A Prototype Natural Language Interface to a Large Complex Knowledge Base: the Foundational Model of Anatomy

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Problem

Providing access to large knowledge bases for different types of users

Specific instance:
Foundational Model of Anatomy

Natural Language Interface to the FMA

Outline

- Foundational Model of Anatomy (FMA)
- GAPP
  - Goal
  - Structure
  - Example Questions
  - Evaluation

Natural Language Interface to the FMA

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What is the Foundational Model of Anatomy (FMA)?

Foundational Model of Anatomy
is a symbolic model of the physical organization of the human body;

declares the principles
for including concepts and relationships
that are implicitly assumed
when knowledge of anatomy
is applied in different contexts;

explicitly defines
concepts and relationships
necessary and sufficient for consistently
modeling the structure of the
human body.

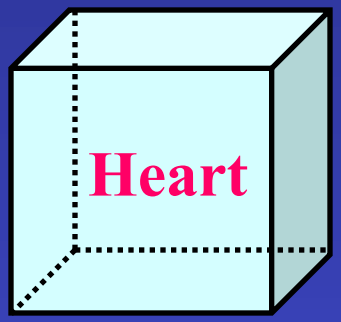
What is the Foundational Model of Anatomy (FMA)?

High level scheme:

FMA = (AT, ASA, ATA, Mk)

where:

AT = Anatomy Taxonomy
ASA = Anatomical Structural Abstraction
ATA = Anatomical Transformation Abstraction
Mk = Metaknowledge
(principles, rules, axioms)



FMA = (AT, ASA, ATA, Mk)

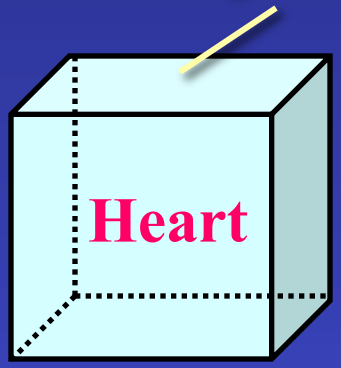
Anatomy Taxonomy

Anatomical Structure

Organ

-is a- Cavitated Organ

Organ with Cavitated Organ Parts



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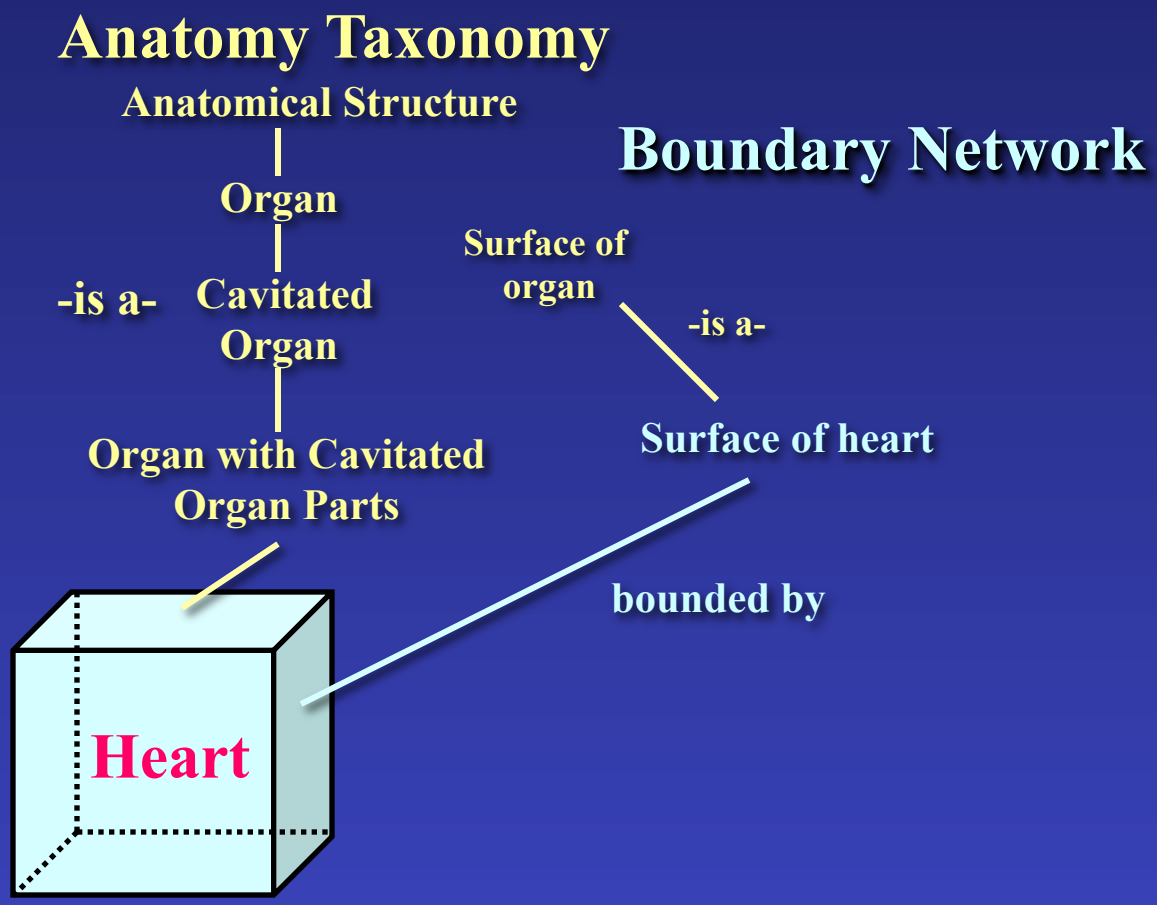

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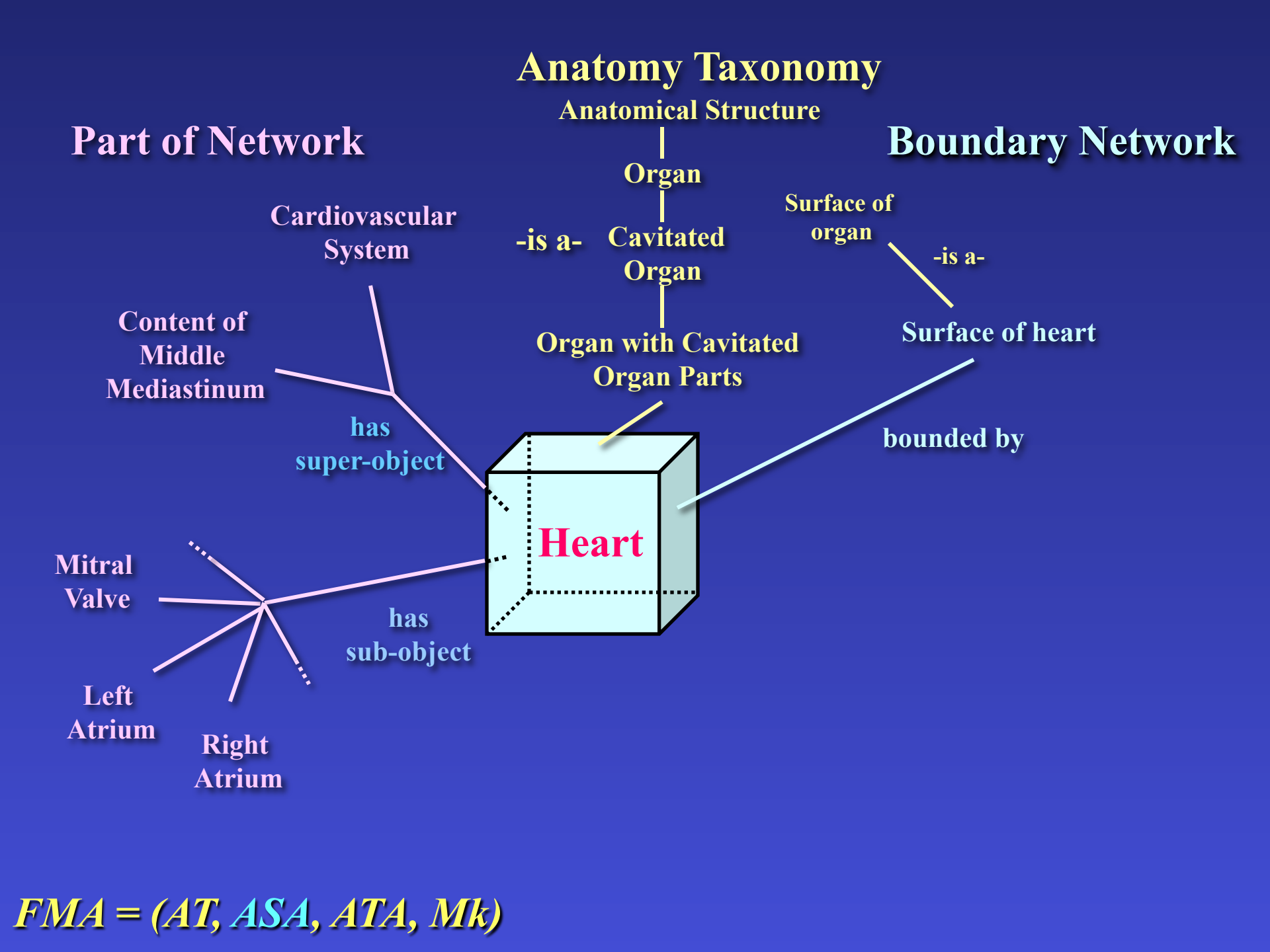
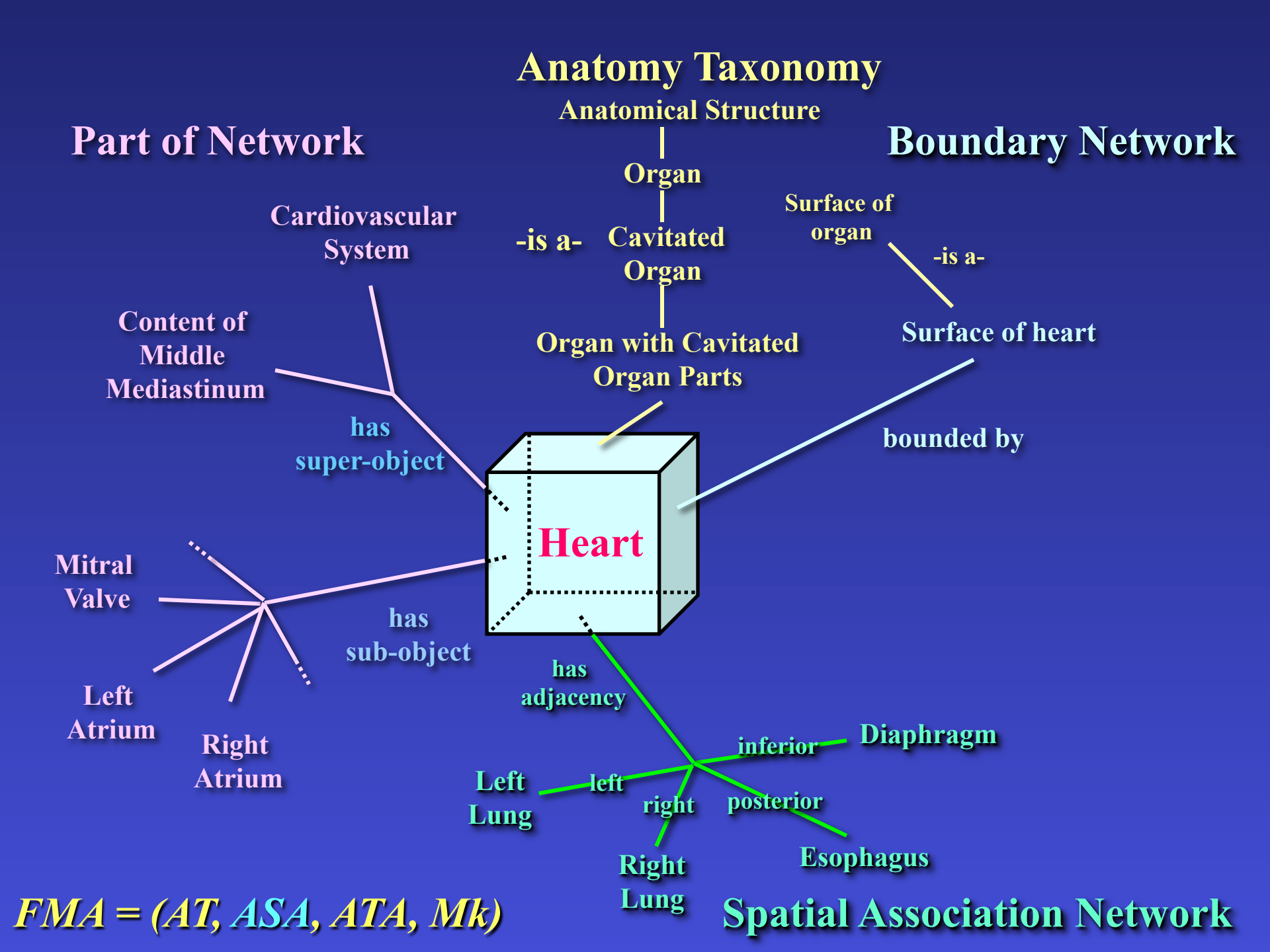

Anatomy Taxonomy
Anatomical Structure
Organ
-is a-
Cavitated Organ
Organ with Cavitated Organ Parts
Part of Network
Boundary Network
Cardiovascular System
Content of Middle Mediastinum
has super-object
Surface of organ
-is a-
Surface of heart
bounded by
Heart
Mitral Valve
Left Atrium
Right Atrium
has sub-object
FMA = (AT, ASA, ATA, Mk)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Left Atrium
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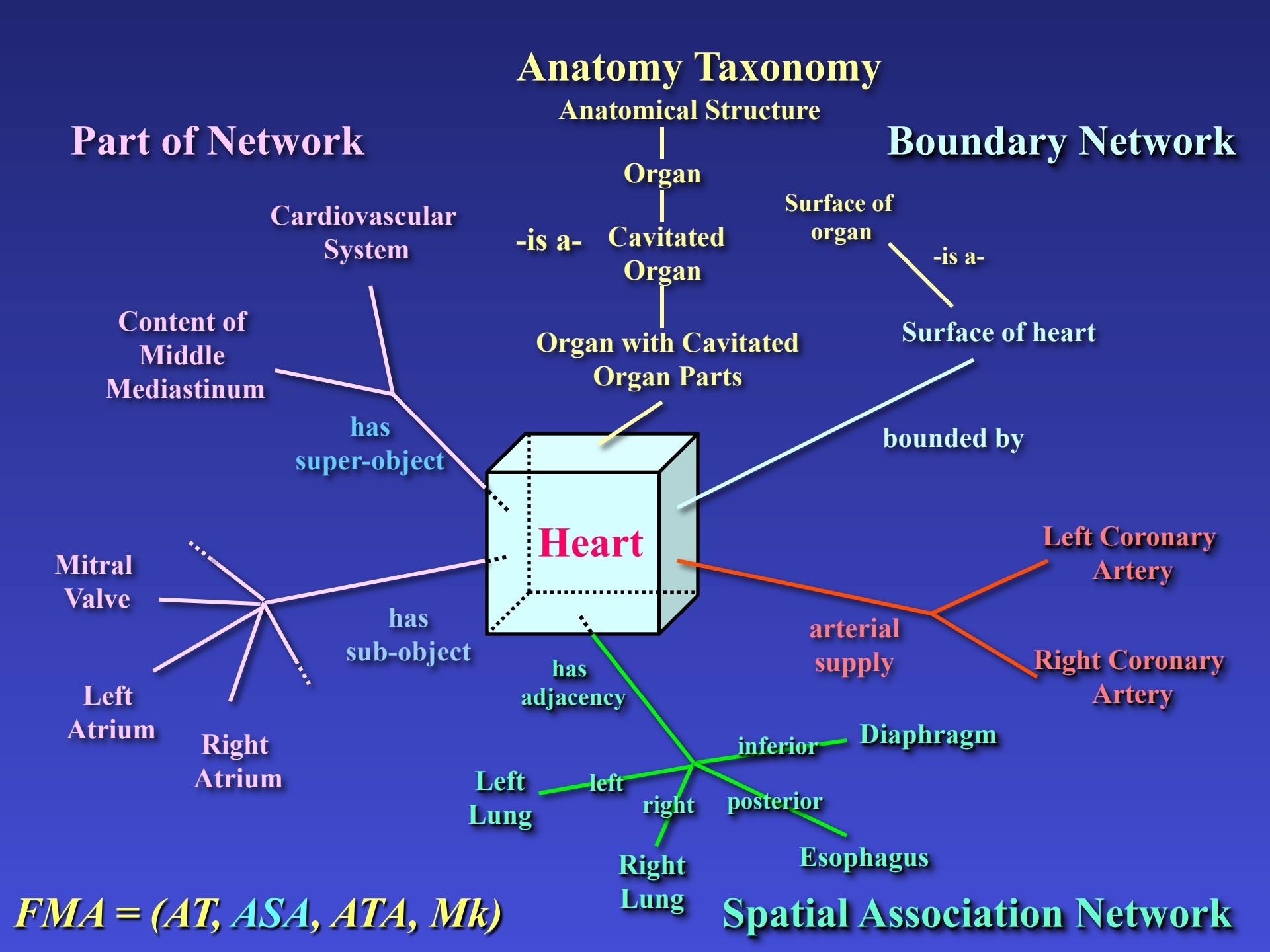
has sub-object
has adjacency
Diaphragm
inferior
Left Lung
left
right
posterior
Right Lung
Esophagus
FMA = (AT, ASA, ATA, Mk)
Spatial Association Network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has adjacency
arterial supply
Left Coronary Artery
Right Coronary Artery
Diaphragm
inferior
Left Lung
left
right
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Esophagus
FMA = (AT, ASA, ATA, Mk)
Spatial Association Network

Natural Language Interface to the FMA

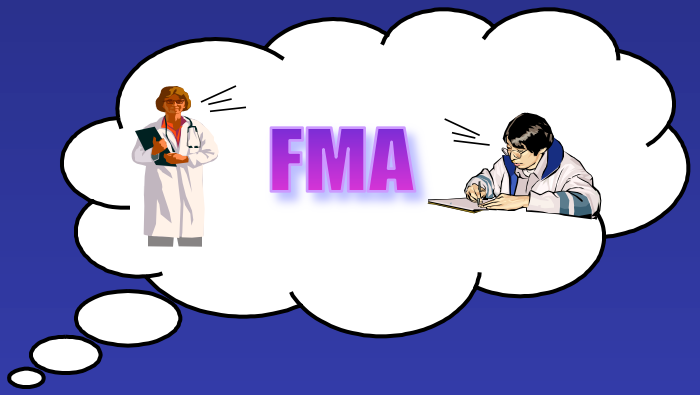
Outline

- Foundational Model of Anatomy (FMA)
- GAPP
  - Goal
  - Structure
  - Example Questions
  - Evaluation

Goals of GAPP

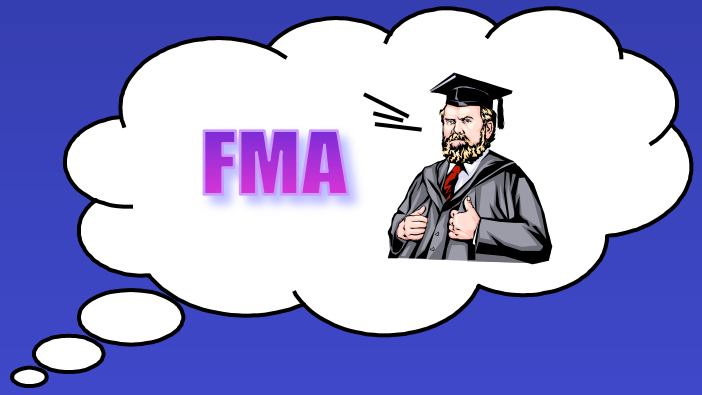
- Long-term goal

  Support Interfaces for
  Experts and Novices

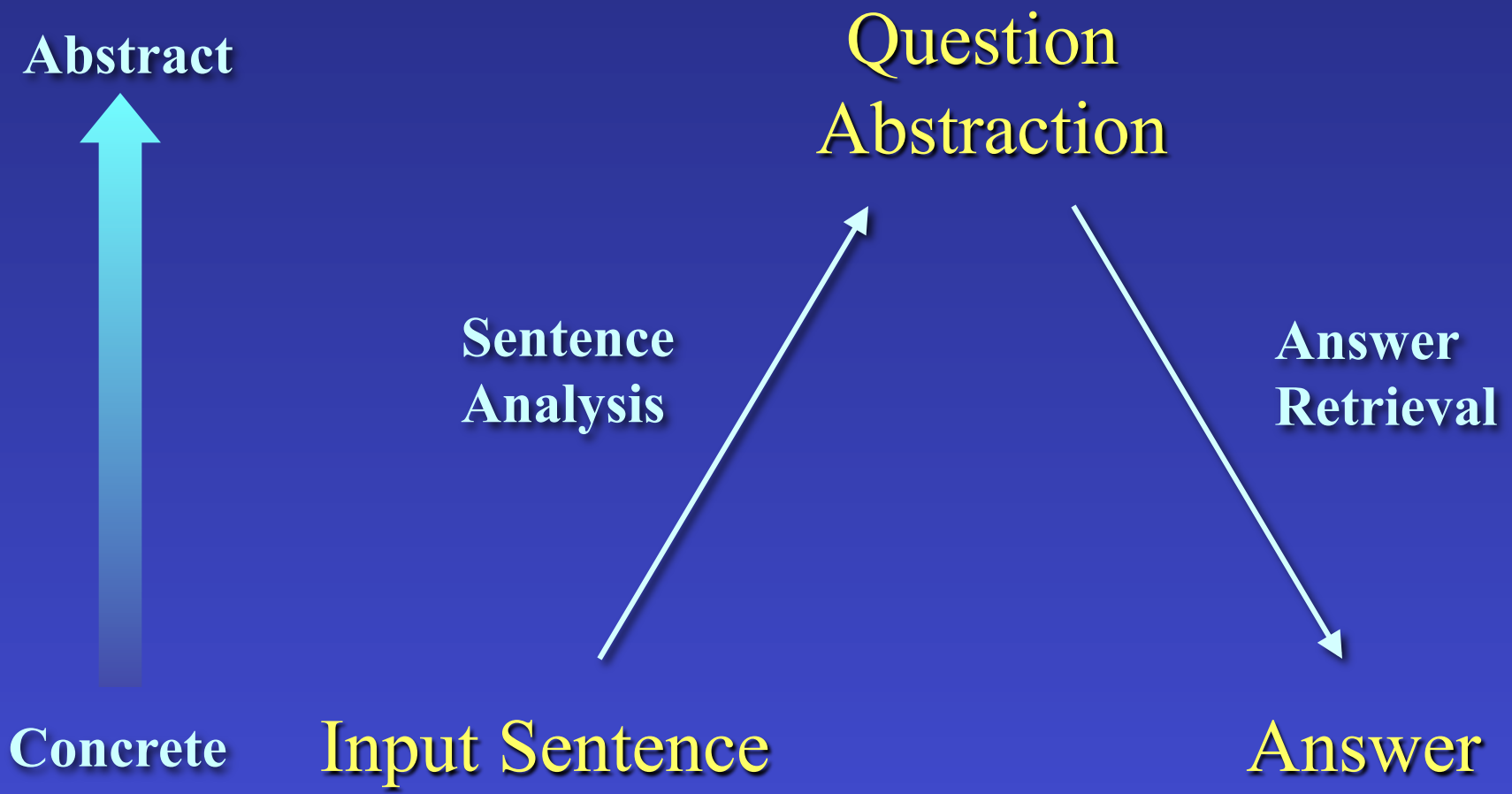


- Short-term goal

  Evaluation of FMA
  by Domain-Experts

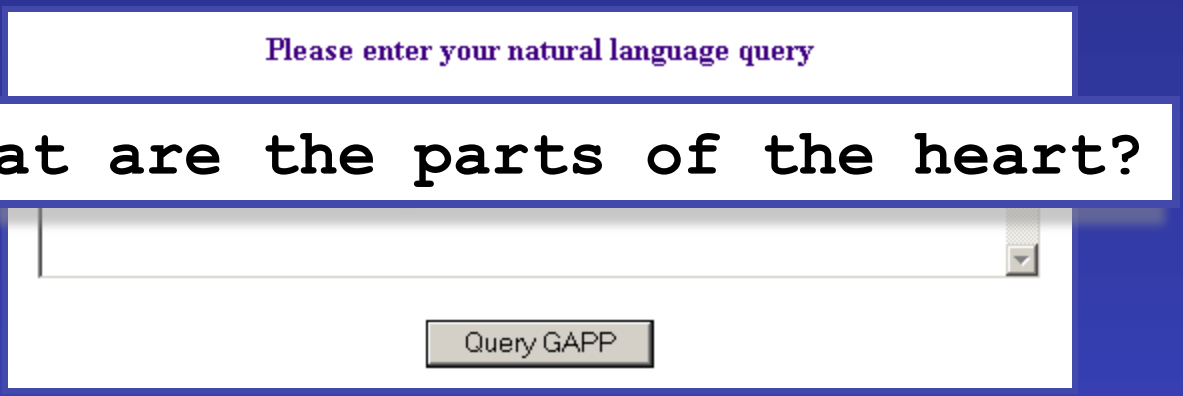


Structure of GAPP



Structure of GAPP
Sentence Analysis: Syntactic Parse

- Input Sentence:



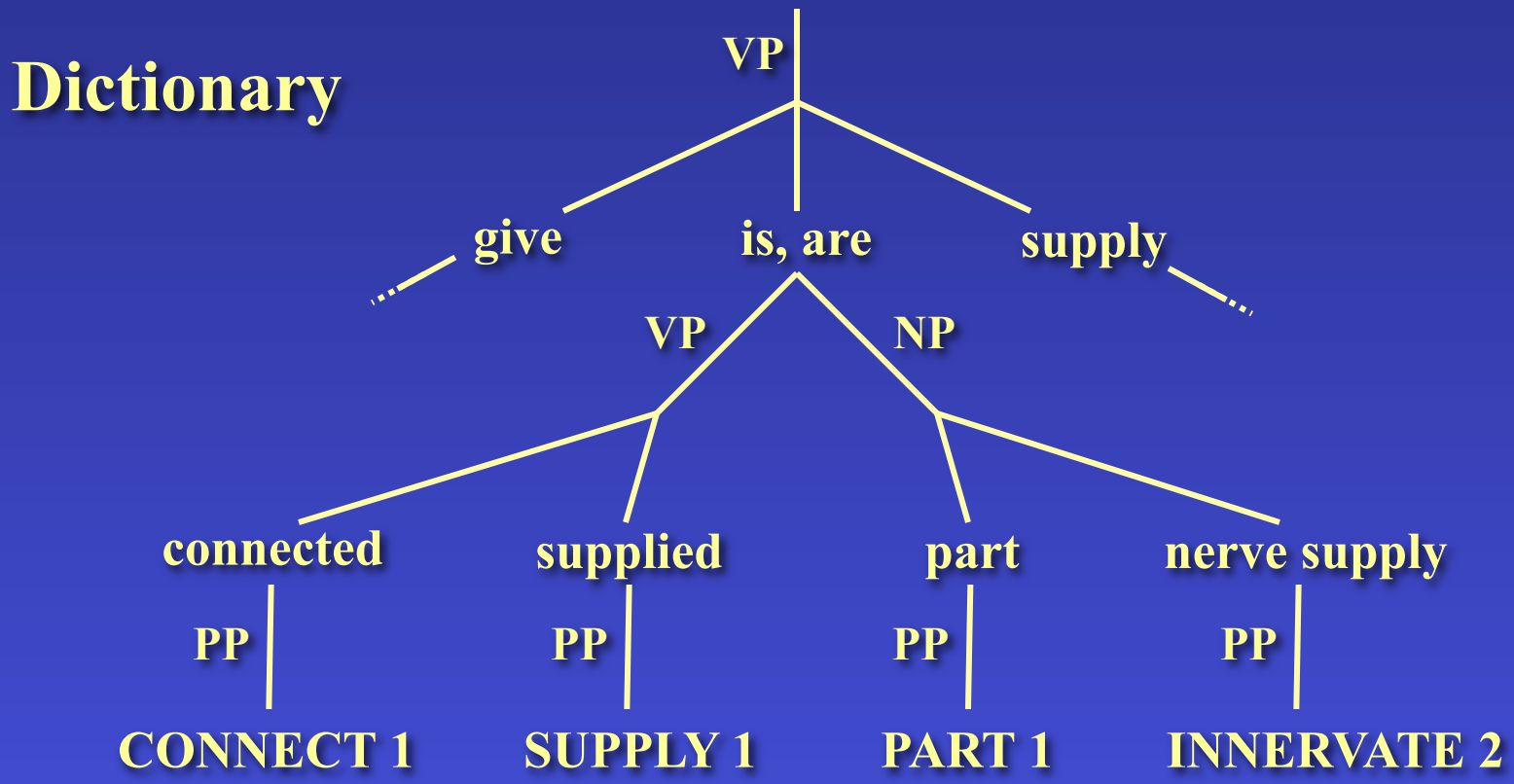
- Syntactic Parse:
  Apple Pie Parser

Structure of GAPP
Sentence Analysis: Syntactic Parse

```
What are the parts of the heart?
```

(S (NP What) (VP are (NP (NP the parts)
(PP of (NP the heart))))?)

Structure of GAPP
Sentence Analysis: Dictionary Search



Structure of GAPP
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Dictionary

Structure of GAPP Sentence Analysis: Dictionary Search

(VP are (NP (NP the parts) (PP of (NP the heart))))

Dictionary

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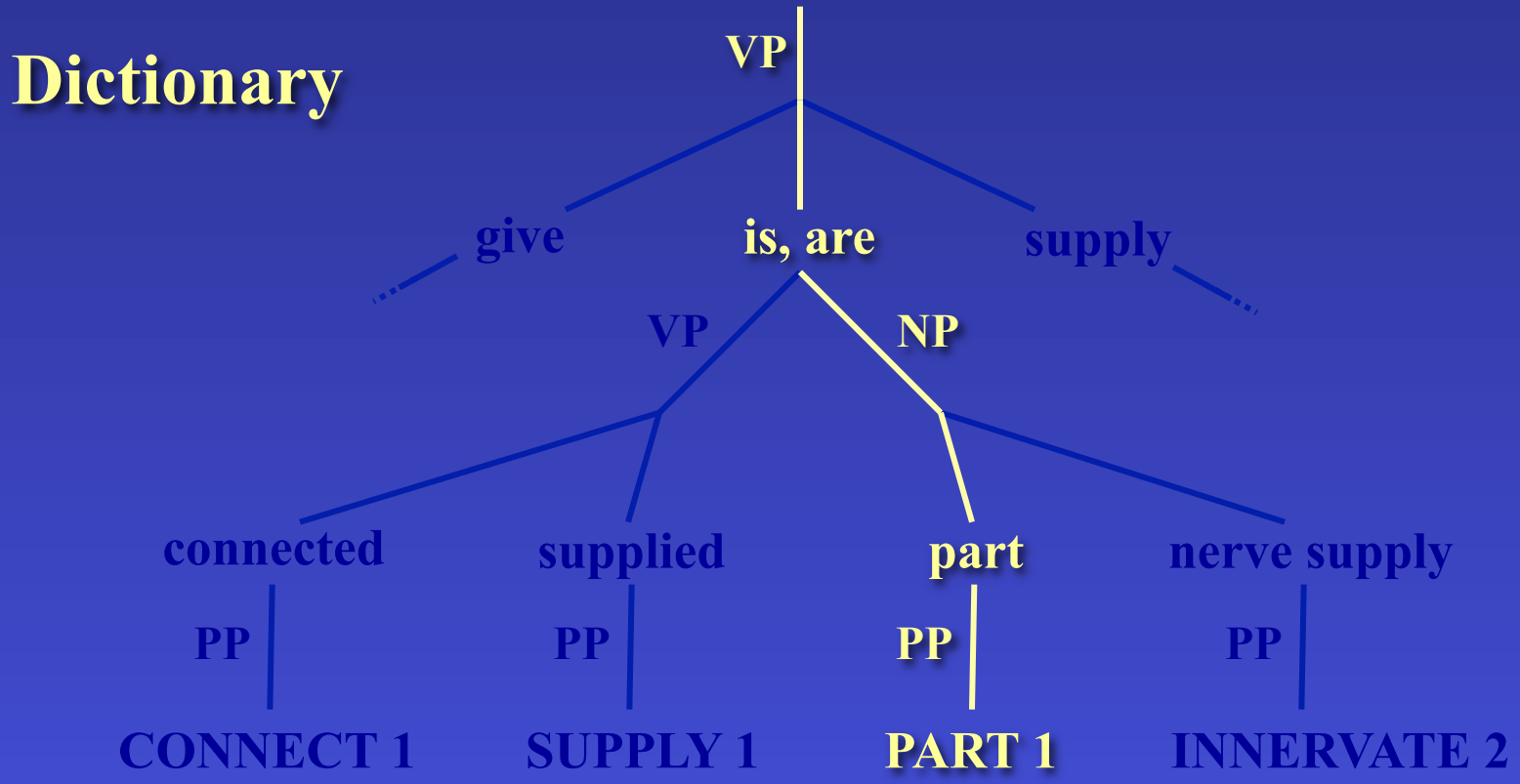

Structure of GAPP
Sentence Analysis: Dictionary Search

(S (NP What) (VP are (NP (NP the parts)
(PP of (NP the heart))))?)

Dictionary Search

(NP What) [PART 1] (NP the heart)

Structure of GAPP
Sentence Analysis: Dictionary Search

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Dictionary Search

(NP What) [PART 1] (NP the heart)

[PART 1]

Structure of GAPP Sentence Analysis: Dictionary Search

(S (NP What) (VP are (NP (NP the parts)
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Dictionary Search

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Question Word

??? [PART 1]

Structure of GAPP Sentence Analysis: Dictionary Search

(S (NP What) (VP are (NP (NP the parts)
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Dictionary Search

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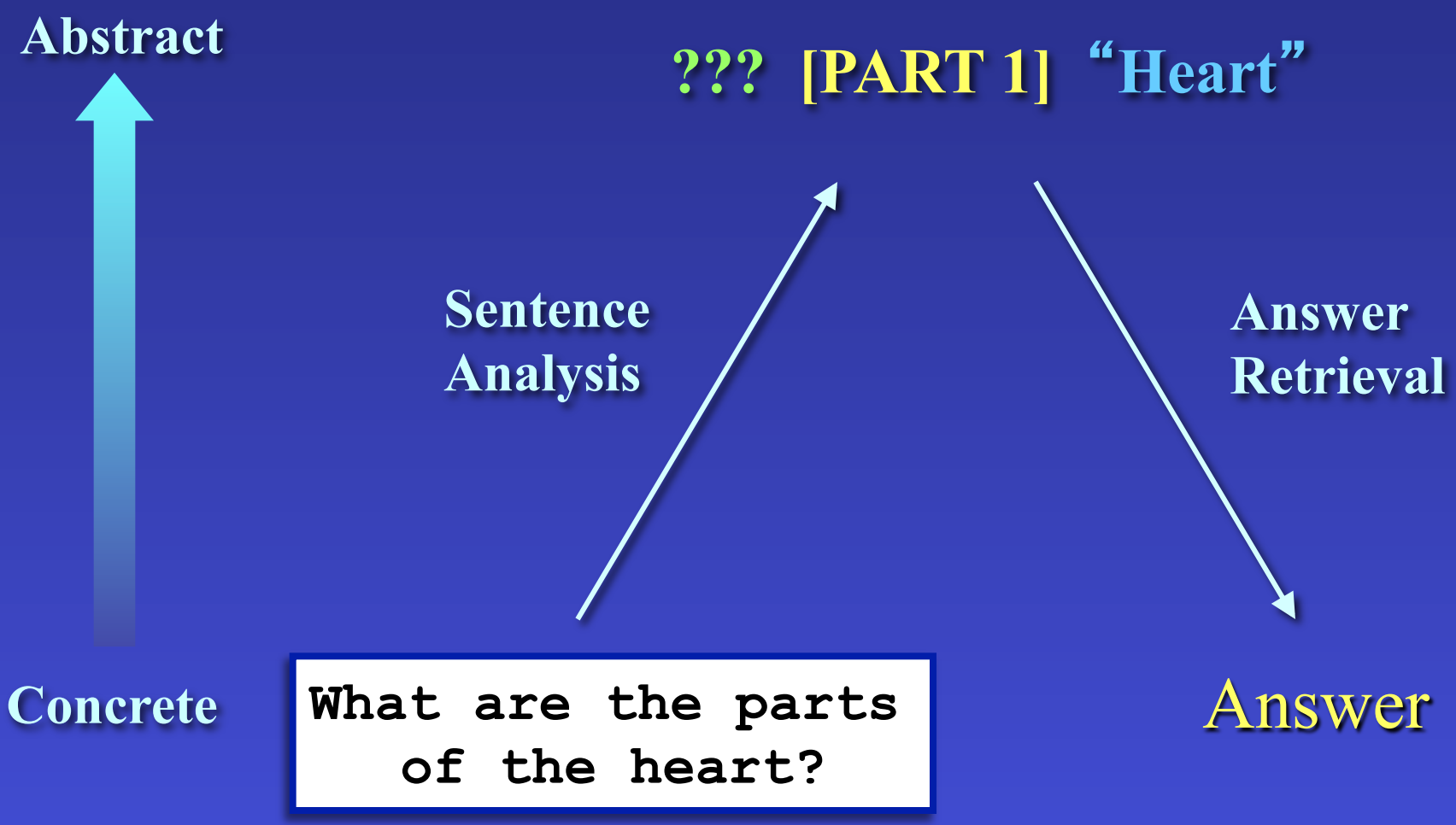
Question Word

Anatomical Term

??? **[PART 1]** **“Heart”**

Structure of GAPP



Structure of GAPP

OQAFMA:

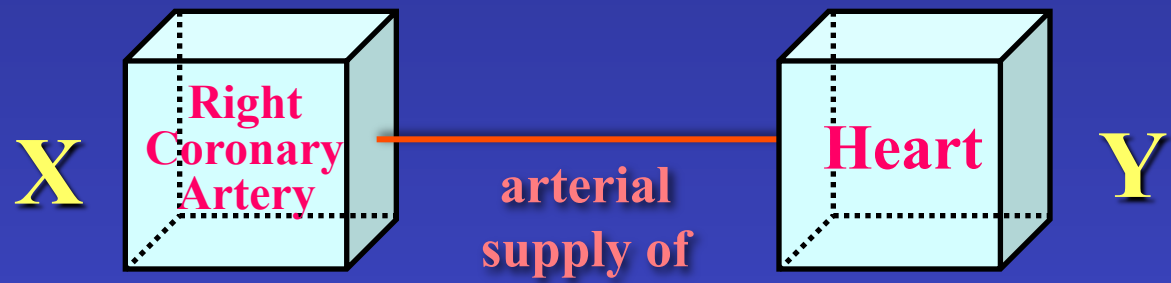
Query Agent for the Foundational Model of Anatomy

- Accepts queries to FMA
- Returns results in XML:

```
<results>
   <Output>
      <Z> Left Lung </Z>
   </Output>
</results>
```

Structure of GAPP StruQL

- Assumes an edge-labeled graph
- Expresses relationships between nodes



X->":NAME"->"Right coronary artery",
Y->":NAME"->"Heart",
X->"arterial supply of"->Y,

Structure of GAPP Query Generation

??? [PART 1] "Heart"

StruQL Query

Structure of GAPP Query Generation

??? [PART 1] "Heart"

```
WHERE
X->":NAME"->"Heart",
X->"part"->Y,
Y->":NAME"->Z,
CREATE
Output(Z);
```

Structure of GAPP Query Generation

??? [PART 1] "Heart"

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WHERE
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Structure of GAPP Query Generation

??? [PART 1] "Heart"

```
WHERE
X->":NAME"->"Heart",
X->"part"->Y,
Y->":NAME"->Z,
CREATE
Output(Z);
```

Structure of GAPP
Answer Retrieval

WHERE
X->":NAME"->"Heart",
X->"part"->Y,
Y->":NAME"->Z,
CREATE
Output(Z);

OQAFMA

Structure of GAPP Answer Retrieval

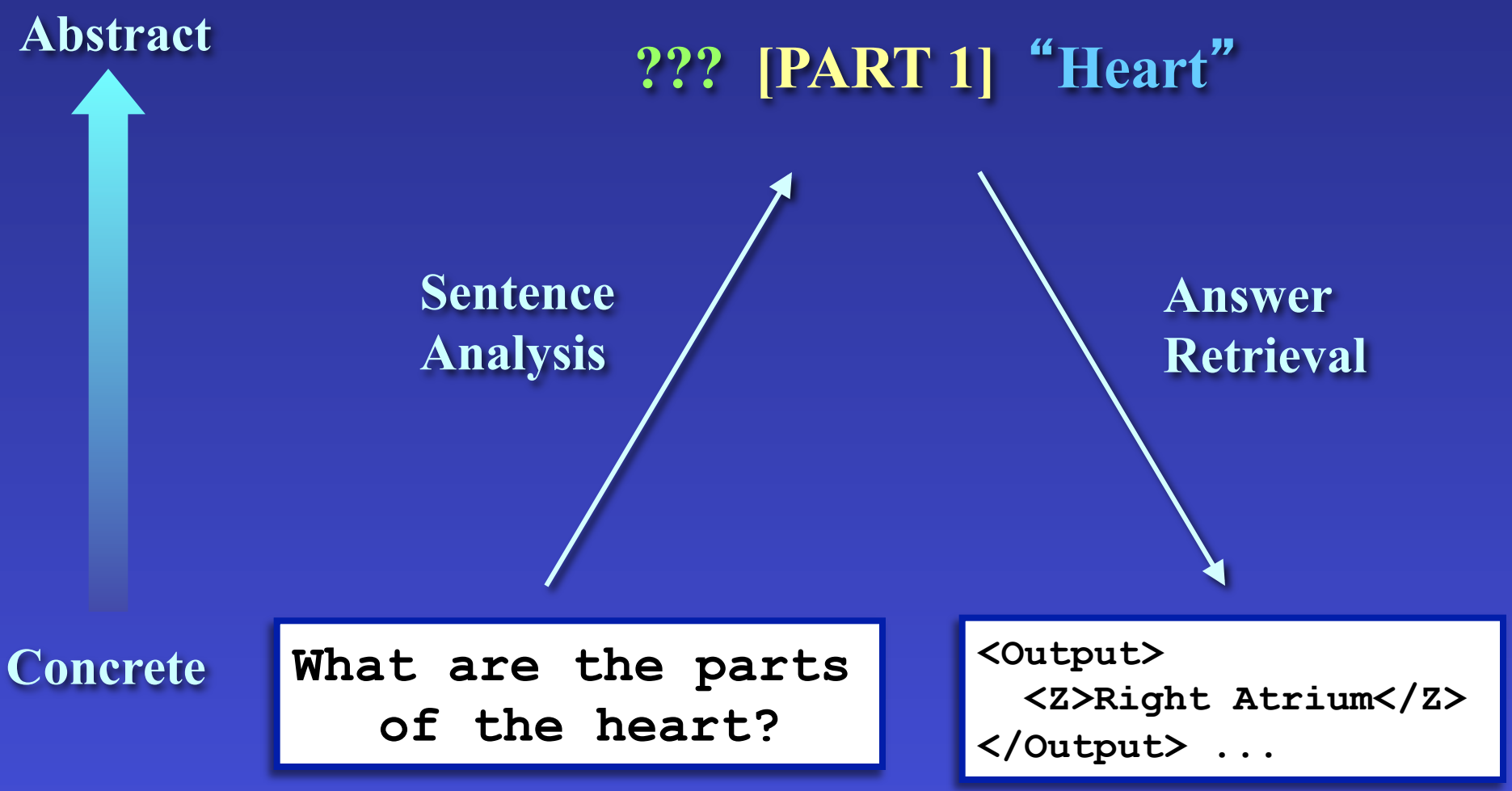
Answer: OQAFMA results

Results of STRUQL Query

```
<results>
  <Output>
    <Z>Right atrium</Z>
  </Output>
  <Output>
    <Z>Left atrium</Z>
  </Output>
  <Output>
    <Z>Right ventricle</Z>
  </Output>
  <Output>
    <Z>Left ventricle</Z>
  </Output>
  <Output>
    <Z>Cardiac valve</Z>
  </Output>
  <Output>
    <Z>Right side of heart</Z>
  </Output>
  <Output>
    <Z>Left side of heart</Z>
  </Output>
  <Output>
    <Z>Tricuspid valve</Z>
```

```
<results>
  <Output>
    <Z> Right Atrium </Z>
  </Output>
  <Output>
    <Z> Left Atrium </Z>
  </Output>
```

Structure of GAPP



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Examples

Simple Questions

"What is the heart?"

Examples

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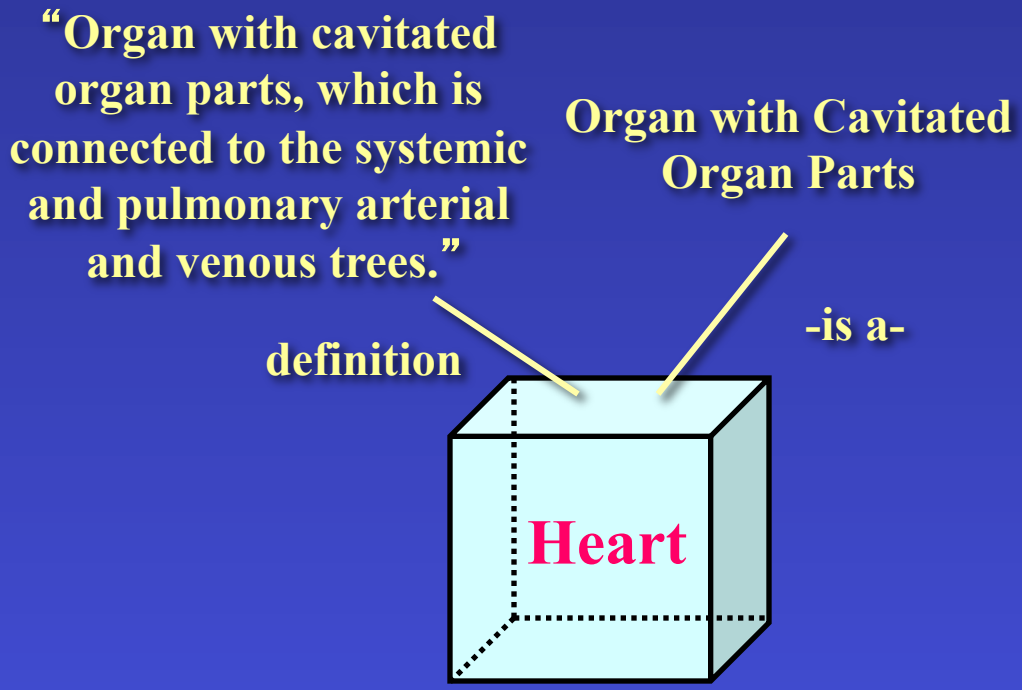


Examples

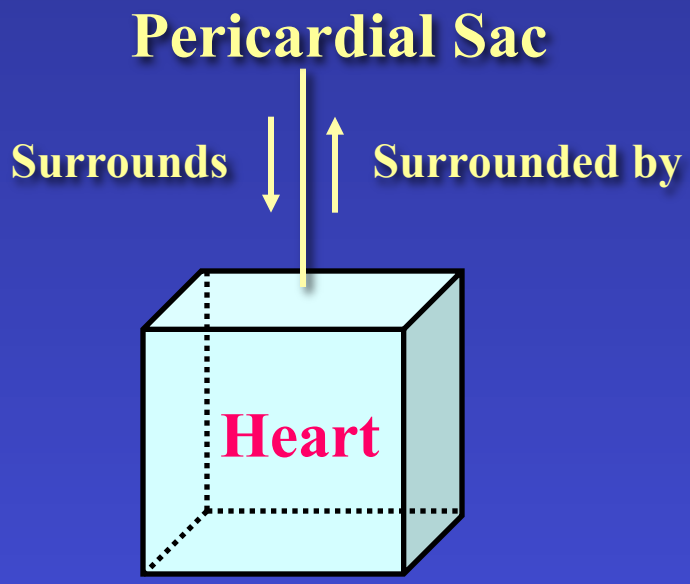
Simple Questions

"What is the heart surrounded by?"

Examples

Simple Questions

"What is the heart surrounded by?"



Examples

Nested Questions

"The arterial-supply of the heart is a branch of what?"

Examples

Nested Questions

"The arterial-supply of the heart is a branch of what?"

⬇

"Arterial-supply of the heart" [BRANCH 1] ???

Examples

Nested Questions

"The arterial-supply of the heart is a branch of what?"

⬇

"Arterial-supply of the heart" [BRANCH 1] ???

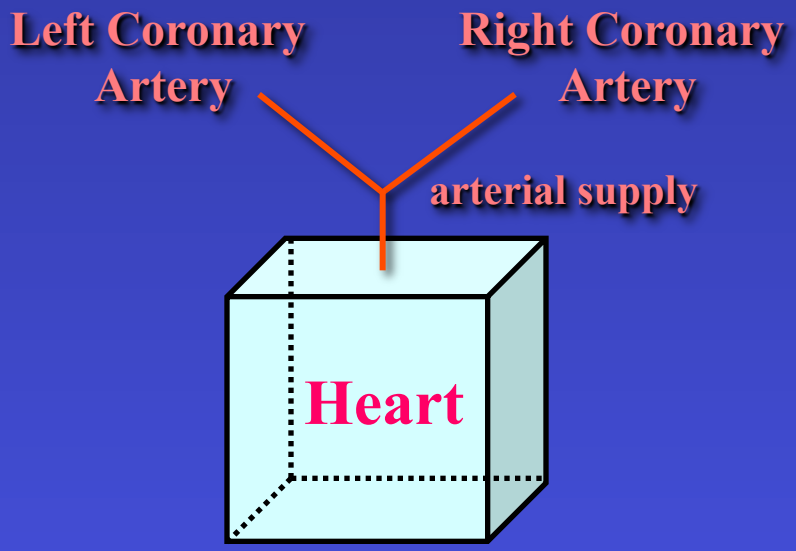
⬇

([ART SUPPLY 1] "Heart") [BRANCH 1] ???

Examples

Nested Questions

"The arterial-supply of the heart is a branch of what?"



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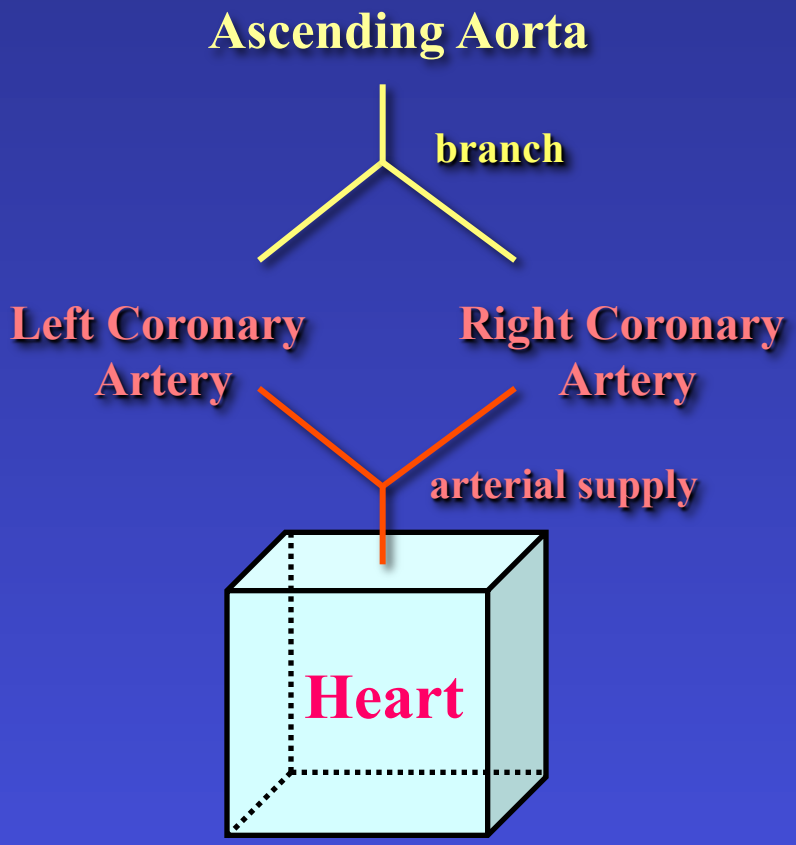

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Question Battery
written by GAPP developers

154 simple questions
42 nested questions

Evaluation

Question Battery
written by GAPP developers

154 simple questions
42 nested questions

⬇

176 of 196 Correct

Evaluation

OK

What gives blood to the liver?

What does the lymphatic drainage of the heart drain to?

What is the esophagus surrounded by?

Evaluation

Not OK

What is the blood supply of the heart connected to?

What is the mitral valve a part of?

What gives blood supply to the right lung?

Evaluation

Not OK

What is the blood supply of the heart connected to?

What is the mitral valve a part of?

What gives blood supply to the right lung?

Parsing Problems:

"supply" : verb or noun?

Wh-movement from NPs

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Conclusions

- Long-term goal

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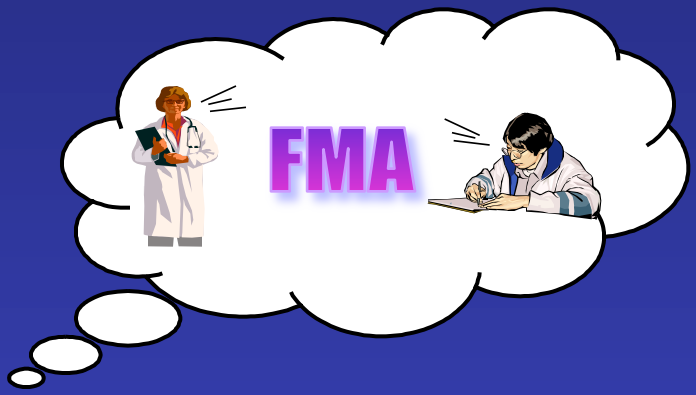

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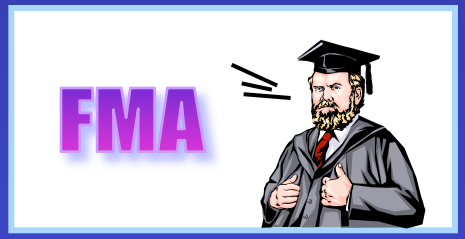
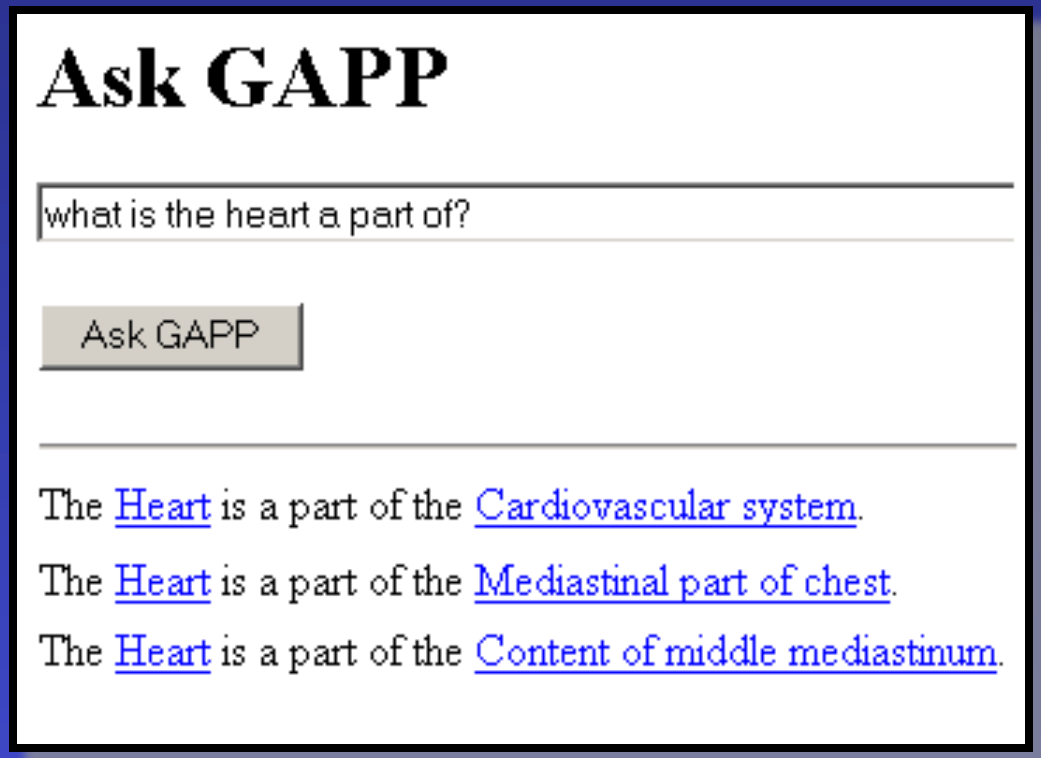


GAPP

Current Work

- New parser
- Clearer output
- Error reporting
- Enhanced speed



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