

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

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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

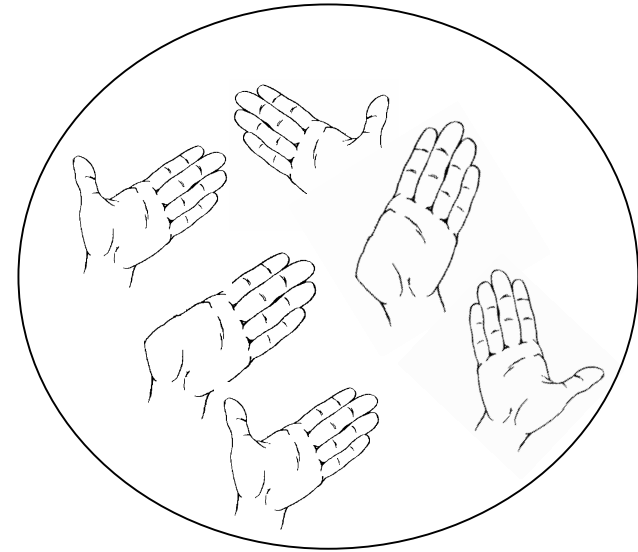
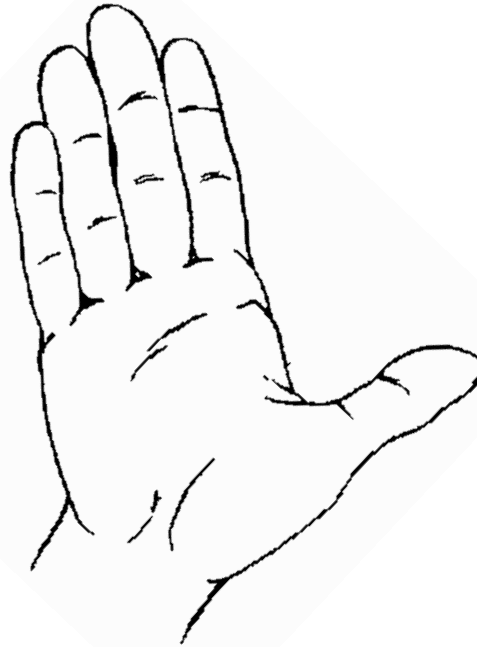
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Part-of between individuals and universals



Hungary *part-of* Europe myThumb *part-of* myHand

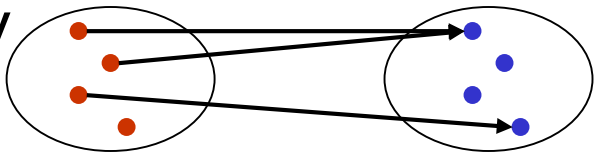
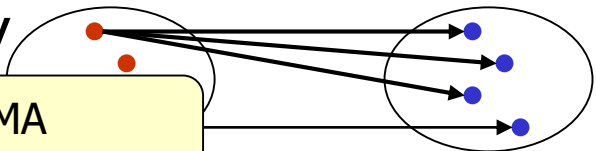
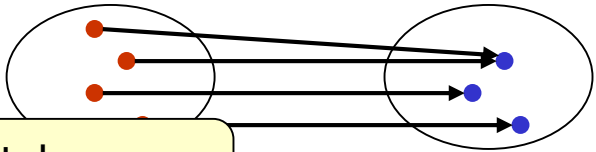
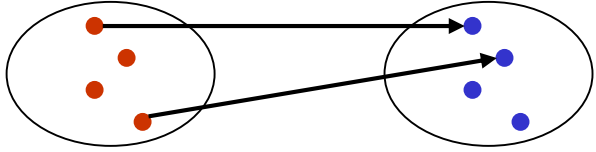


Thumb *part-of* Hand

Class-level Part-Of : Different Interpretations

	Class A (part)	Class B (whole)	Examples
<ul style="list-style-type: none"> One-sided Dependency Part on Whole 			Cell Nucleus – Cell Chlorophyll – Organism Prostate Tumor – Prostate
<ul style="list-style-type: none"> One-sided Dependency Whole on Part 			Sulfur – Methionin Wing – Chicken Heart – Drosophila
<ul style="list-style-type: none"> Mutual Mereological Dependency 			Cell Membrane – Cell Vertebra – Vertebrate Body Surface – Body
<ul style="list-style-type: none"> Mereological Independency 			Uterus – Mammal Sulfur – Amino Acid Tooth – Human

Class-level Part-Of : Different Interpretations

<p>GALEN, Gene Ontology 07 / 2004 (whole)</p>	<p>Examples</p>
<p>■ One-sided Dependency Part on Whole</p> 	<p>Cell Nucleus – Cell Chlorophyll – Organism Prostate Tumor – Prostate</p>
<p>■ One-sided Dependency Whole on Part</p>  <p>FMA</p>	<p>Sulfur – Methionin Wing – Chicken Heart – Drosophila</p>
<p>■ Mutual Mereological Dependency</p>  <p>Gene Ontology 11 / 2003</p>	<p>Cell Membrane – Cell Vertebra – Vertebrate Body Surface – Body</p>
<p>■ Mereological Independency</p> 	<p>Uterus – Mammal Sulfur – Amino Acid Tooth – Human</p>

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

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

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

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

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

**cf. Smith & Rosse, MEDINFO 2004*

Part-Of in Anatomies: Consensus required about

- Domain and range of part-of relations
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Algebraic Properties: *Part-Of* / *Has-Part* vs. *part-of* / *has-part*

■ Instance level :

$part-of(a, b), part-of(b, c) \rightarrow part-of(a, c)$ **Transitivity ?**
 $part-of(a, b) \rightarrow \neg part-of(b, a)$ **Asymmetry**
 $part-of(a, b) \rightarrow a \neq b$ **Irreflexivity ?**
 $part-of(a, b) \rightarrow has-part(b, a)$ **Inverse Relation**

■ Class level*:

$Part-For(A, B), Part-For(B, C) \rightarrow Part-For(A, C)$
 $Part-For(A, B) \rightarrow \neg Part-For(B, A)$
 $Part-For(A, B) \rightarrow \neg Is-A(A, B)$ **?**
 $Part-For(B, A)$ does not necessarily imply $Has-Part(A, B)$
 $Possible-Part(B, A)$ implies $Has-Possible-Part(A, B)$
(...)

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

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

Different notions of part-of

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Parts as Components

Parts “build”
the whole

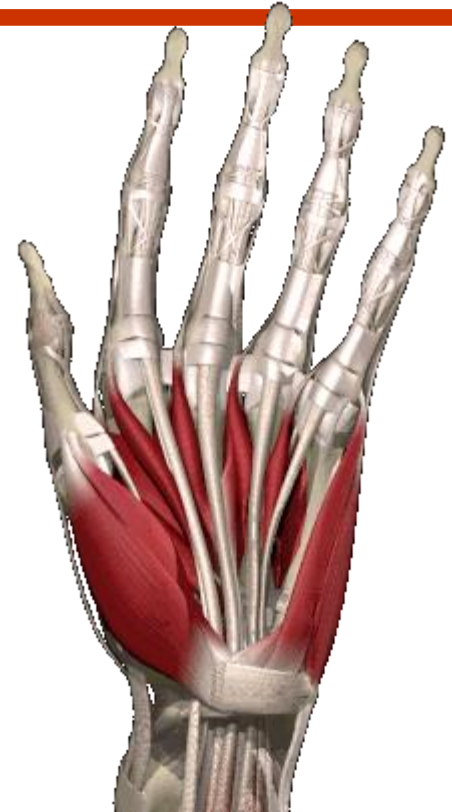
part-of (Finger, Hand)

part-of (Bone Marrow, Bone)

part-of (Sodium Ion, Cytoplasm) ?

part-of (Sarcomer, Muscle)

part-of (Heart, Human Body)



“Intuitive” notion of part. Controversial

Different notions of part-of

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 - *a part-of b* at any point of time → *a part-of b* at every point of time
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Parts as Functional Components

Part contributes to the function of the whole

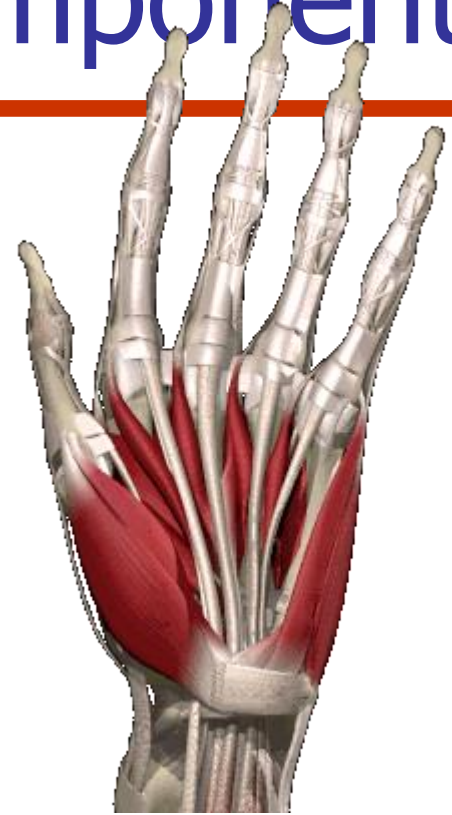
part-of (Finger, Hand)

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

Different notions of part-of

■ Time-independent:

- Compositional

- Functional

- Topological

no clear distinction !

■ Time-dependent:

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Different notions of part-of

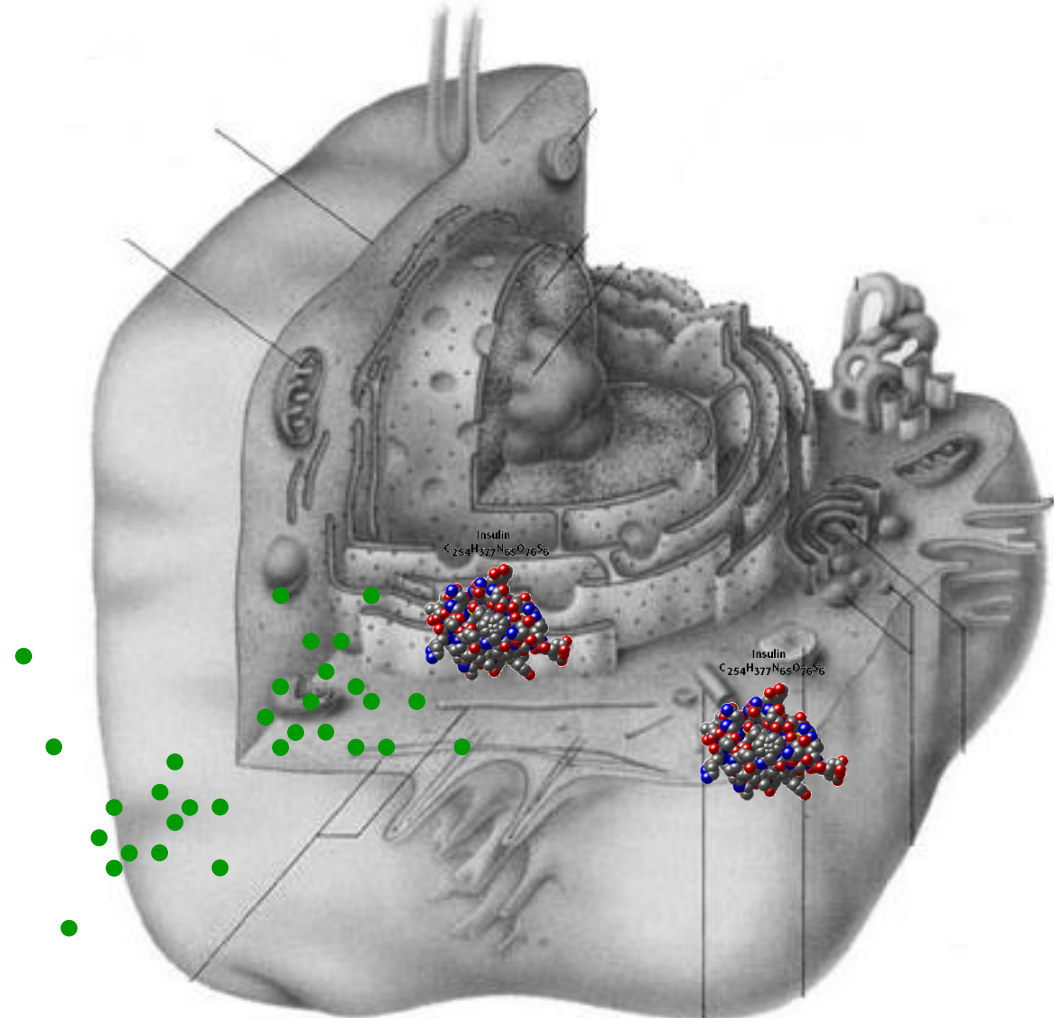
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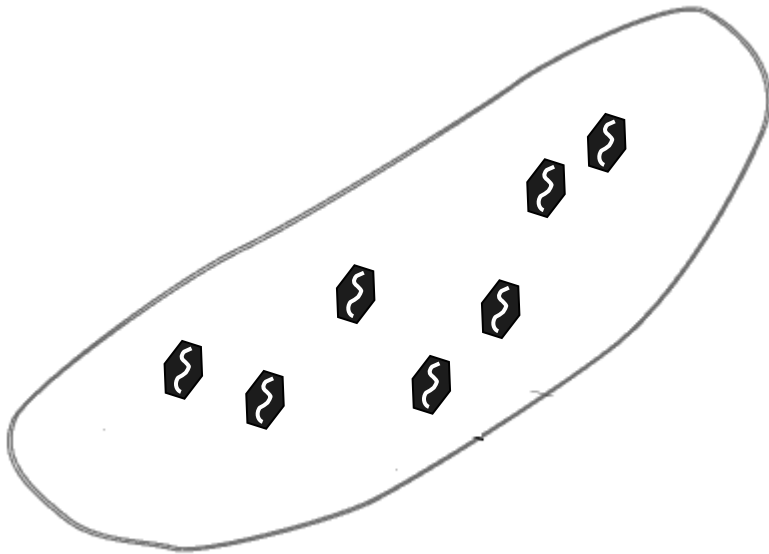
- *a part-of b* at any point of time →
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Continuous exchange of matter

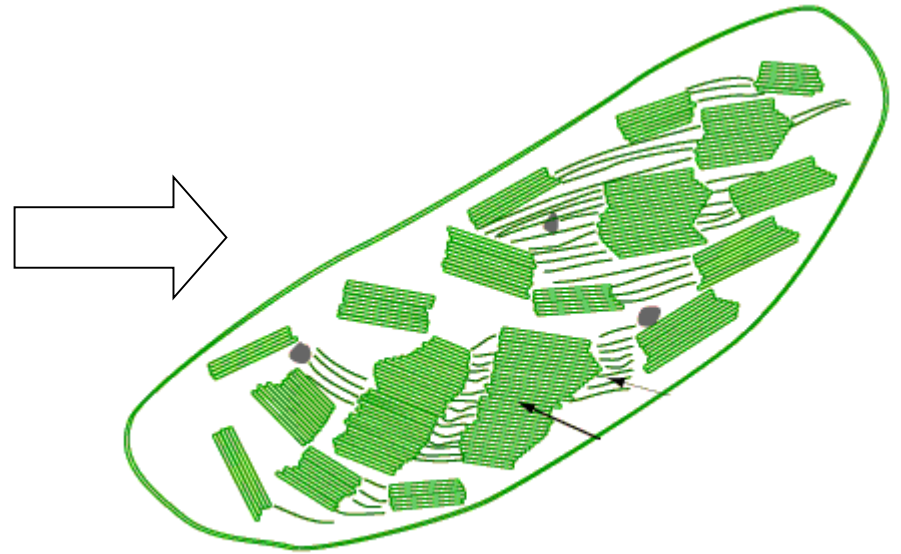


Endosymbiont Hypothesis

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

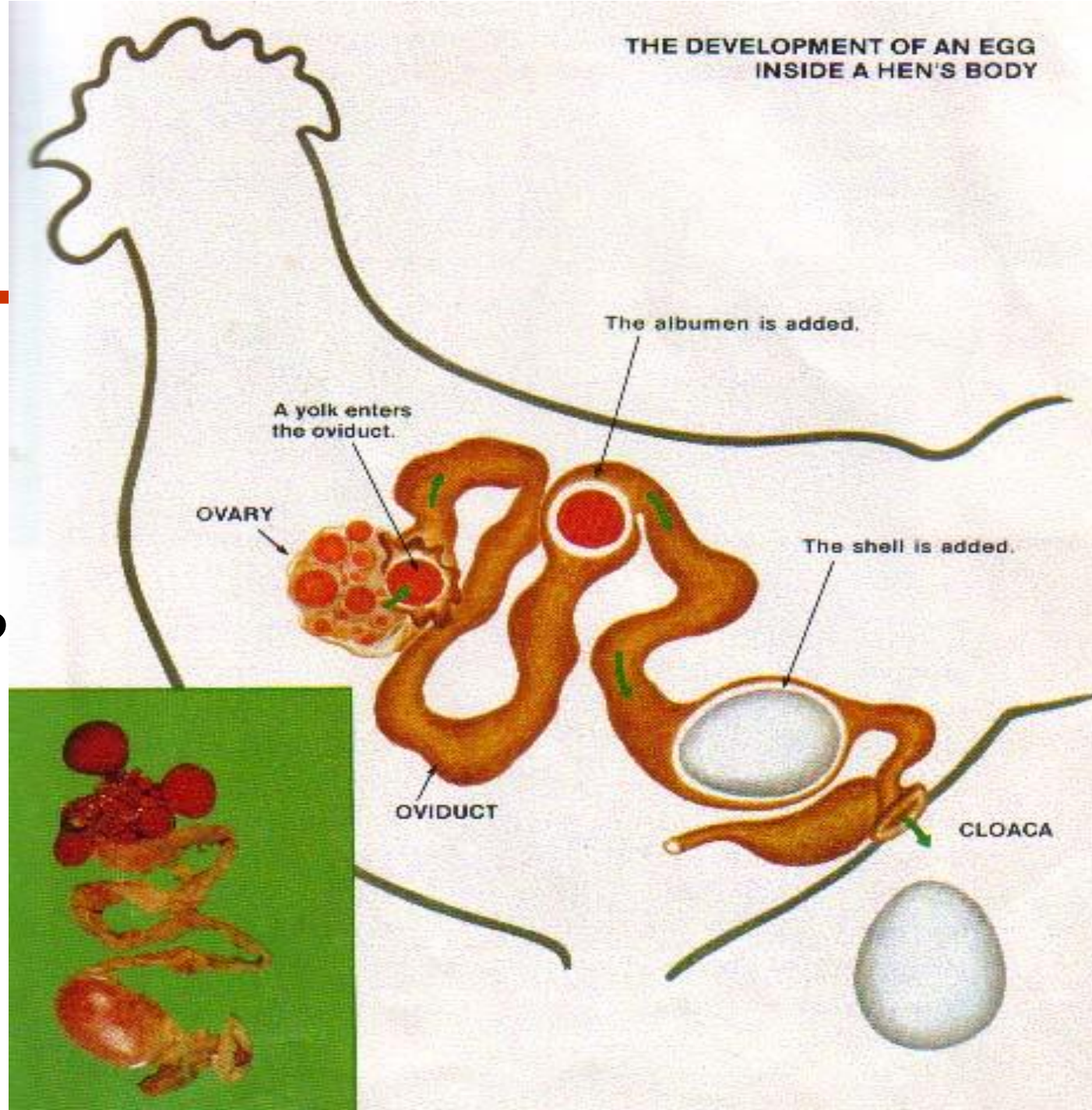


Today:
Chloroplasts (Plants)
Mitochondria



Are the organelles part of the cell

THE DEVELOPMENT OF AN EGG
INSIDE A HEN'S BODY



■ Which eggs are part of the body ?



Topological parts

Located within the boundaries
of an object

part-of (Mitochondrion, 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 (Mitochondrion, Cell)

has-location (Brain, Head)

has-location (Brain, Cranial Cavity)

has-location (Ovum, Oviduct)

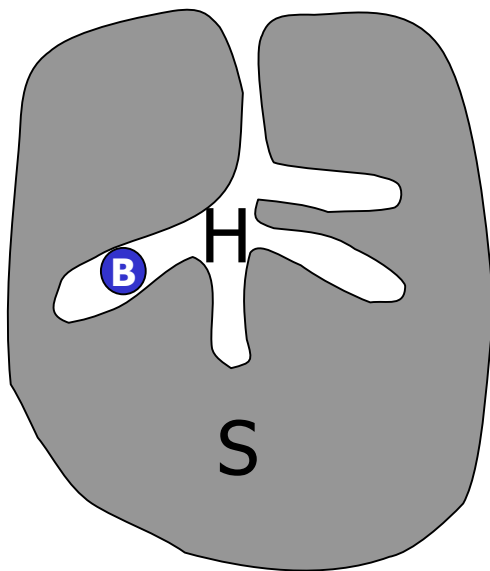
has-location (Finger, Hand)

has-location (amount of Blood, Right Ventricle)

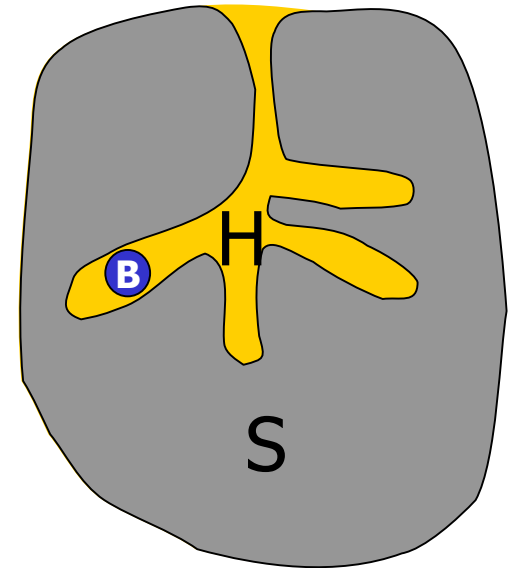
has-location as a mereotopological primitive ?

Topological parts

How to deal with hollow spaces ?



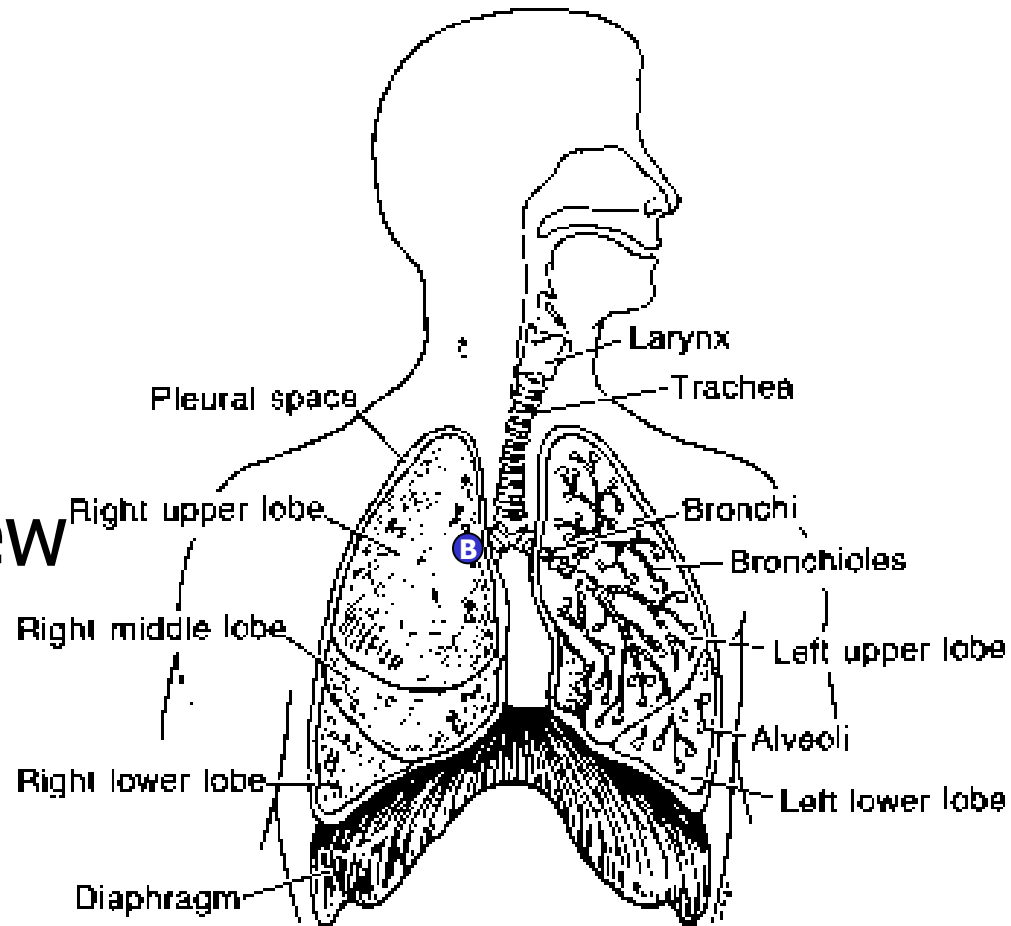
H is part of E, hence B is located **outside** of S



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



Different notions of part-of

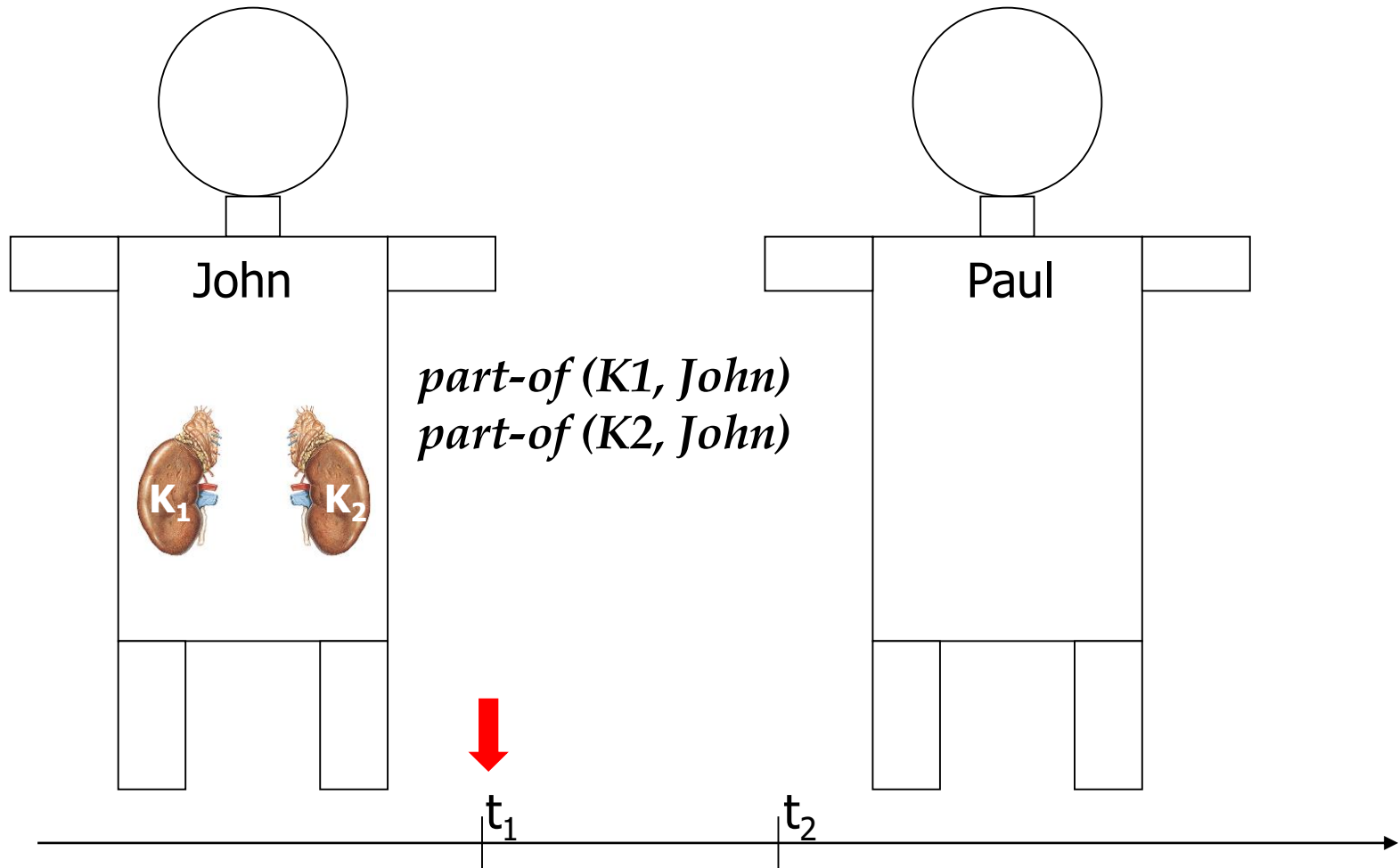
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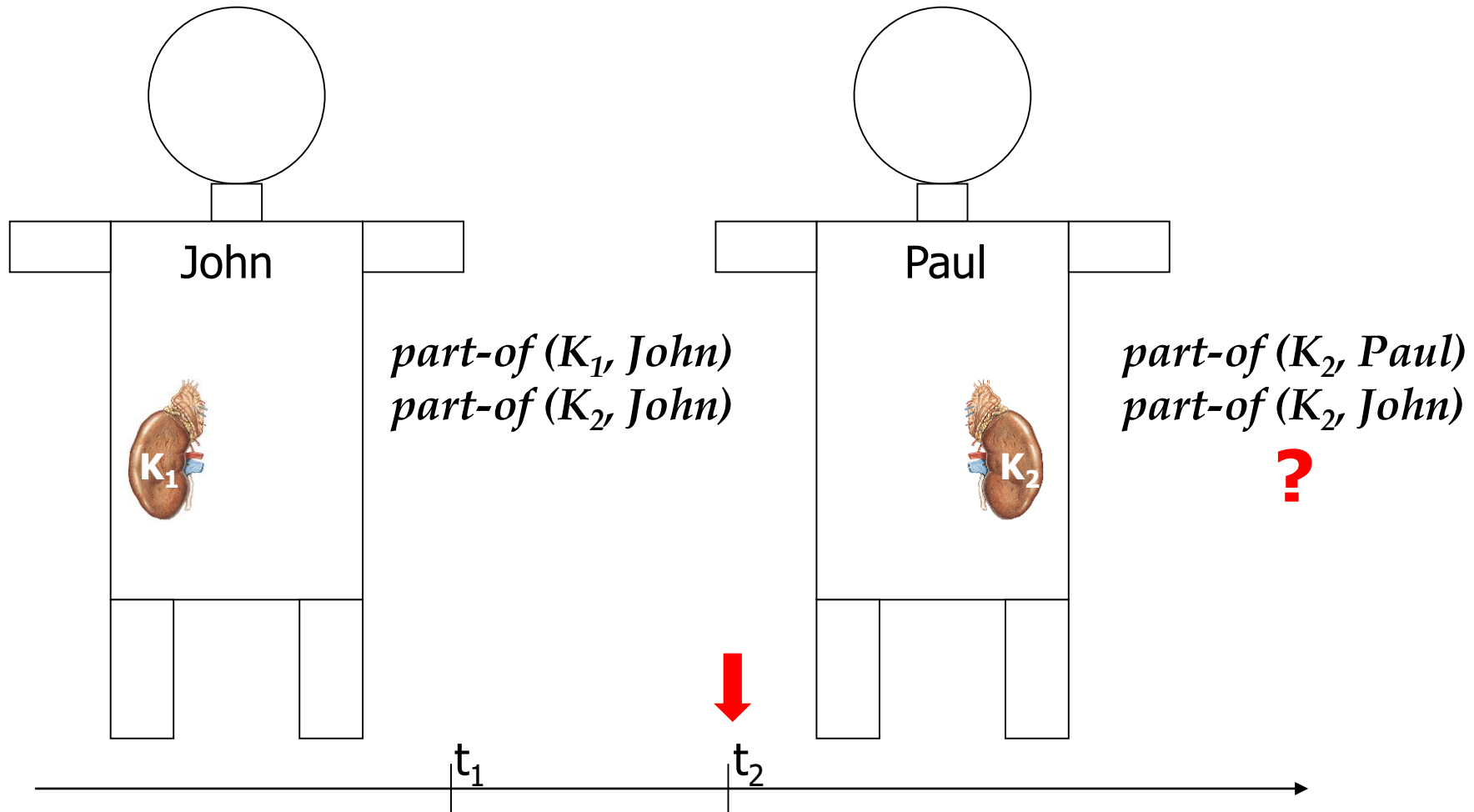
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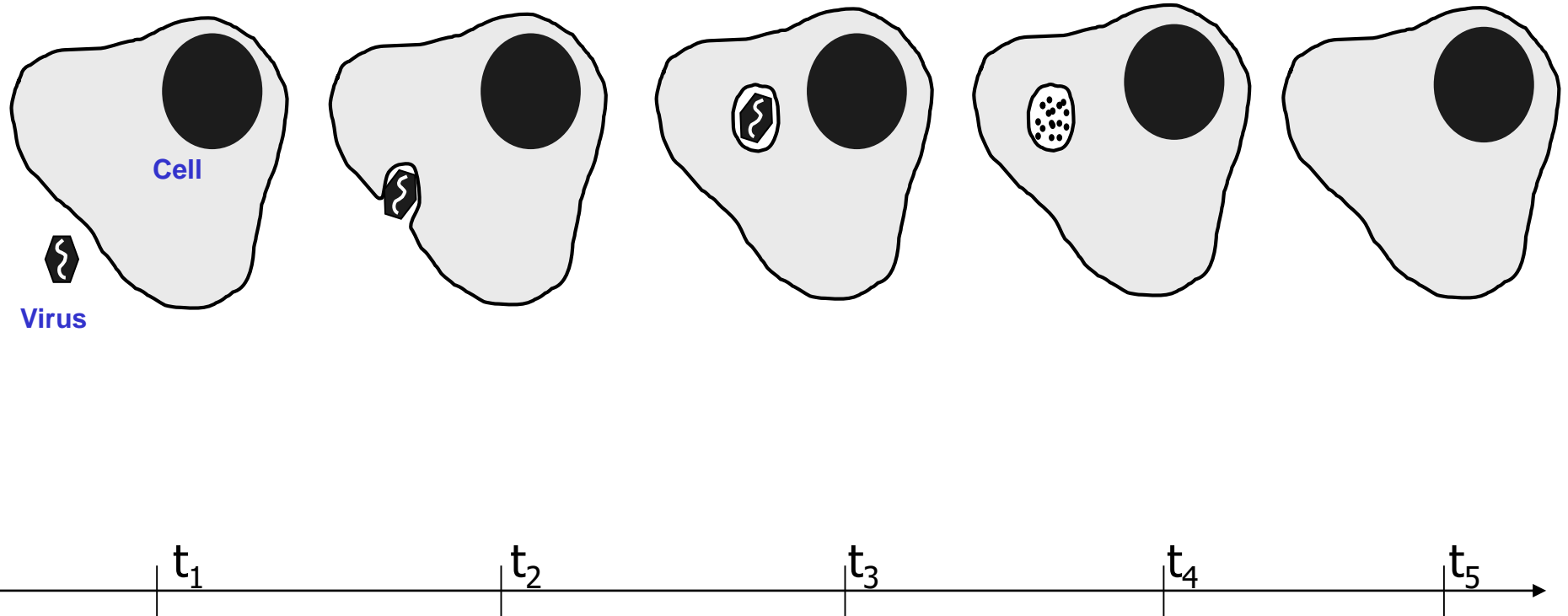
Example: Transplantation



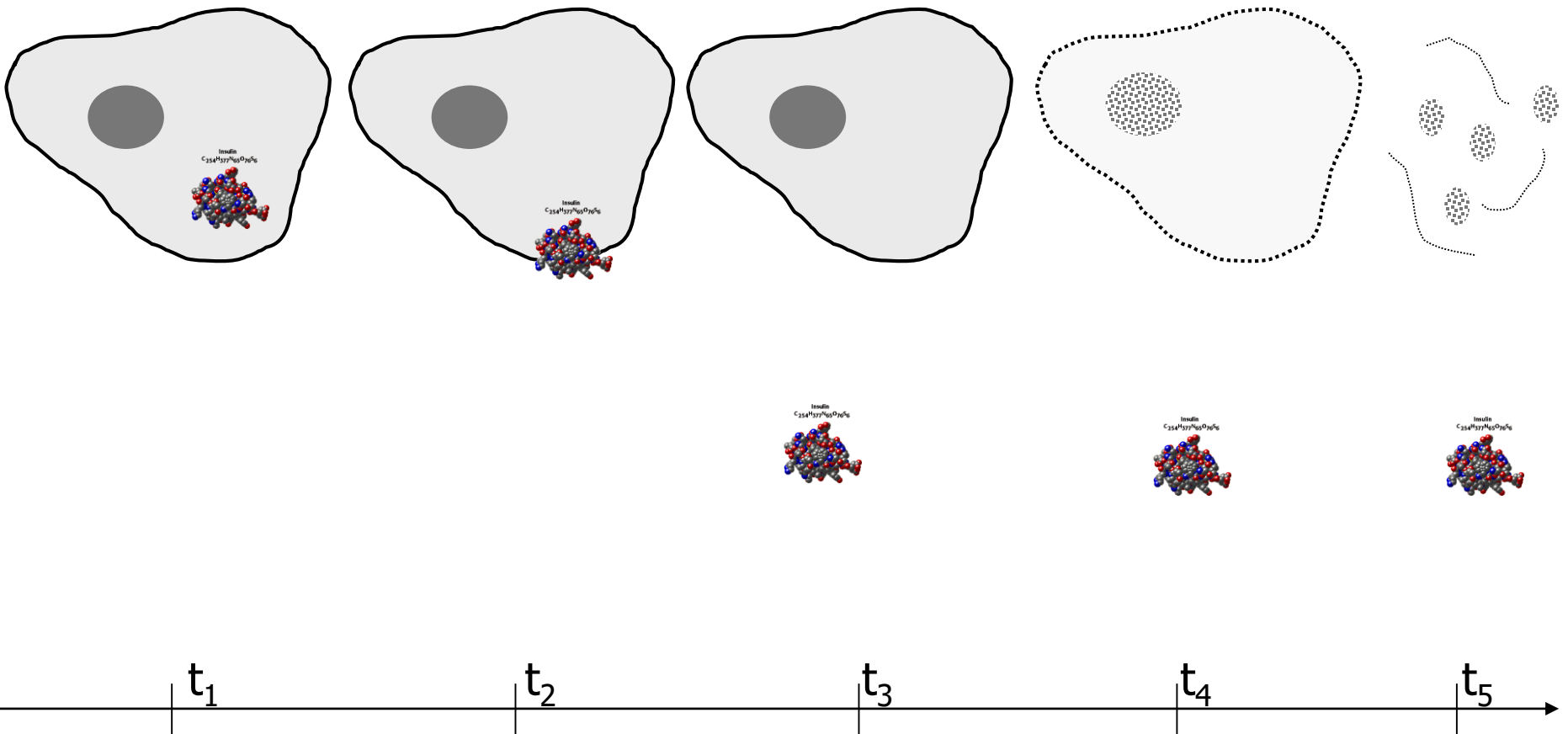
Example: Transplantation



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,...

