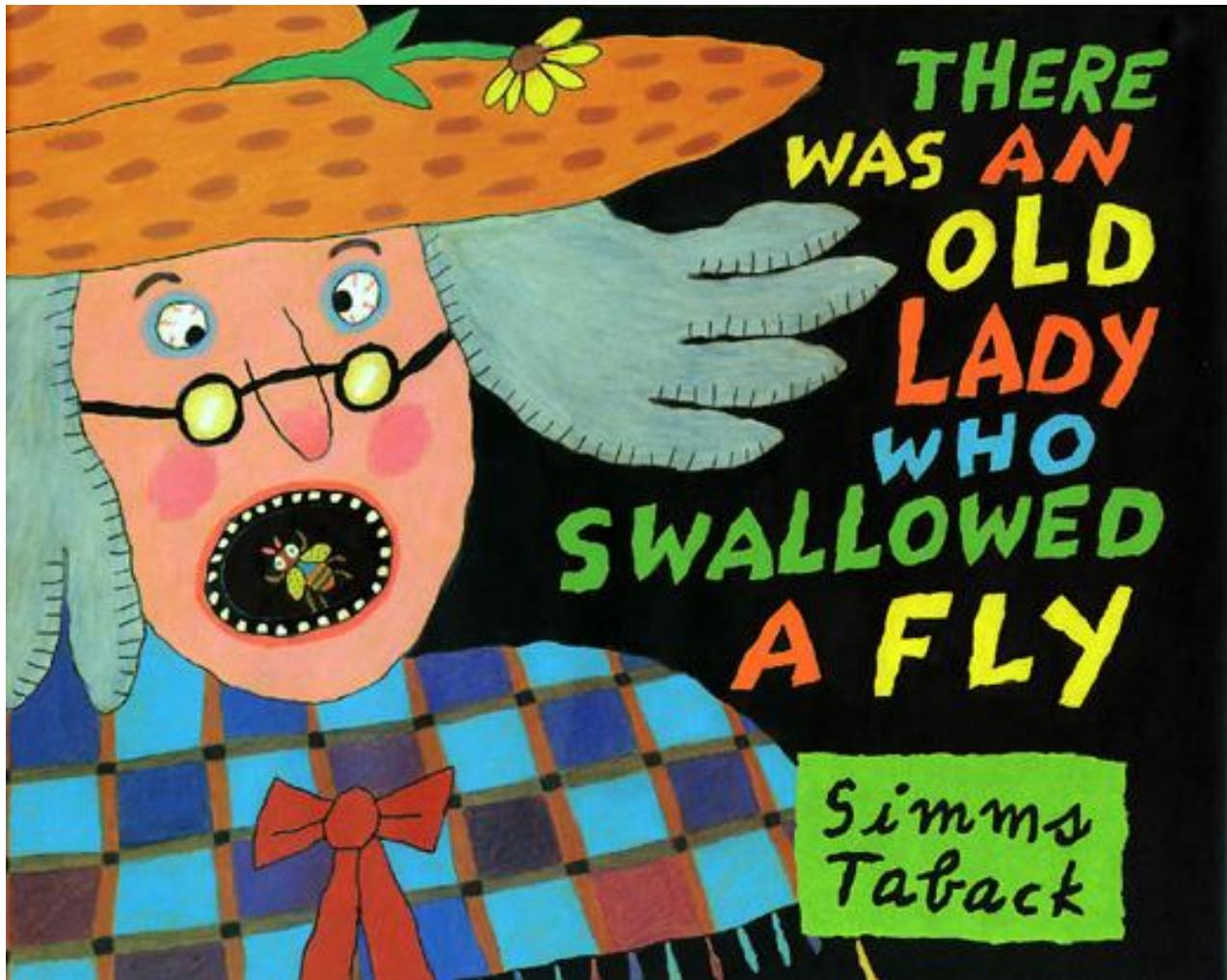


# **Anatomical boundaries and immaterial objects**

**Stefan Schulz**

Department of Medical Informatics  
University Hospital Freiburg (Germany)



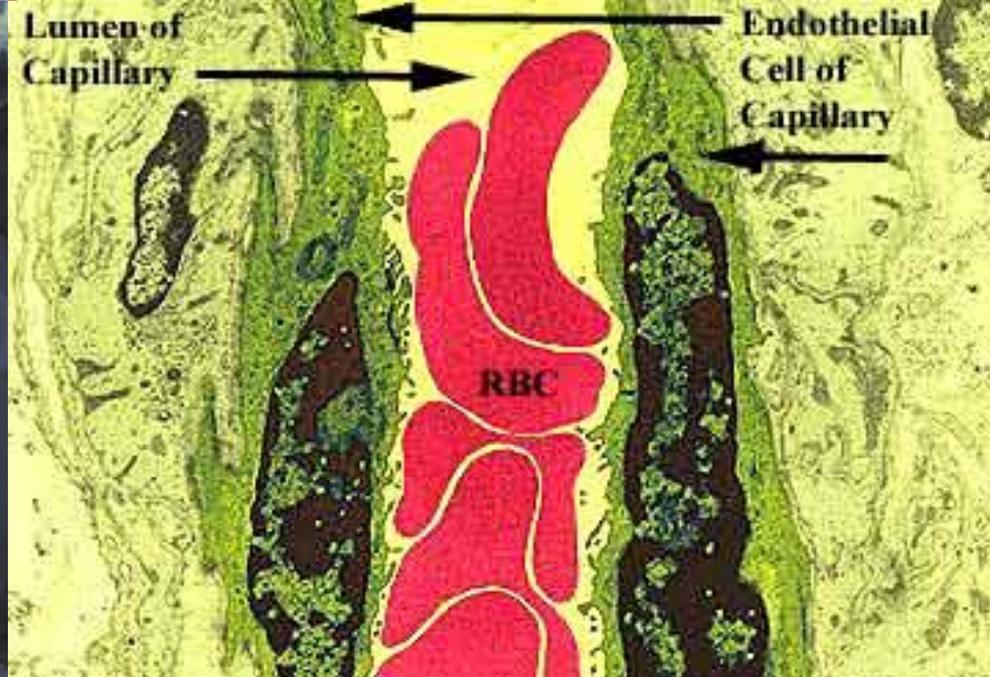
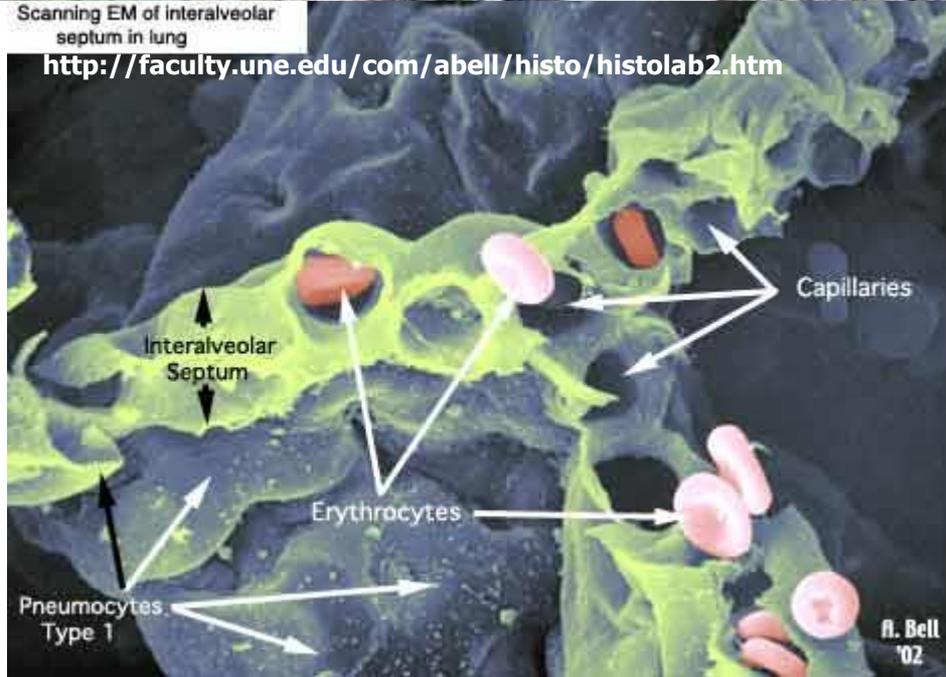
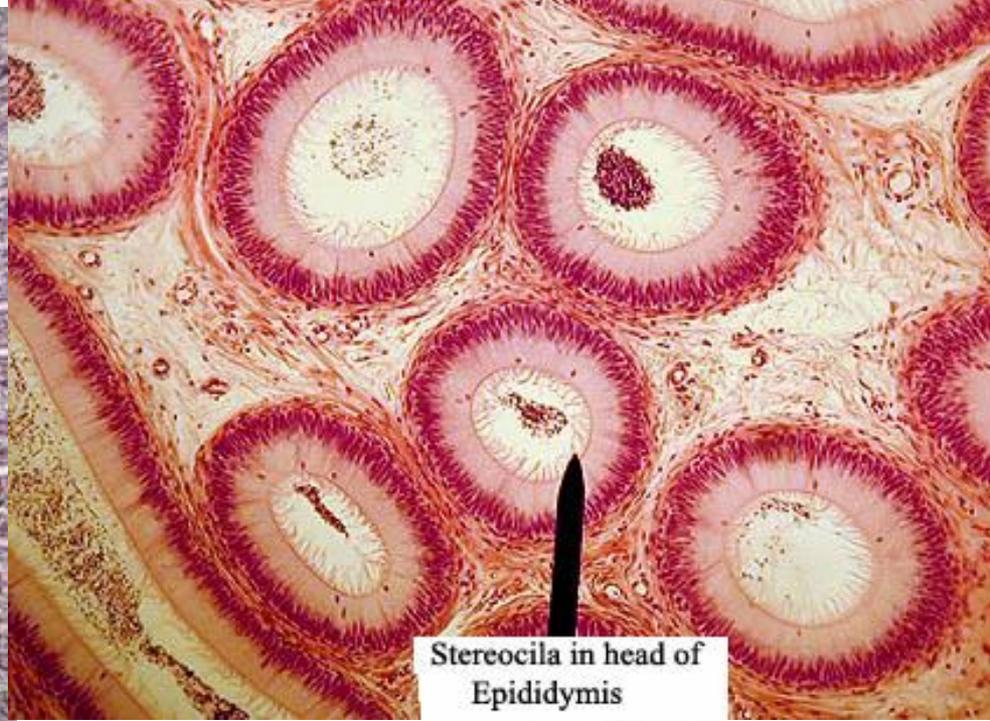
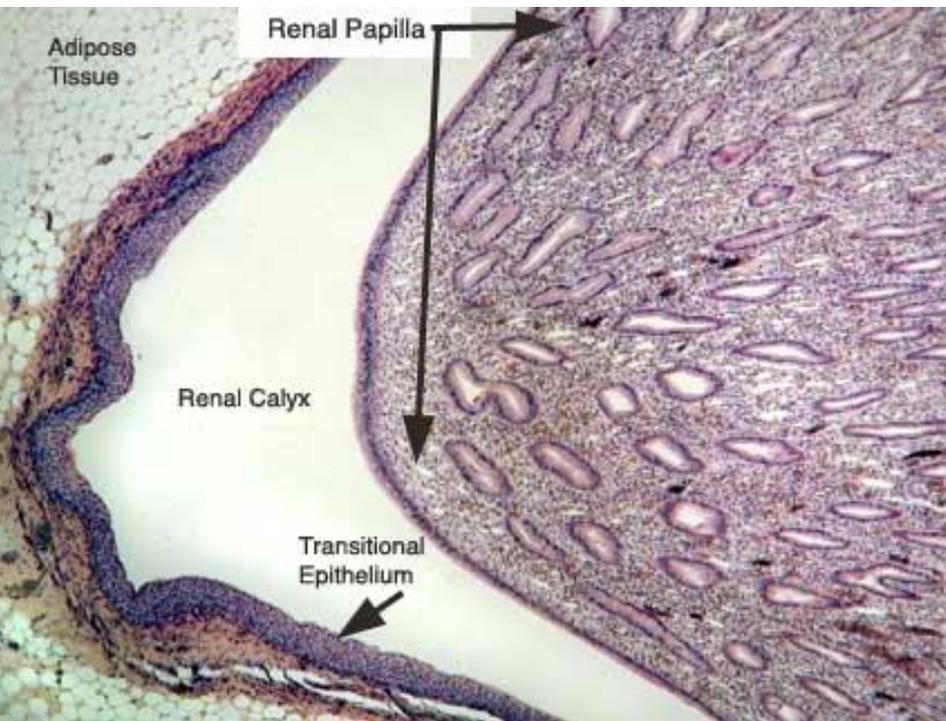


Is the fly inside or outside her body ?

# Problem (I)

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- Biological objects need clearly defined boundaries to enable assertions parthood and location
- Most Biological objects are sponge-like (full of vessels, capillaries, cavities, holes and other hollow spaces)



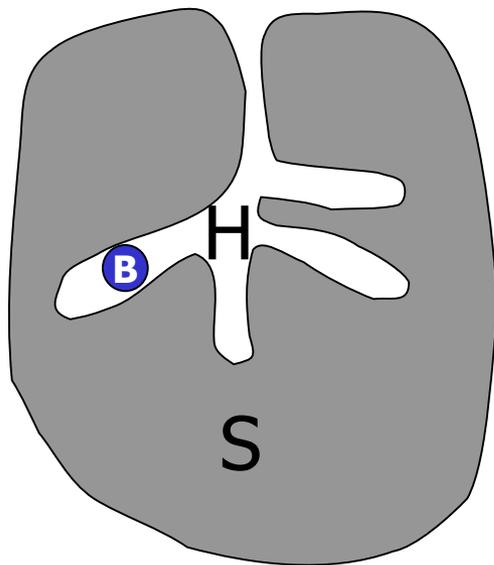
# Problem (II)

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- Many cavities communicate with the exterior space (e.g. respiratory system)
- Common conceptualization (cf. biomedical terminologies): biological objects have immaterial parts, eg. Lumen of esophagus, alveolar lumen, many cavities and holes in bones, ...

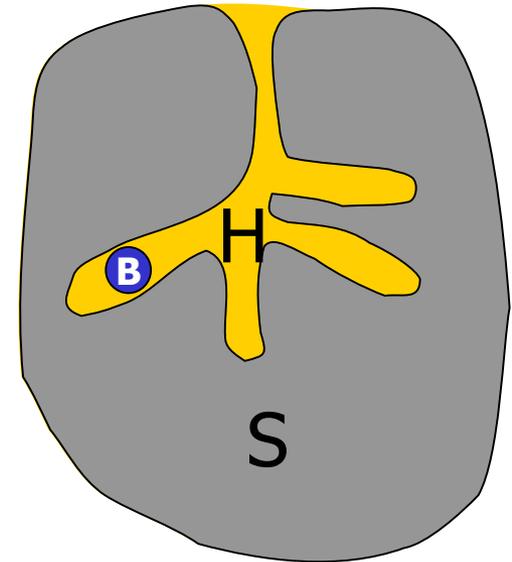
# How to deal with hollow spaces ?

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E

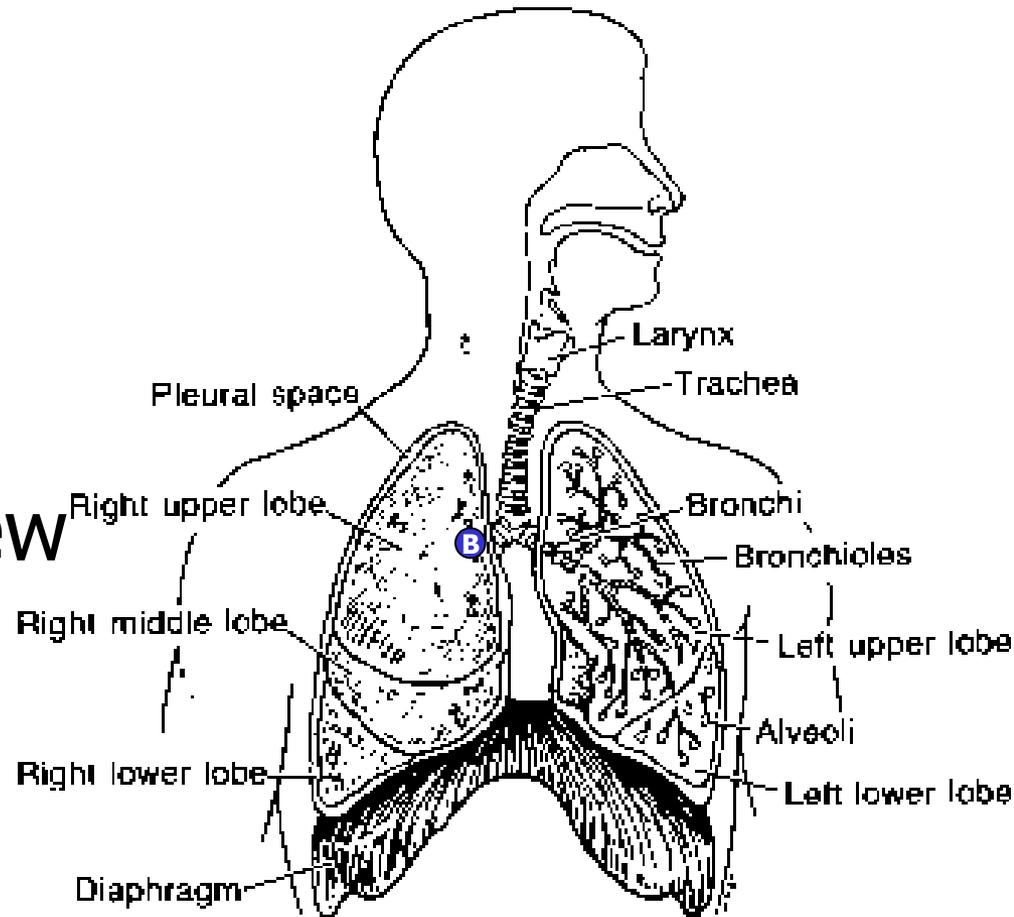
H is part of E, hence B is located **outside** of S



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

# Problem

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



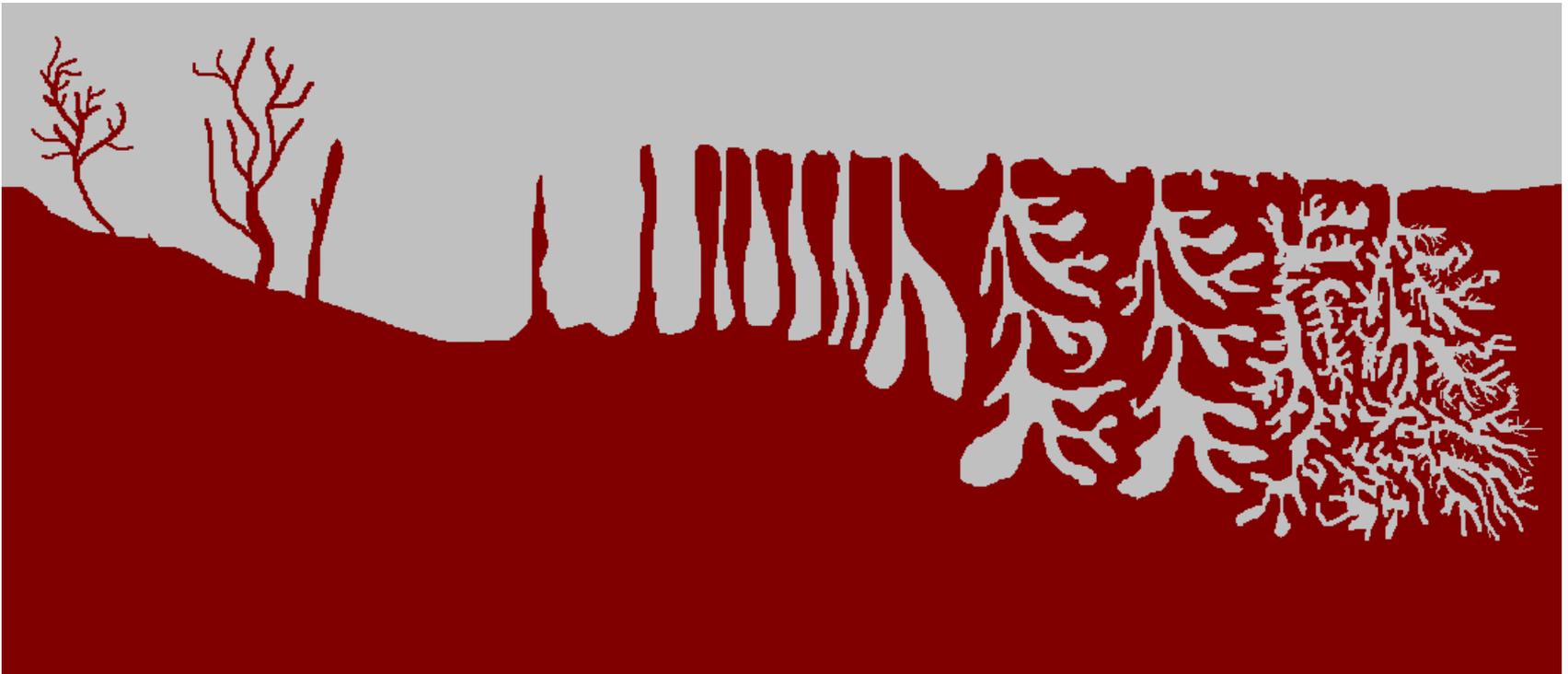
# Where to delimit ?

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# 1. All hollow spaces are part of the exterior...

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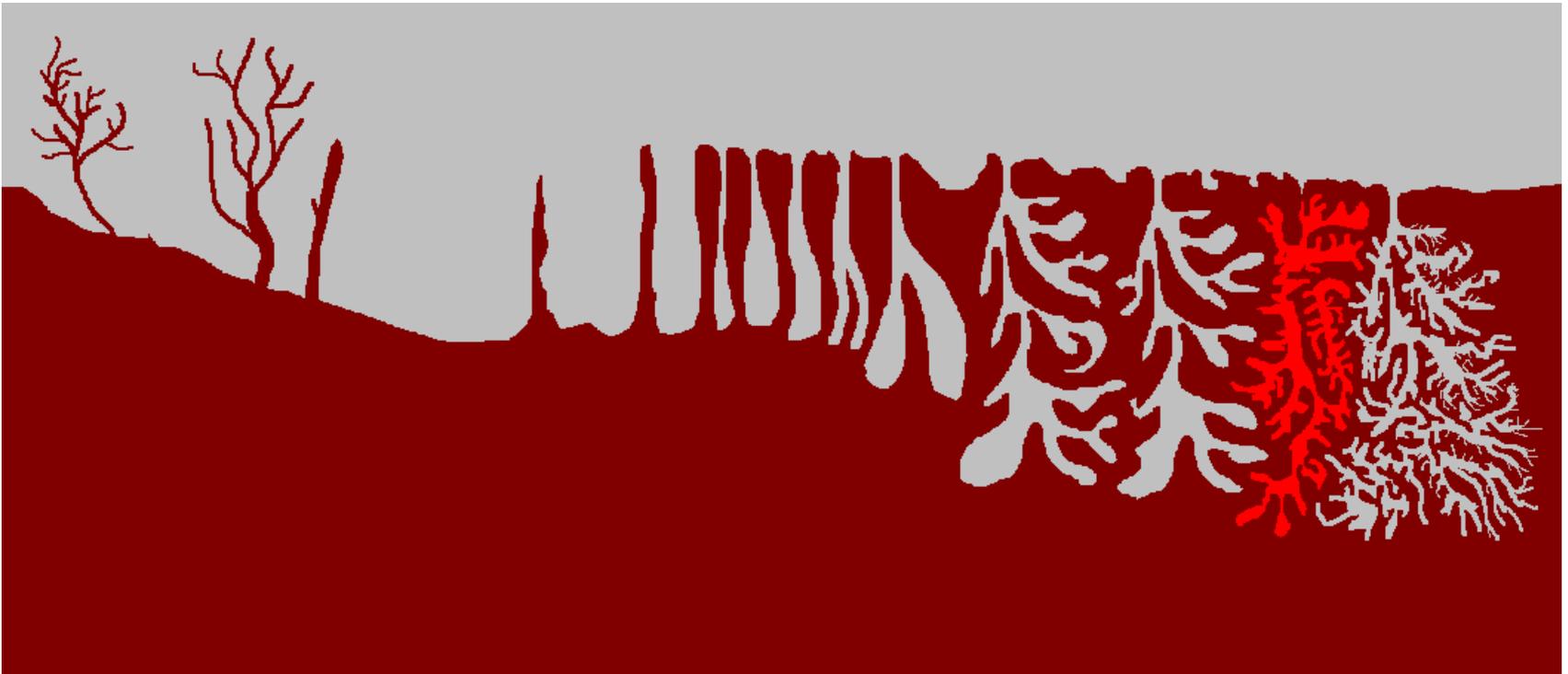
... but nothing can be located inside...



## 2. Those hollow spaces which communicate with the exterior are part of the exterior space...

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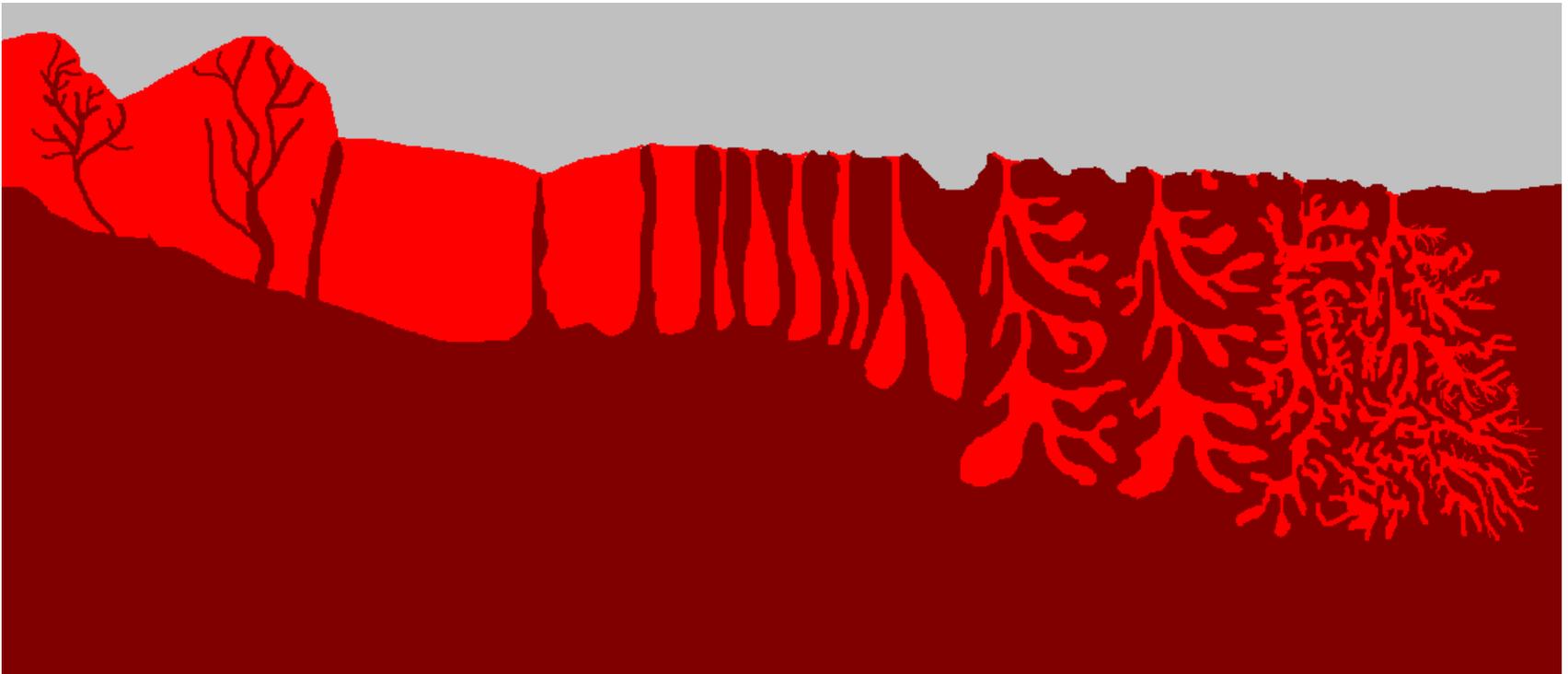
... what if some spaces only temporarily communicate ?

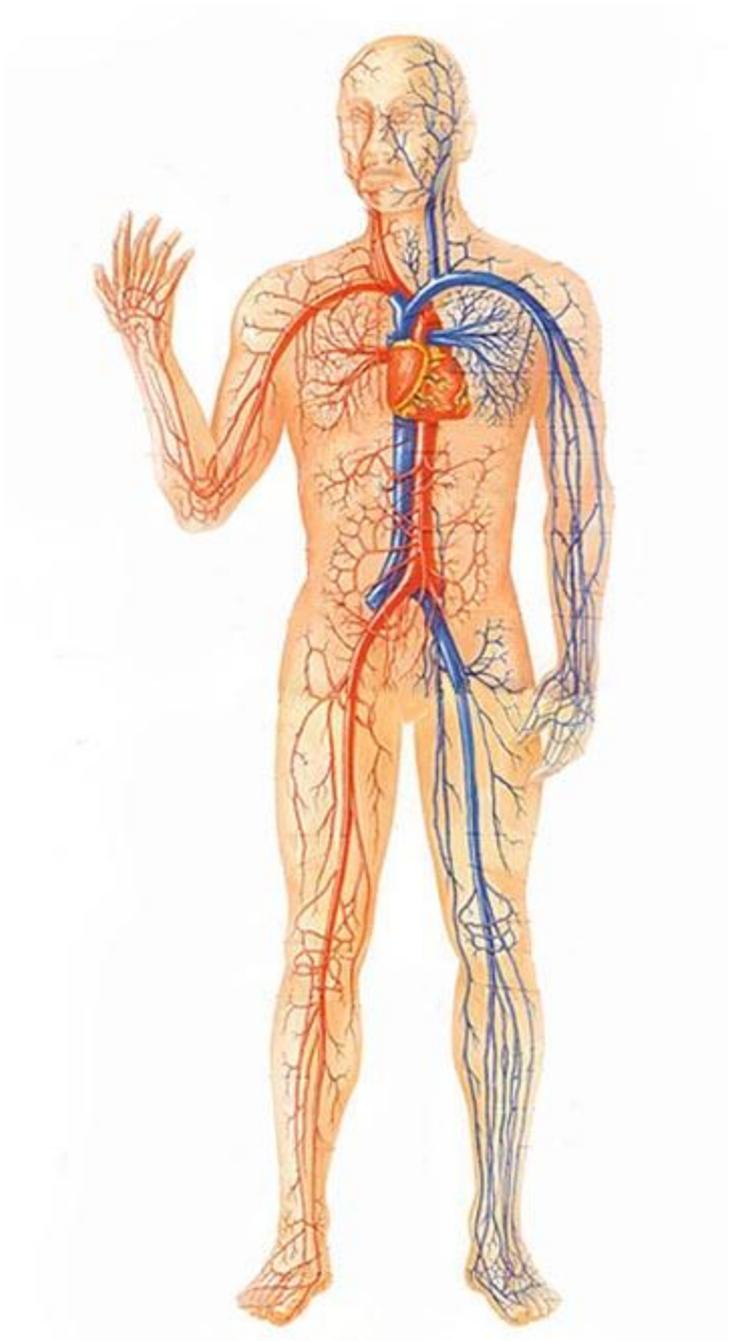


# 4. The complete convex hull is part of the object...

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... then the body would practically spatially coincide with the vascular system !

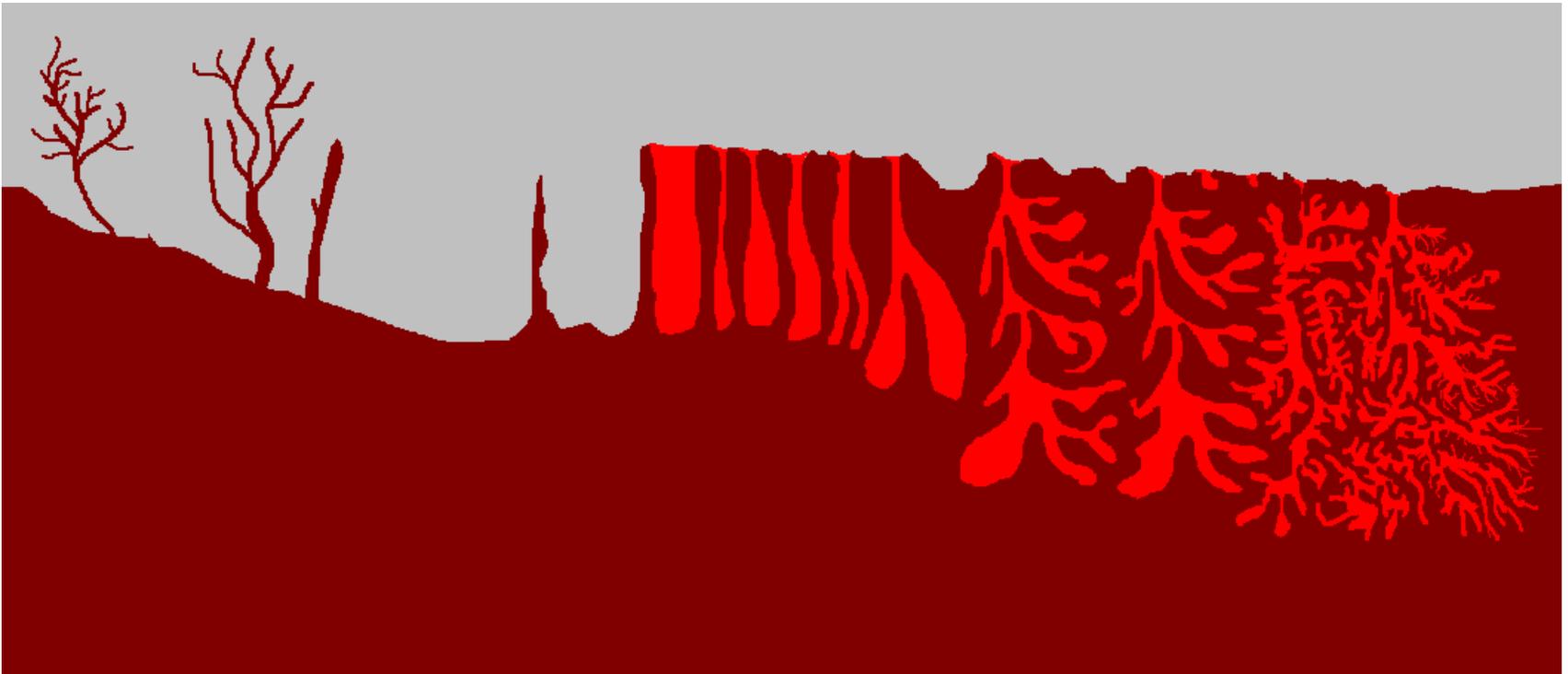




### 3. Only those hollow spaces which are containers something are part of the exterior space...

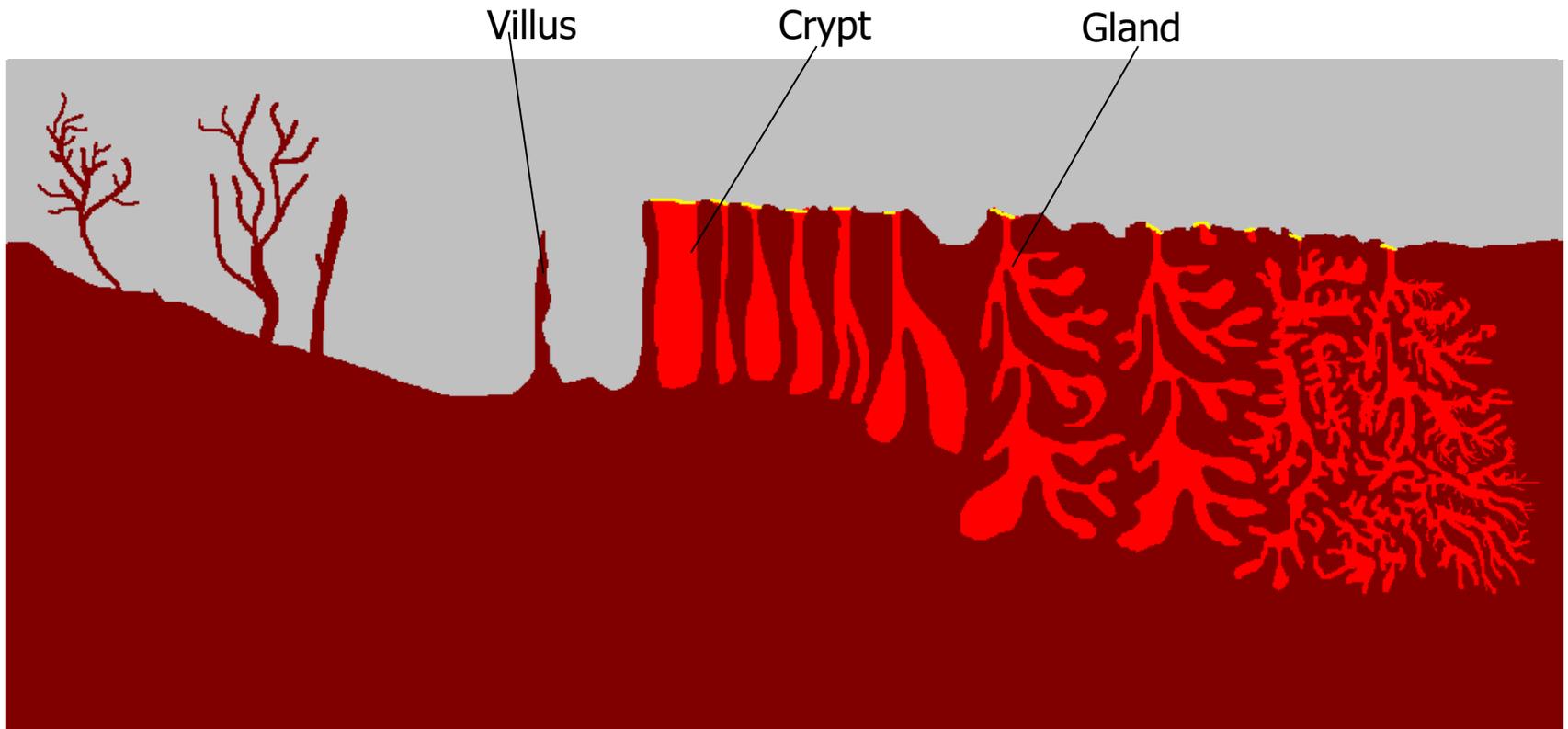
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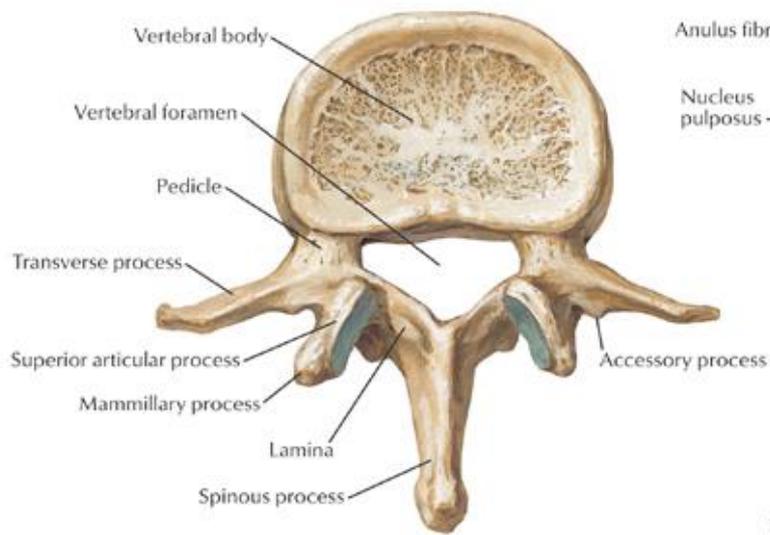
... how to ascertain whether they are containers ?



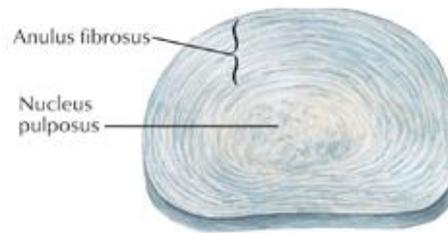
# Anatomists draw fiat boundaries

Surface structures which have a name are considered to be inside the organ

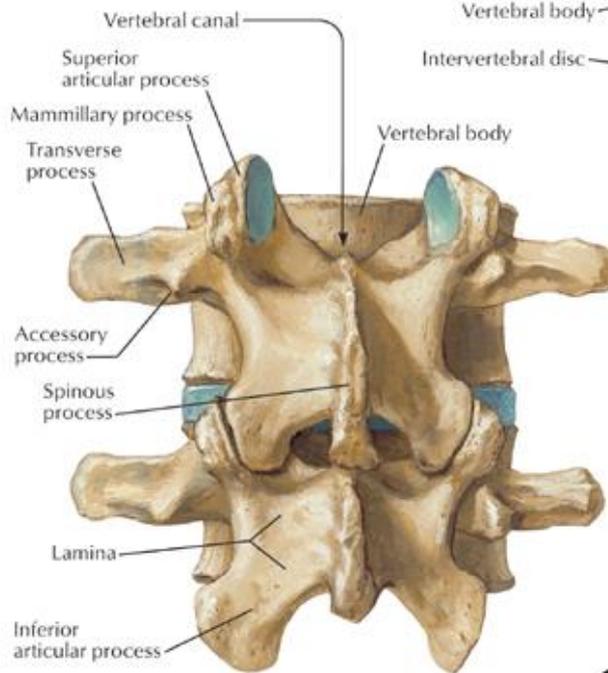




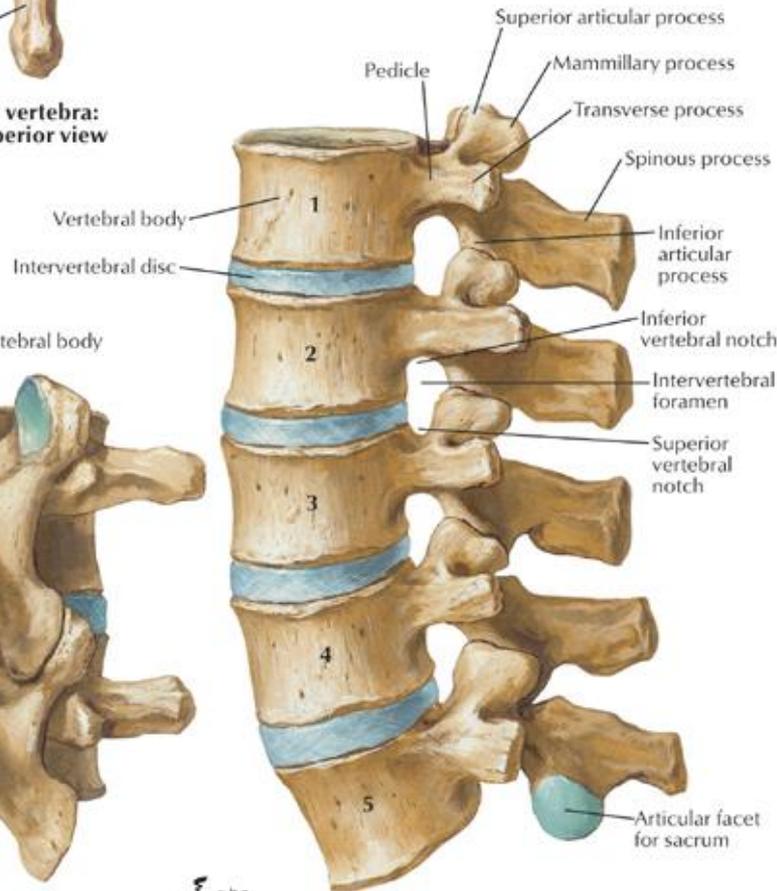
**L2 vertebra:  
superior view**



**Intervertebral disc**



**L3 and L4 vertebrae:**



**Lumbar vertebrae, assembled:**

*F. Netter M.D.*

# 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

---

## ■ 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

# Parts as Components

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Parts “build”  
the whole

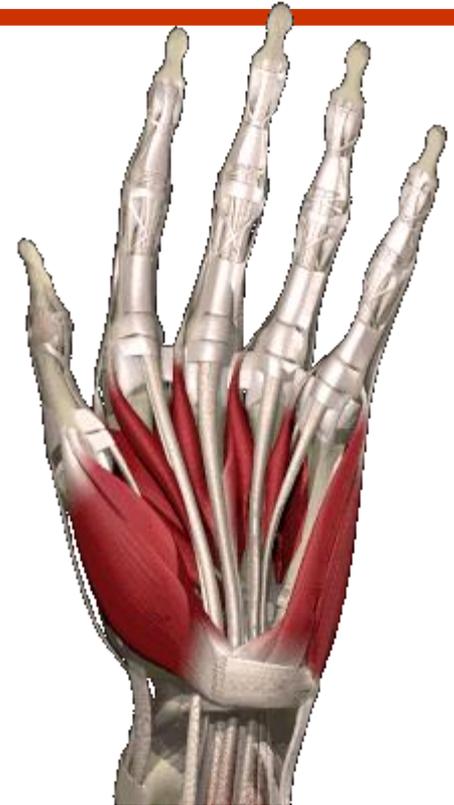
*part-of (Finger, Hand)*

*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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# Parts as Functional Components

---

Part contributes to the function of the whole

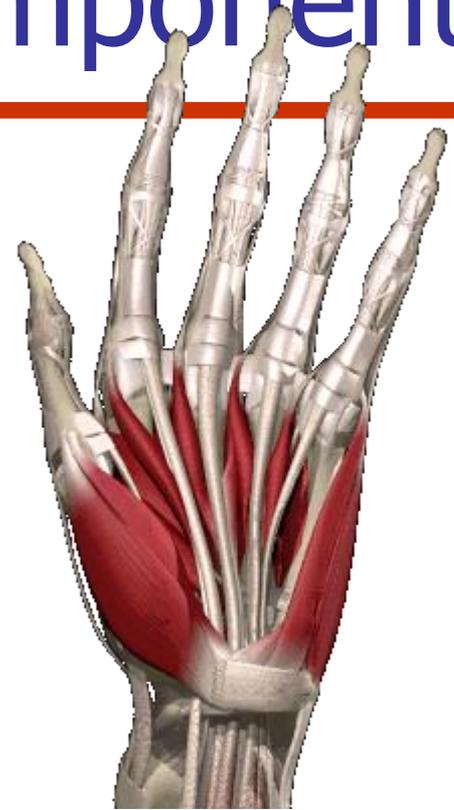
*part-of (Finger, Hand)*

*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:

- *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,  
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# Different notions of part-of

---

- Time-independent:

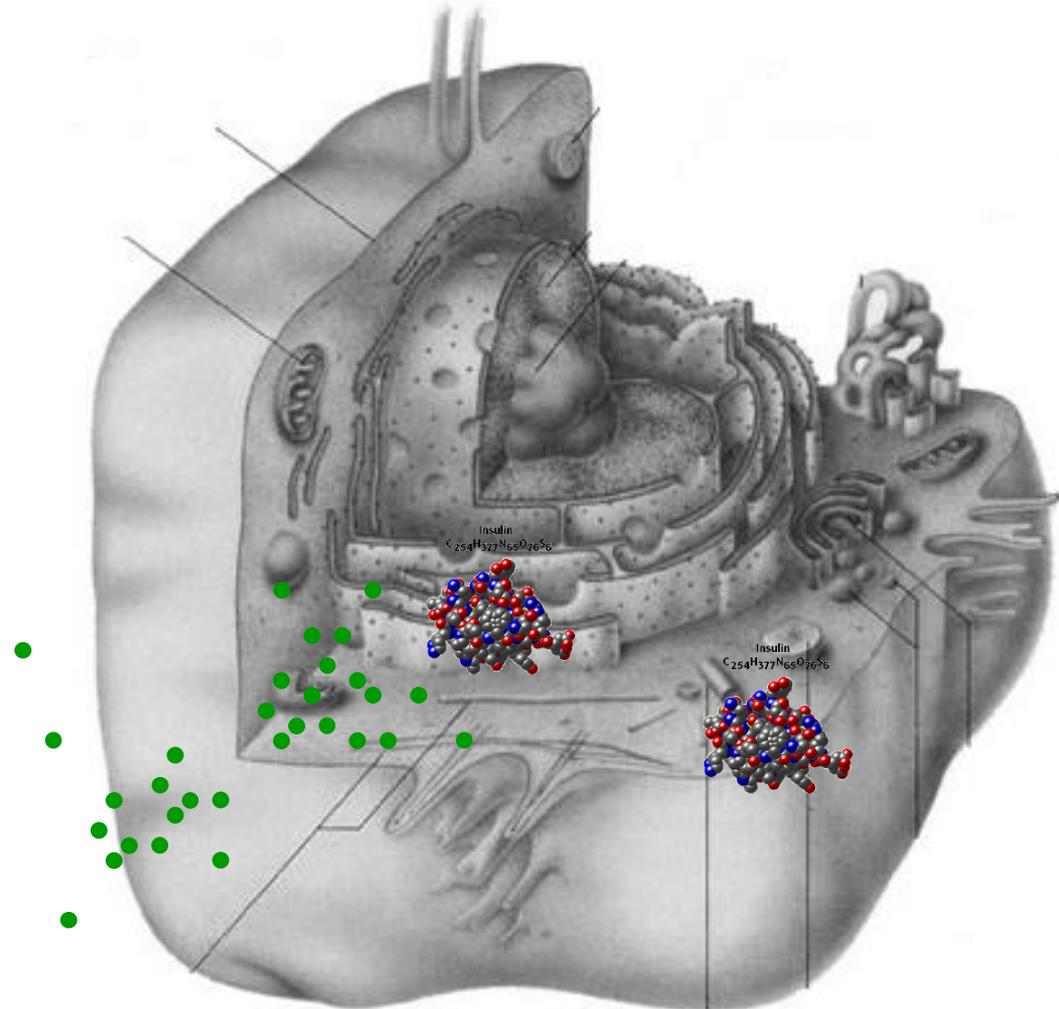
- Compositional
- Functional
- Topological

- Time-dependent:

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# Continuous exchange of matter

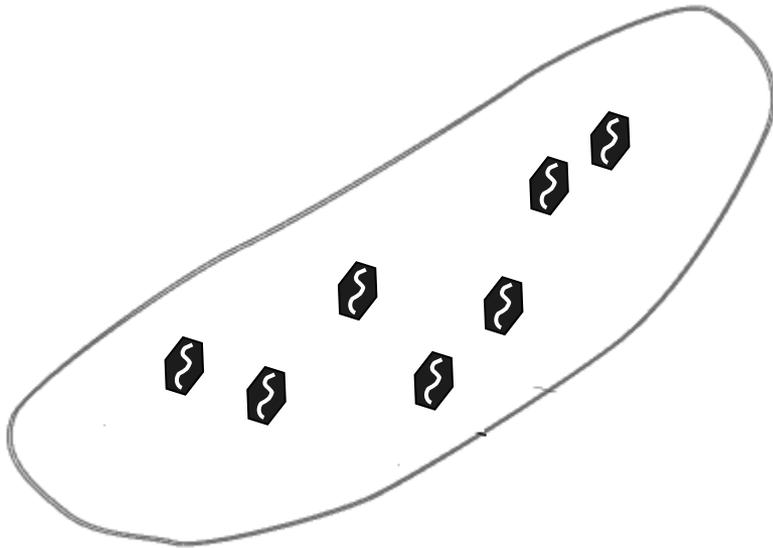
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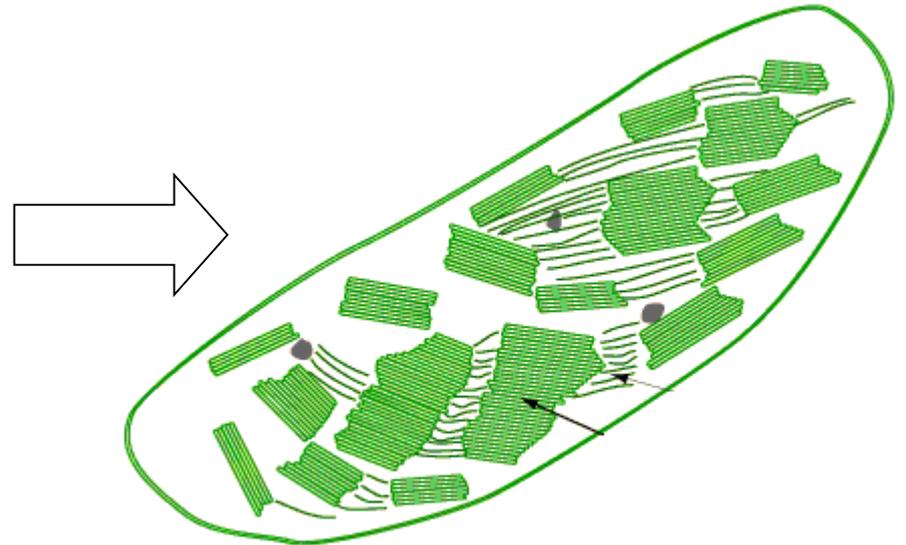
# Endosymbiont Hypothesis

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

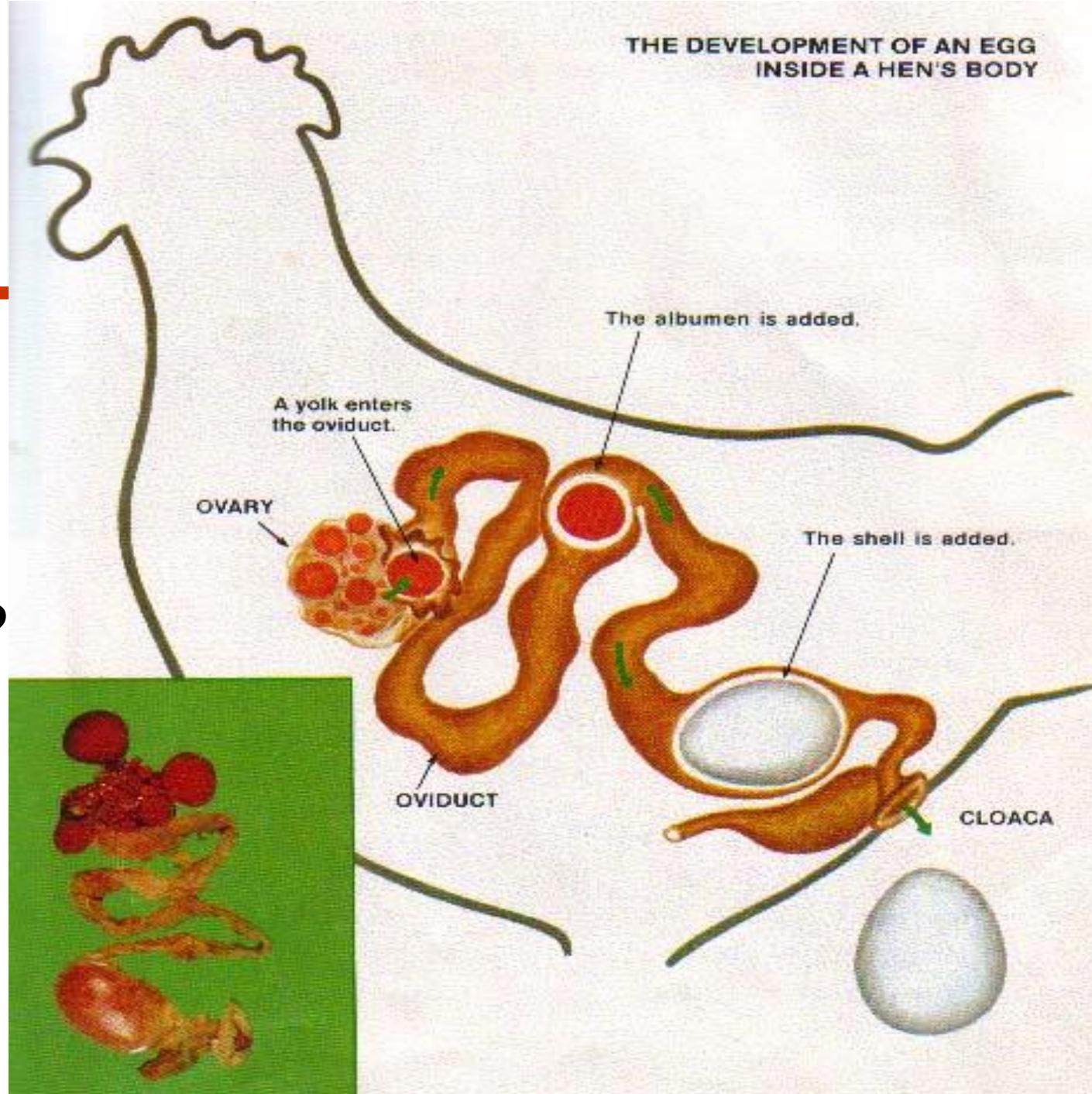


Today:  
Chloroplasts (Plants)  
Mitochondria



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)*

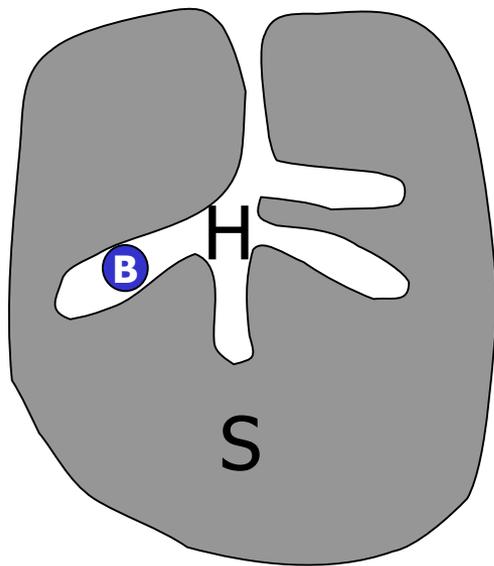
*has-location (amount of Blood, Right Ventricle)*

*has-location* as a mereotopological primitive ?

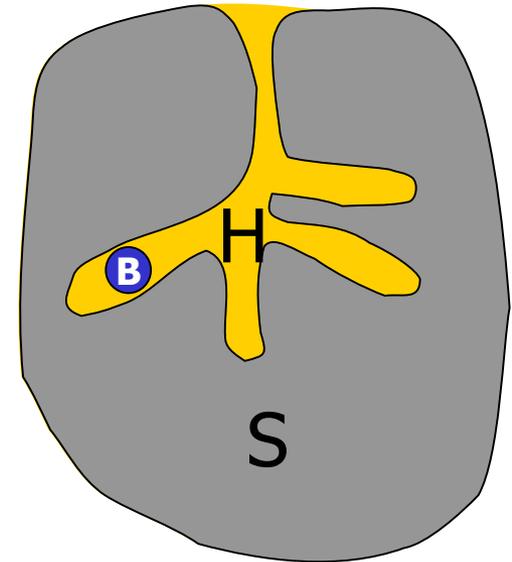
# Topological parts

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How to deal with hollow spaces ?



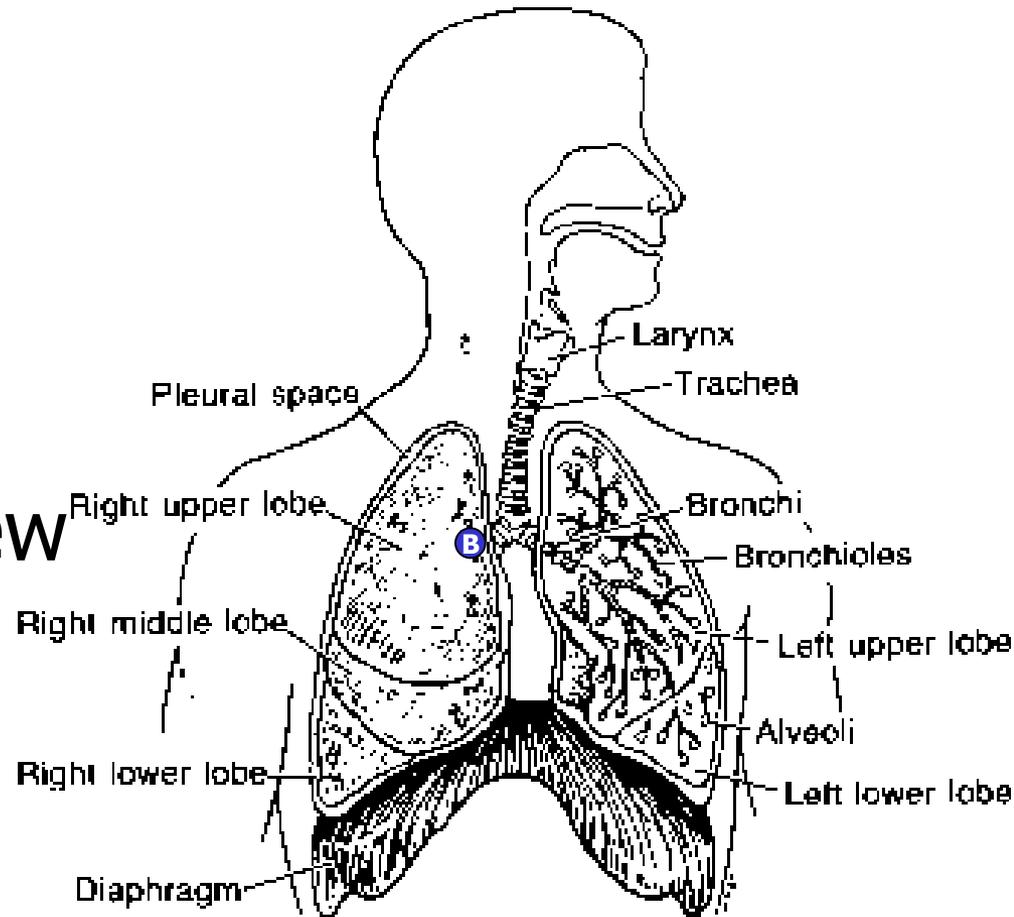
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H is part of S, hence B is located **inside** of S

# 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

---

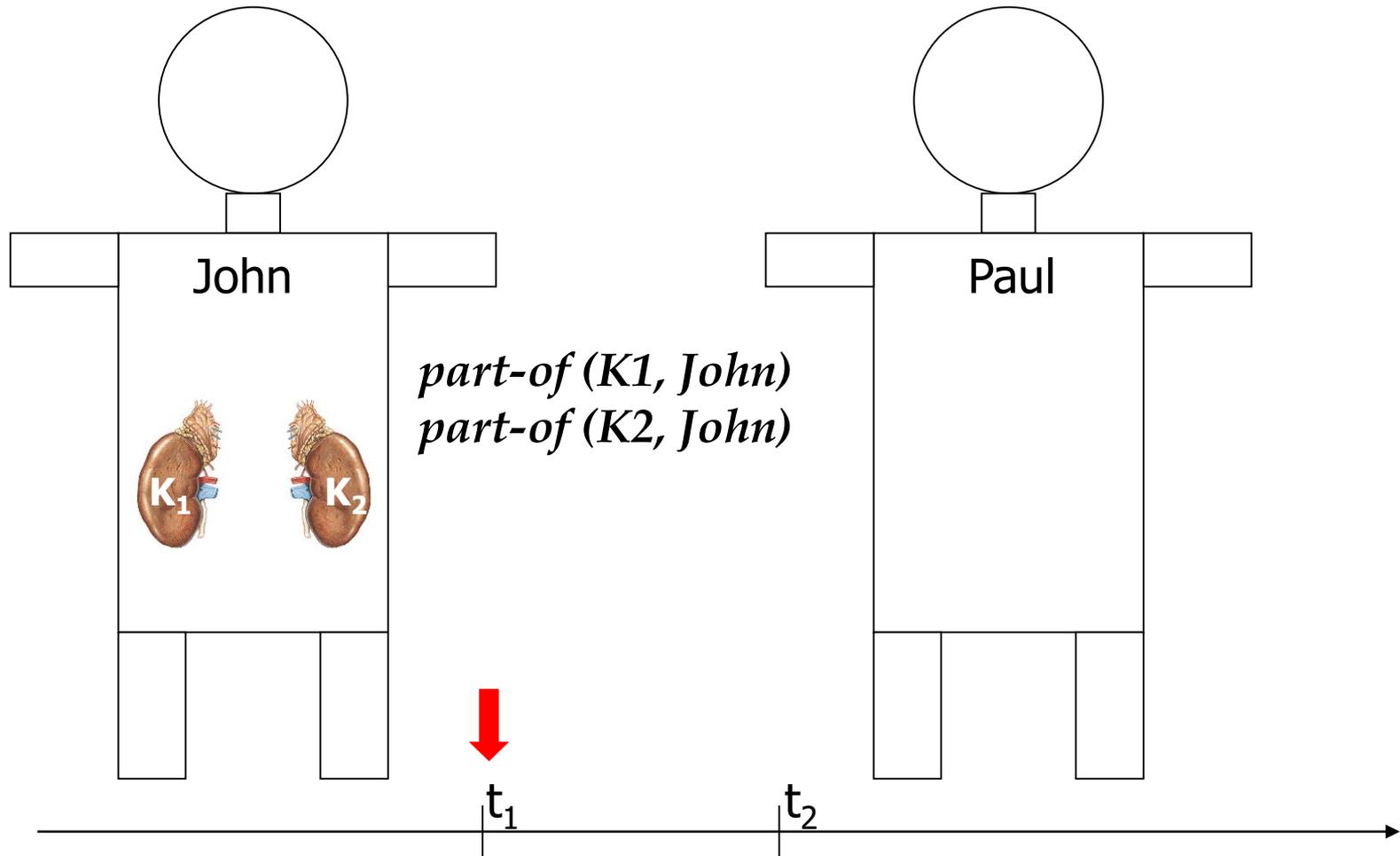
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- Topological

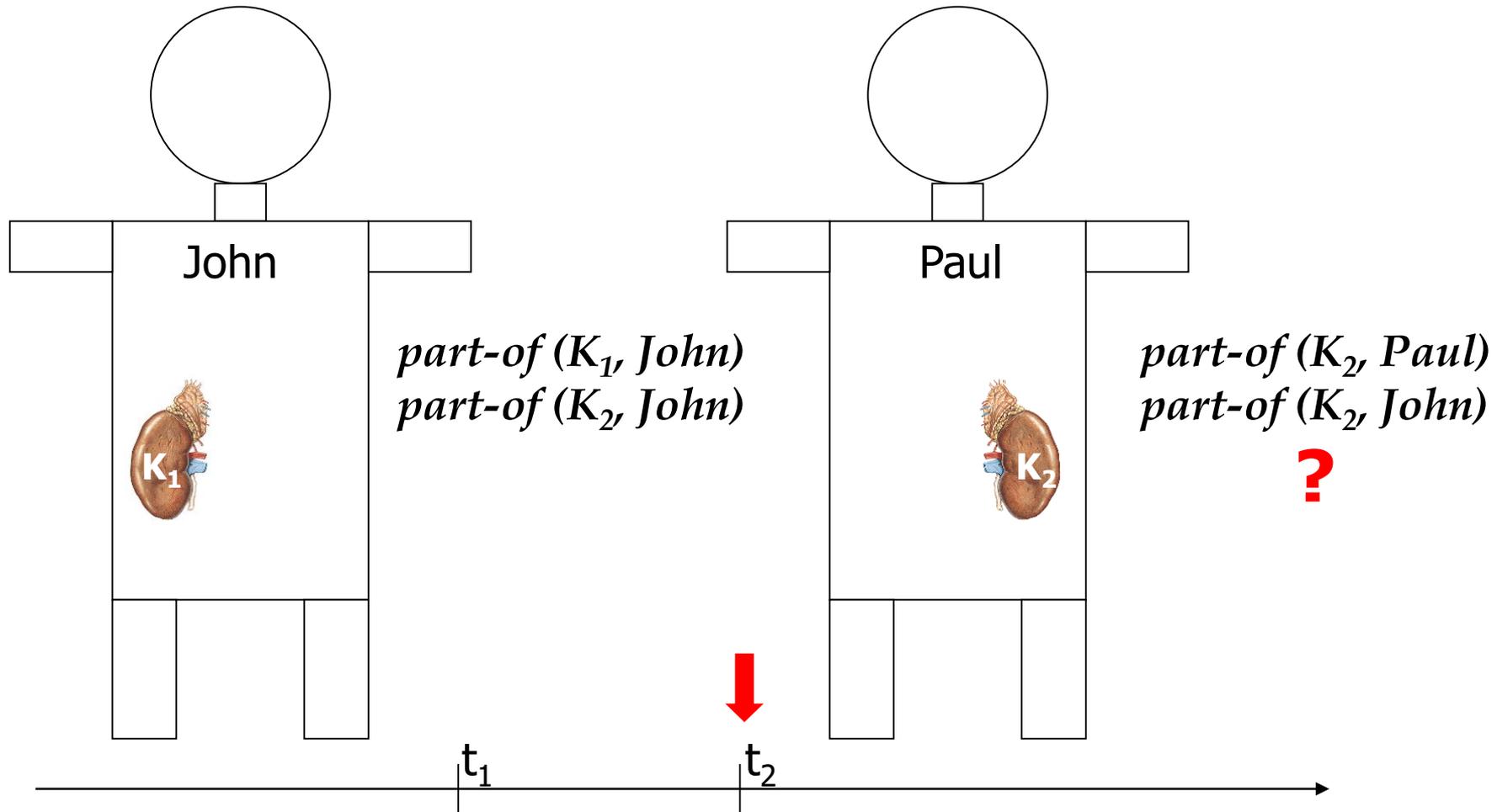
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# Example: Transplantation

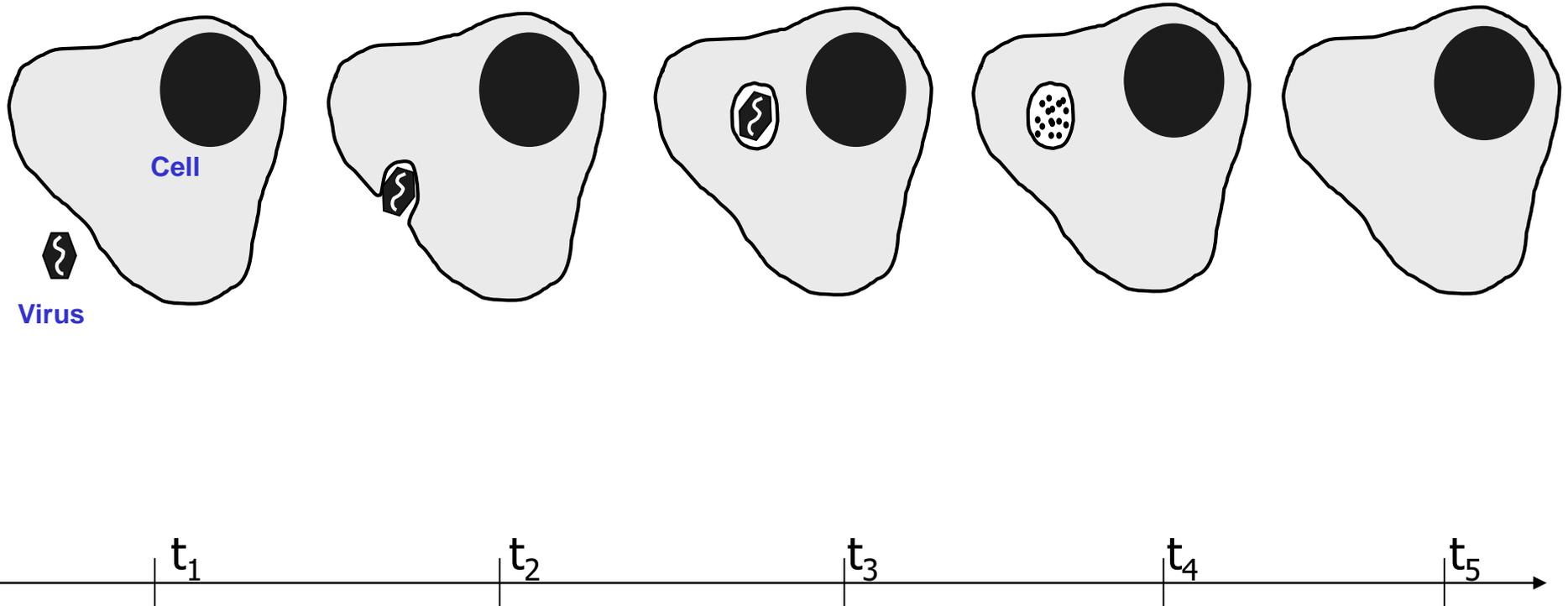


# Example: Transplantation

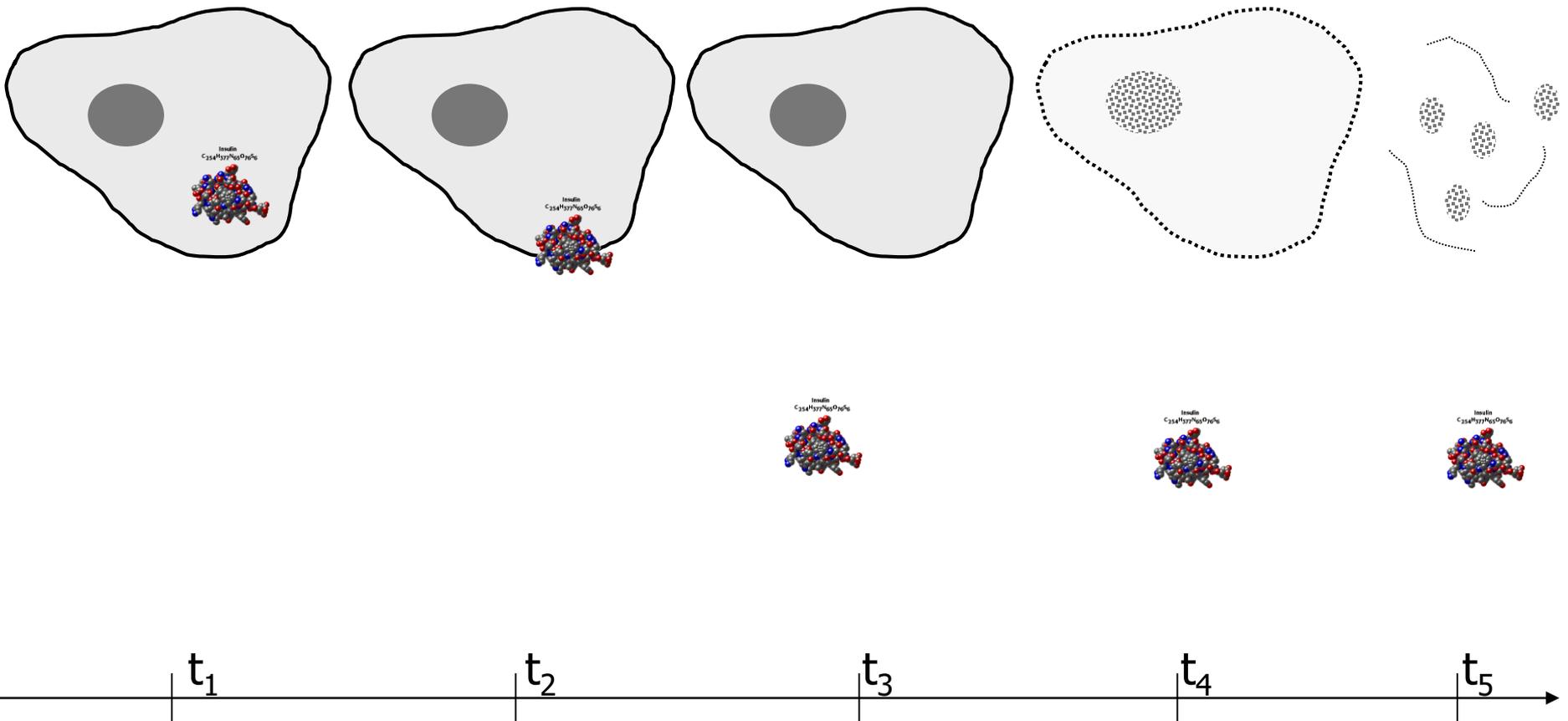


# Phagocytosis / Digestion

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# Secretion



# Conclusion

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- 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,...

