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
Standardization of Biological Structure (Anatomy/Anatomies): Achieving consensus about...

- **Top-level Properties**
  - dimensionality, solid / hollow, boundary, count, mass, collection

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  - species, development, granularity, canonicity

cf. Schulz & Hahn, KR-MED 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
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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

- **One-sided Dependency**: Part on Whole
  - Examples:
    - Cell Nucleus – Cell
    - Chlorophyll – Organism
    - Prostate Tumor – Prostate

- **One-sided Dependency**: Whole on Part
  - Examples:
    - Sulfur – Methionin
    - Wing – Chicken
    - Heart – Drosophila

- **Mutual Mereological Dependency**
  - Examples:
    - Cell Membrane – Cell
    - Vertebra – Vertebrate
    - Body Surface – Body

- **Mereological Independency**
  - Examples:
    - Uterus – Mammal
    - Sulfur – Amino Acid
    - Tooth – Human
# Class-level Part-Of: Different Interpretations

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  - **Part on Whole**
  - Examples:
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  - **Whole on Part**
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    - Sulfur – Amino Acid
    - Tooth – Human

- **Mereological Independency**

The image includes a table and a diagram with different interpretations of class-level part-of relationships.
Class-level Part-Of: Different Interpretations, Different Names

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

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

\[\text{Part-Of } (A, B) = \text{def}^* \text{Part-For } (A, B) \land \text{Has-Part } (B, A)\]

\[\text{Possible-Part } (A, B) = \text{def}^* \exists x,y: \text{inst-of } (x, A) \land \text{inst-of } (y, B) \land \text{part-of } (x, y)\]

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

- **Class level**:  
  Part-For \( (A, B), \) Part-For \( (B, C) \) \( \rightarrow \) Part-For \( (A, C) \)  
  - Transitivity
  - Part-For \( (A, B) \) \( \rightarrow \) Part-For \( (B, A) \)  
  - Asymmetry
  - Part-For \( (A, B) \) \( \rightarrow \) Is-A \( (A, B) \)  
  - Irreflexivity?
  - 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 $\rightarrow$ $a$ 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

- Time-independent:
  - Compositional
  - Functional
  - Topological

- Time-dependent:
  - A *part-of* \( b \) at any point of time \( \rightarrow \) A *part-of* \( b \) at every point of time
  - A *part-of* \( b \) at one point of time, \( \text{a NOT part-of} \) \( b \) at another point of time
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

- Time-independent:
  - Compositional
  - Functional
  - Topological

- Time-dependent:
  - \textit{a part-of b} at any point of time $\rightarrow$
    - \textit{a part-of b} at every point of time
  - \textit{a part-of b} at one point of time,\textit{a NOT part-of b} at another point of time

instance level
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

- Time-dependent:
  - A part-of $b$ at any point of time $\rightarrow$ 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

instance level

No clear distinction!
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
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* (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

- **Time-independent:**
  - Compositional
  - Functional
  - Topological

- **Time-dependent:**
  - A part-of $b$ at any point of time $\rightarrow$
  - 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
Example: Transplantation

part-of (K1, John)
part-of (K2, John)
Example: Transplantation

John

part-of \((K_1, \text{John})\)
part-of \((K_2, \text{John})\)

Paul

part-of \((K_2, \text{Paul})\)
part-of \((K_2, \text{John})\)

\(?\)
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,...