

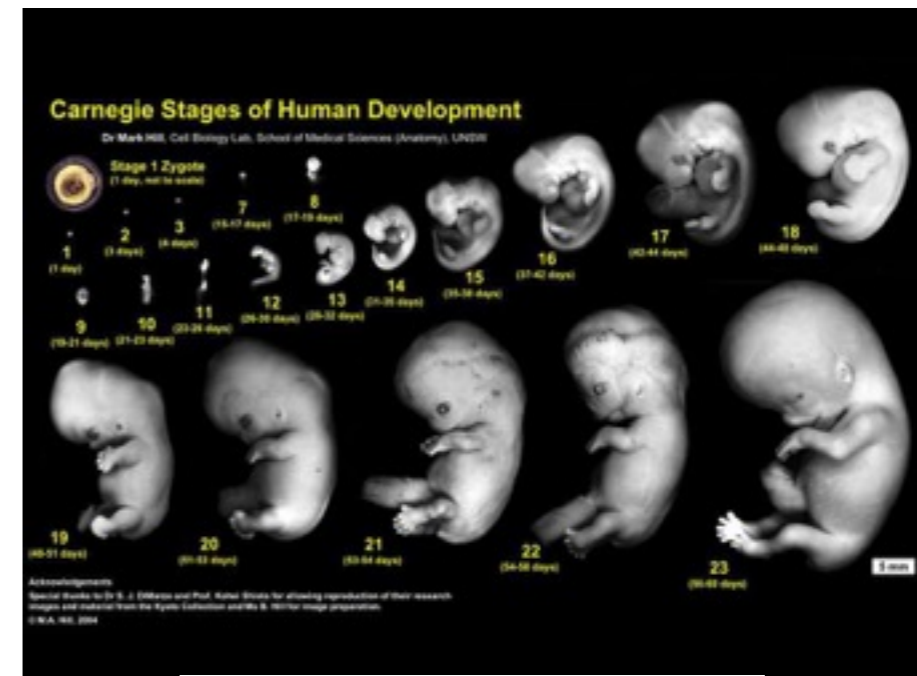
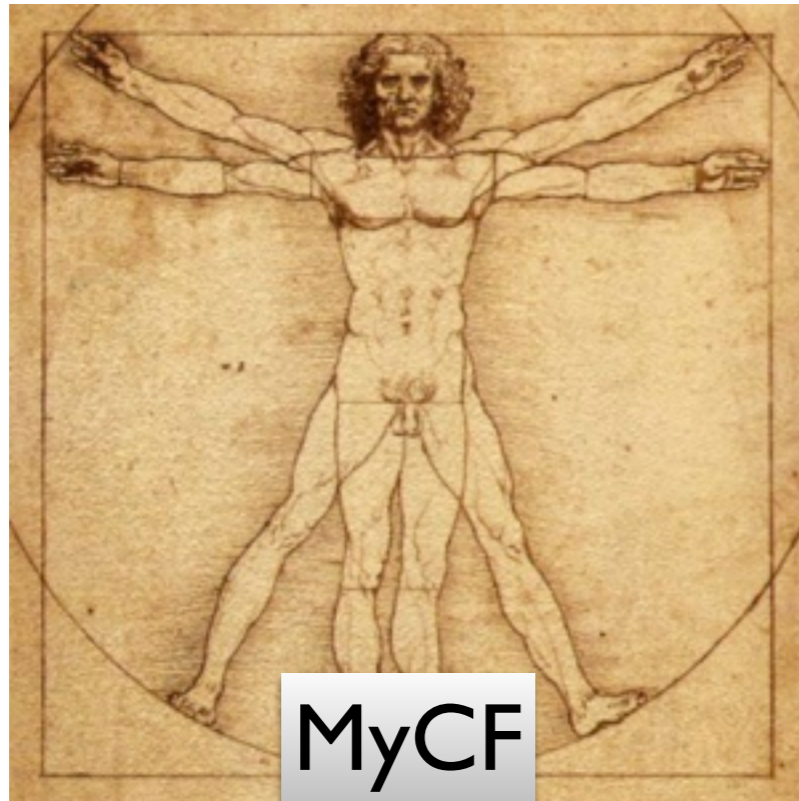


# *My Corporis Fabrica*

*(Intérêt et utilisation d'une ontologie en lien avec des images,  
et enrichissement avec des règles simples)*

**Federico Ulliana**  
**LIRMM - UM2 - INRIA GraphIK**

# My Corporis Fabrica



# Team

## **Anatomy**

- Olivier Palombi (CHU-Grenoble)  
Favier Valentin  
Pierre-Yves Rabattu

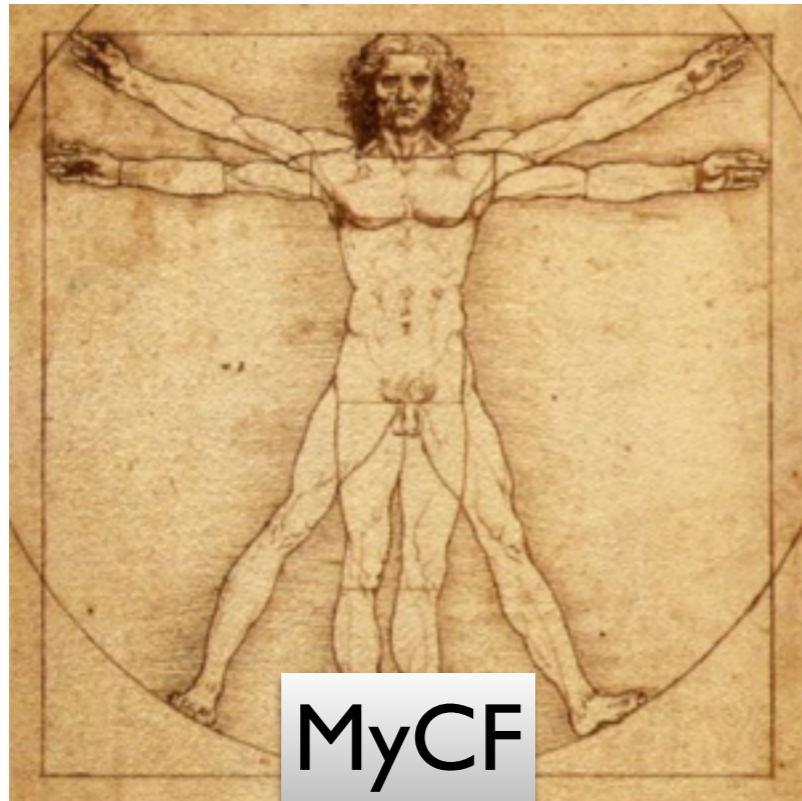
## **Computer Graphics / Mechanics**

- François Faure, Jean-Claude Léon (INRIA Rhone-Alpes)  
Damien Rhomer, Benoît Masse

## **Knowledge Representation / Databases**

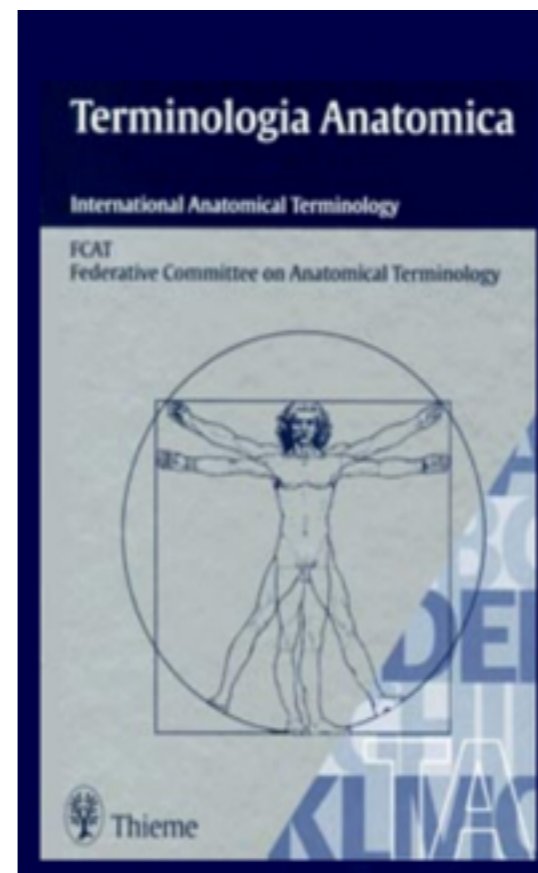
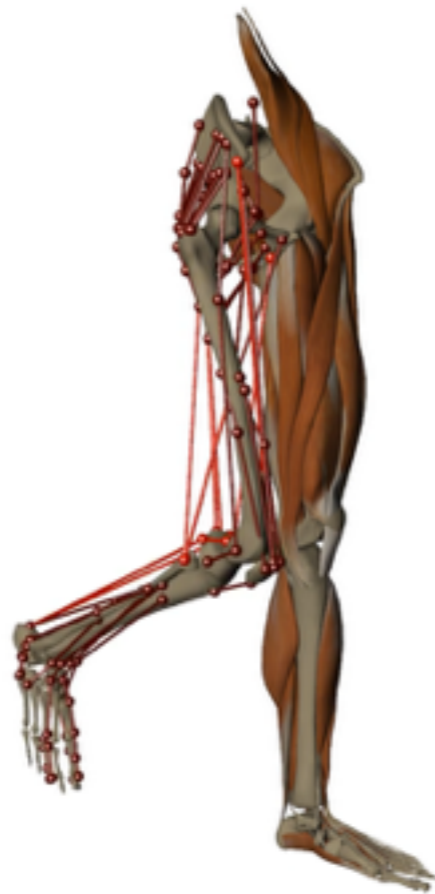
- Marie-Christine Rousset, myself (LIG Grenoble, LIRMM)

# My Corporis Fabrica



# MyCF Goal

Simulation of patient-specific 3D models



Needs coherence between 3D and canonical anatomy

# The Glue is an Ontology

Anatomy

finger, knee, hand

Physiological Functions

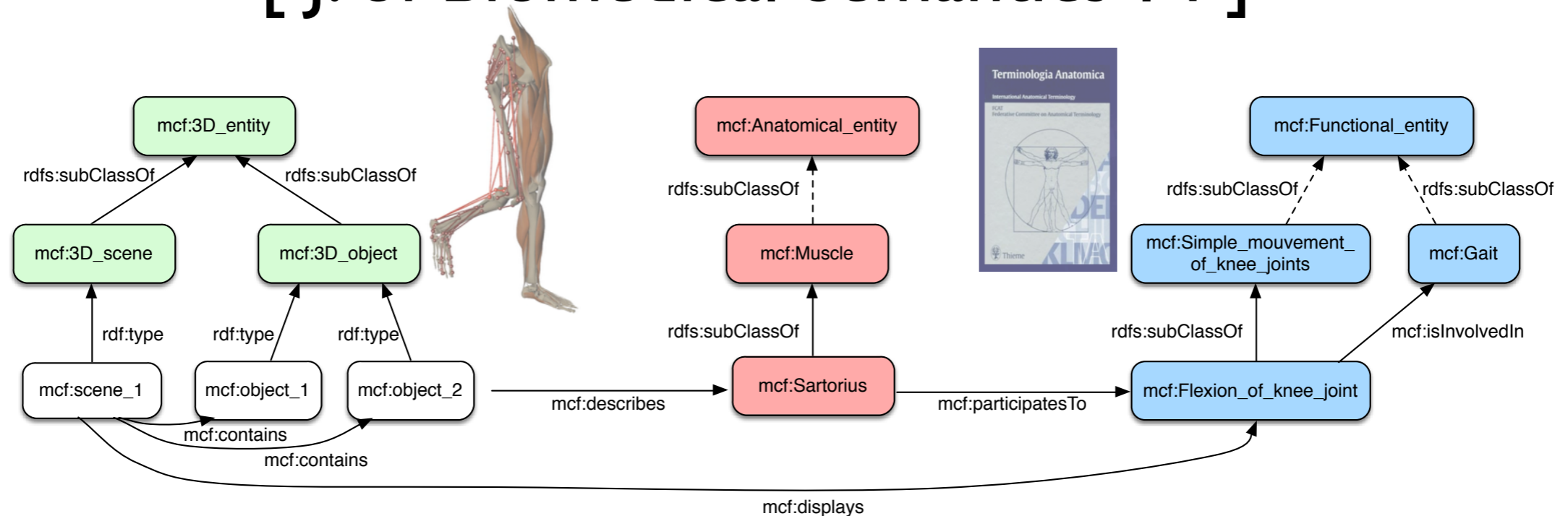
breath, gait, stability

3D models

“**object1** *describes* the **Sartorius Muscle**  
which *is* a **Muscle** *inserted on* the **Pelvis**  
that *participates to* the **Plantar Flexion of the Foot**”

# The Glue is an Ontology

[ J. of Biomedical Semantics '14 ]



3D | `<mcf:scene_1, mcf:contains, mcf:object_2>`  
 | `<mcf:object_2, mcf:describes, fma:Sartorius>`

Anatomy | `<fma:Sartorius, rdfs:subClassOf, fma:Muscle>`

Physiological functions | `<fma:Sartorius, mcf:ParticipatesTo, mcf:Flexion_of_knee_joint>`  
 | `<mcf:Flexion_of_knee_joint, mcf:isInvolvedIn, mcf:Gait>`

# Deductive RDF Triplestores

## RDF + Datalog [AAAI'15]

RDF to manage vocabulary in collaborative environments

- Meta-modeling/punning: classes/properties as instances

`<fma:Sartorius, rdf:type, owl:Class>`

`<fma:Sartorius, mcf:ParticipatesTo, mcf:Flexion_of_knee_joint>`

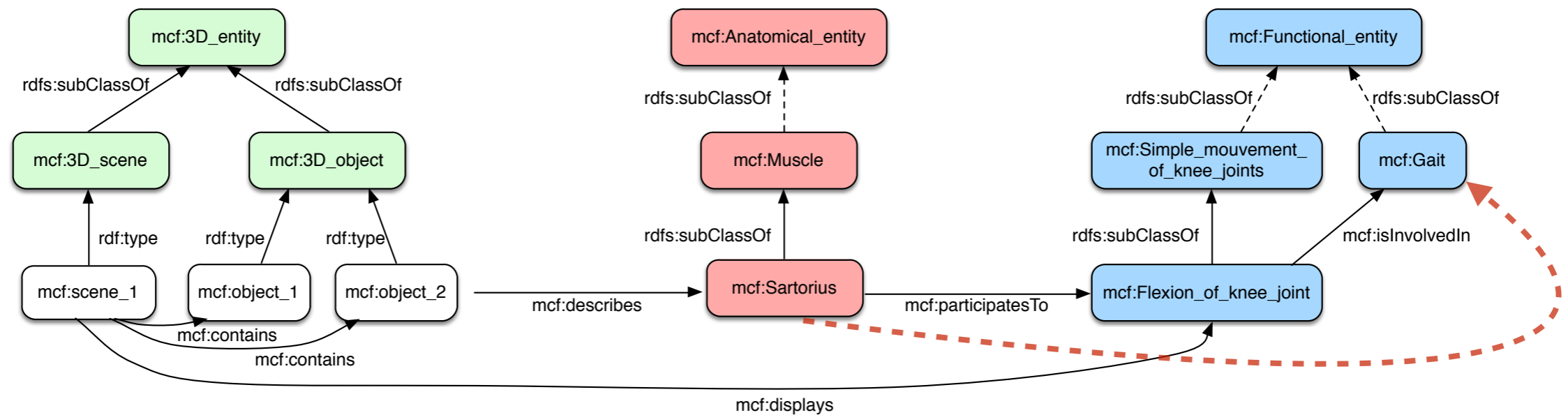
- Needed to safely reuse the FMA Ontology





# Deductive RDF Triplestores

## RDF + Datalog [AAAI'15]



Inference rules à la Datalog

MyCF : 15 domain-specific rules

$$(x, \text{PartOf}, y), (y, \text{PartOf}, z) \rightarrow (x, \text{PartOf}, z)$$

$$(x, \text{PartOf}, y), (x, \text{subClassOf}, y) \rightarrow \perp$$

$$(x, \text{participatesTo}, y), (y, \text{isInvolvedIn}, z) \rightarrow (x, \text{participatesTo}, z)$$

# Visualization by Query

```
<femur, subclassOf, bone>  
<bone subclassOf, organ>  
<model1, type, femur>
```



```
select    ?object ?color  
where {  mcf:Sartorius , mcf:InsertOn , ?bone .  
         ?object , mcf:describes , ?bone .  
         ?object , mcf:color , ?color }
```

# Visualization by Query

<femur, subClassOf, bone>

<bone subClassOf, organ>

<model1, type, femur>

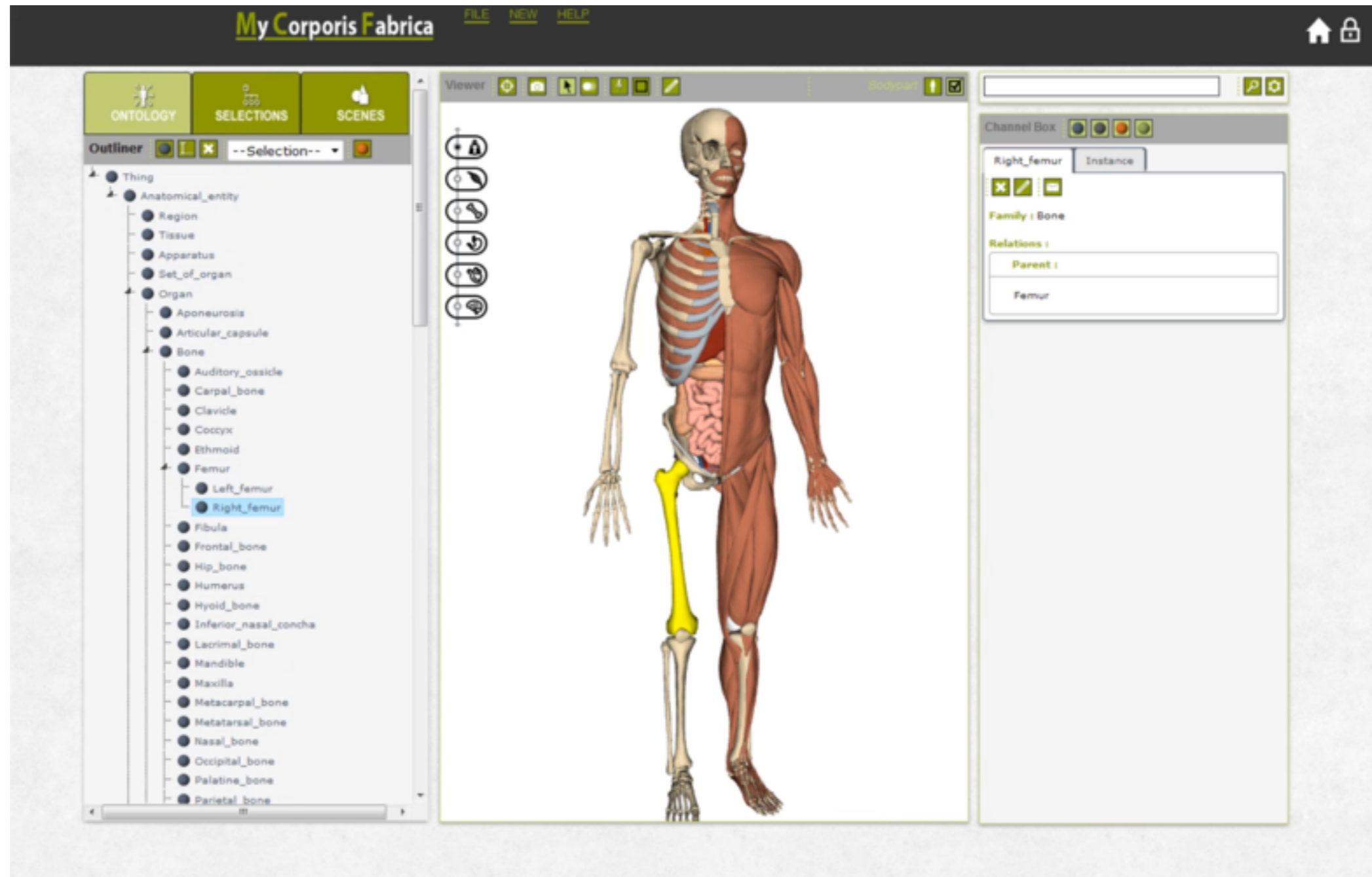
...



```
select    ?object
where {   ?muscle , mcf:ParticipatesTo , mcf:Knee_joint_flexion
         ?muscle , rdfs:subClassOf , mcf:Muscle .
         ?object , mcf:describes , ?muscle }
```

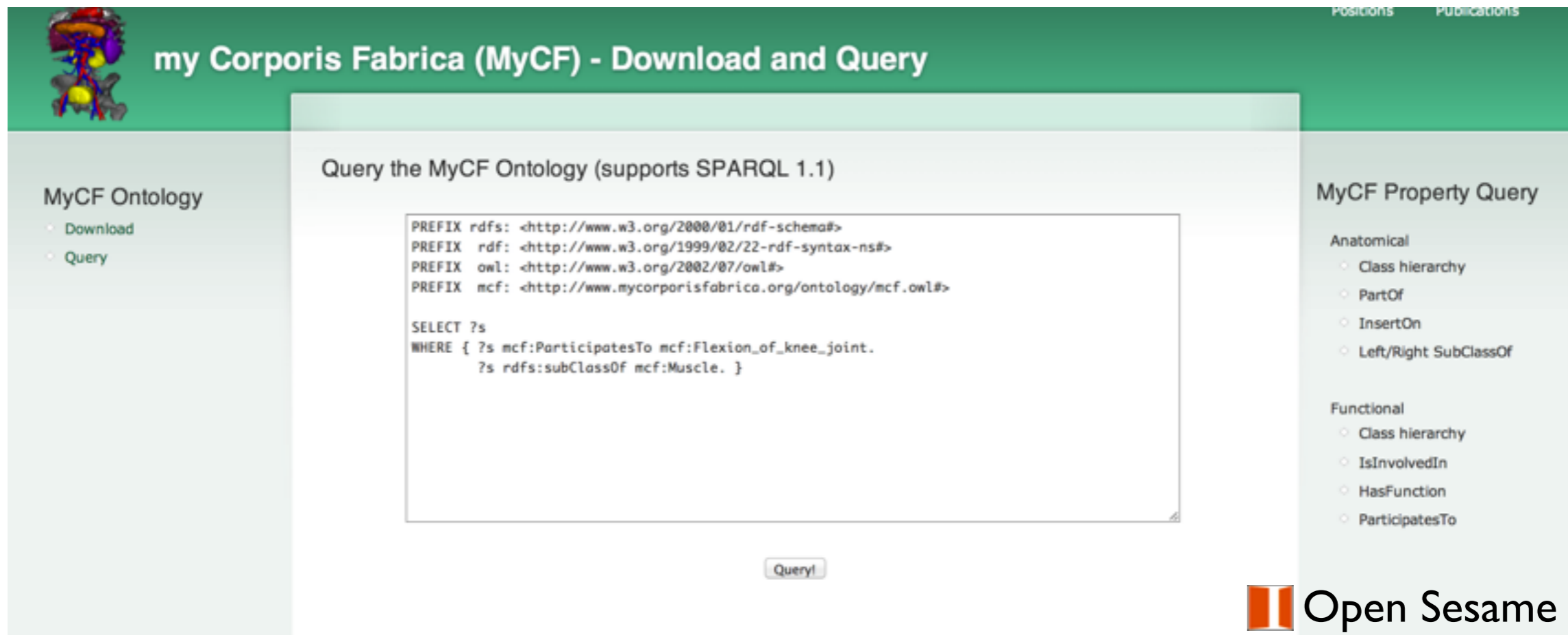
# MyCF Browser

[SIGGRAPH'14 Demo]



# MyCF Web

[www.mycorporisfabrica.org](http://www.mycorporisfabrica.org)



The screenshot displays the MyCF Web interface. At the top, there is a green header with the text "my Corporis Fabrica (MyCF) - Download and Query" and a small anatomical icon on the left. Below the header, the main content area is divided into three sections:

- MyCF Ontology**: A sidebar on the left with links for "Download" and "Query".
- Query the MyCF Ontology (supports SPARQL 1.1)**: A central text area containing a SPARQL query:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX mcf: <http://www.mycorporisfabrica.org/ontology/mcf.owl#>

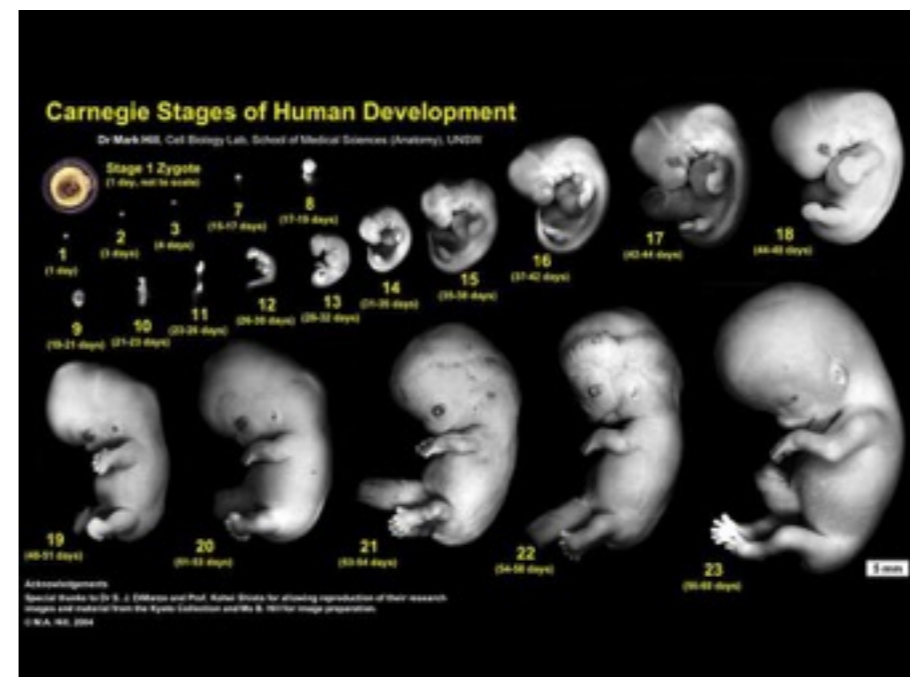
SELECT ?s
WHERE { ?s mcf:ParticipatesTo mcf:Flexion_of_knee_joint.
        ?s rdfs:subClassOf mcf:Muscle. }
```

A "Query!" button is located below the query text.
- MyCF Property Query**: A sidebar on the right with two categories of query options:
  - Anatomical**:
    - Class hierarchy
    - PartOf
    - InsertOn
    - Left/Right SubClassOf
  - Functional**:
    - Class hierarchy
    - IsInvolvedIn
    - HasFunction
    - ParticipatesTo

In the bottom right corner of the interface, there is an orange icon and the text "Open Sesame".

MyCF Ontology Integrates 70K FMA classes  
+ 4K classes as new anatomy / functions  
+ 10K triples using new relations

# My Corporis Fabrica



MyCF Embryo

# MyCF Embryo

[P. -Y. Rabattu and B. Masse, M2R]

## Motivations

- Teaching embryology and teratology
- Research tools for studying the development of pathologies
- An open dataset to share with the medical community

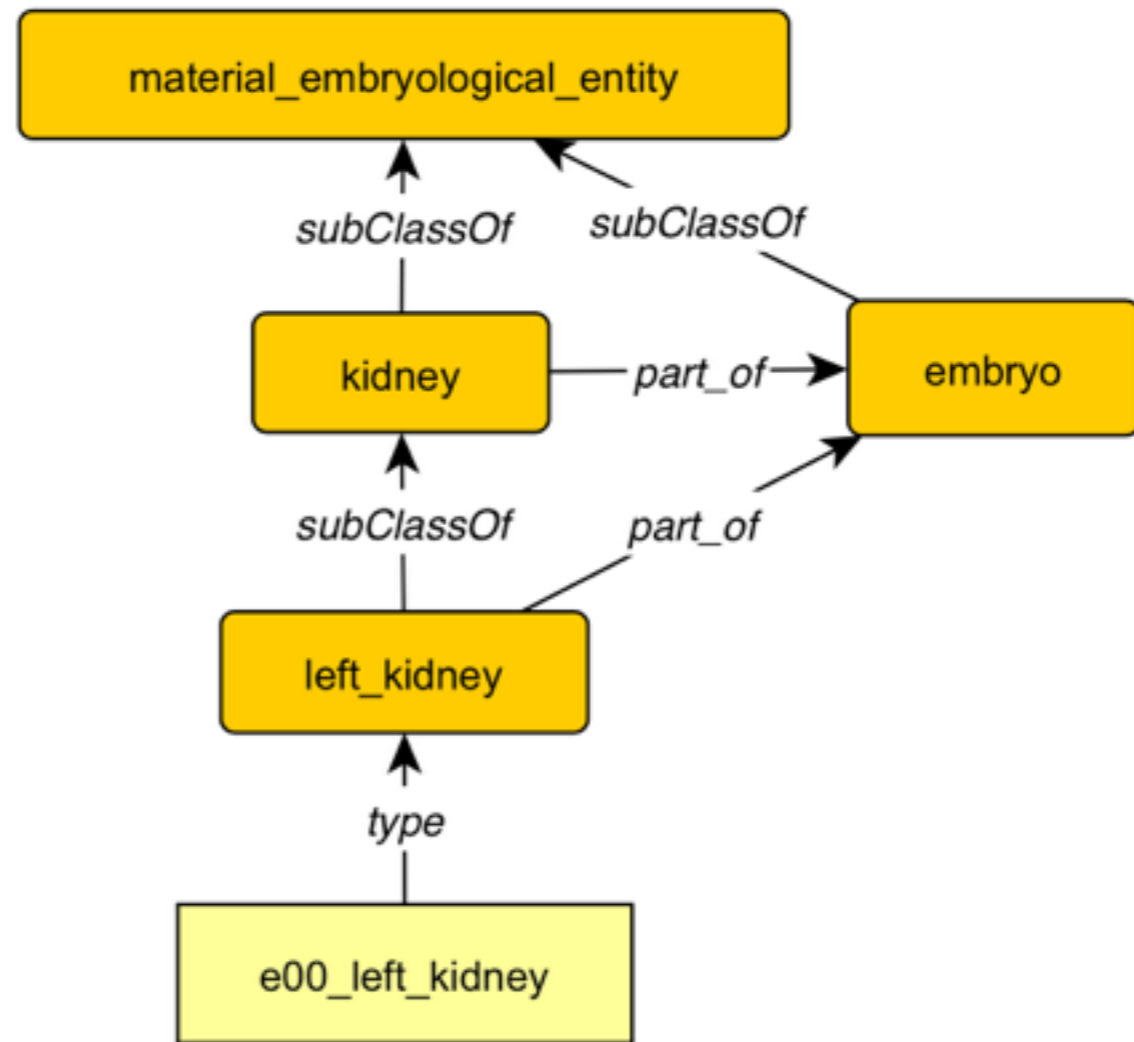
# Scope

- Appareil urinaire : migration rénale, développement des uretères, descente gonadique, division du cloaque et représentation de l'embryon.





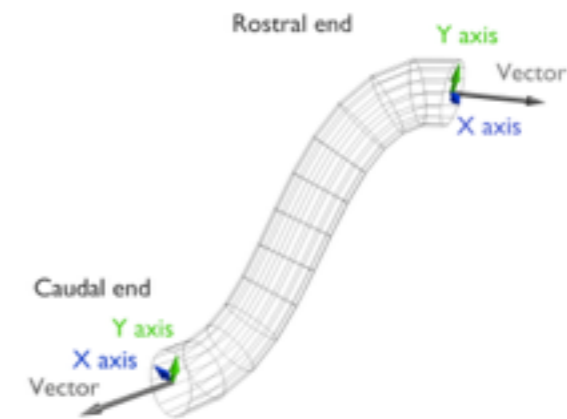
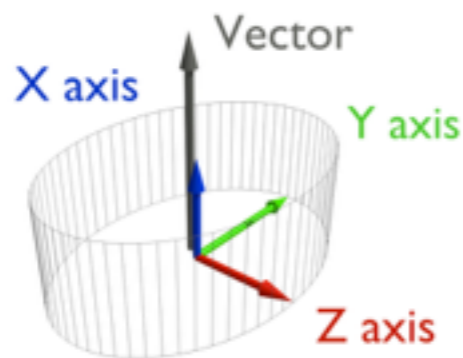
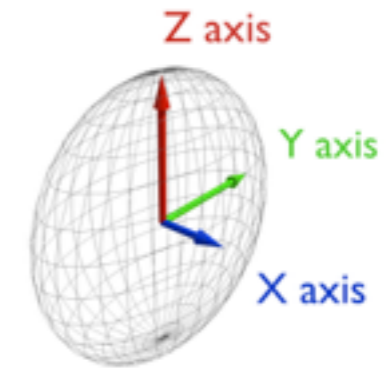
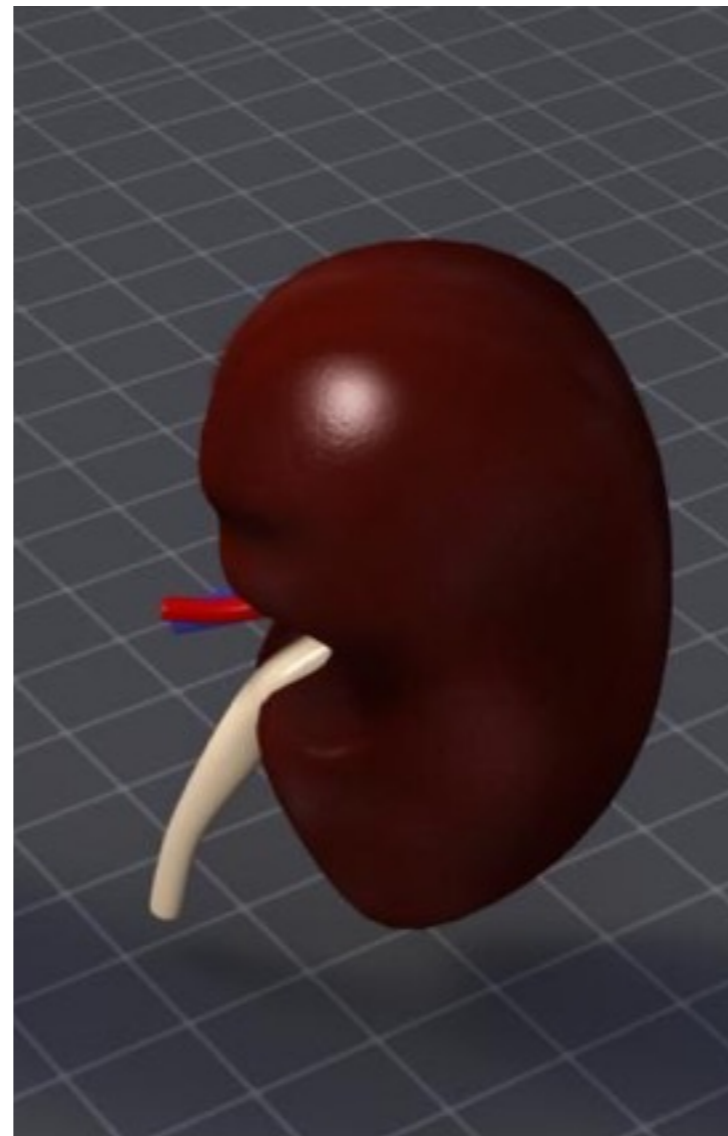
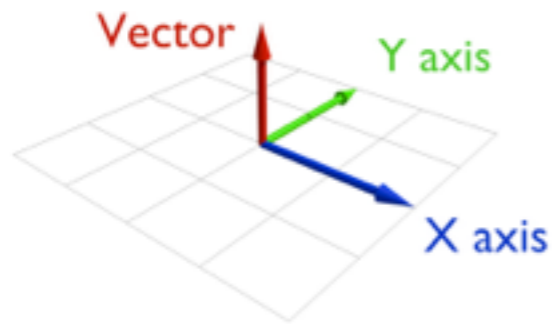
# Embryo Anatomy



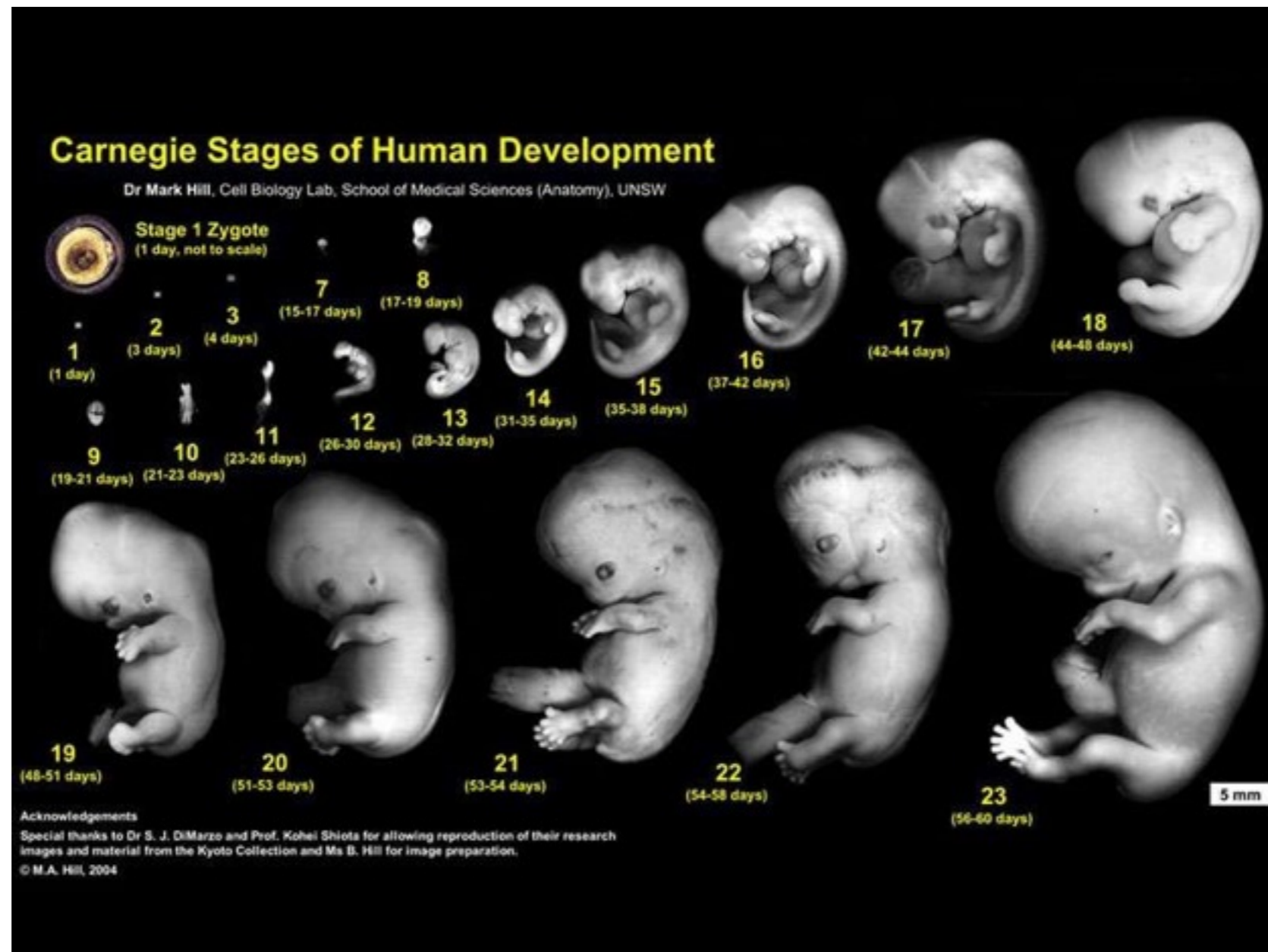
Integrates J.B. BARD Embryo Anatomy Ontology

# Organs as Geometrical Entities

(point, line, ovoid, cylinder, duct, plan)



# Time : Gestation Weeks



23 Carnegie stages modeled as classes

# Kidney at Carnegie Stage 14

< mcfе:kid\_1\_te14, rdf:type, mcfе:SpatioTemporalRepresentation >

< mcfе:kid\_1\_te14, mcfе:hasGeometricalRepresentation, mcfе:geom\_1 >

< mcfе:geom\_1, rdf:type, mcfе:ovoid >

< mcfе:ovoid, rdfs:subClassOf, mcfе:GeometricalEntity >

< geom\_1, mcfе:hasBaricenter, "x,y,z" >

< geom\_1, mcfе:hasAxisSize, "x,y,z" >

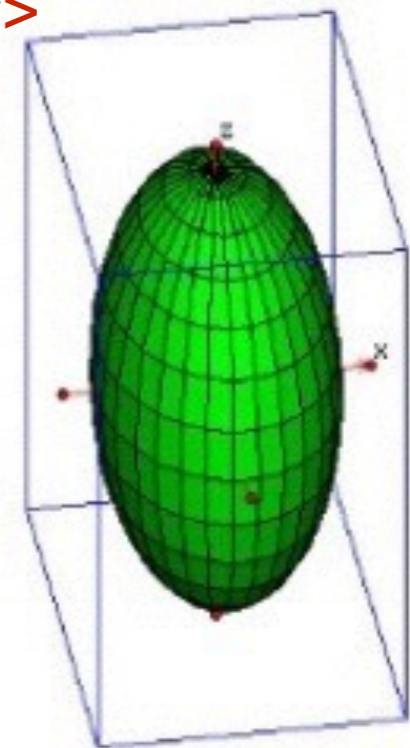
< geom\_1, mcfе:vectorCoordinate, "x,y,z" >

< mcfе:kid\_1\_te14, mcfе:atStage, mcfе:TE14 >

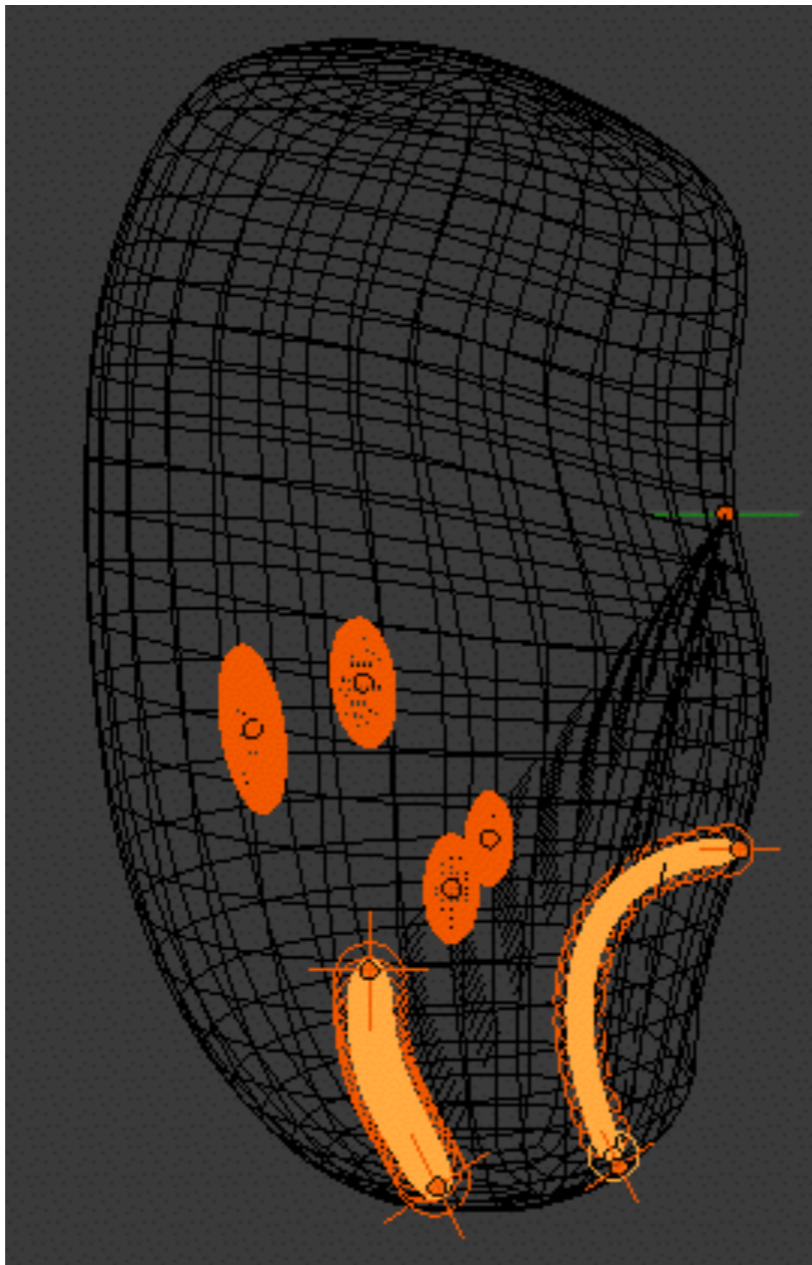
< mcfе:TE14, rdfs:subClassOf, mcfе:TemporalEntity >

Space

Time



# Visualization by Query



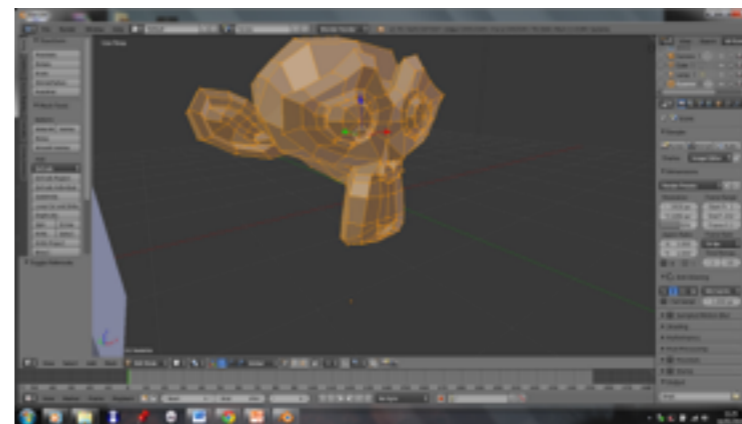
```
select "all 3D objects  
for embryo organs  
at stage 14"
```



```
< geom_1, mcf:hasBaricenter, "x,y,z">  
< geom_1, mcf:hasAxisSixe, "x,y,z">  
< geom_1, mcf:vectorCoordinate, "x,y,z">
```



...

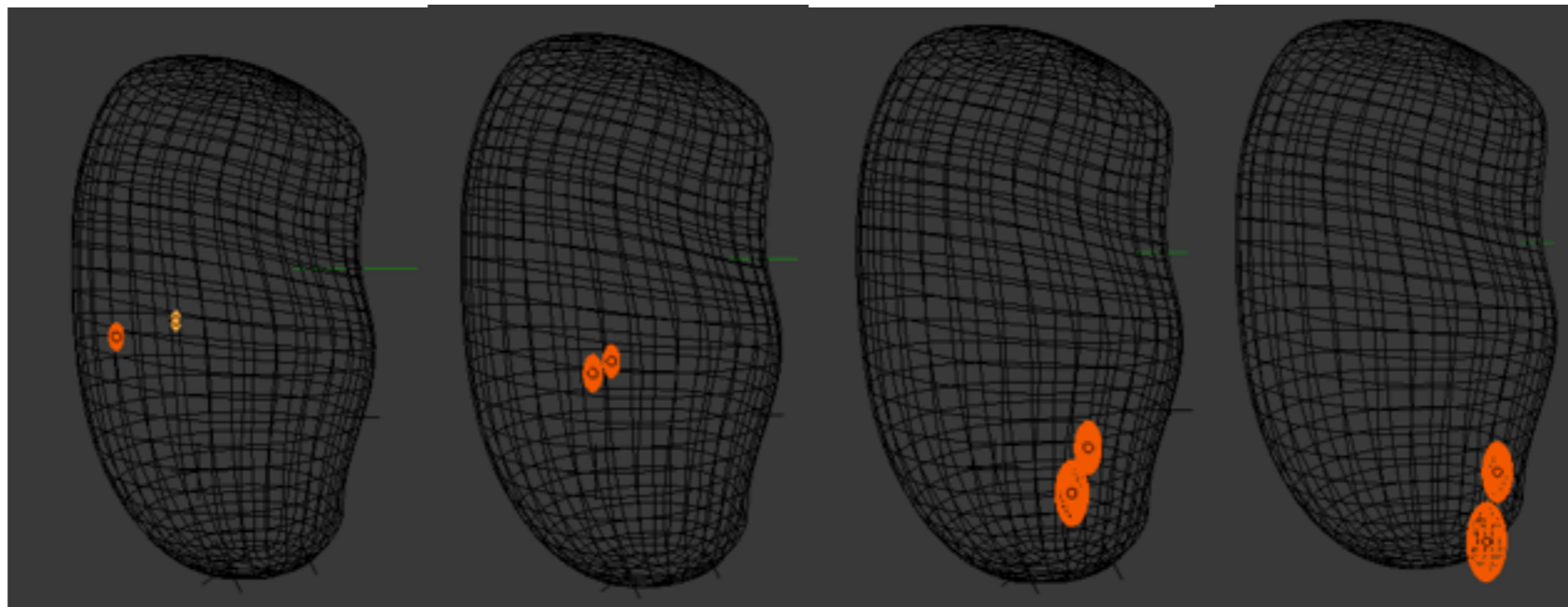


Python



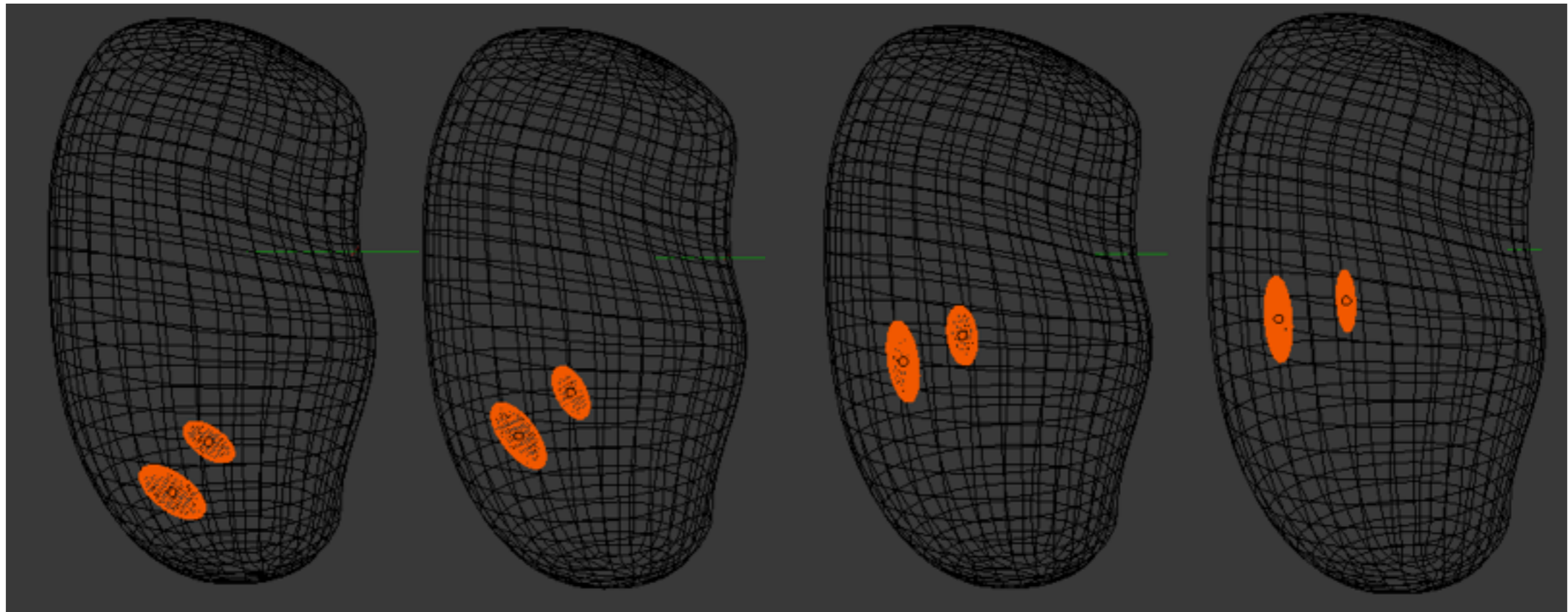
# Simulation by Query

## Gonad descent



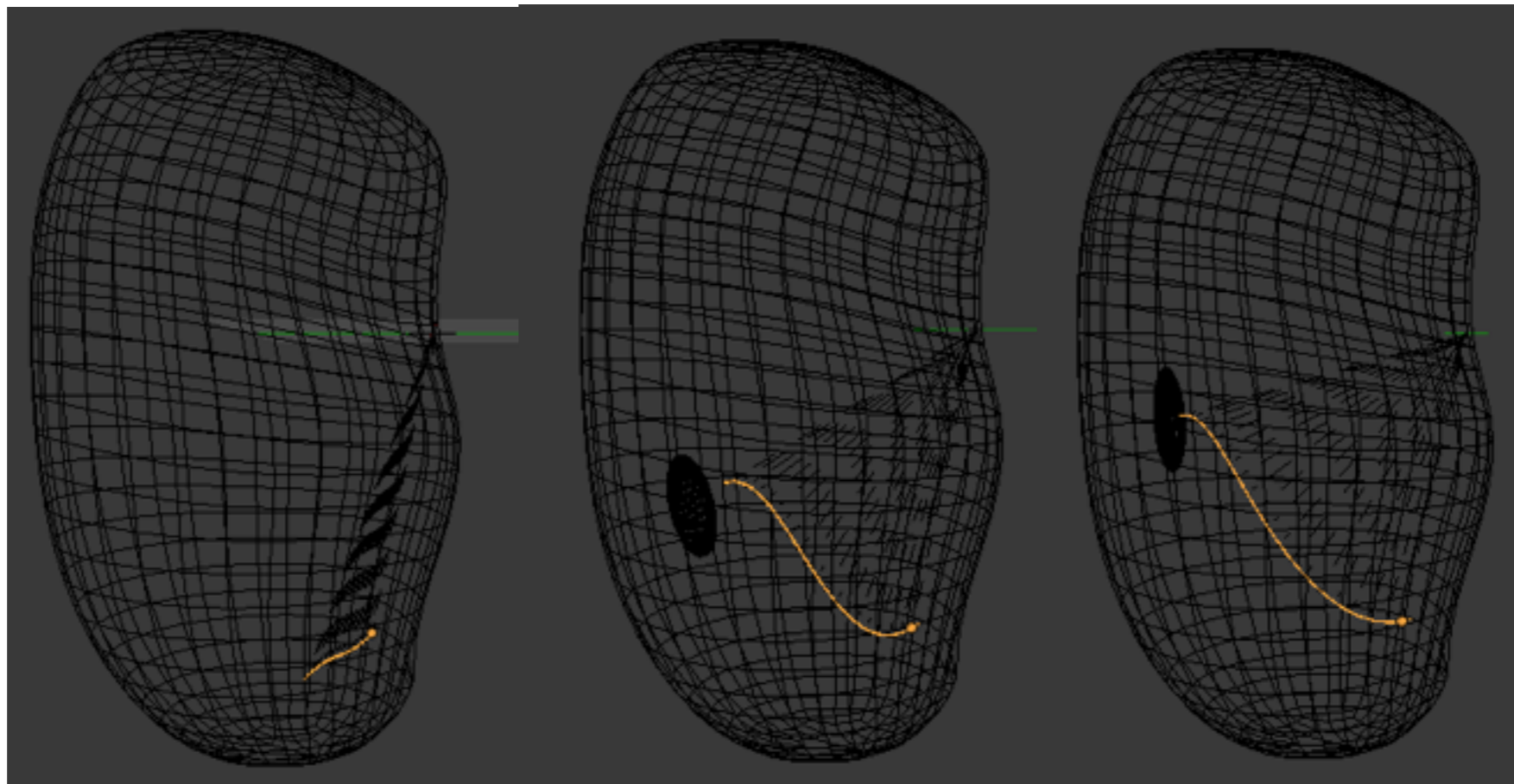
# Simulation by Query

## Kidney ascent



# Simulation by Query

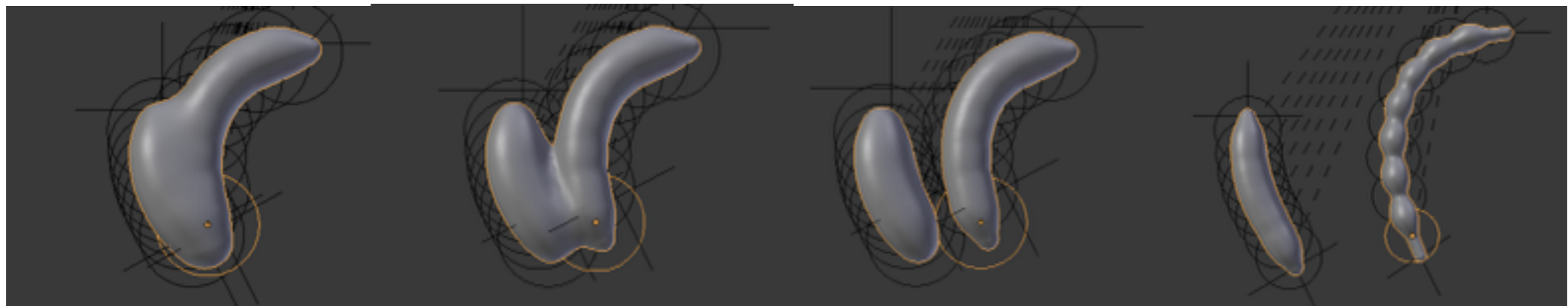
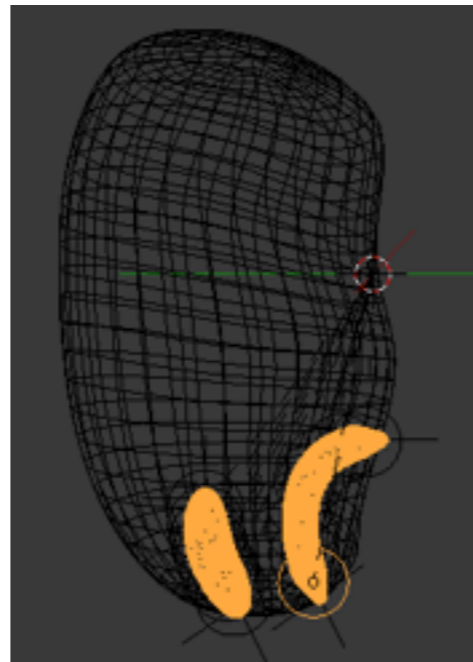
## Ureter development





# Simulation by Query

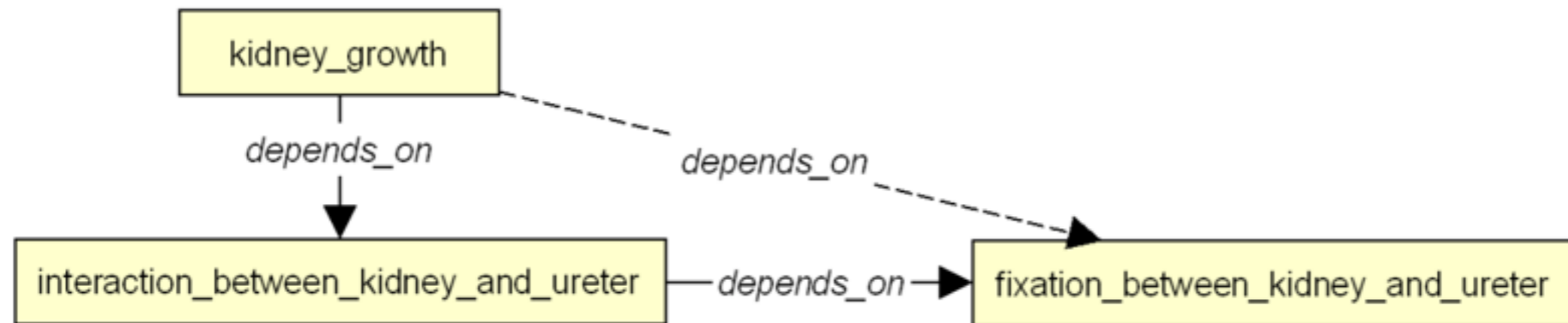
Cloaca division into bladder and rectum



# Embryo Evolution Processes

- Division (e.g., cloaca)
- Fixation (e.g., kidney-ureter)
- Growth (all organs)
- Interaction (e.g., kidney-ureter)
- Migration (e.g., kidney-gonad)
- Rotation (e.g., kidney)

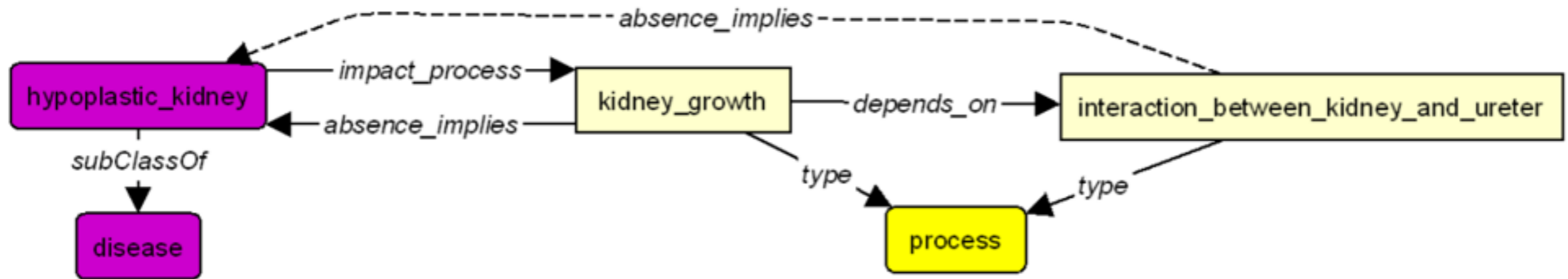
# Process Interaction



$(?x \text{ depends\_on } ?y) , (?y \text{ depends\_on } ?z) \longrightarrow (?x \text{ depends\_on } ?z)$

Inferring all dependencies between evolution process.

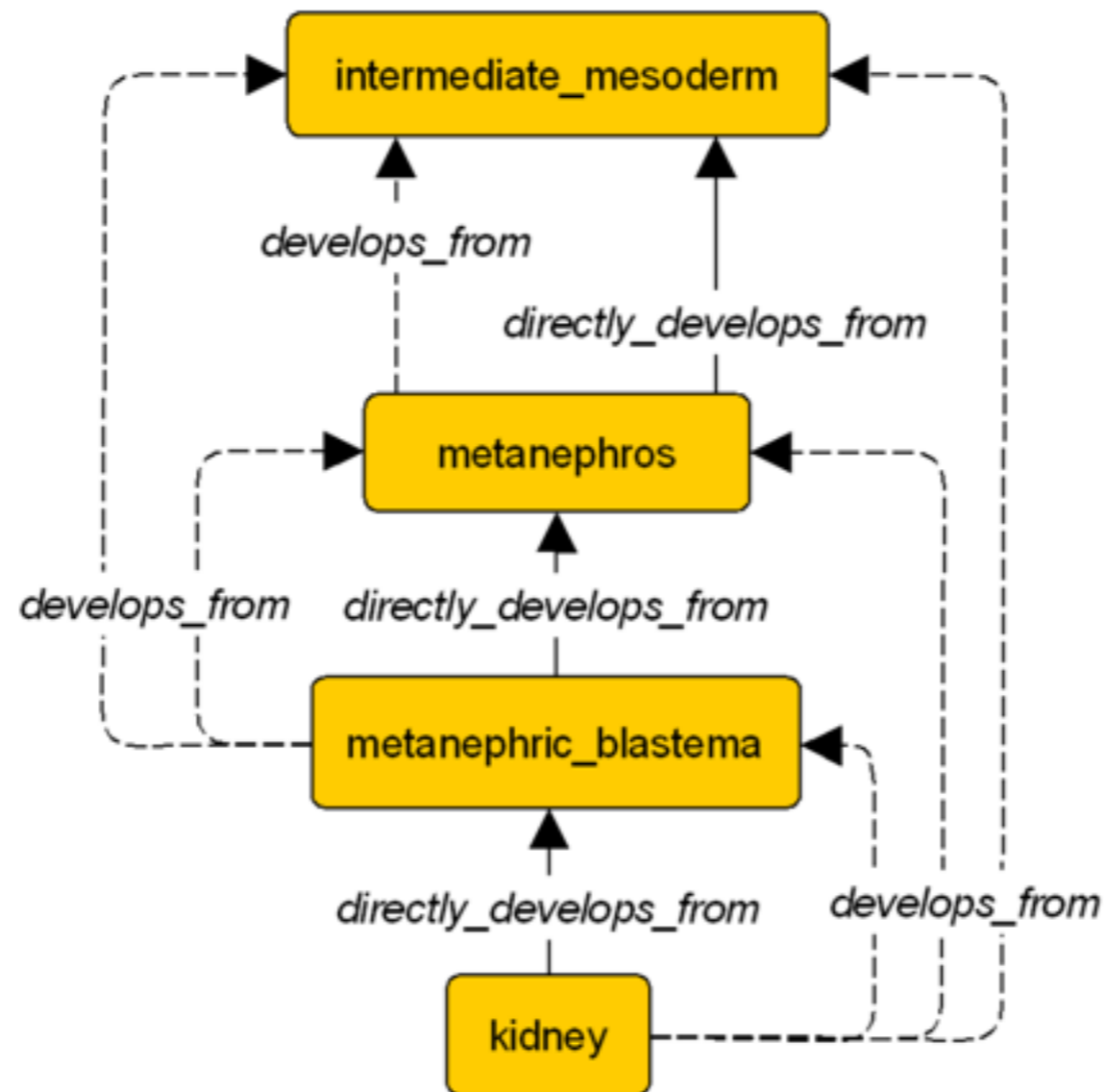
# Pathology



$(?x \text{ absence\_implies } ?y) , (?x \text{ depends\_on } ?z) \longrightarrow (?z \text{ absence\_implies } ?x)$

Inferring all processes (and organs) impacted by a disease.

# Development Lineage

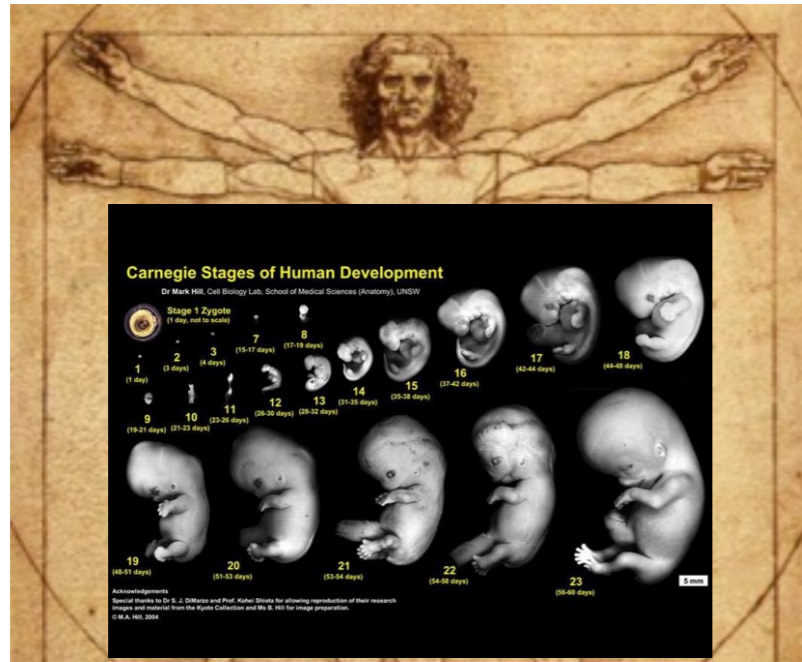


$(?x \text{ develops\_from } ?y) , (?y \text{ develops\_from } ?z) \longrightarrow (?x \text{ develops\_from } ?z)$

Inferring all dependencies between organs.



**“My Ontology Fabrica”**



My Corporis Fabrica  
Anatomy, Embryology



My3D



My Product Fabrica



My Dramatis Fabrica