



# **An Intuitive Graphical Query Interface for Protégé Knowledge Bases**

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# Emily

- Query interface for Protégé KBs
  - Graphical, point-and-click
  - Stand-alone Java application
  - Built on the Protégé API library
  - Class-to-class relationships
- Foundational Model of Anatomy (FMA)
- Goal: Usable by novice users with little instruction

# FMA

- Foundational Model of Anatomy
- Symbolic model of the physical organization of the human body
- Goals
  - Foundation for interoperability between biological domains
  - Basis for the construction of intelligent biomedical applications

# FMA Complications

- Space complexity

- > 70,000 classes
- > 185,000 frames
- > 170 slots in use
- > 1.5 million slot values

- Classes without the instances (individuals)

- Existing tools and the FMA

# Example Questions

- What is the heart?
- What are the parts of the heart?
- Is the epicardium a part of the heart?
- Which part of the heart is continuous with the superior pulmonary vein?
- What is the relationship between the right atrium and blood?

# Example Questions

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# Composing a Simple Query

EMILY - Foundational Model query interface

Select tree to search:  Subject  Object Heart Search

**Subject**

Please choose an item

- Unknown
- Physical anatomical entity
  - Material physical anatomical entity
    - Anatomical structure
      - Body
      - Organ
        - Solid organ
          - Cavitated organ
            - Organ with organ cavity
              - Organ with cavitated organ parts
                - Heart**
                - Bone (organ)
                - Cavernous organ
  - Organ part
  - Tissue
  - Tissue subdivision
  - Cell
  - Cell part
  - Body part
  - Body part subdivision
  - Organ system
  - Organ system subdivision
  - Acellular anatomical structure
  - Biological macromolecule
  - Gestational structure
  - Vestigial embryonic structure

**Relation**

Please choose a relation

- Unknown
  - has superclass
    - has superclass(directly)**
    - has superclass
  - has subclass
  - is part of
  - has part
  - is boundary of
  - has boundary
  - is contained in
  - contains
  - is branch of
  - has branch
  - is tributary of
  - has tributary
  - is segmental contribution to
  - has segmental contribution from
  - is continuous with
  - is nerve supply of
  - has nerve supply
  - is adjacent to

**Object**

Please choose an item

- Unknown
- Physical anatomical entity
  - Material physical anatomical entity
    - U1
  - Non-material physical anatomical entity

Make relation
query

V	D	C	I	E		Perform logic
Number	Not	Logic	Query		Result	
1	<input type="checkbox"/>	AND	Heart has superclass(directly) Unknown (U1)		Organ with cavitated organ parts	
2	<input type="checkbox"/>	AND				
3	<input type="checkbox"/>	AND				
4	<input type="checkbox"/>	AND				
5	<input type="checkbox"/>	AND				
6	<input type="checkbox"/>	AND				
7	<input type="checkbox"/>	AND				
8	<input type="checkbox"/>	AND				
9	<input type="checkbox"/>	AND				
10	<input type="checkbox"/>	AND				
11	<input type="checkbox"/>	AND				
12	<input type="checkbox"/>	AND				
13	<input type="checkbox"/>	AND				
14	<input type="checkbox"/>	AND				
15	<input type="checkbox"/>	AND				
16	<input type="checkbox"/>	AND				
17	<input type="checkbox"/>	AND				
18	<input type="checkbox"/>	AND				

# Composing a Simple Query

The image displays three panels for composing a query, each with a red border and a red label at the bottom. The panels are arranged horizontally.

- Subject Panel:** Titled "Please choose an item". It shows a hierarchical tree structure. The "Heart" item is selected. Below the panel is a red box containing the word "Subject".
- Relationship Panel:** Titled "Please choose a relation". It shows a list of relations. The "has superclass" relation is selected, and "has superclass(directly)" is highlighted. Below the panel is a red box containing the word "Relationship".
- Object Panel:** Titled "Please choose an item". It shows a hierarchical tree structure. The "Unknown" item is selected. Below the panel is a red box containing the word "Object".

At the bottom of the Subject and Relationship panels, there are additional items that are partially visible:

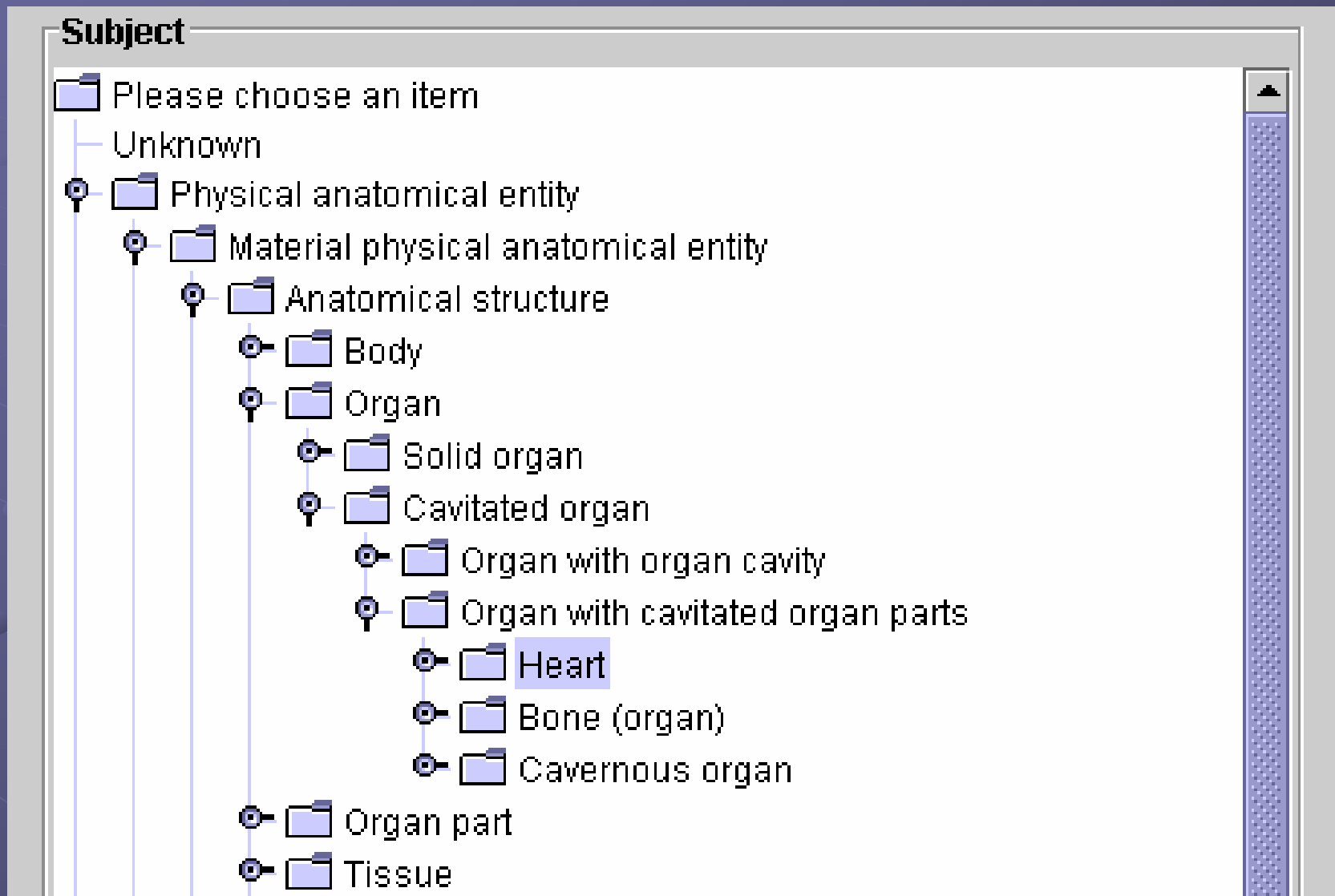
- Biological macromolecule
- Gestational structure
- Vestial embvonic structure



# What is the heart?

Subject	Relationship	Object
Heart	has superclass (directly)	Unknown

# Subject Tree

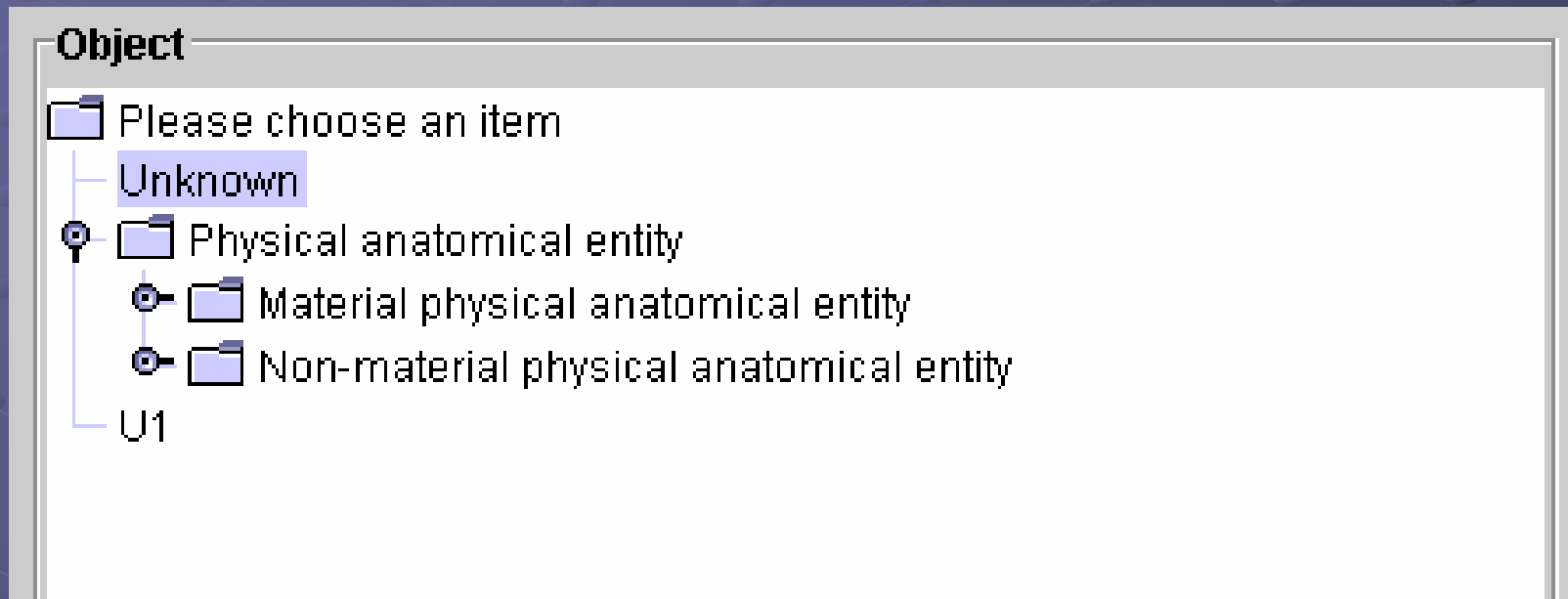


# Relationship Tree

## Relation

- Ⓛ Please choose a relation
  - ├ Unknown
    - Ⓛ has superclass
      - ├ has superclass(directly)
      - └ has superclass
    - Ⓛ has subclass
    - Ⓛ is part of
    - Ⓛ has part
    - Ⓛ is boundary of
    - Ⓛ has boundary
    - Ⓛ is contained in
    - Ⓛ contains

# Object Tree



# What is the heart?

Subject	Relationship	Object
Heart	has superclass (directly)	Unknown

## Results

Organ with cavitated organ parts

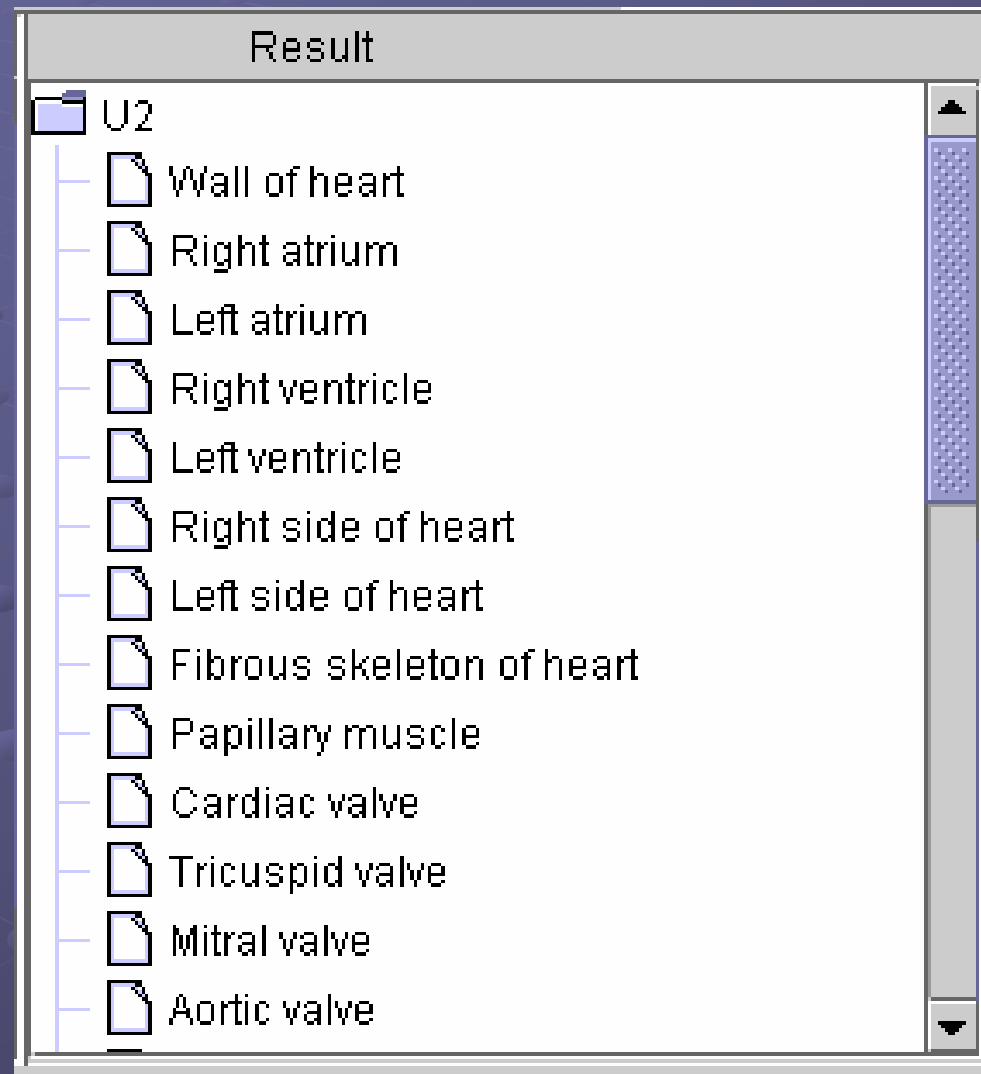
# Example Questions

- What is the heart?
- What are the parts of the heart?
- Is the epicardium a part of the heart?
- Which part of the heart is continuous with the superior pulmonary vein?
- What is the relationship between the right atrium and blood?

# What are the parts of the heart?

Subject	Relationship	Object
Heart	has part (directly)	Unknown

# What are the parts of the heart?





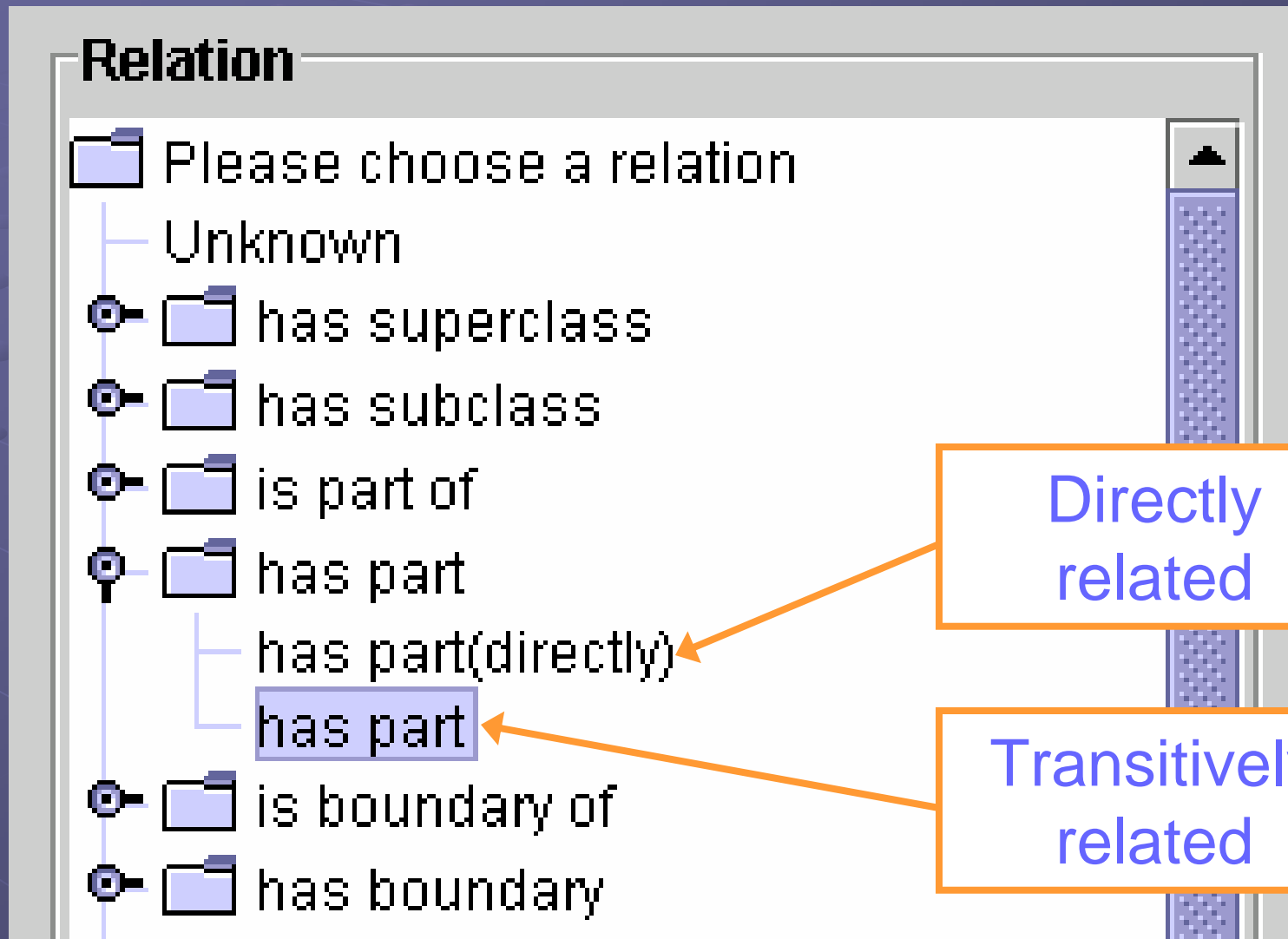
# Example Questions

- What is the heart?
- What are the parts of the heart?
- **Is the epicardium a part of the heart?**
- Which part of the heart is continuous with the superior pulmonary vein?
- What is the relationship between the right atrium and blood?

# Is the epicardium a part of the heart?

- Why was Epicardium not in the previous result set?
  - Epicardium not a direct part of heart
  - **Heart** has part **Wall of heart** which has part **Epicardium**
- But aren't the parts of any direct part of the Heart still a part of the Heart?
  - Yes, because part is transitive

# Relationship Tree



# Is the epicardium a part of the heart?

Subject	Relationship	Object
Heart	has part	Epicardium

Results

Yes

# Example Questions

- What is the heart?
- What are the parts of the heart?
- Is the epicardium a part of the heart?
- Which part of the heart is continuous with the superior pulmonary vein?
- What is the relationship between the right atrium and blood?

# Which part of the heart is continuous with the superior pulmonary vein?

- What is the Subject?
- What is the Relationship?
- What is the Object?

# Compound queries

- Two methods for creating compound queries
  - Query chaining
  - Set operations

# Which part of the heart is continuous with the superior pulmonary vein?

- Subject: part of the heart
- Relationship: is continuous with
- Object: Superior pulmonary vein












# Which part of the heart is continuous with the superior pulmonary vein?

- Subject: **part of the heart**
    - Subject: **Heart**
    - Relationship: **has part**
    - Object: **Unknown**
  - Relationship: **is continuous with**
  - Object: **Superior pulmonary vein**
- U1

Which part of the heart is continuous with the superior pulmonary vein?

- Subject: U1
- Relationship: is continuous with
- Object: Superior pulmonary vein

# Which part of the heart is continuous with the superior pulmonary vein?

Result	
 Left atrium	 Yes
 Left ventricle	 No
 Papillary muscle	 No
 Fibrous skeleton of heart	 No
 Tricuspid valve	

Which part of the heart is continuous with the superior pulmonary vein?

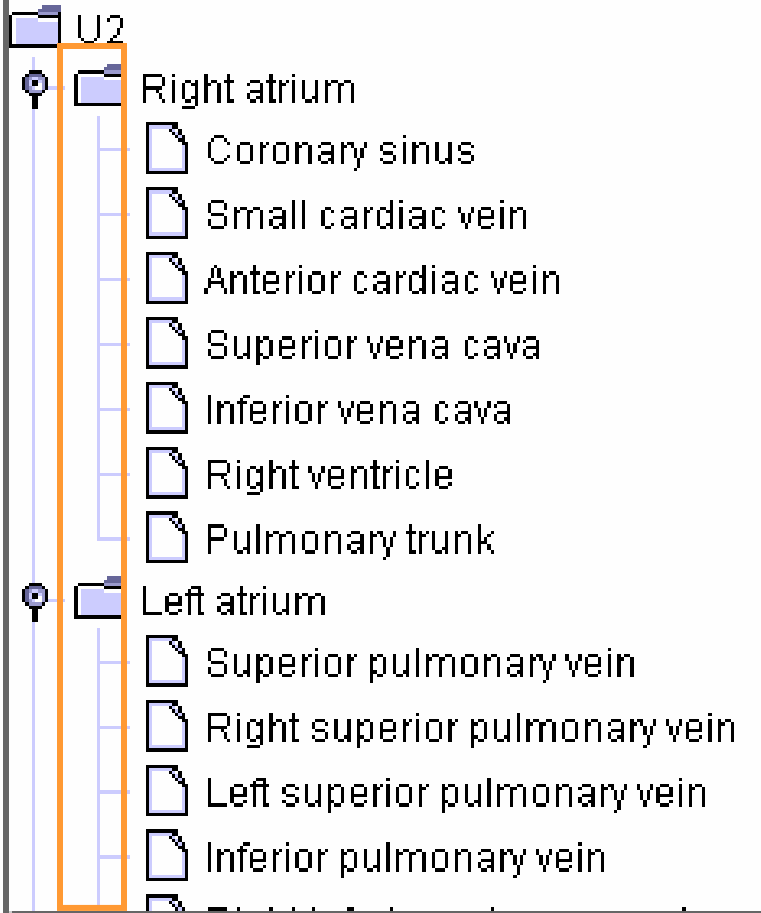
Subject	Relationship	Object
Heart	has part	Unknown (U1)
U1	is continuous with	Unknown (U2)

# Result Sets

## Subject

- Folder icon Please choose an item
  - Unknown
  - Folder icon Physical anatomical entity
    - Folder icon Material physical anatomical entity
    - Folder icon Non-material physical anatomical entity
    - U1
    - U2

# Query History Panel

Query	Result
Heart has part Unknown (U1)	
U1 is continuous with Unknown (U2)	

U1

# Query History Panel

Query	Result
Heart has part Unknown (U1)	
U1 is continuous with Unknown (U2)	U2
	Right atrium
	Coronary sinus
	Small cardiac vein
	Anterior cardiac vein
	Superior vena cava
	Inferior vena cava
	Right ventricle
	Pulmonary trunk
	Left atrium
	Superior pulmonary vein
	Right superior pulmonary vein
	Left superior pulmonary vein
	Inferior pulmonary vein

U2

# Query History Panel

Query	Result
Heart has part Unknown (U1)	U2
U1 is continuous with Unknown (U2)	Right atrium
	Coronary sinus
	Small cardiac vein
	Anterior cardiac vein
	Superior vena cava
	Inferior vena cava
	Right ventricle
	Pulmonary trunk
	Left atrium
	Superior pulmonary vein
	Right superior pulmonary vein
	Left superior pulmonary vein
	Inferior pulmonary vein

What part of the heart is continuous with the superior pulmonary vein?





# Compound queries

- Two methods for creating compound queries
  - Query chaining
  - Set operations

# Set Operations

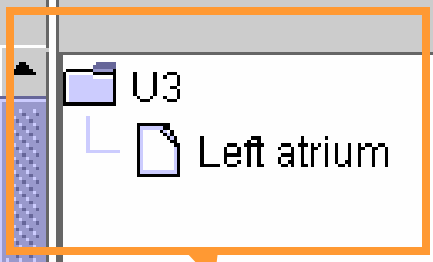
- Results of some queries are sets
- Available operations
  - AND
  - OR
  - NOT

Which part of the heart is continuous with the superior pulmonary vein?

Subject	Relationship	Object
Heart	has part	Unknown (U1)
Unknown (U2)	is continuous with	Superior pulmonary vein
U1	AND	U2

# Set Operations

Not	Logic	Query
<input type="checkbox"/>	AND	Heart has part Unknown (U1)
<input type="checkbox"/>	AND	Unknown (U2) is continuous with(directly) Superior pulmon...
<input type="checkbox"/>	AND	U3 = [(U1)] AND [(U2)]
<input type="checkbox"/>	AND	



What part of the heart is continuous with the superior pulmonary vein?

# Example Questions

- What is the heart?
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# Unknown Relationship

- What if the user chooses the 'Unknown' node for the query relationship?
  - FMA is highly connected
    - Many paths between classes
    - Not practical (nor useful) to find all paths
  - First path
    - Assumption: The simplest path is likely to be the most desirable

# Unknown Relationship

## ● Algorithm

- Direct connections
- Transitive closure connections
- Predetermined connection types
- Depth-limited breadth-first search

# What is the relationship between the right atrium and blood

Subject	Relationship	Object
Right atrium	Unknown	Blood

## Results

Right atrium **part** Cavity of right atrium **contains**  
Blood in right atrium :**DIRECT-SUPERCLASSES**  
Blood



# Issues

- Translating into S-R-O triple
- Translating into FMA terms
- Attributed relationships (e.g. right lateral adjacency)

# Conclusion

- Simple, point-and-click query construction
- Query types
  - Simple
  - Compound
- “Real world” limits
  - Triple formulation
  - Knowledge base content

