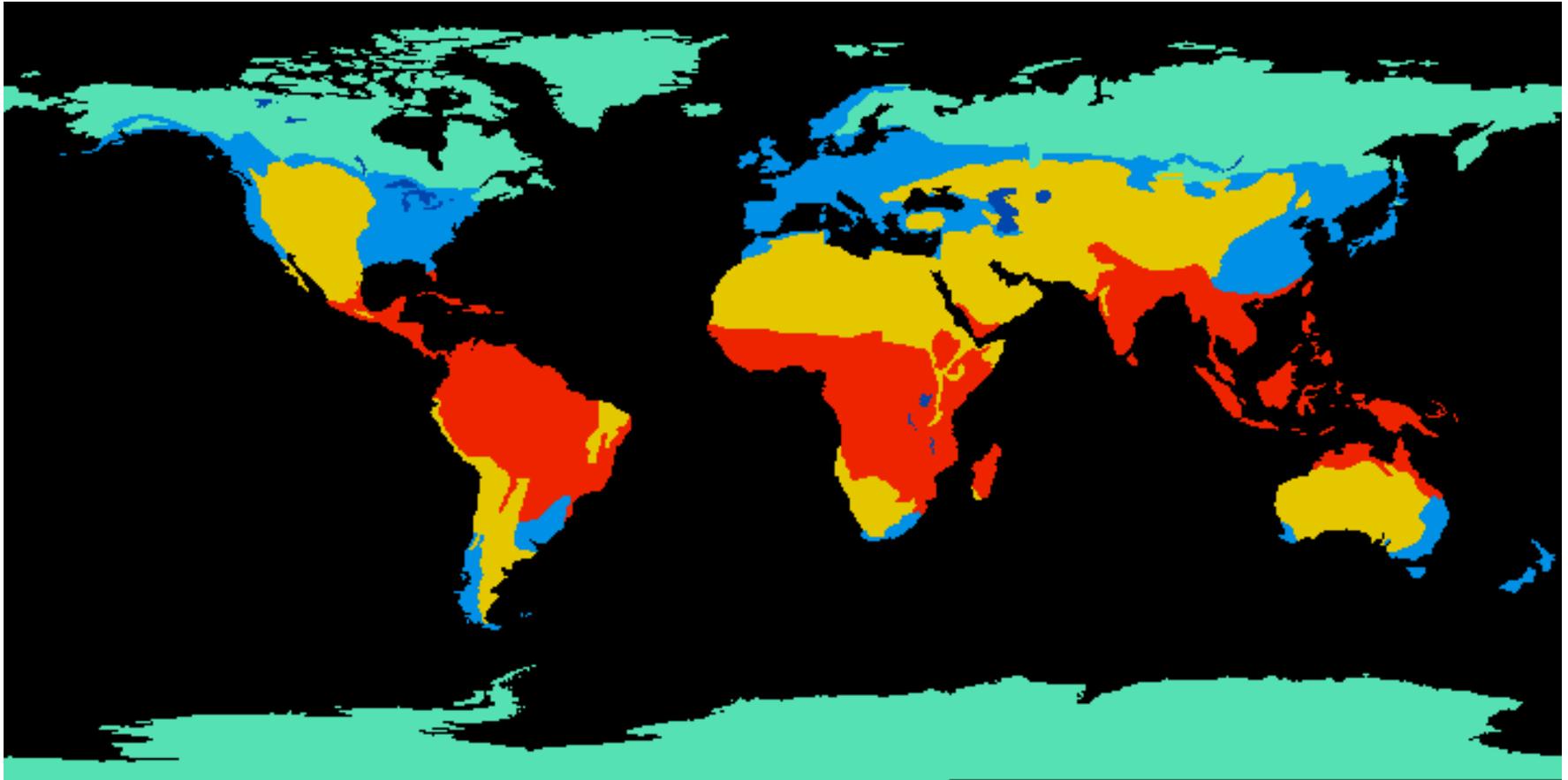
the *blood* in your *body*

the *Staph. aureus bacteria* in his *lungs*

the *sum* of all *humid temperate domains* on
the *surface* of the Earth

Cartesian cross-products

humid temperate X Earth



Maximal instances-of the Bailey universals *Polar Domain*, *Dry Domain*, *Humid Temperate Domain*, and *Humid Tropical Domain* partition the terrestrial surface of the Earth



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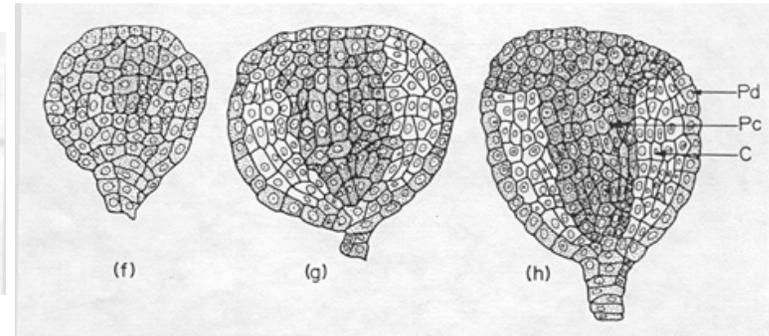
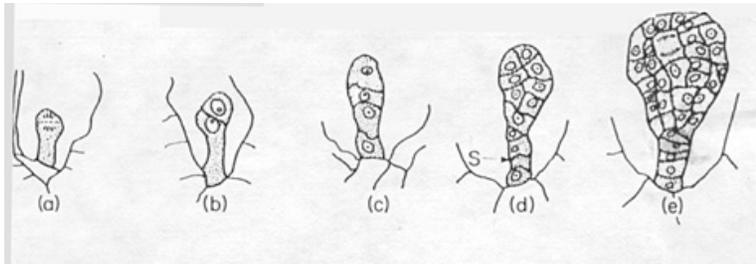
Gazetteer

A gazetteer constructed on ontological principles

 [Download](#)

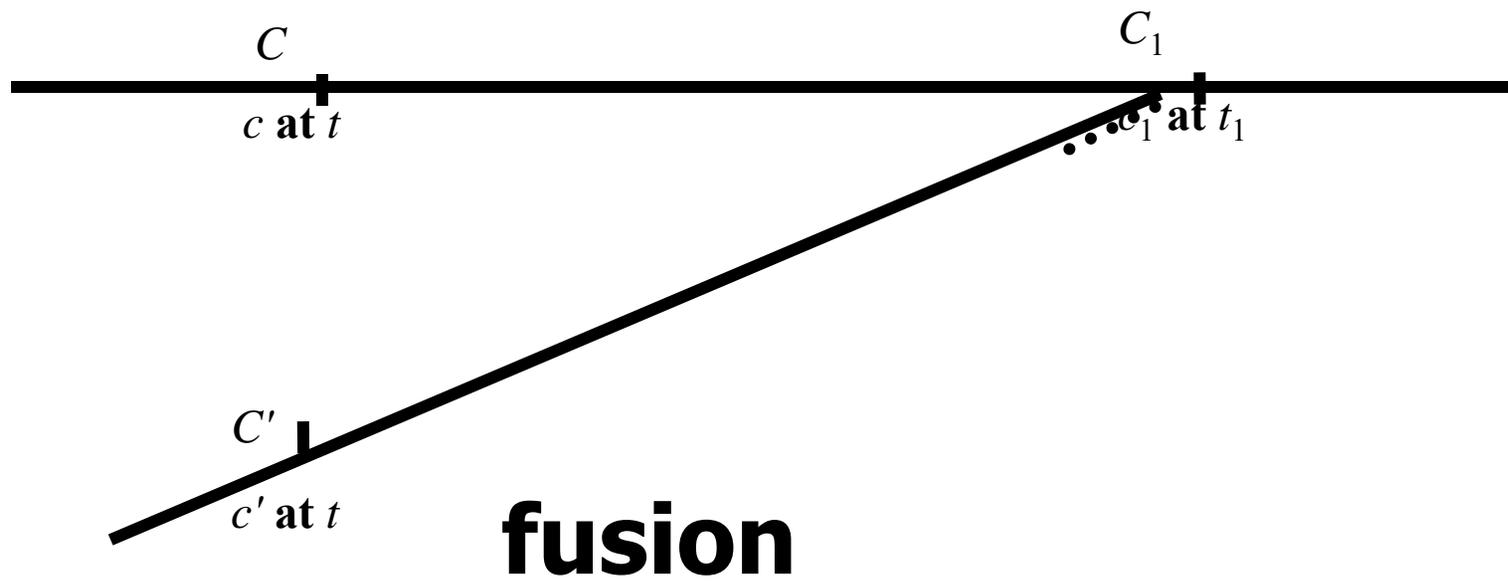
 [Ontology Homepage](#)

<http://www.ebi.ac.uk/ols/beta/ontologies/gaz>

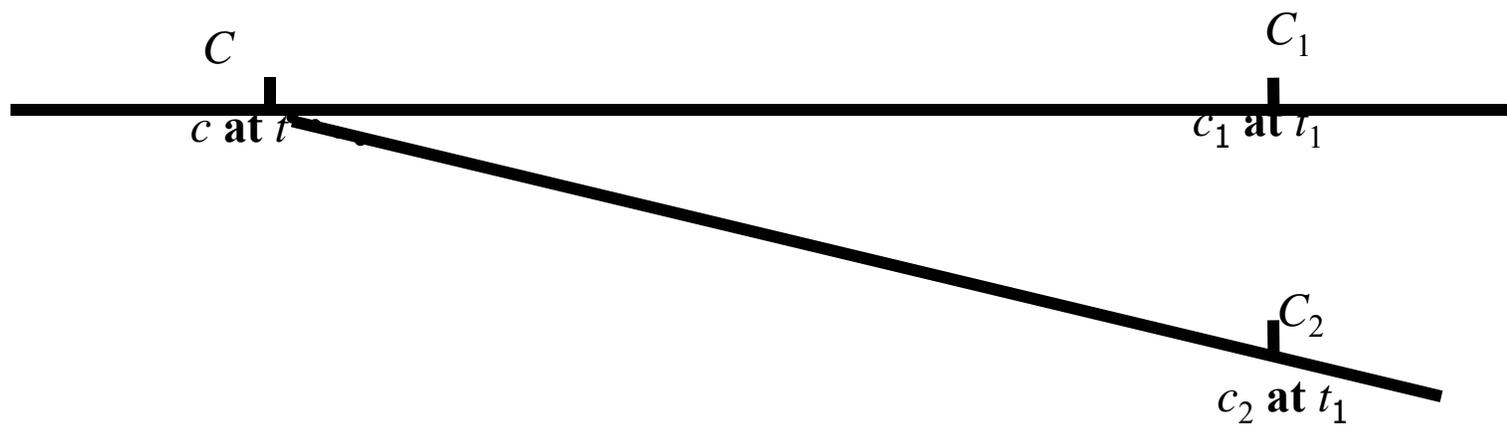


OBO Relation Ontology not just for organisms

two continuants fuse to form a new continuant

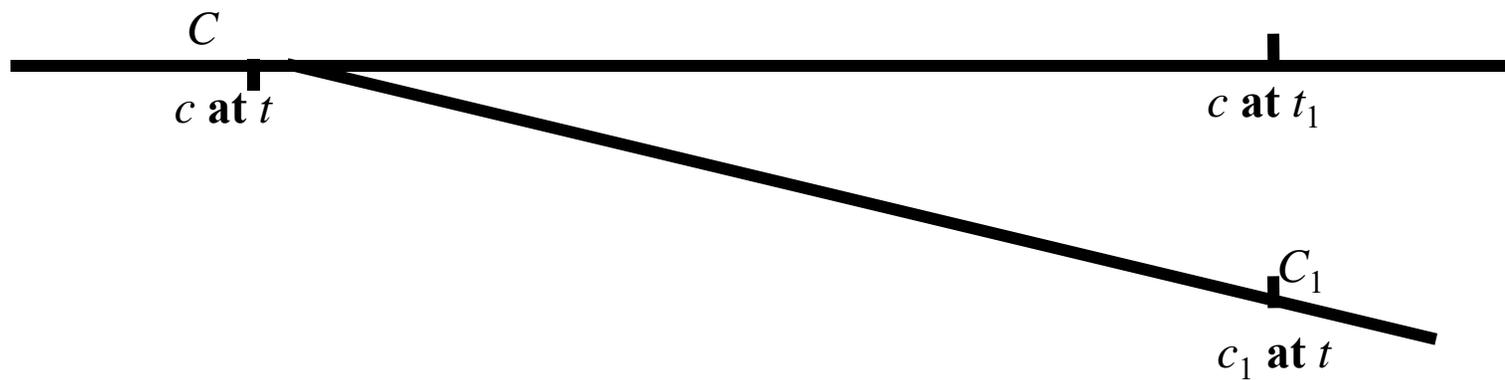


**one initial continuant is replaced by two
successor continuants**



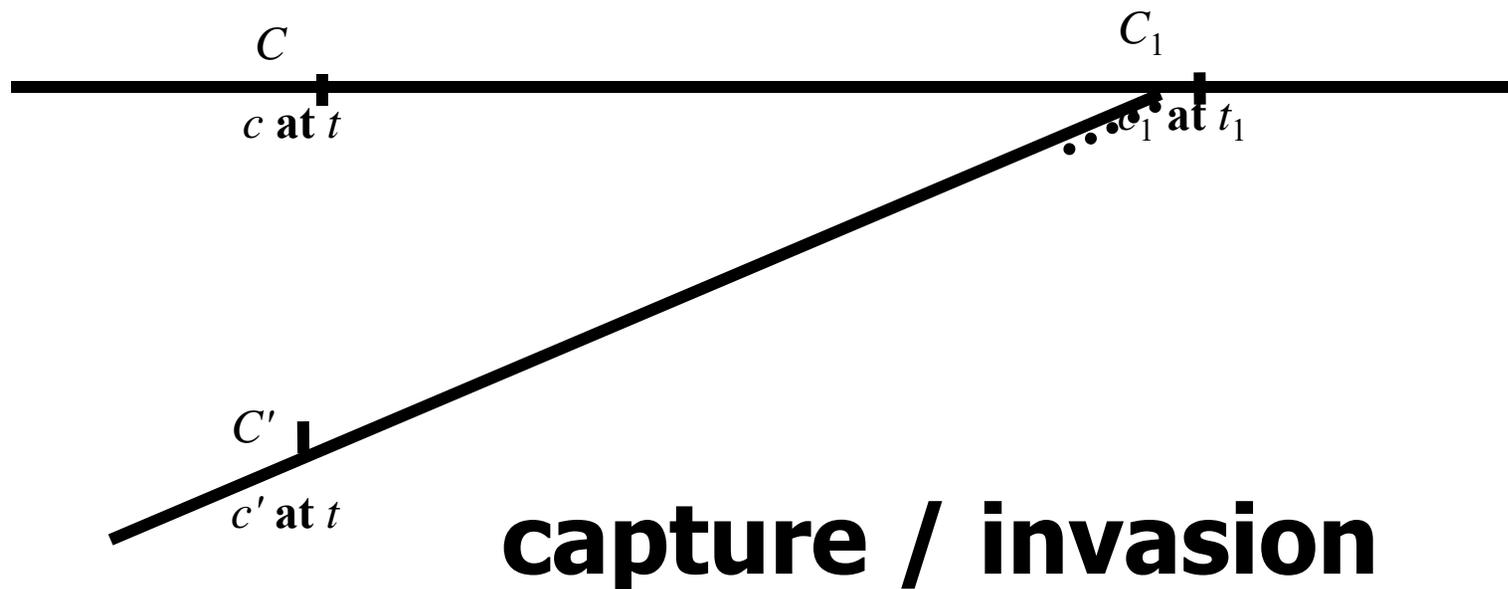
fission

one continuant detaches itself from an initial continuant, which itself continues to exist



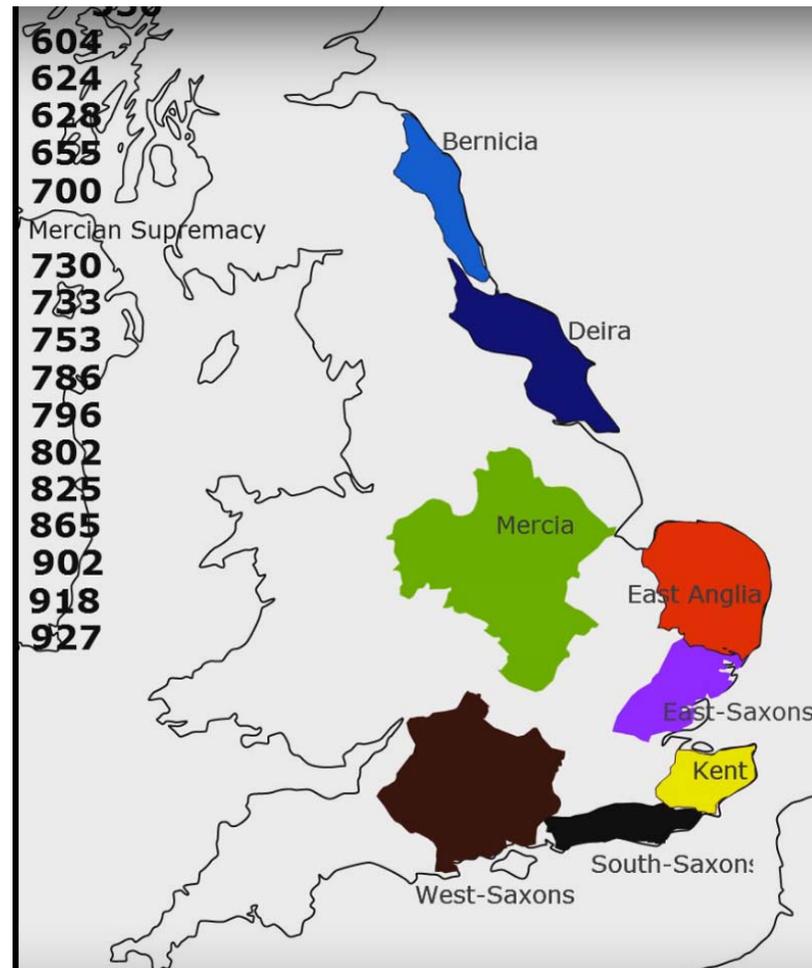
budding

**one continuant is absorbed by
a second continuant**



Environments too can bud and fuse

<https://www.youtube.com/watch?v=4eDU543tjoc>



Shabbat Tazria - Rosh Chodesh - Parshat HaChodesh The Eruv is UP

The ERUV is UP

The eruv is unsponsored.

April 8, 2016
29 Adar II 5776



<http://www.laeruv.com/>

An eruv

- a ceremonially demarcated area within which Orthodox Jews may engage on the Sabbath in activities that would otherwise be prohibited:
 - carrying walking sticks, pushing wheelchairs ...
- typically, an *eruv* is put in place by using existing horizontal wires strung on utility poles together with small vertical black rubber strips, called *lechis*, that form a symbolic "doorway."



if there is an
eruv in your
town, it looks
like this

eruv

from 'erubin', meaning literally 'mixture' or 'mingling'

a public area is *halachically* converted into a private area

(Transactions of the Institute of British Geographers 2002)



Los Angeles Community Eruv.

News and information about the *Los Angeles Community Eruv Society*.

For the Week of: Friday,

July 21, 2006

The Eruv is
UP

The Eruv is up

as of 12:30 Friday



Tenafly (NJ) eruv

Tenafly Council votes to have the U.S. Supreme Court hear its case against the Tenafly Eruv Association (Jewish Week 2.7.2003)

Without permission from the borough, the association put up *lechis* on utility poles, contravening a 1954 ordinance that prohibits placing signs or advertisements in the public right of way without permission (though such items as house numbers and church signs had often been posted on the poles without complaint).

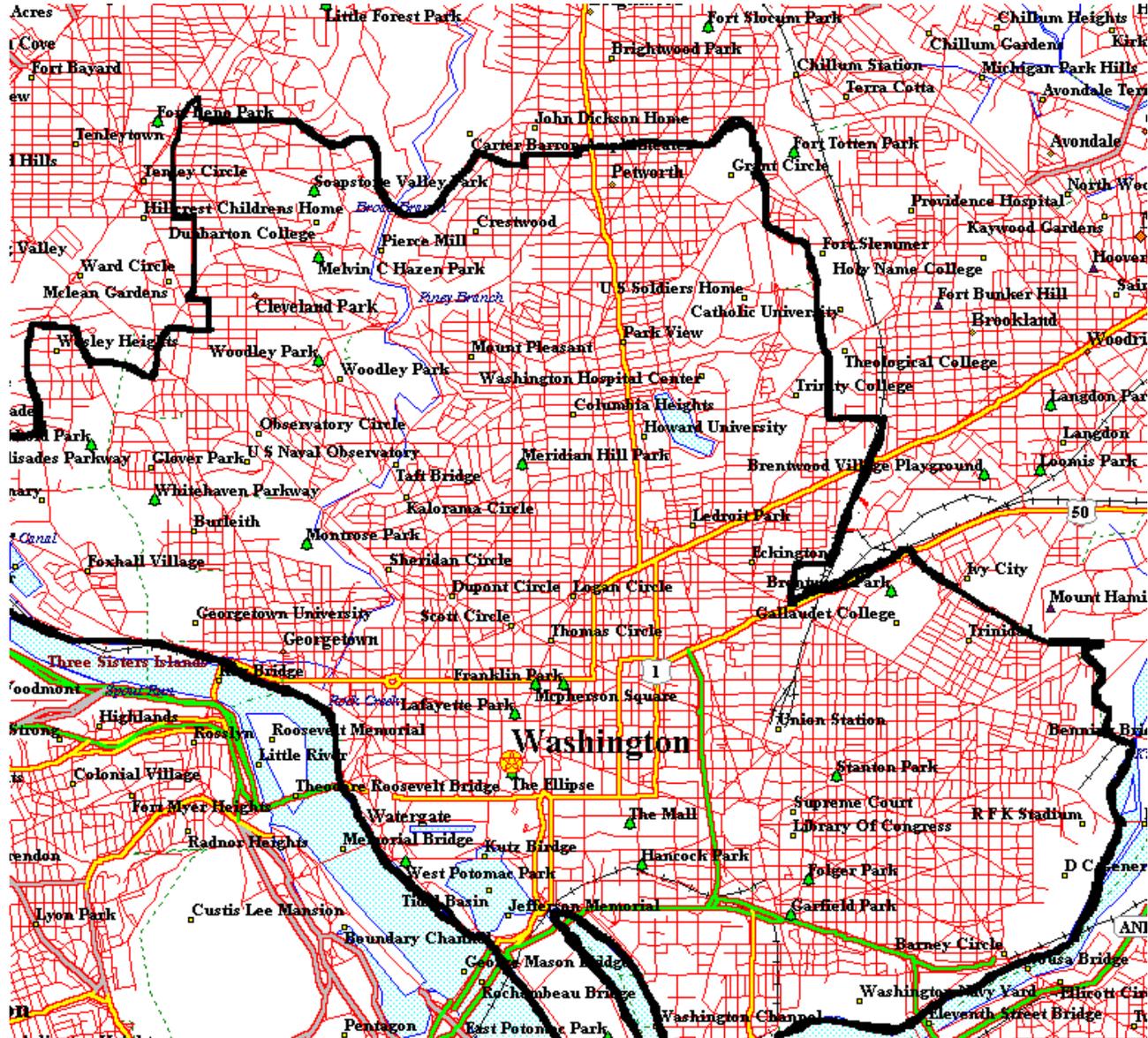


Photo : Baptiste Coulmont, NY, 08/2004

Chicago eruv



Washington eruv



Barnet (N. London) eruv

completed via strands of nylon fishing line stretched between poles at a height of 10 meters from the ground forming a 6½ sq. mile halachically enclosed area

Barnet eruv

- Some Orthodox objected because they saw the restrictions on carrying as necessary to maintain social order
- Liberal Jews objected because they feared “the re-creation of ghettos” (*Geoforum* 2000)
- Secular liberals objected that the eruv impinges on their “human rights to freedom of thought, conscience and religion”.

Ways of Worldstaining

liberal opponents perceive the eruv to be a challenge to ideas of secularism, the public–private divide and enlightenment rationality

– the eruv seems to ‘symbolically stain space’

D. Cooper, “Talmudic territory? Space, law, and modernist discourse”, *Journal of Law and Society* 1996

Liberal objection to the Barnet eruv

- “Eruv-believers would happily pass through their symbolic gateways in the streets, but everyone else would be compelled to do so without such a benefit, even if the compulsory passage through the Eruv structures is offensive to a person’s beliefs.”

- what is the mistake here?

through?



or *under*?

img by ShalomNewYork.com

The Peace of Westphalia (1648)

the governments of sovereign states are free to structure their relationships with their citizens independent of all external interference

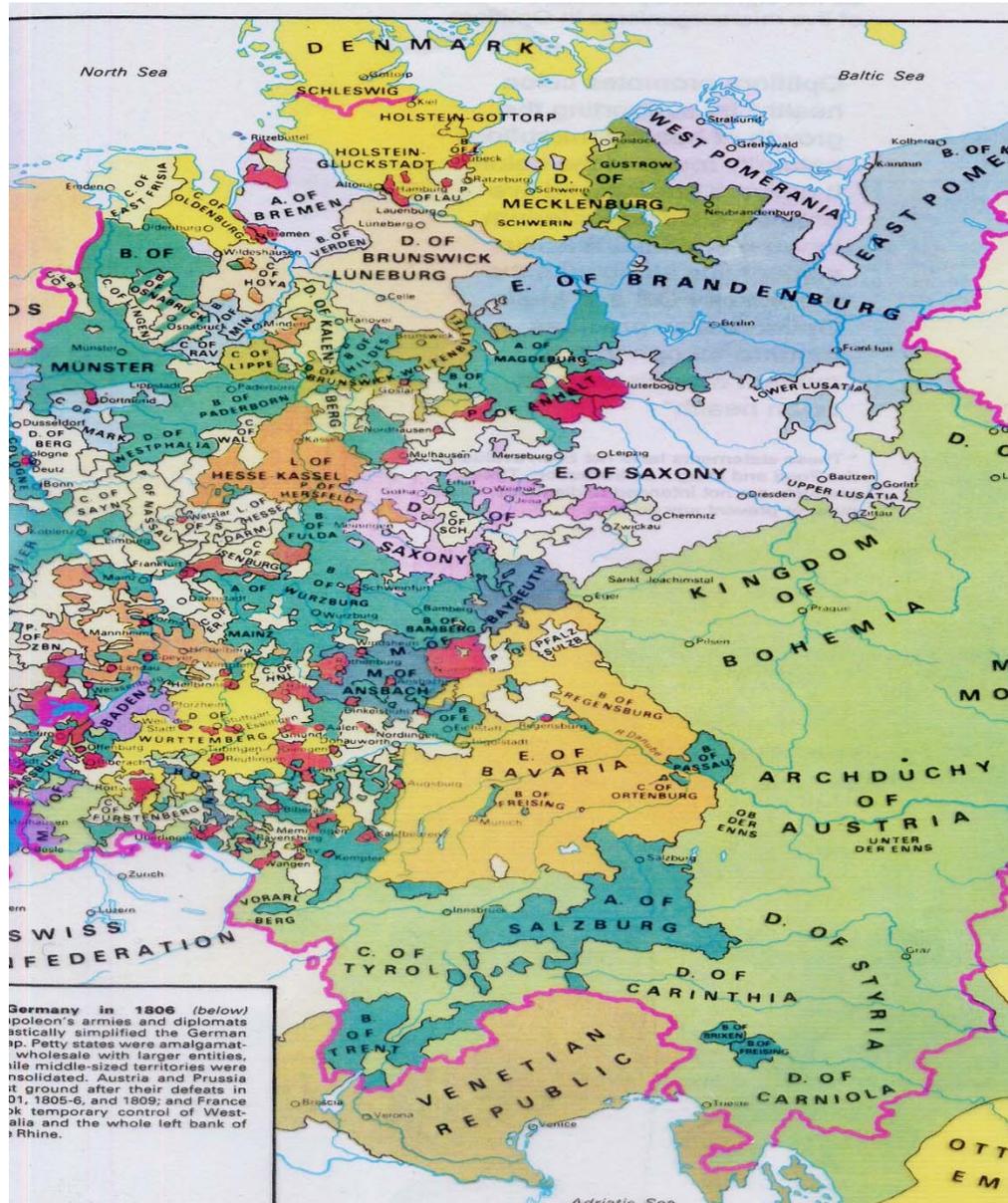
the king has 'all Rights...without any reserve...with all manner of Jurisdiction and Sovereignty.'

The Peace of Westphalia Declared Eternal

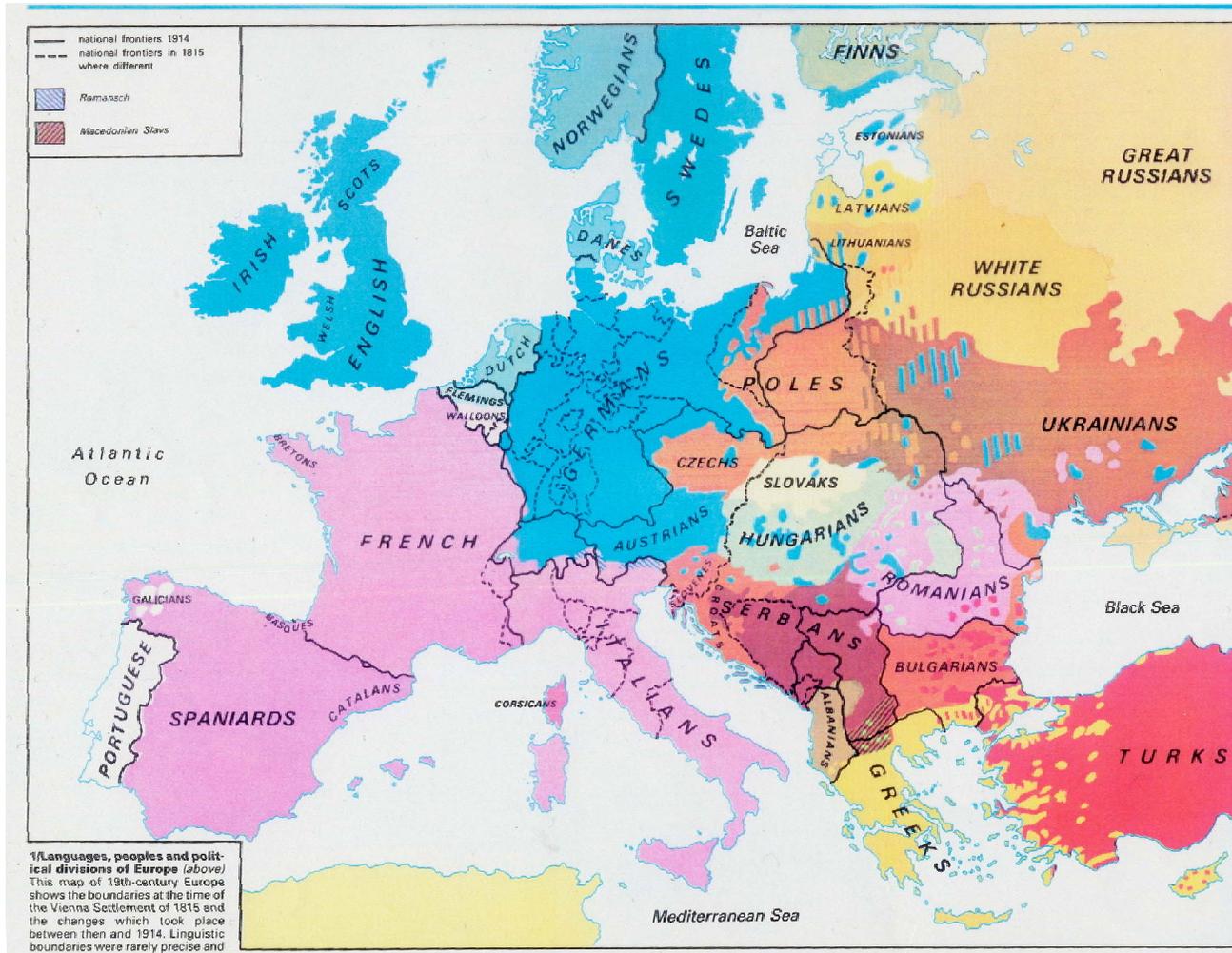
The year 1624 was declared the 'standard year', according to which territories should be deemed to be in Roman Catholic or Protestant possession, with the provision that a prince should forfeit his lands if he changed his religion

(Can the Westphalian Sovereign Paradigm Survive in Cyberspace?)

German states in 1648



1914





Types of non-Westphalian partitions

condominiums

(overlapping sovereignties)

- The River Our is in Luxemburg *and* in Germany
- Lake Constance
- The Antarctic
- The Moon
- Berlin under the Four Powers

Types of **non-Westphalian partition**

temporary boundaries

Camp Zeist, a Scottish enclave located in the Netherlands from 1999 to 2002

created in order to allow the UK authorities to bring two Libyans accused of the 1988 Lockerbie bombing to trial on Scottish soil.

The eruv boundary is there only on certain days of the week

The Eruv is
UP

The Eruv is up

as of 12:30 Friday

Types of non-Westphalian partition

indeterminate boundaries

Lake Constance



An ontological black hole in the heart of Europe



Lake Constance

- Switzerland takes the view that the border runs through the middle of the Lake.
- Austria takes the view that all three countries have shared sovereignty over the whole Lake.
- Germany takes the view that Germany takes no view on the matter.

A patchwork of international treaties regulate specific matters subject to dispute.

Types of non-Westphalian boundary-structures

one-sided boundaries

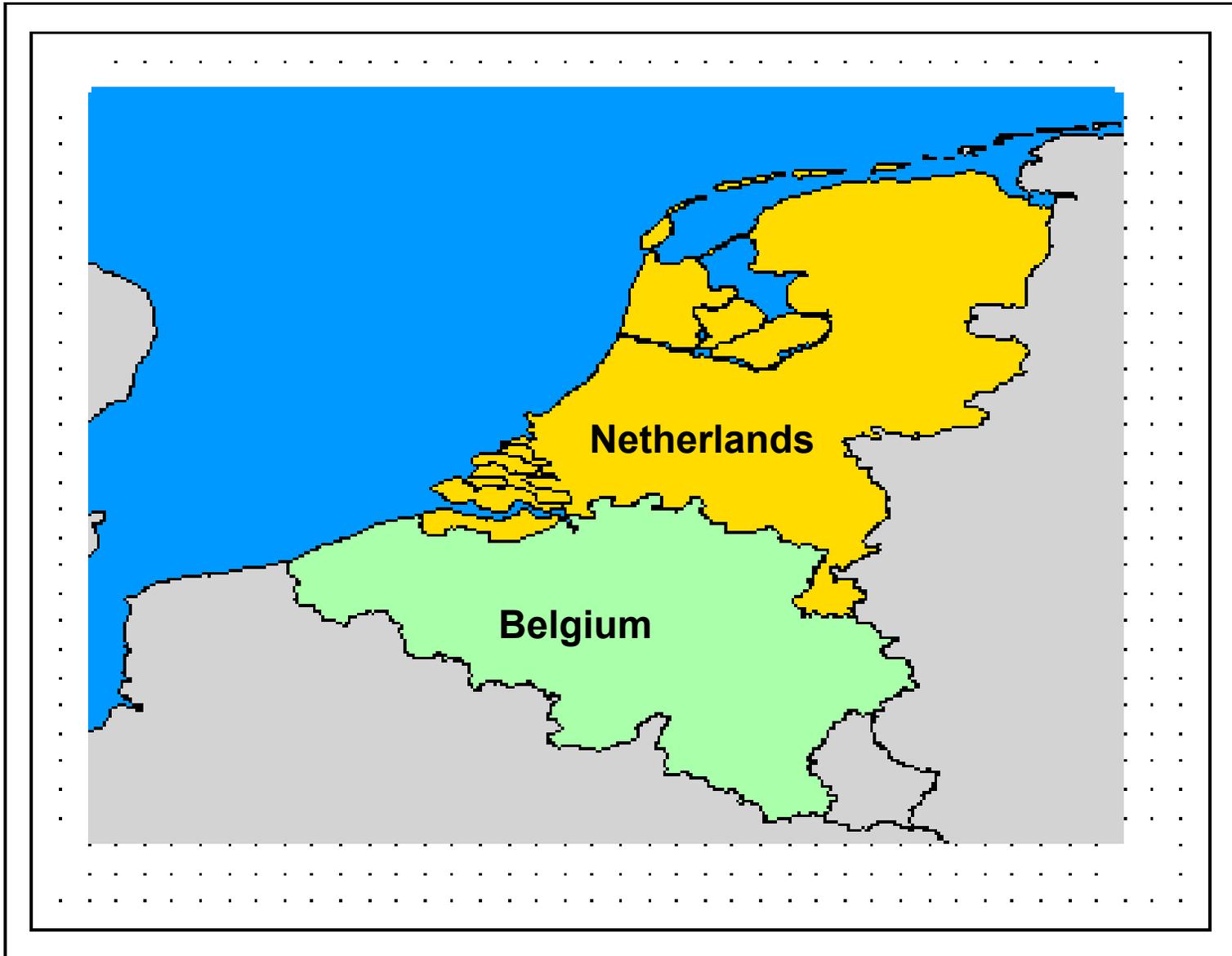


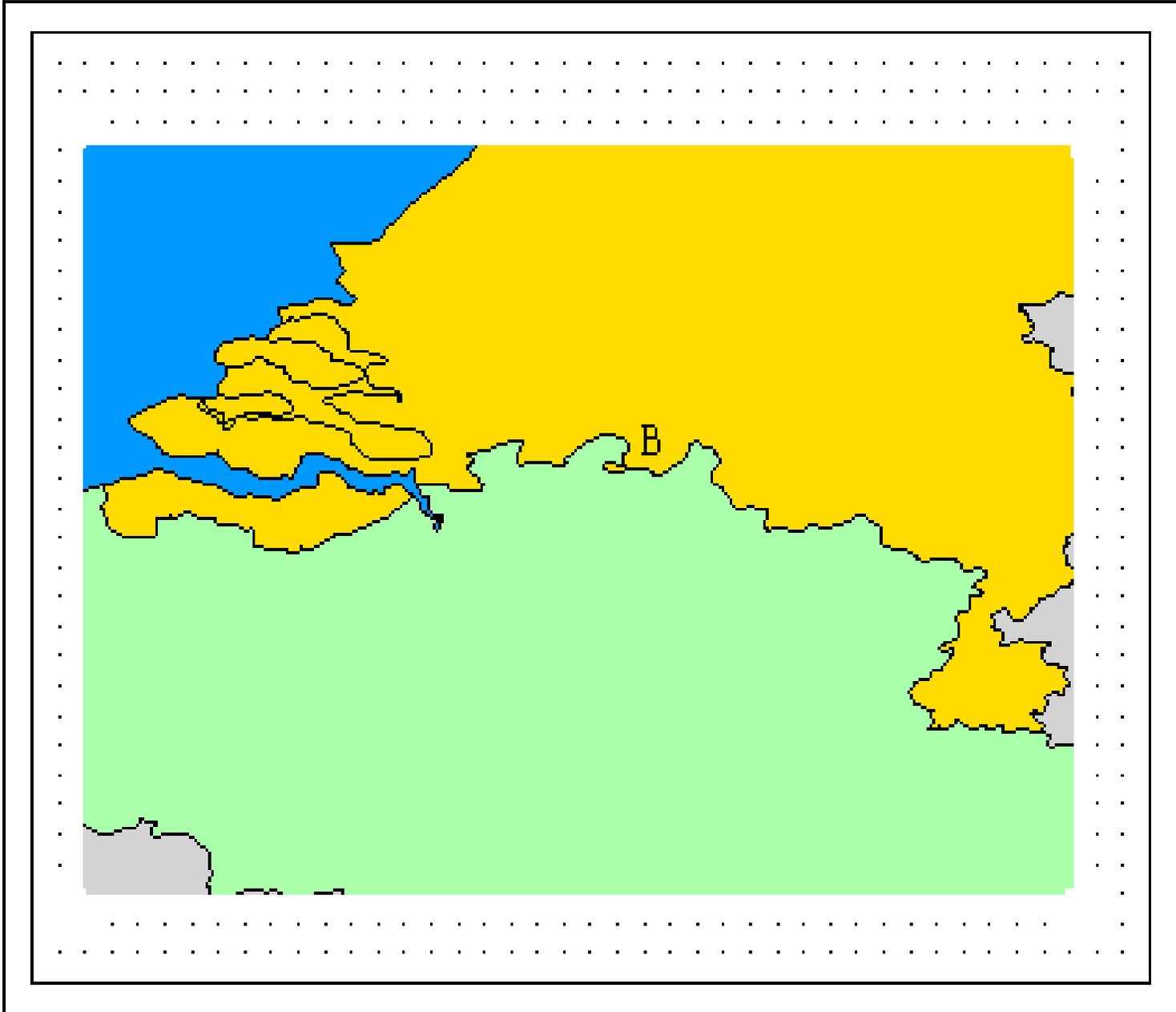
From the Western side



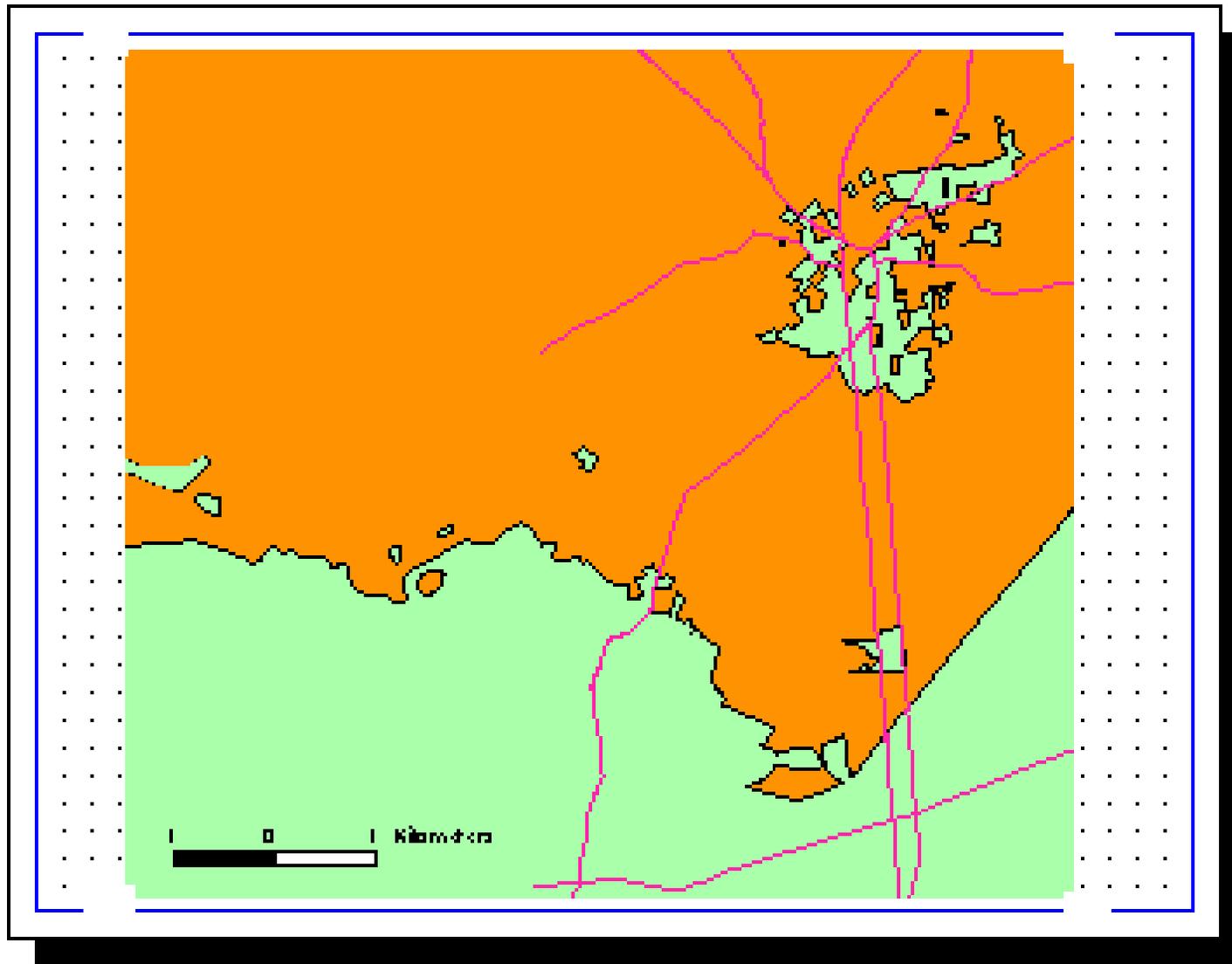
Types of non-Westphalian partition

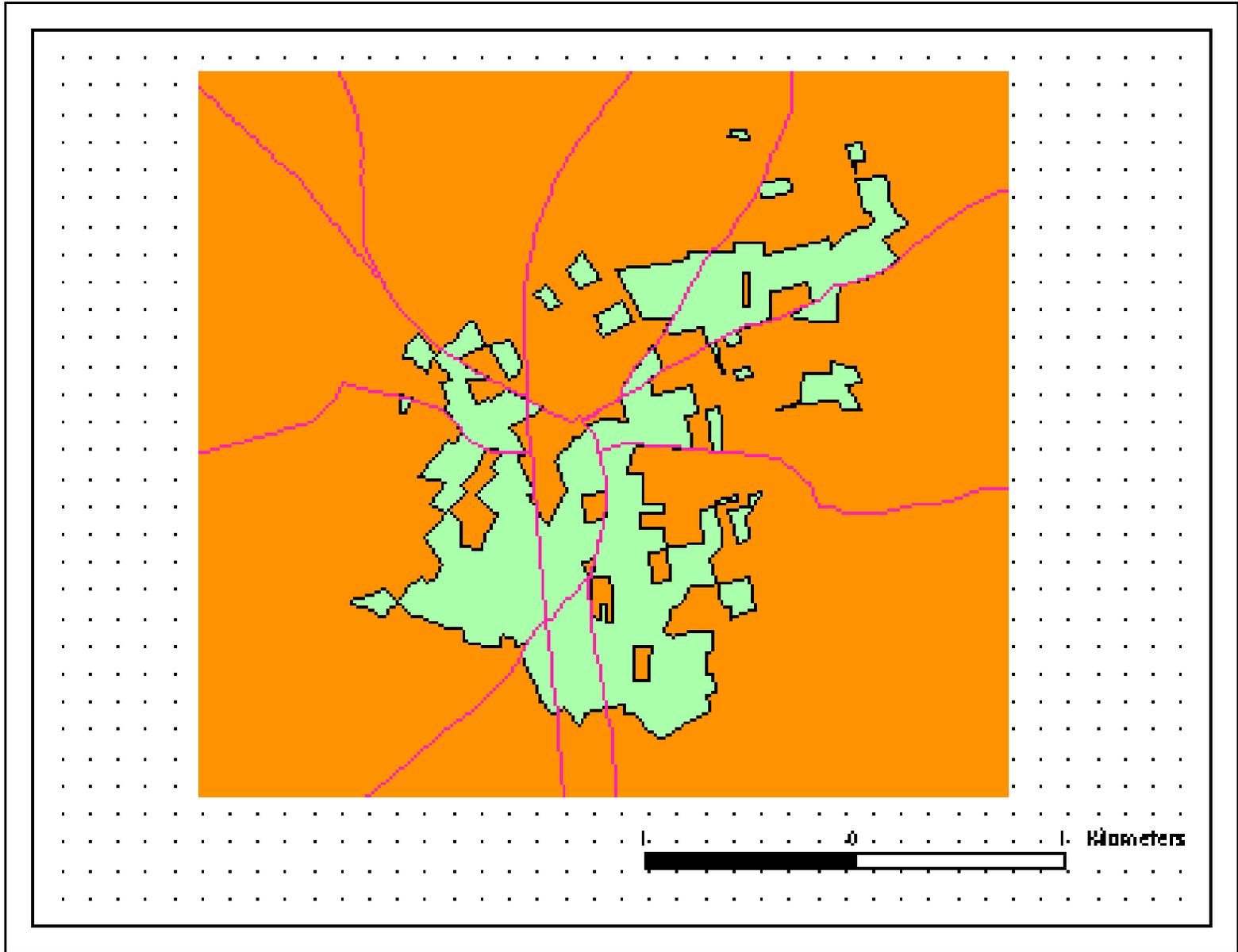
fractal boundaries





Baarle Nassau/Baarle Hertog





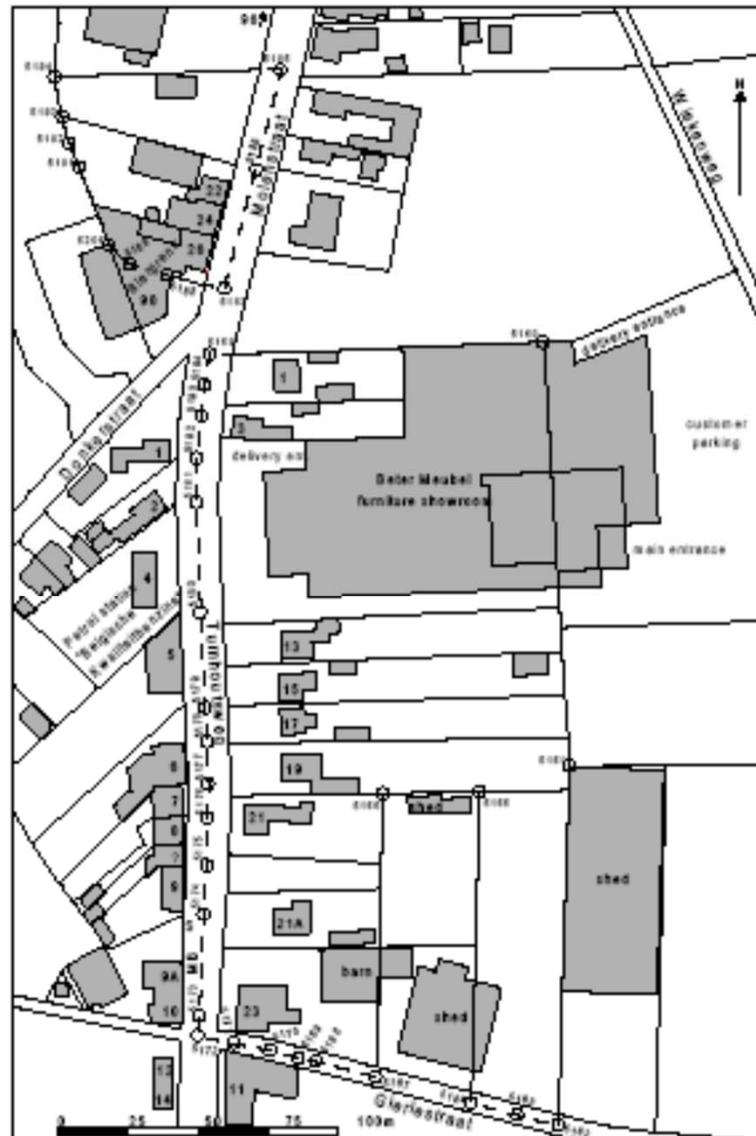


Figure 5a. Dutch counter-enclaves N3 & N5 in Belgian enclave H1

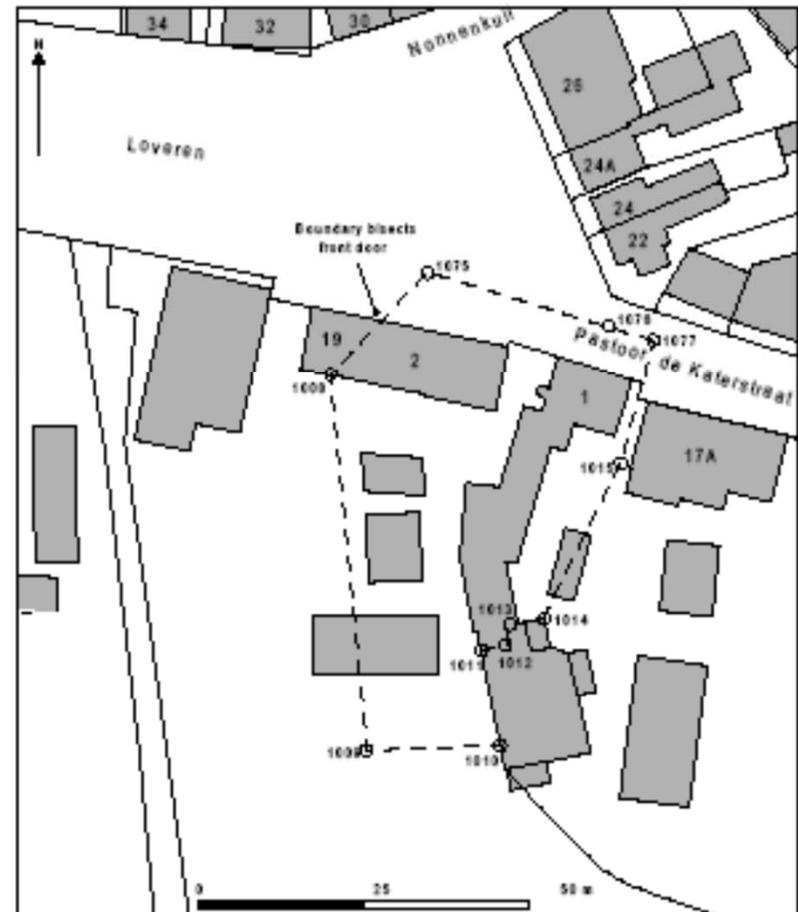
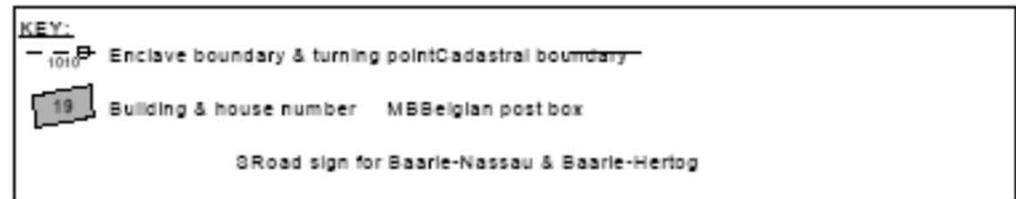
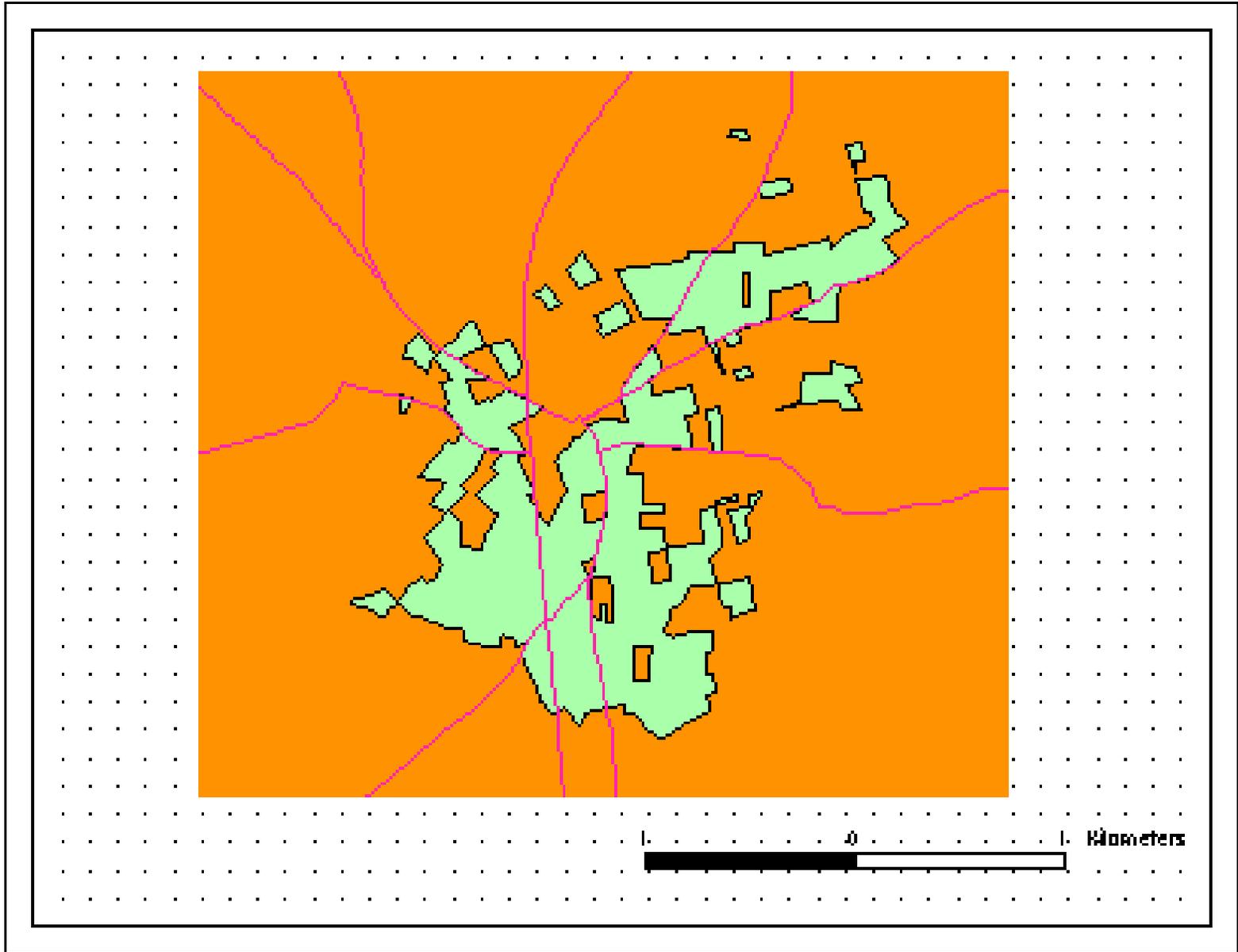
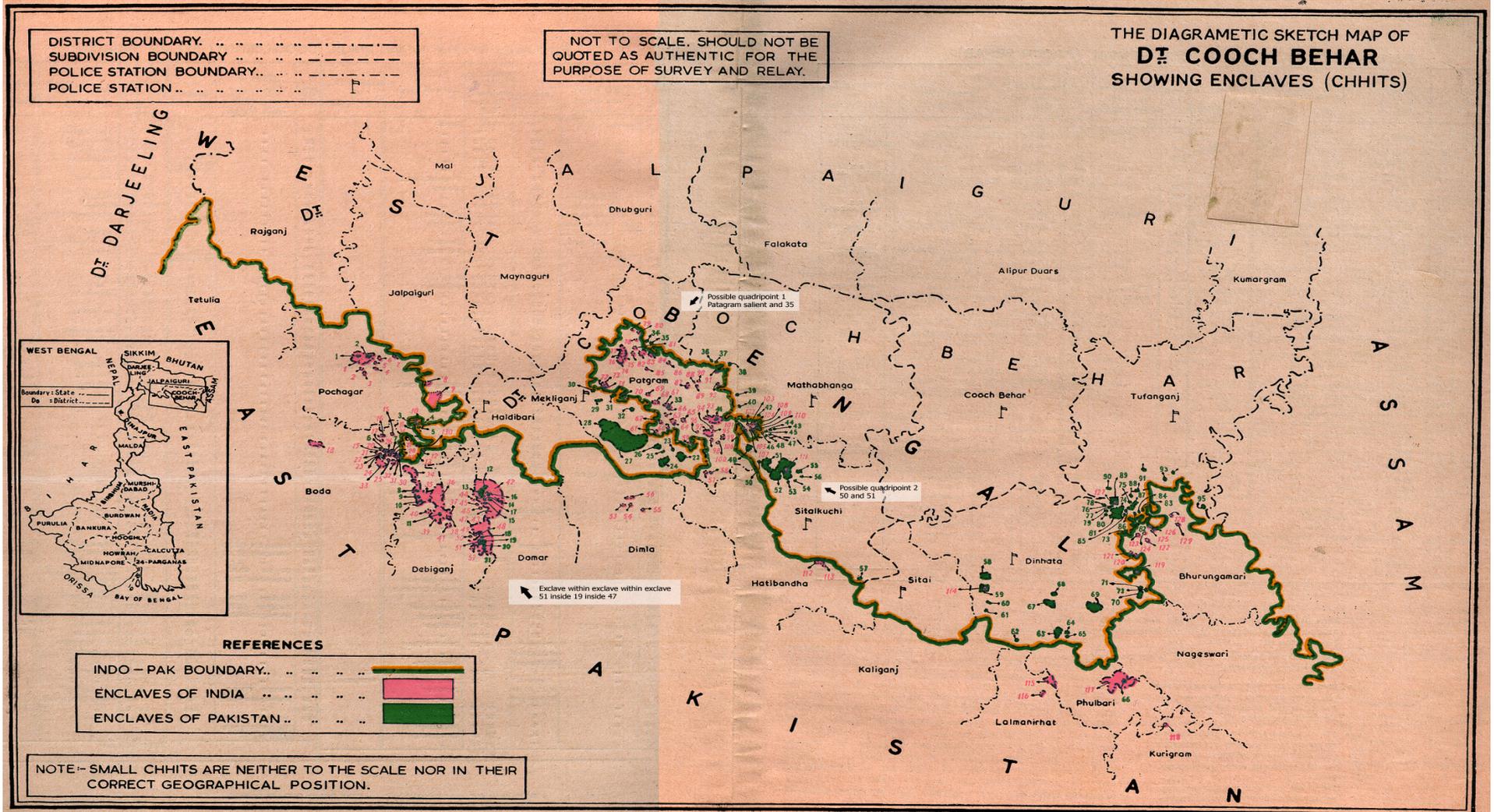


Figure 5b. Belgian enclave H7

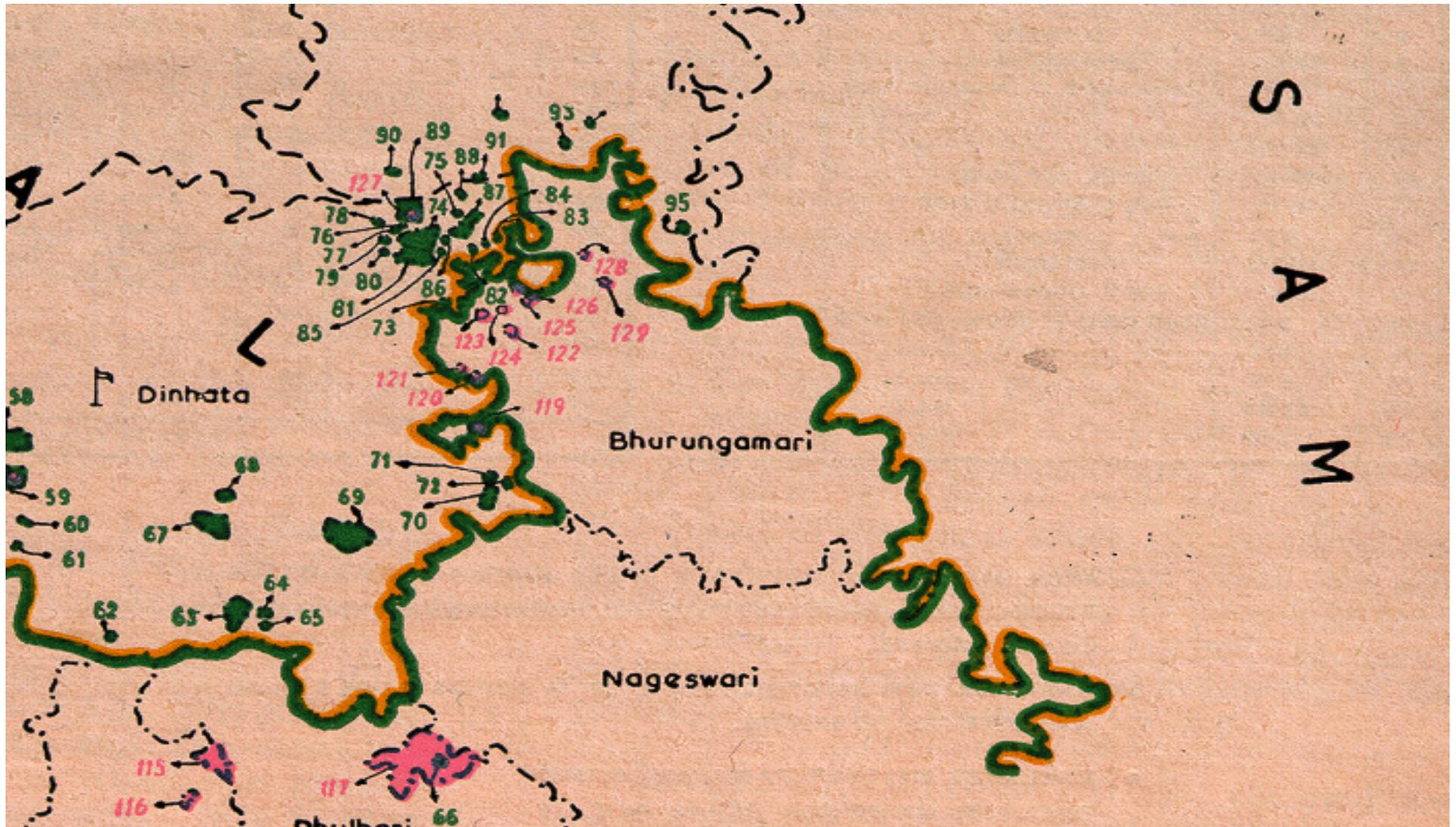


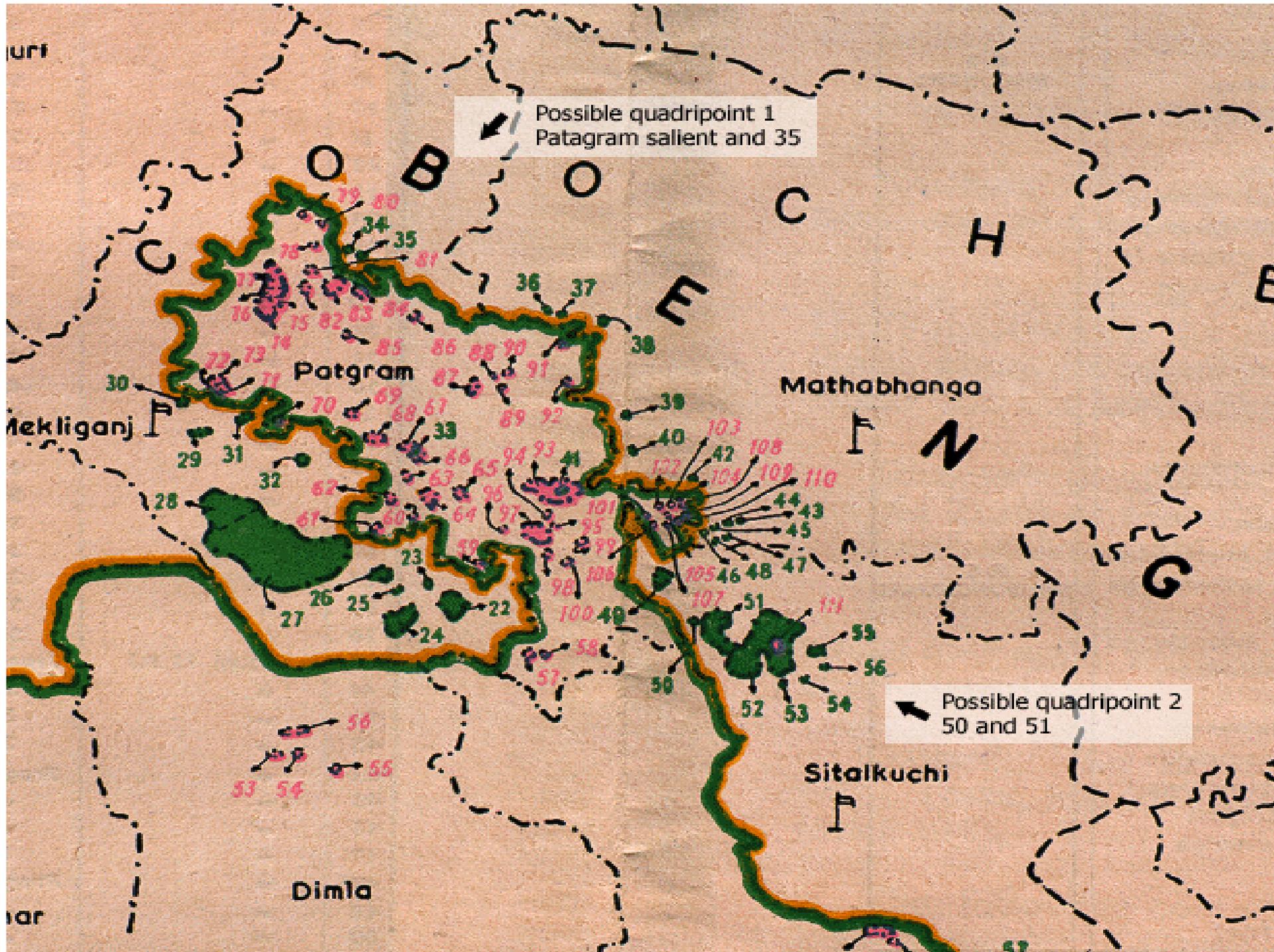


fractal boundaries in Bengal



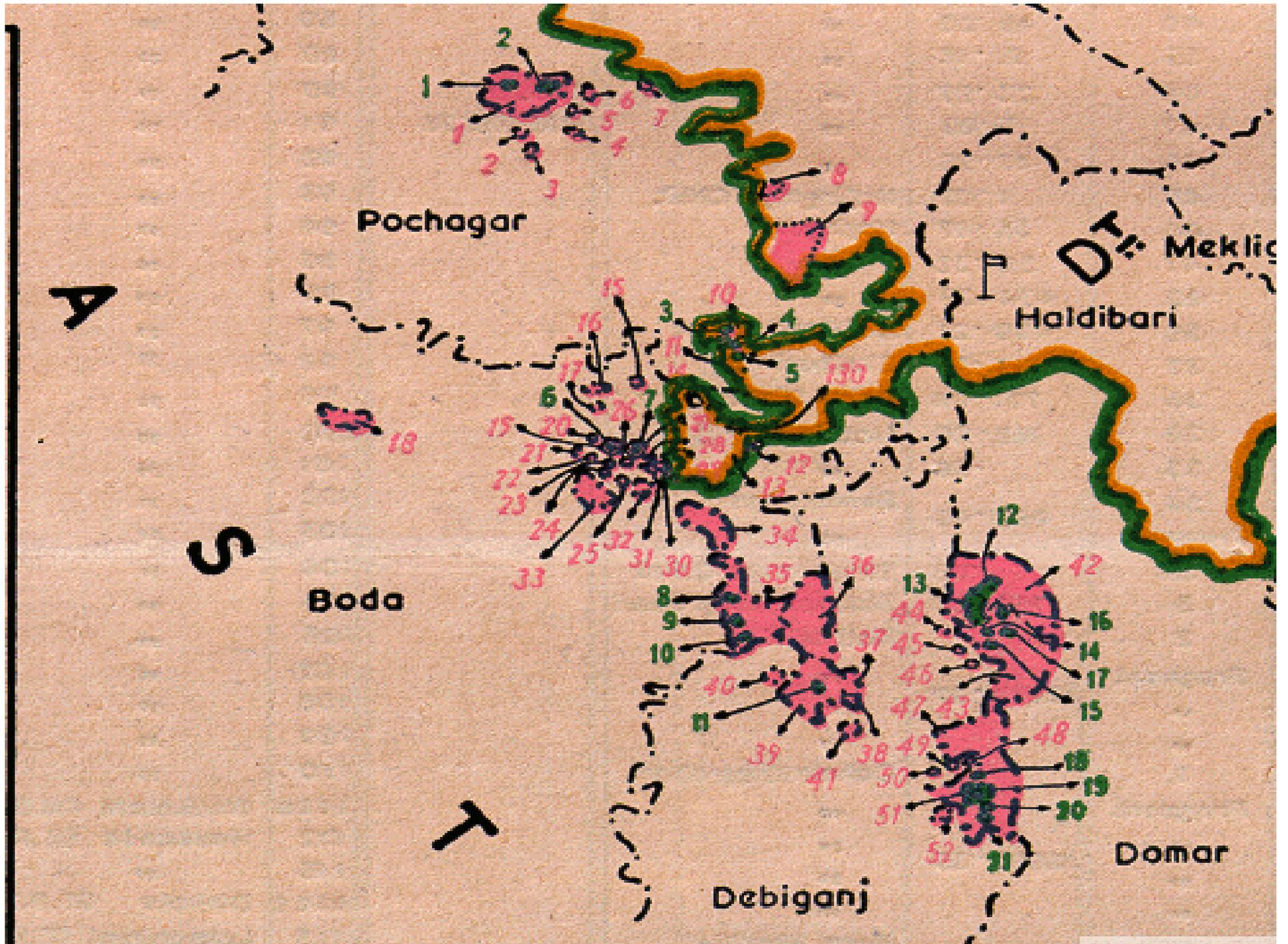
fractal boundaries in Bengal



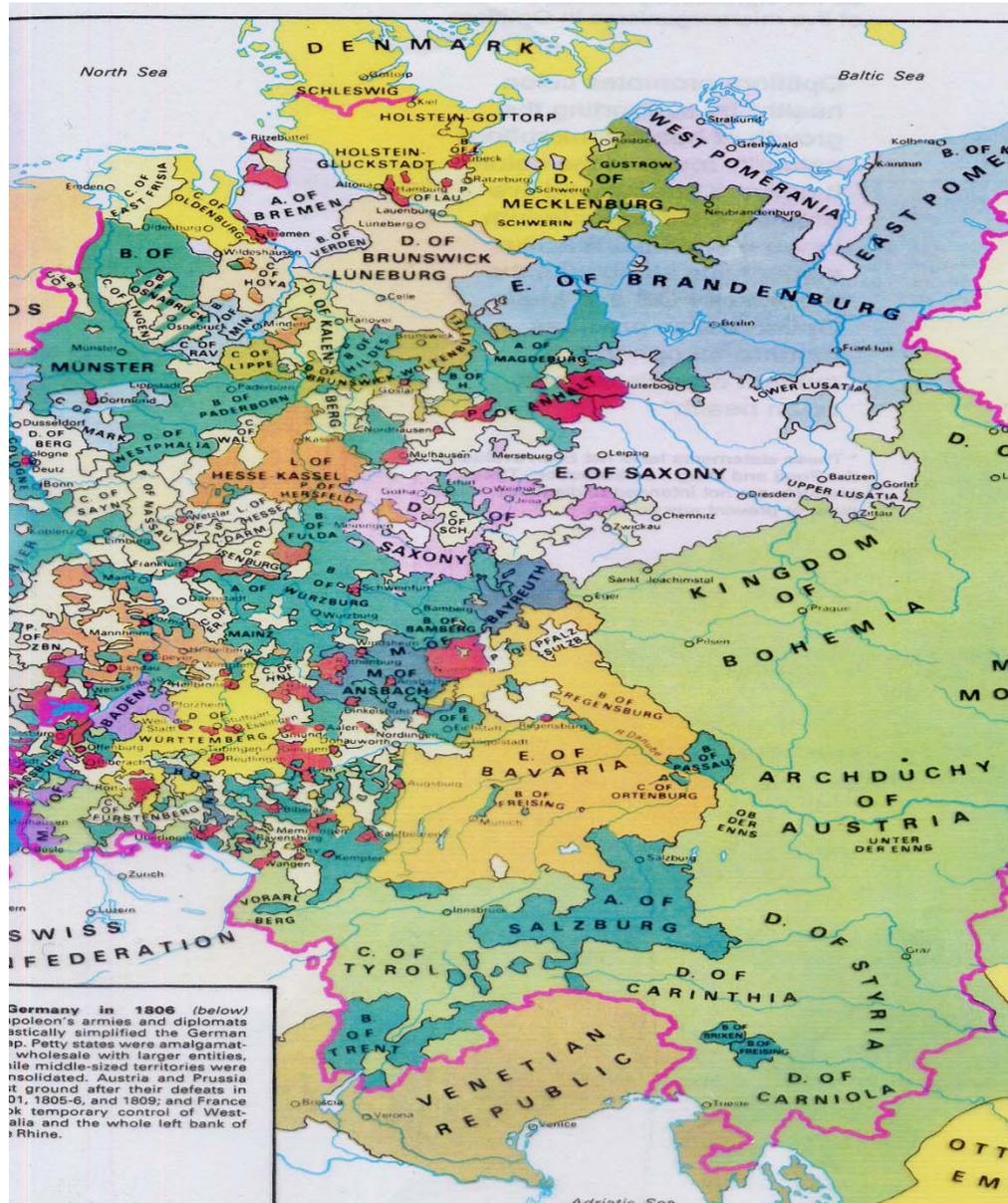


Possible quadripoint 1
Patgram salient and 35

Possible quadripoint 2
50 and 51



fractal boundaries in Europe in 1648

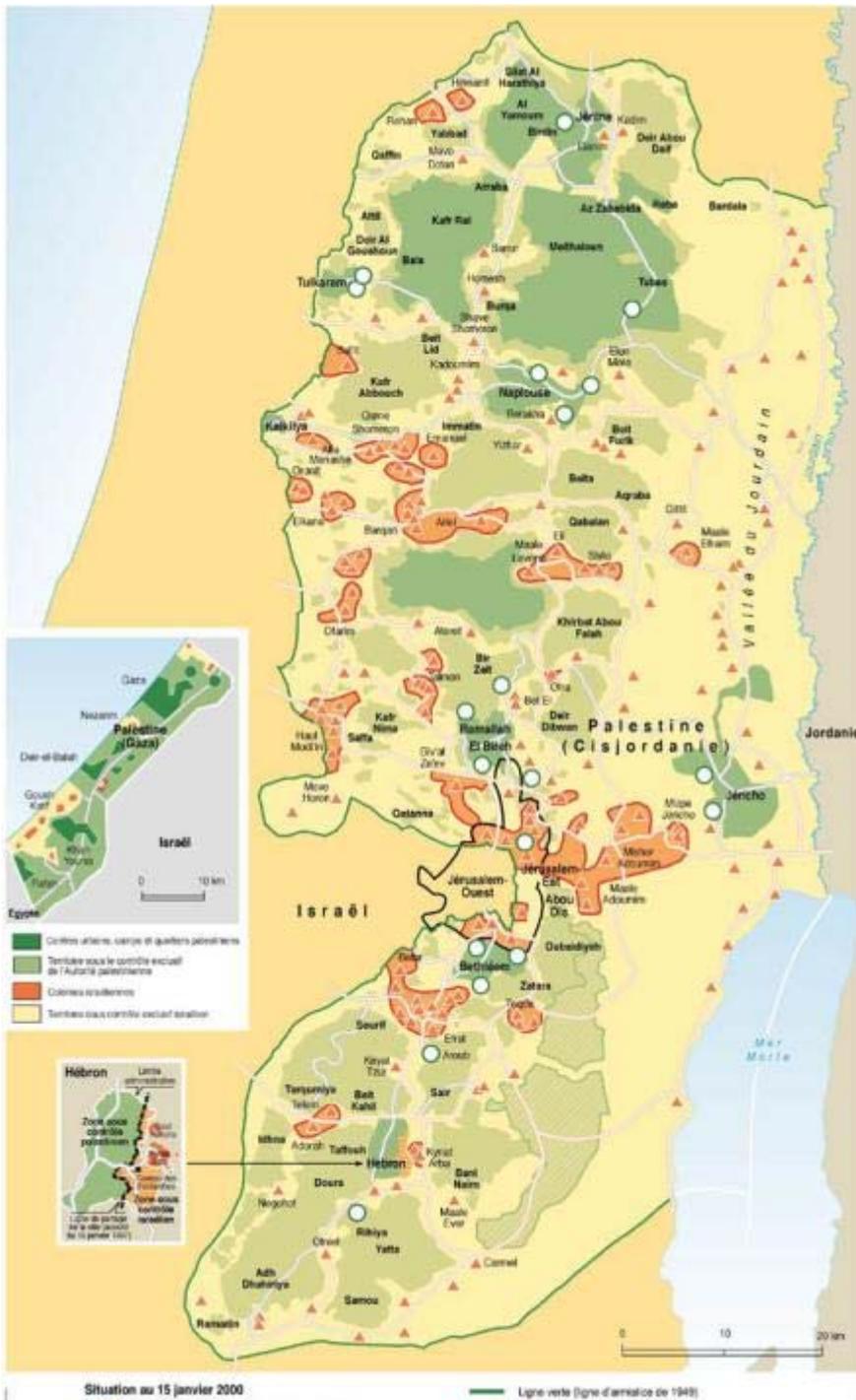


Four Cypriot exclaves within British territorial enclaves in Cyprus

The two Cypriot villages of Ormidhia and Xylotimbou are each surrounded by territory that belongs to the British Sovereign Base Area of Dhekelia. This includes two Cypriot exclaves formed by the territory of the Dhekelia Power Station divided into two parts by a British road



Fractal boundaries in the Middle East in 2006



Types of non-Westphalian partition

porous boundaries and co-located multiple
layers





Chinatown Manchester

New York erubin

In parts of New York, there are a number of different erubin constructed by the numerous different religious branches, leading to the creation of a web of overlapping erubin (*Geoforum* 31)

Liberal objection to the Barnet eruv

- “Eruv-believers would happily pass through their symbolic gateways in the streets, but everyone else would be compelled to do so without such a benefit, even if the compulsory passage through the Eruv structures is offensive to a person’s beliefs.”

The meaning of life

- We want our lives to mark the world (we want to leave a trace)
- On the Westphalian paradigm this means we want (e.g.) our nation to be a single contiguous whole over which we have exclusive dominion

we all want to leave traces on reality

what the liberal objectors do not see
is that we can leave traces on reality
in a variety of non-Westphalian (=
non-exclusive) ways

Consequences

- people should recognize other peoples' use of space

Liberals who owned property especially worried

- even though property values in an eruv rise

The End

Virtual Philadelphia

- Imagine a Nozickian virtual reality machine, which generates three-dimensional visual and tactual simulations of landscapes and architectural works. So impressive is the illusion that those inside the machine feel that they are experiencing ordinary reality.
- We could even imagine a community of individuals connected to a single machine that coordinates their experiences in such a way that they seem to be moving around together, meeting in Philadelphia, walking hand-in-hand along the sidewalk.
- A travel agent might advertise trips to Virtual Philadelphia. A real estate agent might offer to sell land there.

Virtual Philadelphia might be better than real Philadelphia

- But if we discovered at some later point that we were living not in real Philadelphia but in virtual Philadelphia, then we would be disappointed. Why?
- In Virtual Philadelphia I can live in the same building with Madonna. But so can 1 million other people. They can all show photographs of themselves in the elevator with Madonna.
- It is precisely this possibility which tells us what is missing. Living in the same building with Madonna is an *achievement*. It is something highly valued precisely because not everyone can do it. What space provides is the possibility of competition, of economizing; it imposes an ordering of preferences.

Franchise-Operated Quasi-National Entities (Starbucks, Pizza Hut, ...)

(from Neal Stephenson, *Snow Crash*)

A FOQNE is an organization that, like a nation-state, provides and enforces a system of rules within a given geographic territory but with non-contiguous territory.

A FOQNE consists of plots of real estate that are relatively small (ranging in size from a city-state to a portion of a building).

Each FOQNE offers its citizens a number of havens where the rules and culture are uniform and familiar, no matter what region the individual FOQNE site is in.

Snow Crash

- For Stephenson a FOQNE may offer citizens a place to live, or it may specialize in providing certain goods or services (physical plant security protection, drugs, religion, ...):
 - Mr. Lee's Greater Hong Kong
 - Nova Sicilia
 - Narcolombia
 - Reverend Wayne's Pearly Gates.

Snow Crash

- Burbclaves = a specialized type of FOQNE consisting of a chain of suburban subdivision-sized city-states (gated communities) and offering citizens a place to reside.

Other explanations

- people do not like physical signs of other peoples' religions

people like to mark this world

- people like to mark this world by making it point to something transcendent (der Gewölbe des Himmels)