Standardization of Anatomy Parts and Wholes – From Function to Location

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Standardization of Biological Structure (Anatomy/Anatomies): Creating consensus about…

- Top-level Properties
  dimensionality, solid / hollow, boundary, count, mass, collection
- Foundational Relations
  is-a, instance-of, part-of, has-location, has-branch, has-developmental-form, descends-from, connects, bounds
- Theories
  species, development, granularity, canonicity

cf. Schulz & Hahn, KR-MED 2004

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Part-Of in Anatomies: Consensus required about

- Domain and range of part-of relations
- Algebraic properties of part-of relations
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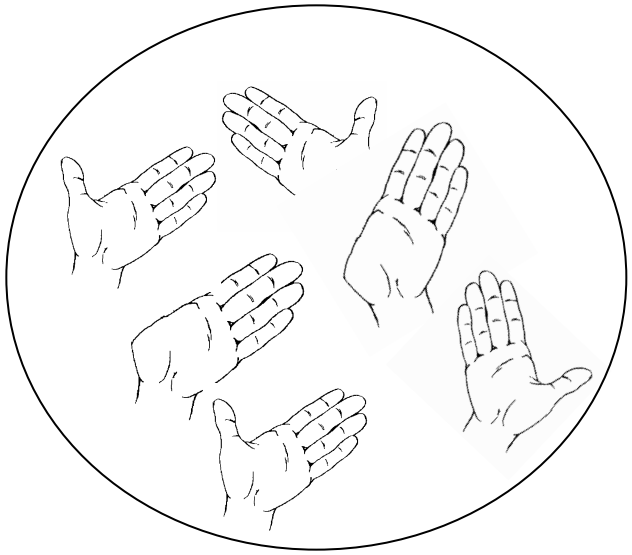
Part-of between individuals and universals

Hungary part-of Europe

myThumb part-of myHand

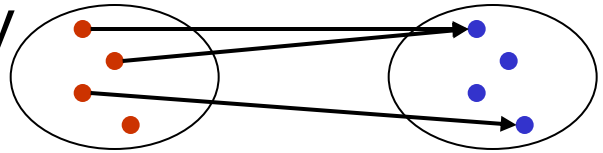


Thumb part-of Hand

Class-level Part-Of : Different Interpretations

Class A (part) Class B (whole)

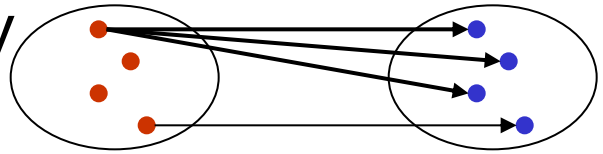
- One-sided Dependency Part on Whole



Examples

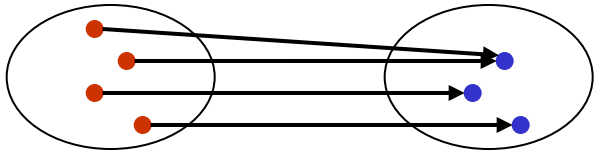
Cell Nucleus – Cell
Chlorophyll – Organism
Prostate Tumor – Prostate

- One-sided Dependency Whole on Part



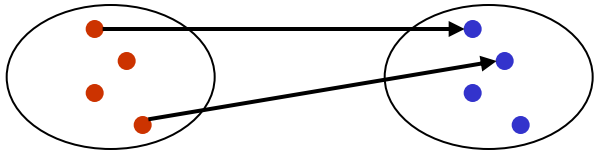
Sulfur – Methionin
Wing – Chicken
Heart – Drosophila

- Mutual Mereological Dependency



Cell Membrane – Cell
Vertebra – Vertebrate
Body Surface – Body

- Mereological Independency

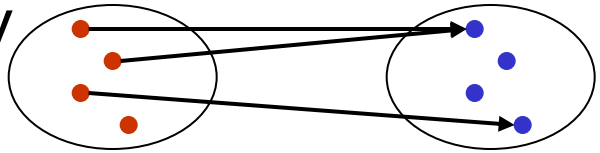


Uterus – Mammal
Sulfur – Amino Acid
Tooth – Human

Class-level Part-Of : Different Interpretations

GALEN,
Gene Ontology 07 / 2004

- One-sided Dependency Part on Whole



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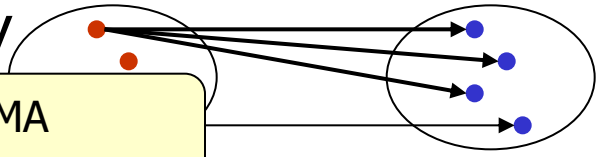
- One-sided Dependency Whole on Part

FMA



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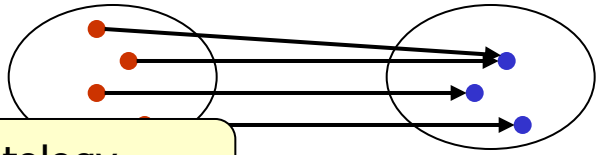

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Gene Ontology
11 / 2003

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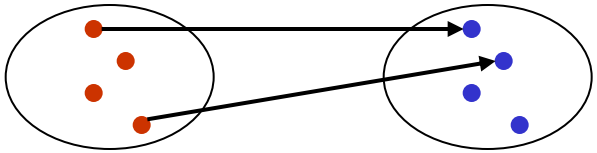

Uterus – Mammal
Sulfur – Amino Acid
Tooth – Human

Class-level Part-Of : Different Interpretations, Different Names

- $Part\text{-}For\ (A, B) =_{def^*}$
  $\forall x: inst\text{-}of\ (x, A) \rightarrow \exists y: inst\text{-}of\ (y, B) \wedge part\text{-}of\ (x, y)$

- $Has\text{-}Part\ (B, A) =_{def^*}$
  $\forall y: inst\text{-}of\ (y, B) \rightarrow \exists x: inst\text{-}of\ (x, A) \wedge part\text{-}of\ (x, y)$

- $Part\text{-}Of\ (A, B) =_{def^*} \overbar{Part\text{-}For}\ (A, B) \wedge \overbar{Has\text{-}Part}\ (B, A)$

- $Possible\text{-}Part\ (A, B) =_{def}$
  $\exists x,y: inst\text{-}of\ (x, A) \wedge inst\text{-}of\ (y, B) \wedge part\text{-}of\ (x, y)$

*cf. Smith & Rosse, MEDINFO 2004

Part-Of in Anatomies: Consensus required about

- Domain and range of part-of relations
- Algebraic properties of part-of relations
- Intended meaning of part-of relations in the domain of biology and medicine

Algebraic Properties: *Part-Of | Has-Part vs. part-of | has-part*

- Instance level :

  $part\text{-}of\ (a, b),\ part\text{-}of\ (b, c) \rightarrow part\text{-}of\ (a, c)$ ***Transitivity ?***

  $part\text{-}of\ (a, b) \rightarrow \neg\ part\text{-}of\ (b, a)$ ***Asymmetry***

  $part\text{-}of\ (a, b) \rightarrow a \neq b$ ***Irreflexivity ?***

  $part\text{-}of\ (a, b) \rightarrow has\text{-}part\ (b, a)$ ***Inverse Relation***

- Class level*:

  $Part\text{-}For\ (A, B),\ Part\text{-}For\ (B, C) \rightarrow Part\text{-}For\ (A, C)$

  $Part\text{-}For\ (A, B) \rightarrow \neg\ Part\text{-}For\ (B, A)$

  $Part\text{-}For\ (A, B) \rightarrow \neg\ Is\text{-}A\ (A, B)$ ***?***

  $Part\text{-}For\ (B, A)$ does not necessarily imply $Has\text{-}Part\ (A, B)$

  $Possible\text{-}Part\ (B, A)$ implies $Has\text{-}Possible\text{-}Part\ (A, B)$

  $(\ldots)$

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instance level

Different notions of part-of

- Time-independent:
  - Compositional
  - Functional
  - Topological
- Time-dependent:
  - *a part-of b* at any point of time → *a part-of b* at every point of time
  - *a part-of b* at one point of time, *a NOT part-of b* at another point of time

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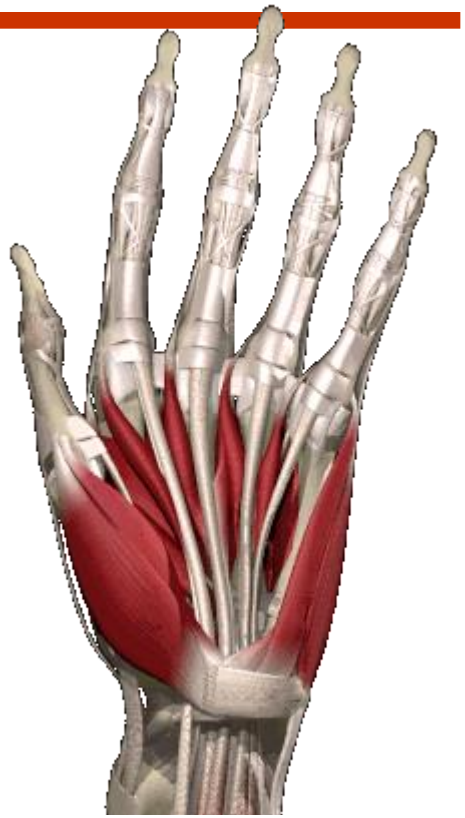
Parts as Components

Parts "build"
the whole



part-of (Finger, Hand)

part-of (Bone Marrow, Bone)

part-of (Sodium Ion, Cytoplasm) ?

part-of (Sarcomer, Muscle)

part-of (Heart, Human Body)

"Intuitive" notion of part. Controversial

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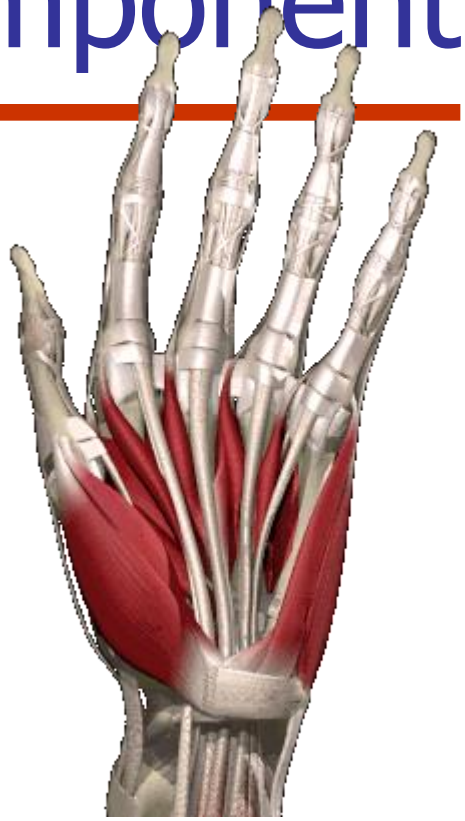
Parts as Functional Components

Part contributes to the function of the whole



part-of (Finger, Hand)

part-of (Lymph Node, Lymphatic System)

part-of (Cell Nucleus, Cell)

part-of (Tendon, Muscle)

part-of (Tooth, Jaw)

More restricted, may conflict with notions of connection

instance level

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no clear distinction !

instance level

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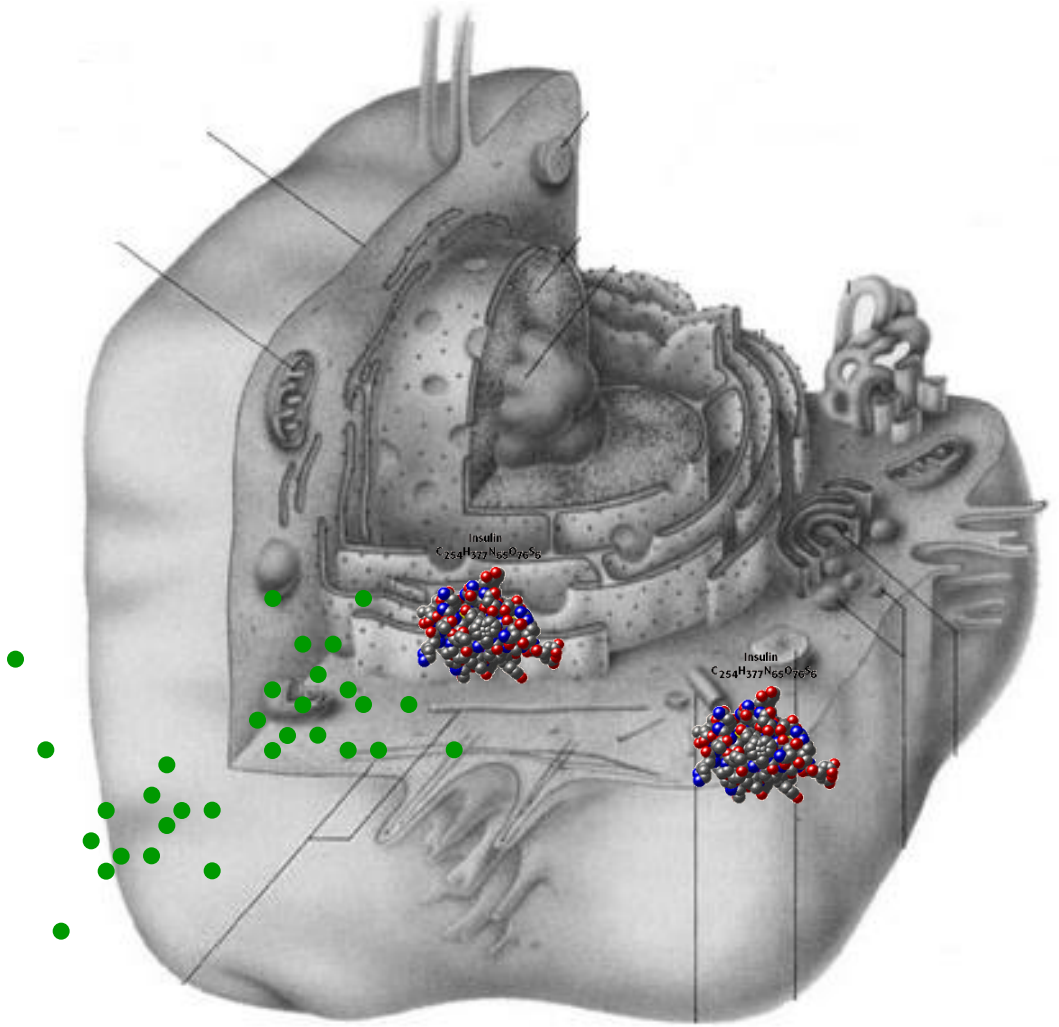
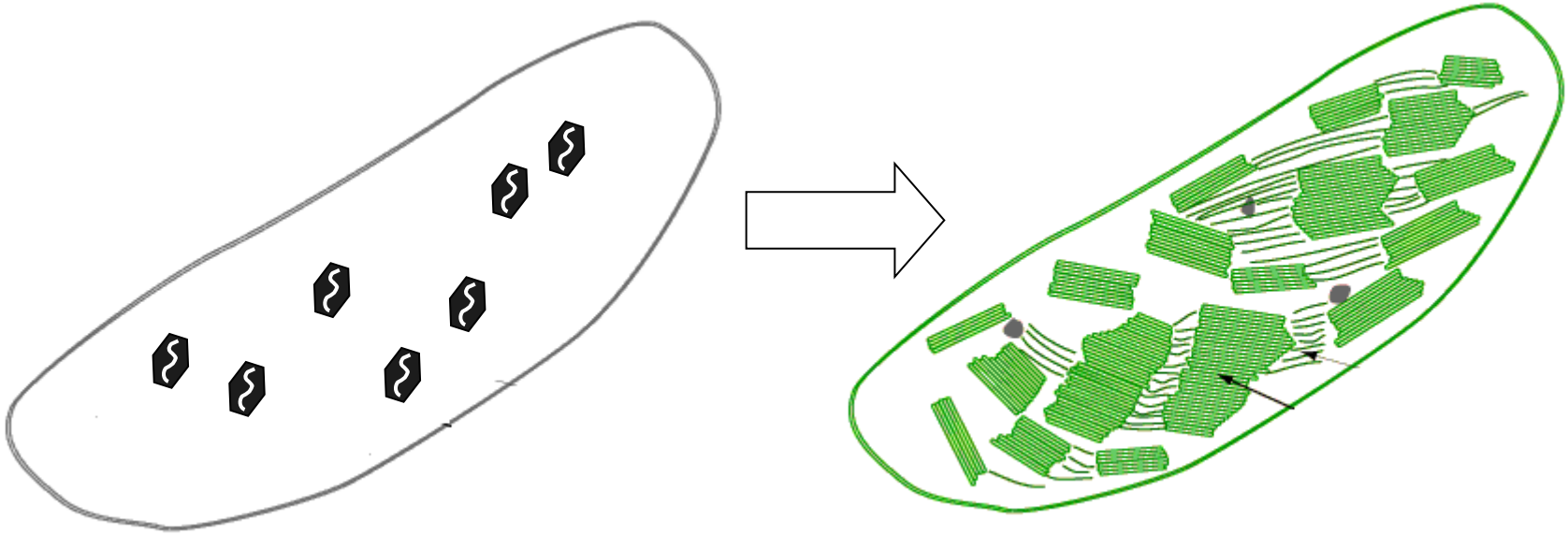
Continuous exchange of matter



Endosymbiont Hypothesis

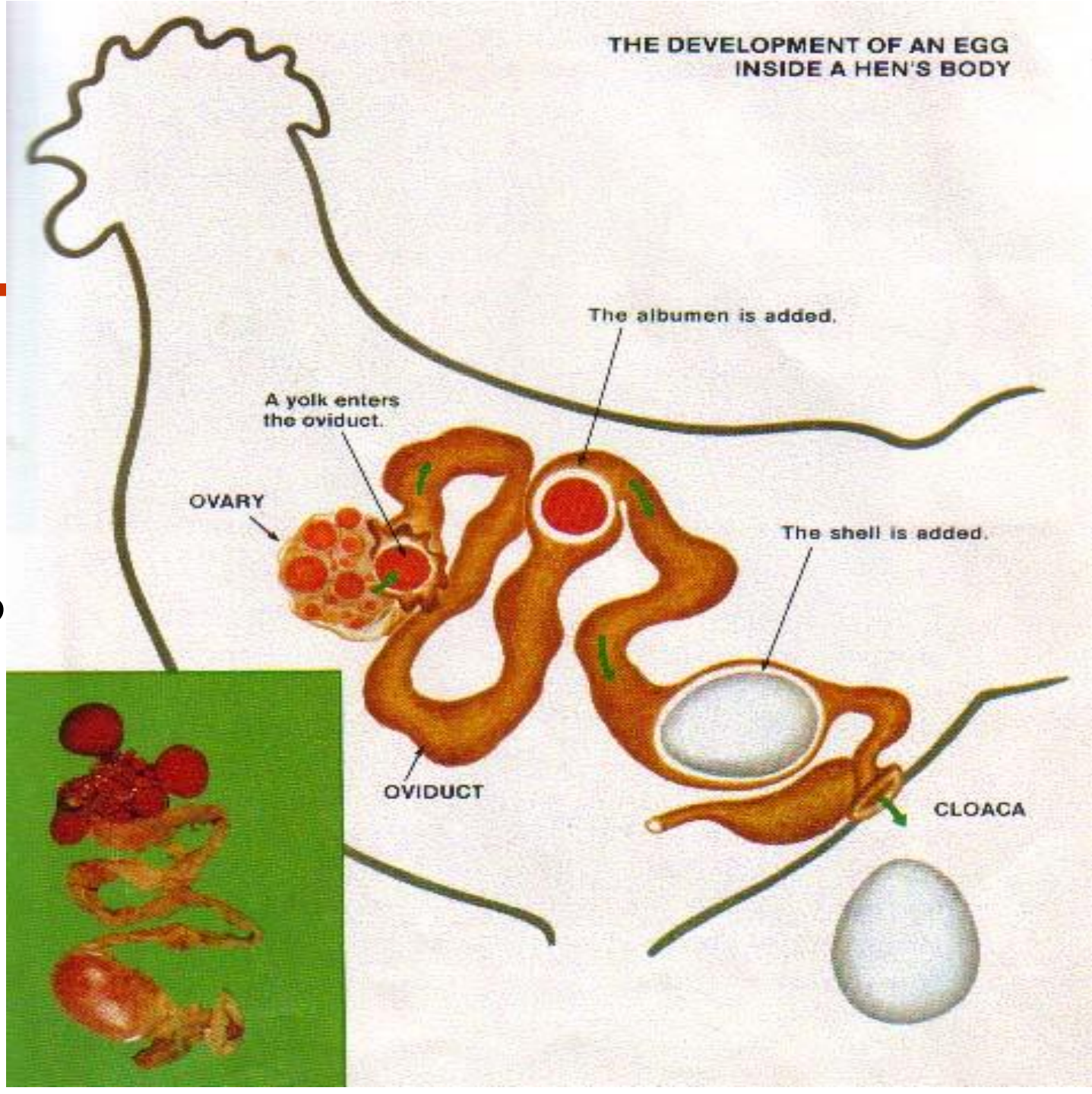
2.5 billion years ago:
Primitive cell with
bacterium-like symbionts

Today:
Chloroplasts (Plants)
Mitochondria



Are the organells part of the cell

- Which eggs are part of the body ?



Topological parts

Located within the boundaries of an object

part-of (Mitochondrium, Cell)
part-of (Brain, Head)

part-of (Brain, Cranial Cavity) ?

part-of (Ovum, Oviduct) ?

part-of (Finger, Hand)

part-of (Amount of Blood, Right Ventricle) ?

has-location instead of ***part-of*** ?

Topological parts

Located within the boundaries of an object

has-location (Mitochondrium, Cell)
has-location (Brain, Head)

has-location (Brain, Cranial Cavity)

has-location (Ovum, Oviduct)

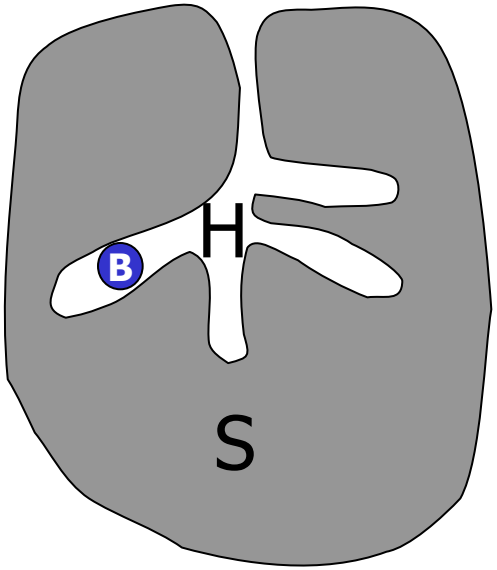
has-location (Finger, Hand)

has-location (amount of Blood, Right Ventricle)

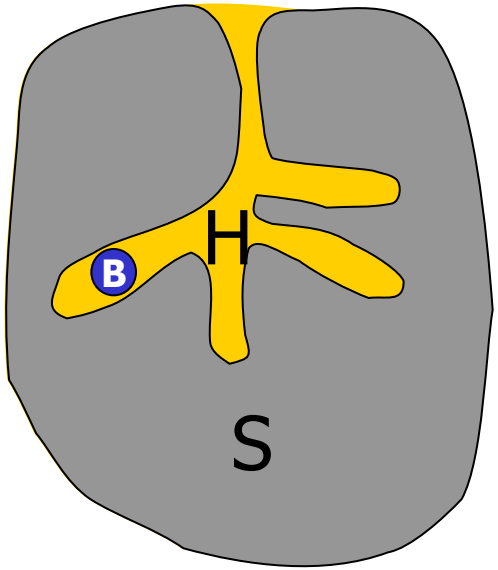
has-location as a mereotopological primitive ?

Topological parts

How to deal with hollow spaces ?



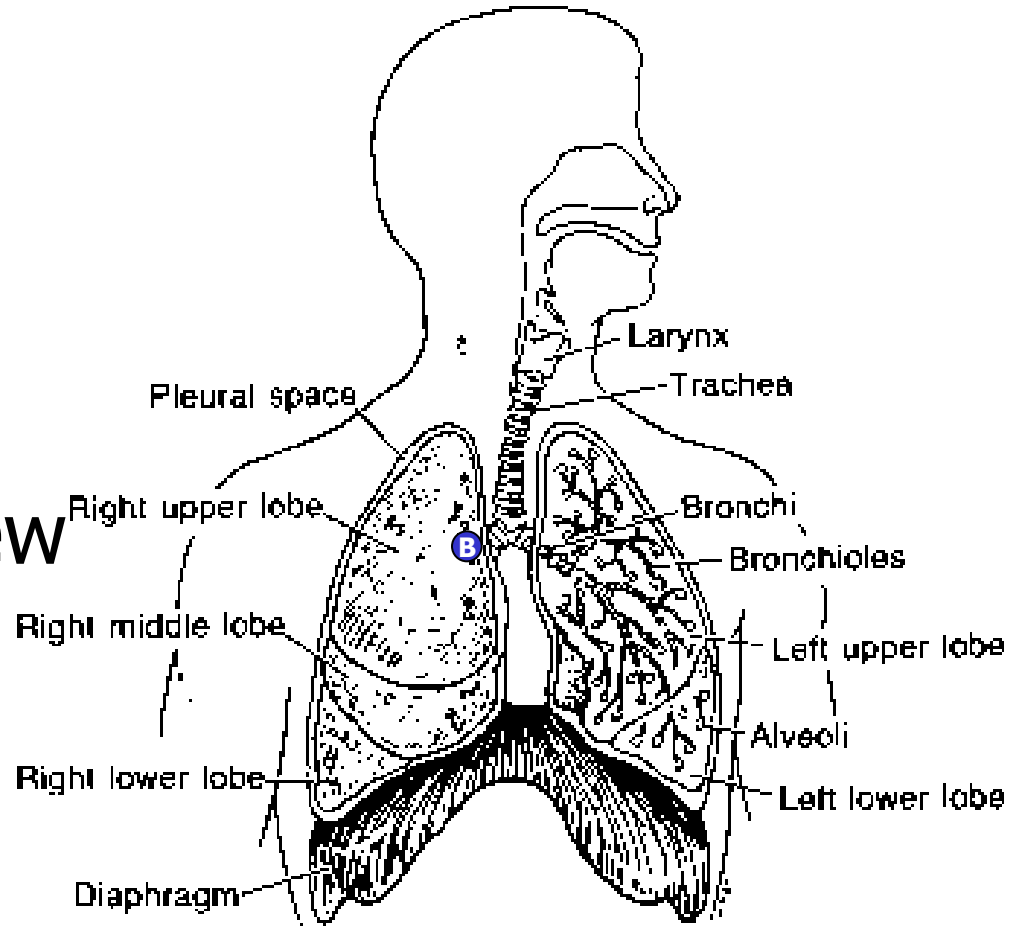
H is part of E, hence B is located outside of S



H is part of S, hence B is located inside of S

Example

- Inside or outside ?
- Example: Bronchi
  A foreign body
  in a bronchus
  is in the lung
- Strict topological view
  conflicts with
  shared
  conceptualization



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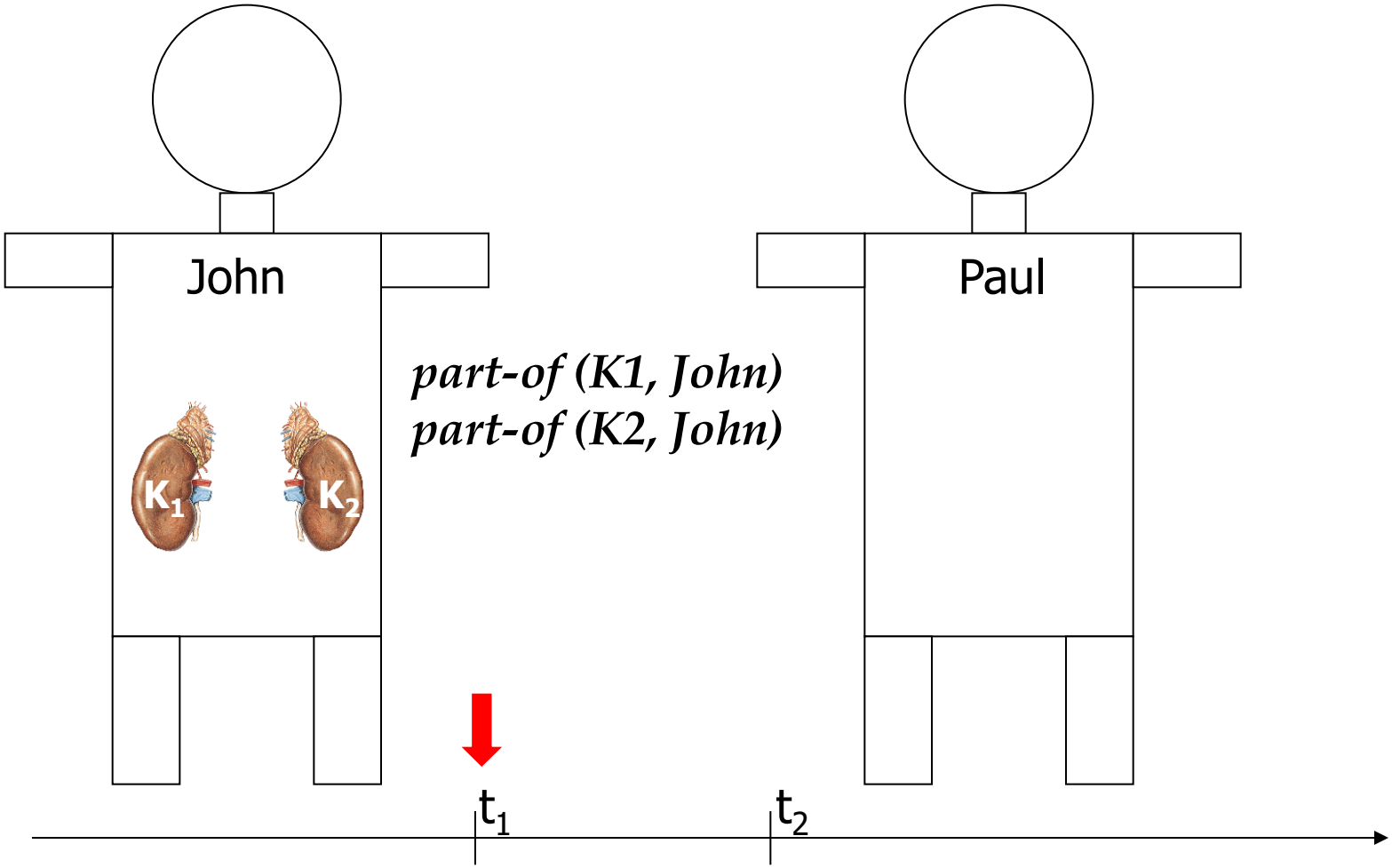
Example: Transplantation



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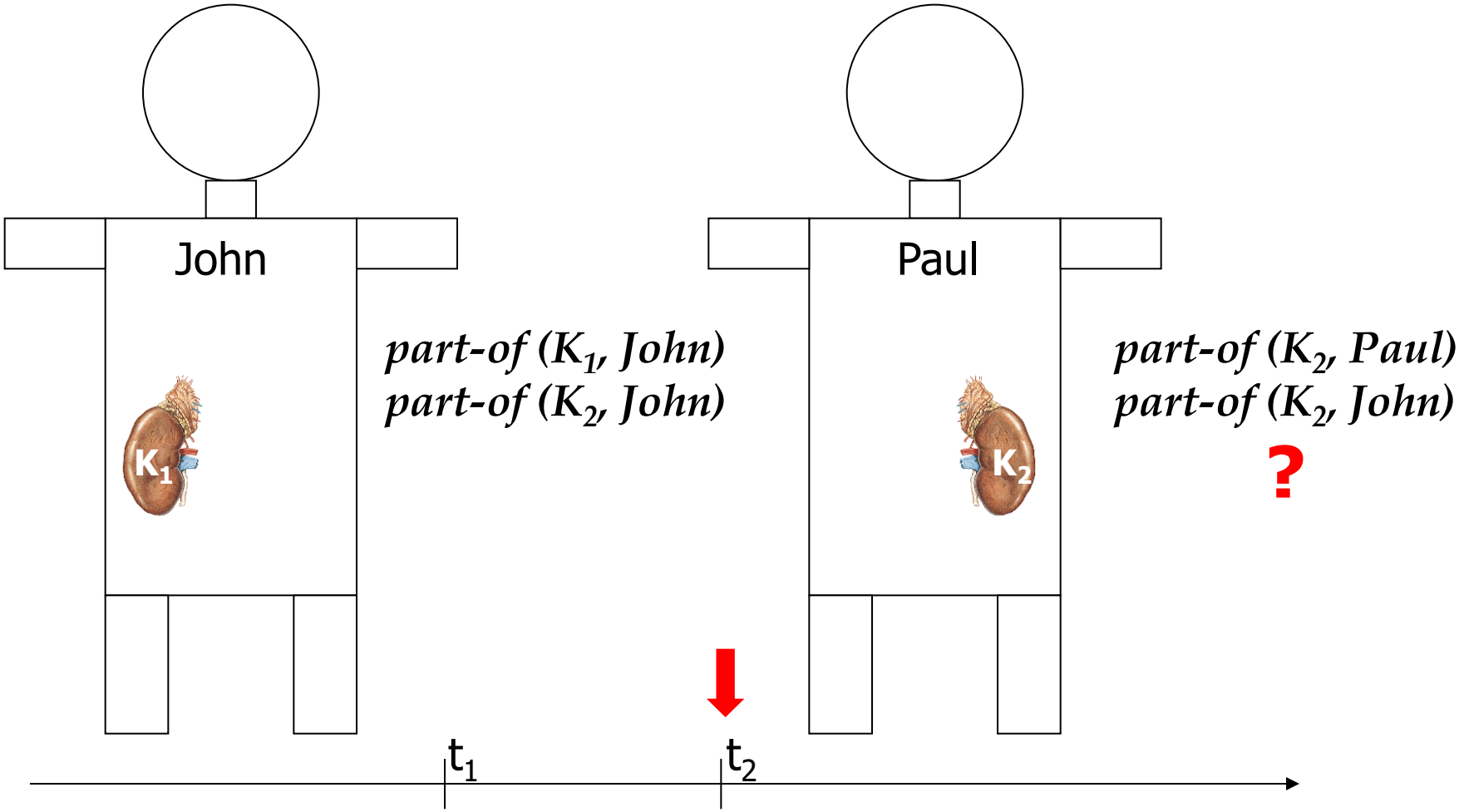
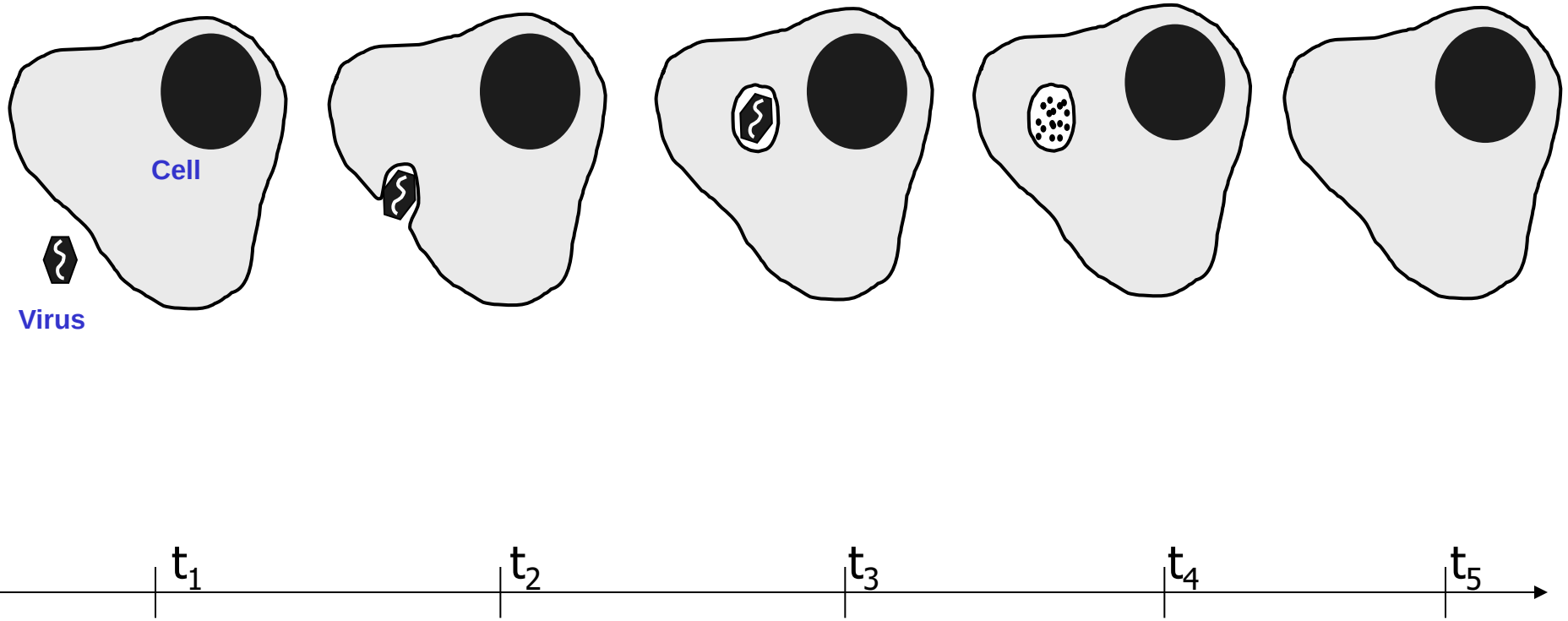
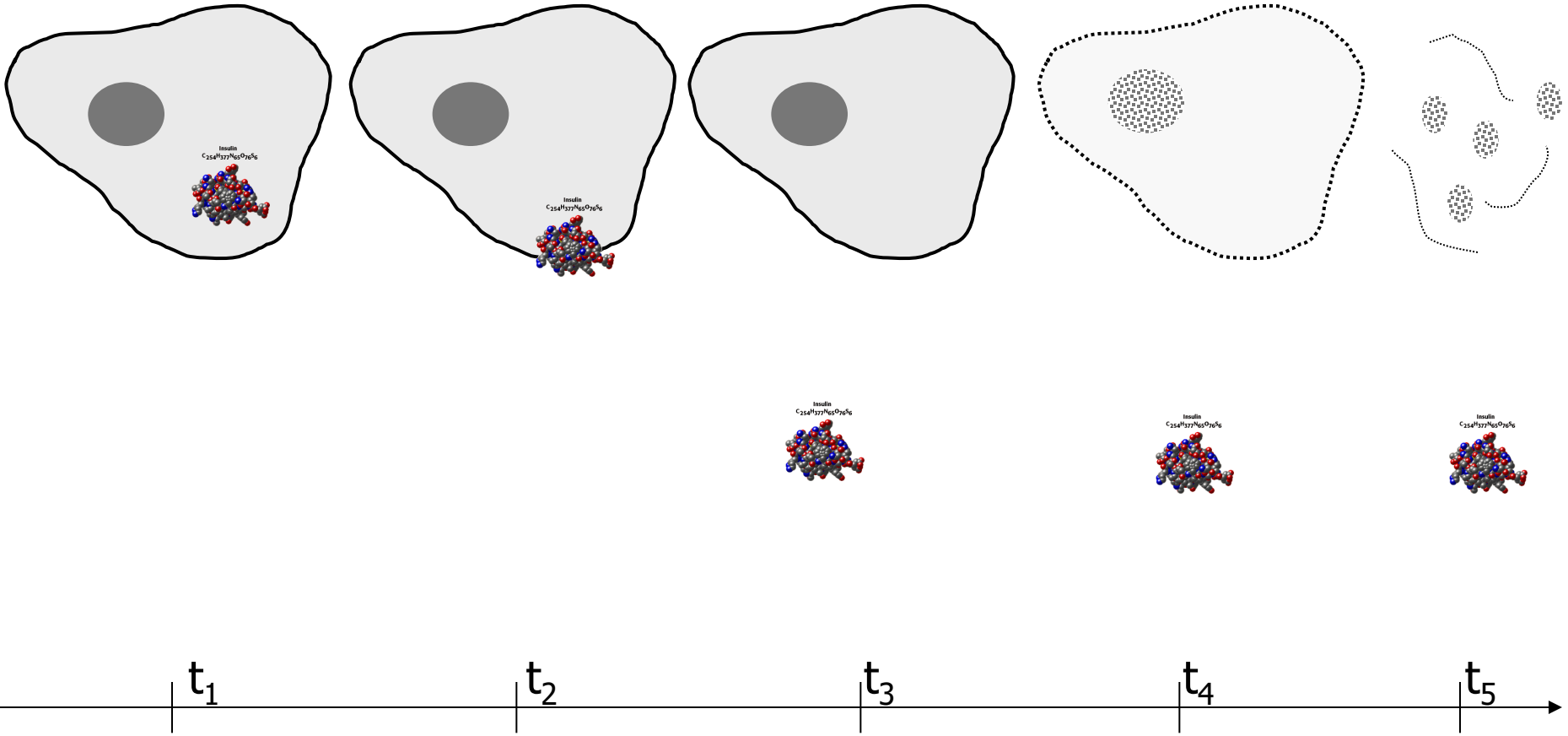


Phagocytosis / Digestion



Secretion



Conclusion

- Part-of: example, how many different interpretations co-exist
- Standardization: need to eliminate ambiguity by precise characterization of foundational primitives (properties, relations)
- Solid theoretical basis is needed, e.g. mereotopology: Simons, Casati, Smith, Varzi,…