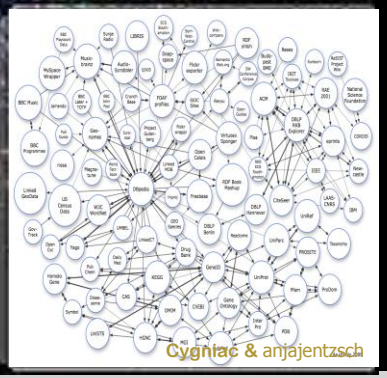
Knowledge for/from People for/from Computers

Michael Witbrock

Cycorp Europe

witbrock@cycorp.eu



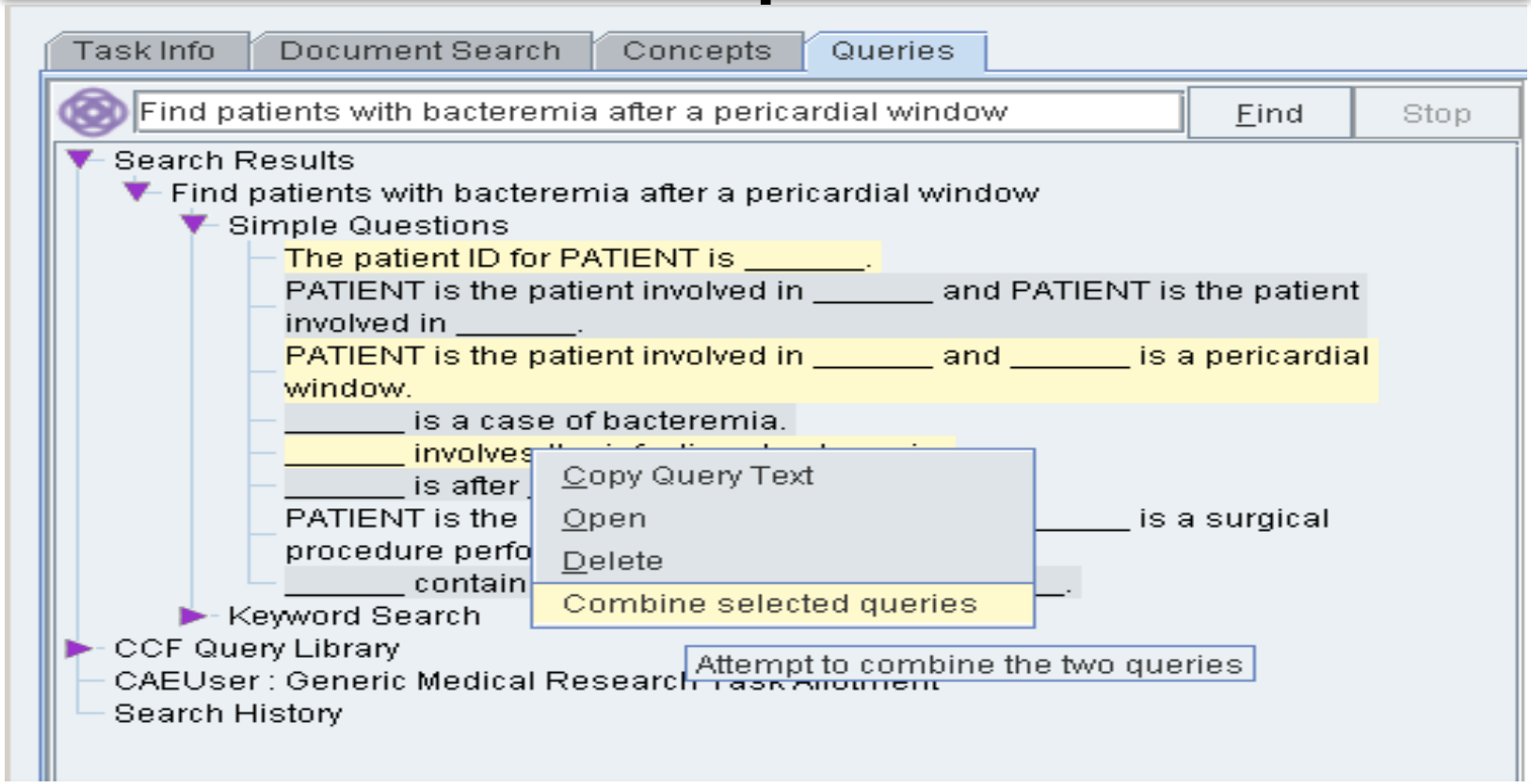
Cygniac & anjajentzsch

- **Human Computer Collaboration**
  - Vast power: fast communications, near infinite memory, computational learning (recommendation, data mining)
- *Fundamentally Harder Problems*
  - This power is creating systems that are more complex than can be managed by unaided humans
- *Fundamental Change*
  - Much content not stored in human understandable form (text, audio, diagrams …) but dynamically combined and synthesized
- *Needs infrastructure*
  - Knowledge in machine understandable form
  - Background knowledge to provide that understanding

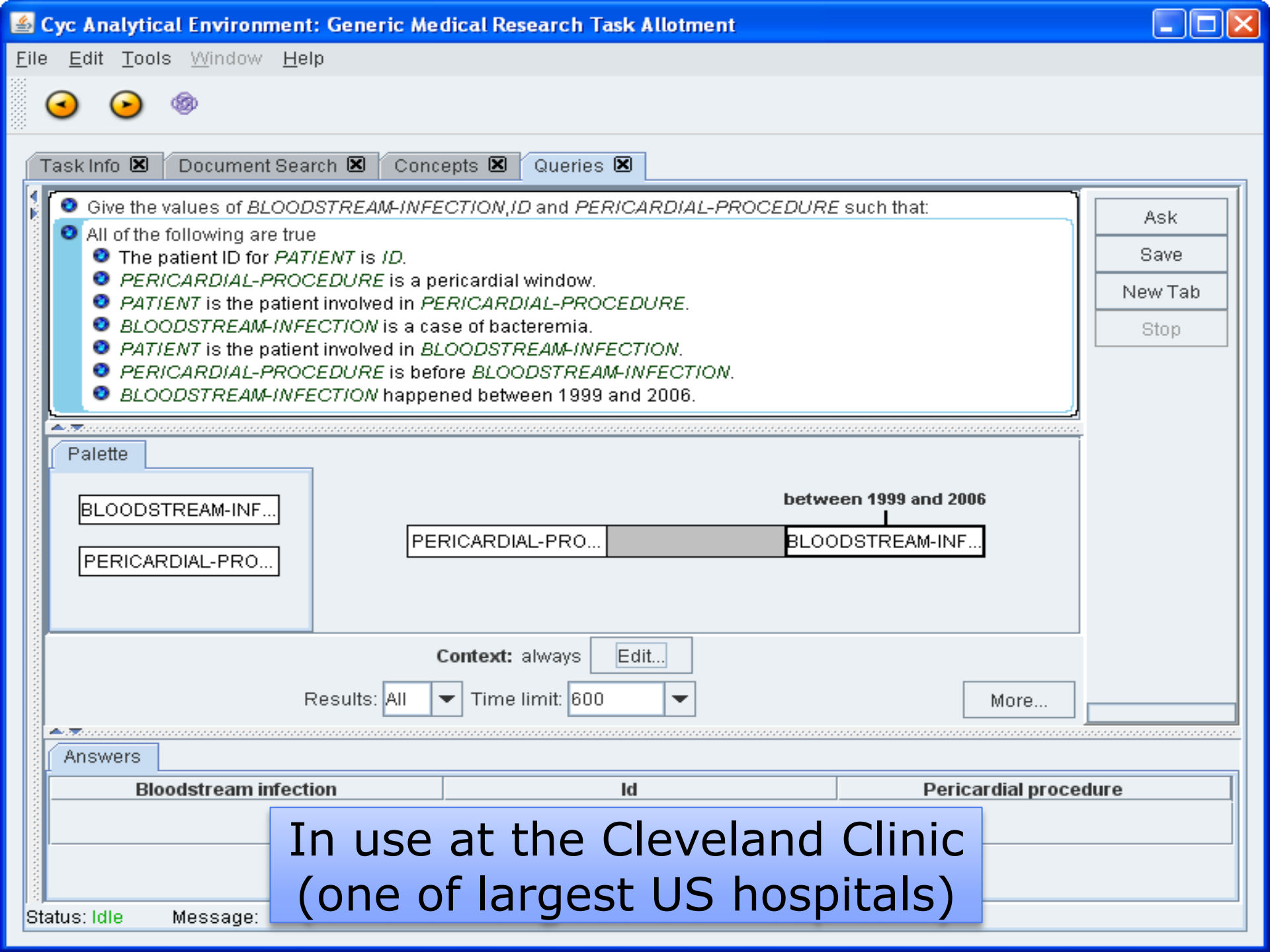
What's all this about people and computers

Use Case: Semantic Patient Records

Reasoning-based, question answering



User-assisted query understanding



In use at the Cleveland Clinic
(one of largest US hospitals)

Intelligent Search

Valve Surgery Search

Semantic Search Results

Valve Disease

104 Valve operations performed for the treatment of endocarditis in 2006. 73 procedures... Valve Procedure Volume Cleveland Clinic continues to perform the largest number of valve procedures in the United States. In 2006, Cleveland Clinic surgeons performed 2,127 valve procedures1,524

http://tomcat/html-content/Valve_Disease_.html (cached)

Eric E. Roselli, M.D.

Eric E. Roselli, M.D. Specialties: Adult cardiac surgery, thoracic aortic surgery, endovascular approaches to cardiothoracic diseases, minimally invasive valve repair and replacement, high-risk valve surgery, peripheral vascular surgery,

http://tomcat/html-content/roselli_.html (cached)

A. Marc Gillinov, M.D.

A. Marc Gillinov, M.D. Specialties: Minimally invasive mitral valve, aortic valve, and tricuspid valve surgery; mitral valve repair,...; and high-risk mitral valve surgery. Medical Degree:

http://tomcat/html-content/gillinov_.html (cached)

Gosta B. Pettersson, M.D., Ph.D.

valve surgery; heart and lung transplantation; reoperations; endocarditis; complex coronary artery surgery; aortic and mitral valve repair/replacement (including the Ross procedure); and adult... Dr. Gosta Pettersson has performed 387 valve operations at Cleveland Clinic since 1999.

http://tomcat/html-content/pettersson_PetterssonValveProc.html (cached)

Minimally Invasive

Isolated valve procedure CABG + valve procedure valve procedure +... VIDEO-ASSISTED MITRAL/TRICUSPID VALVE PROCEDURE Video-assisted mitral/tricuspid valve surgery is a minimally invasive technique enabling valve repair or replacement to be performed without sternotomy.

http://tomcat/html-content/Minimally_Invasive_.html (cached)

Intelligent Search

heart valve repair Search

Semantic Search Results

A. Marc Gillinov, M.D.
A. Marc Gillinov, M.D. Specialties: Minimally invasive mitral valve, aortic valve, and tricuspid valve surgery; mitral valve repair, surgical... Gillinov, M.D. has performed 125 heart-valve repair operations at
http://tomcat/html-content/gillinov_GillinovHeartValveRepair.html (cached)

Valve Disease
AV Repair or Replace + Other AV Repair o
Replacements AV = Aortic
http://tomcat/html-content/Valve_Disease_

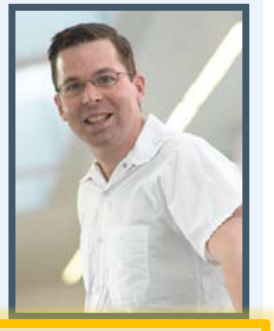
Nicholas G. Smedira, M.D.
Nicholas G. Smedira, M.D. Specialties: He
replacement, off-pump coronary artery byp
http://tomcat/html-content/smedira_.html (

Joseph F. Sabik III, M.D.
Joseph F. Sabik III, M.D. Specialties: Adult
surgery, off-pump coronary artery bypass s
http://tomcat/html-content/sabik_.html (cac

Eric E. Roselli, M.D.
Eric E. Roselli, M.D. Specialties: Adult card
and replacement, high-risk valve surger
http://tomcat/html-content/roselli_.html (ca

Gosta B. Pettersson, M.D., Ph.
aortic and mitral valve repair/replacemen
http://tomcat/html-content/pettersson_.h

A. Marc Gillinov, M.D.



Specialties: Minimally invasive mitral valve, aortic valve, and tricuspid valve surgery; mitral valve repair, surgical treatment and minimally invasive surgery for atrial fibrillation; off-pump coronary artery bypass surgery; and high-risk mitral valve surgery.

Medical Degree: Johns Hopkins University School of Medicine, Baltimore, Maryland

Special Training: Johns Hopkins University School of Medicine, Baltimore, Maryland

A native Clevelander, Dr. Gillinov spent the summers of 1978 to 1980 dividing his time between working at Cleveland Clinic and playing tennis. He still enjoys both activities.

Gillinov, M.D. has performed 125 heart-valve repair operations at the Cleveland Clinic Foundation since 1998.

This graph, based on a small sample of patient data, is given for demonstration purposes only.

Content adapted to query: Heart Valve repairs by Dr. Gillinov

Content adaptation: heart valve repair

Intelligent Search

coronary artery Search

Semantic Search Results

A. Marc Gillinov, M.D.
Gillinov, M.D. has performed 316 coronary artery operations at the Cleveland Clinic... invasive mitral valve, aortic valve, and tricuspid valve surgery repair, surgical treatment and minimally invasive surgery for atrial fibrillation; off-pump coronary artery bypass surgery
http://tomcat/html-content/gillinov_GillinovCoronaryArtery.html (cached)

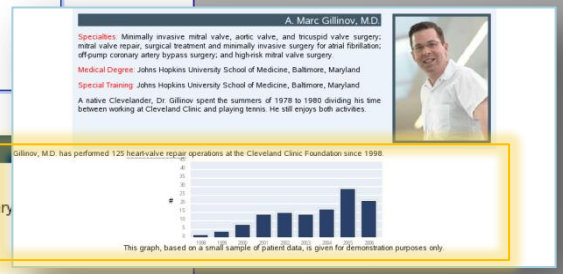
Nicholas G. Smedira, M.D.
and heart-lung transplantation, ventric grafting, myectomy, reoperations, an
http://tomcat/html-content/smedira_.h

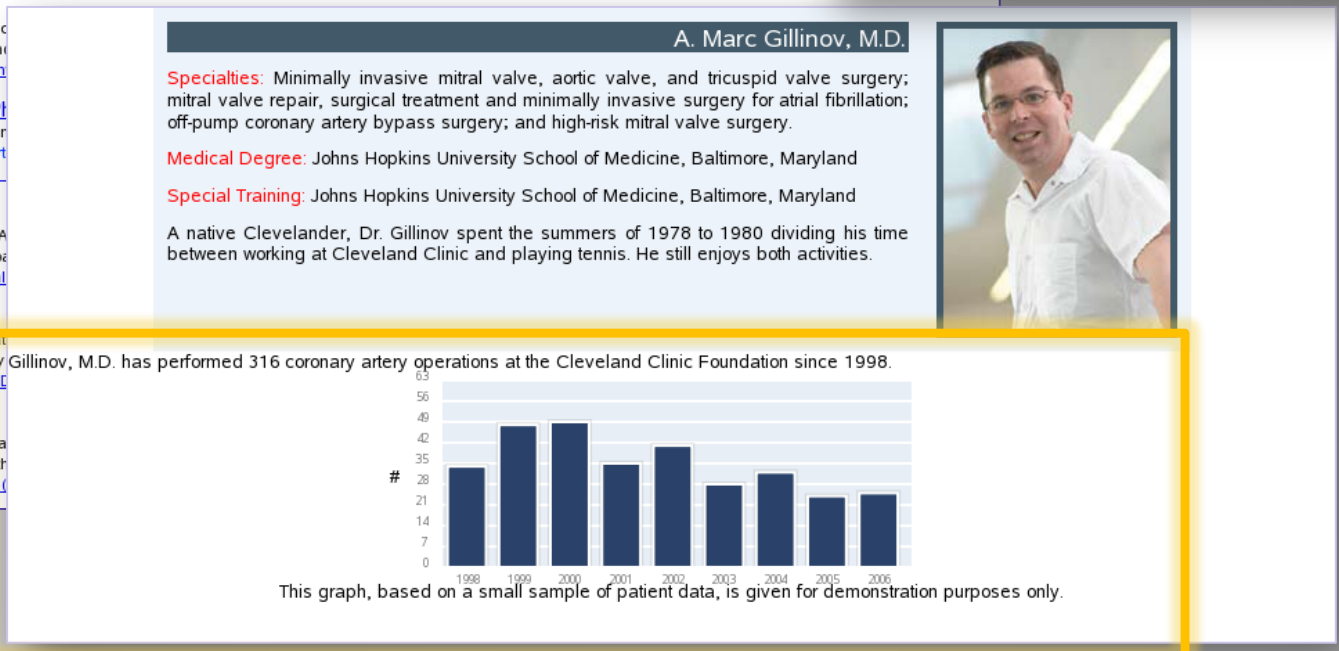
Gosta B. Pettersson, M.D., Ph
Adult acquired heart disease (includir complex coronary artery surgery; aort
http://tomcat/html-content/pettersson_

Joseph F. Sabik III, M.D.
Joseph F. Sabik III, M.D. Specialties: A surgery, off-pump coronary artery bypa
http://tomcat/html-content/sabik_.html

Coronary Disease
Primary isolated CABG refers to a pat images... excellent long-term pate cy
http://tomcat/html-content/Coronar_D

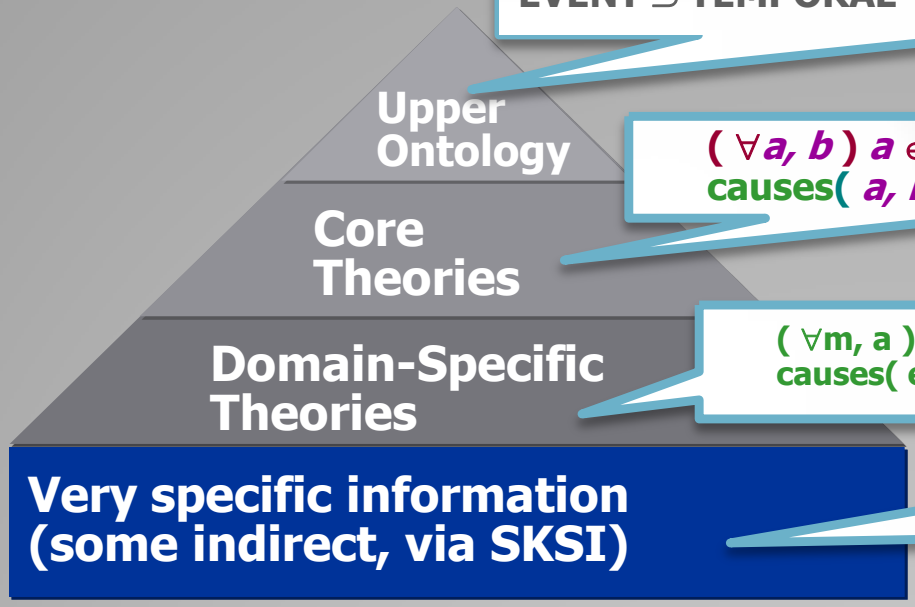
Bruce W. Lytle, M.D.
Bruce W. Lytle, M.D. Chairman, D pa diseases, reoperations, diseases f th
http://tomcat/html-content/lytle_.html (





Content adapted to new query: *Artery* repairs by Dr. Gillinov

Content adaptation: coronary artery



EVENT ⊃ TEMPORAL-THING ⊃ PARTIALLY-TANGIBLE-THING

(∀*a, b*) *a* ∈ EVENT ∧ *b* ∈ EVENT ⇒
causes(*a, b*) ⇒ precedes(*a, b*)

(∀m, a) m ∈ MAMMAL ∧ a ∈ ANTHRAX ⇒ □
causes(exposed-to(m, a), infected-by(m, a))

(ist FtLaudHolyCrossERCase#403921
(caused CutaneousAnthrax
(SkinLesions Ahmed_al-Haznawit)))

First Order Predicate Calculus: unambiguous; enable mechanical reasoning

Every American has a president.
Every American has a mother.

∃y.∀x. Amer(x) ⇒ president(x,y)
∀x.∃y. Amer(x) ⇒ mother(x,y)

Higher Order Logic: contexts, predicates as variables, nested modals, reflection,…

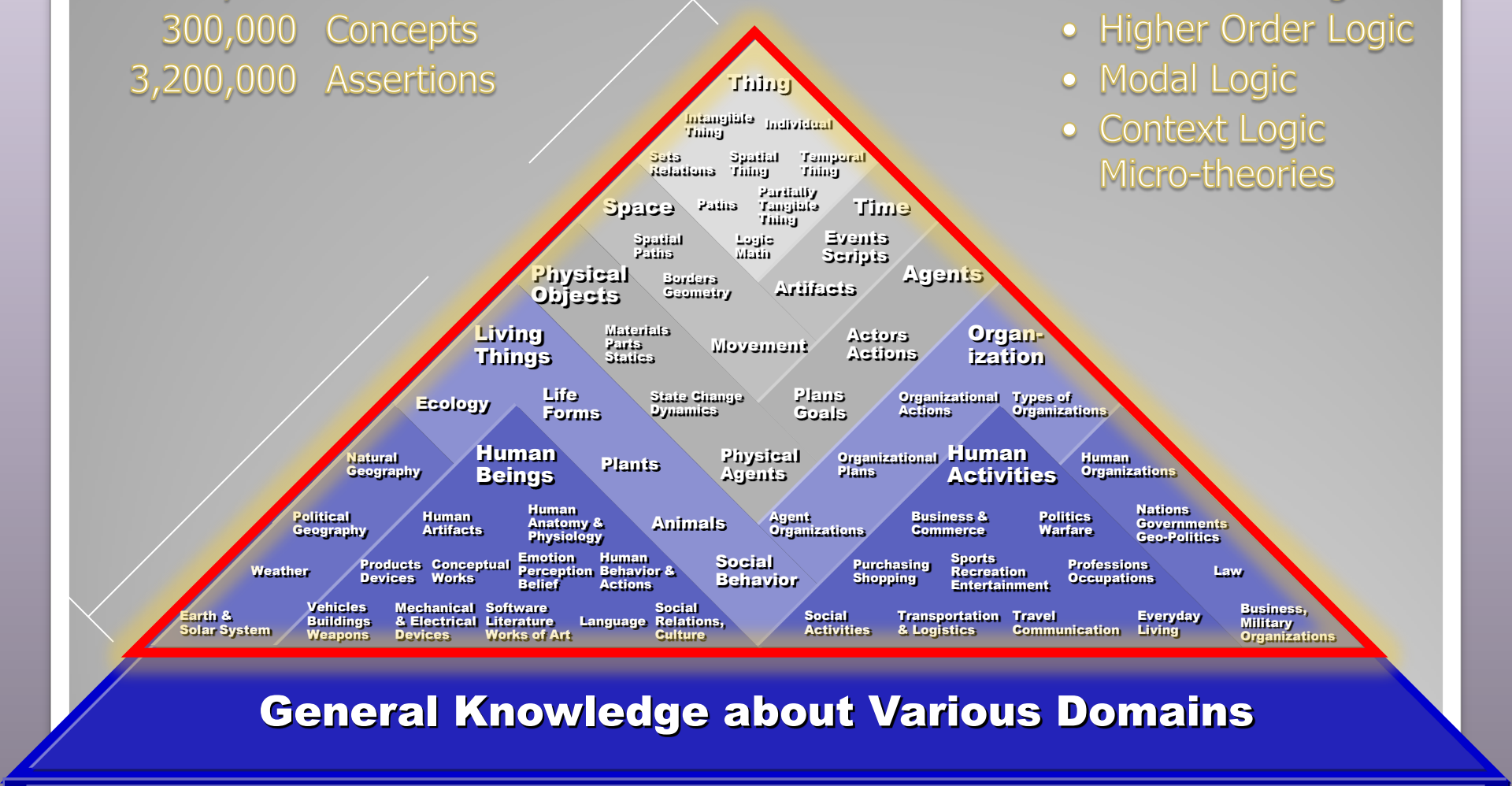
Formal Representation for Reasoning

Cyc contains:

15,000 Predicates
300,000 Concepts
3,200,000 Assertions

Represented in:

- First Order Logic
- Higher Order Logic
- Modal Logic
- Context Logic
  Micro-theories



General Knowledge about Various Domains

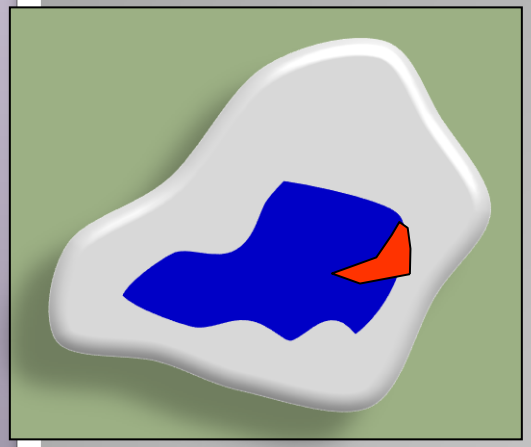
Specific data, facts, and observations

- #$TransportationEvent
- #$ControllingATransportationDevice
- #$TransportWithMotorizedLandVehicle
- (#$SteeringFn #$RoadVehicle)
- #$TransporterCrashEvent
- #$VehicleAccident
- #$CarAccident
- #$Colliding
- #$IncurringDamage
- #$TippingOver
- #$Navigating
- #$EnteringAVehicle …

Simple Language, MANY terms

Is it attached to the inside of the outer object?

– Yes -- Try **#$connectedToInside**

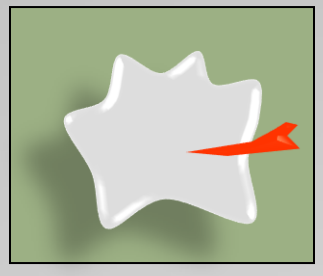


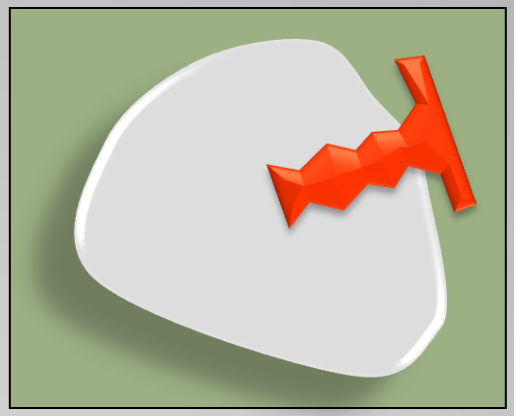
Can it be removed by pulling, if enough force is used, without damaging either object?

– No -- Try **#$in-Snugly** or **#$screwedIn**

Does the inner object stick into the outer object?

–Yes – Try **#$sticksInto**

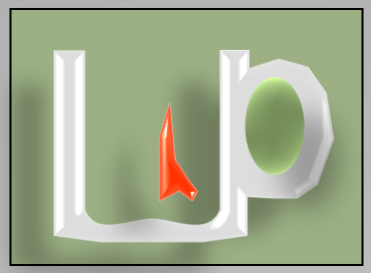


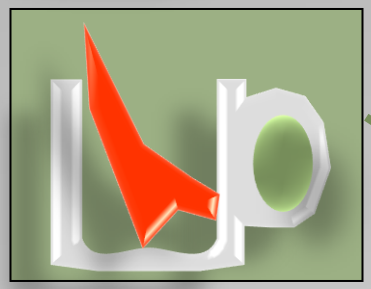


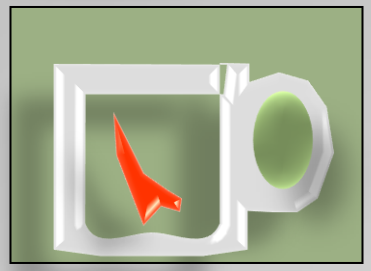
Senses of 'In'

Cycorp © 2007

- Does part of the inner object stick out of the container?
  - None of it.
    #$in-ContCompletely
  - Yes
    #$in-ContPartially
  - No
    #$in-ContClosed



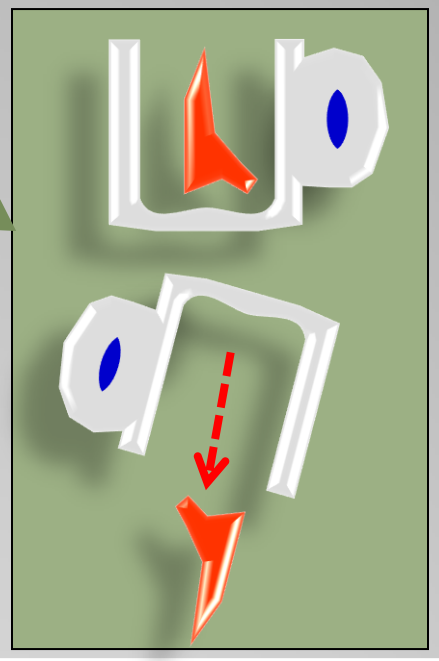




- If the container were turned around could the contained object fall out?

  Yes

  #$in-ContOpen



For Inference:
Senses of 'In'

Cycorp © 2008

First Order

- (isa ASBFinancialCorp PubliclyHeldCorporation)
- (corporateOfficers ASBFinancialCorp GeraldRJenkins)

With Context

- In Mt : FinancialTransactionMt
  (relationAllExists performedBy RepurchaseProgram PubliclyHeldCorporation)

Rule

- In Mt: FinancialTransactionMt
  (forAll ?X (implies
  (isa ?X RepurchaseProgram)
  (thereExists ?Y (and (isa ?Y PublicallyHeldCorporation) (performedBy ?X ?Y)))))

Second Order

- (implies
  (and (isa ?SET Set-Mathematical) (cardinality ?SET 1) (elementOf ?THING ?SET))
  (equals ?SET (TheSet ?THING)))

Modal

- (beliefs Israel (relationInstanceExists possesses Syria ClusterBomb))

Meta

- (opaqueArgument beliefs 2)

Syntactic Power

Logistics

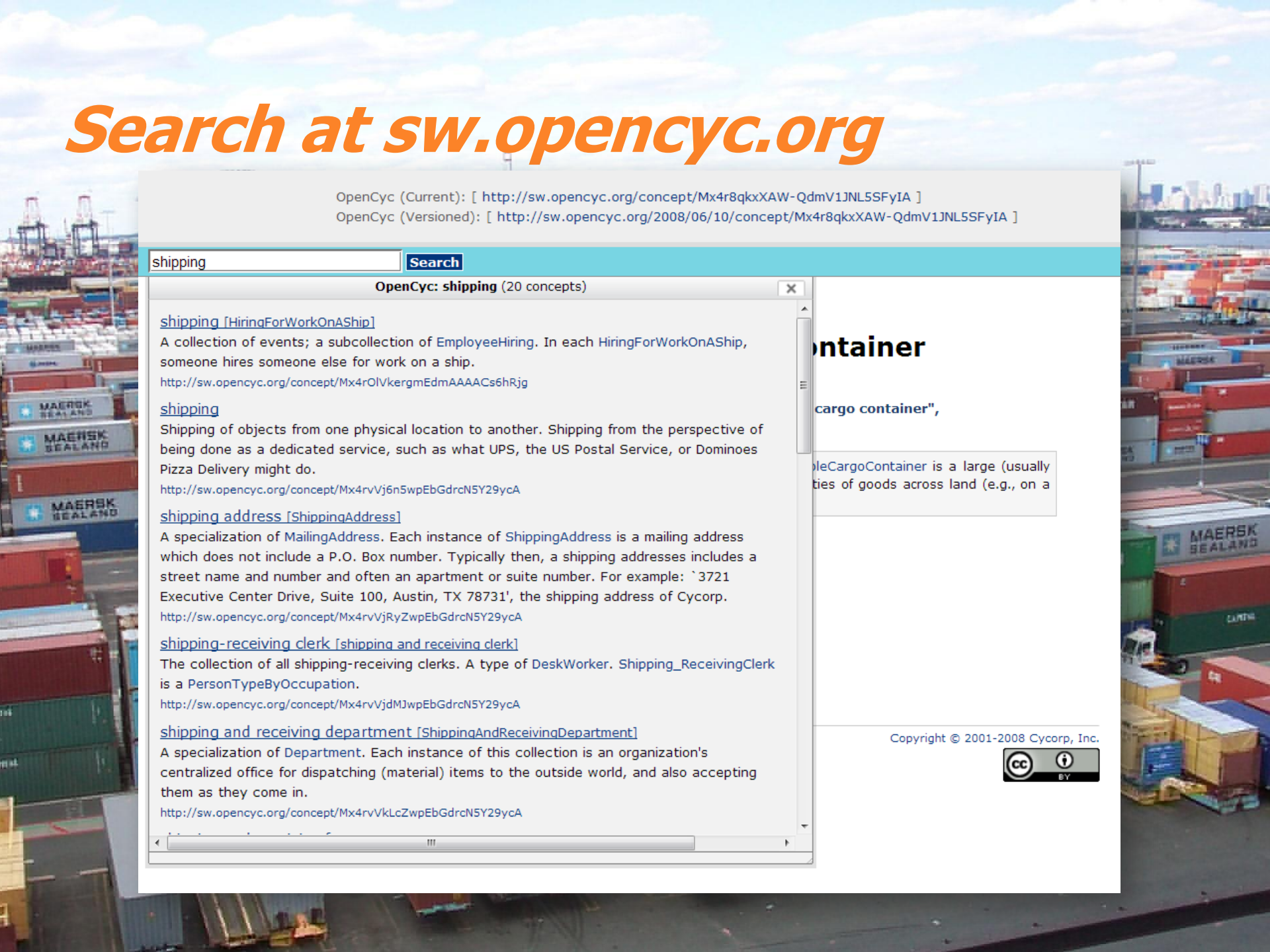
http://ws.opencyc.org/webservices/concept/find?str=shipping%20container

```
<concepts hasMore="false">
   <concept uri="http://sw.opencyc.org/concept/Mx4r8qkxXAW-QdmV1JNL5SFyIA"/>
</concepts>
```

Logistics

OpenCyc (Current): [http://sw.opencyc.org/concept/Mx4r8qkxXAW-QdmV1JNL5SFyIA]
OpenCyc (Versioned): [http://sw.opencyc.org/2008/06/10/concept/Mx4r8qkxXAW-QdmV1JNL5SFyIA]
Search
cYcorp
OpenCyc Collection: shipping container
Unique ID: [Mx4r8qkxXAW-QdmV1JNL5SFyIA]
English ID: [LargePortableCargoContainer]
English Aliases: ["cargo container", "cargo containers", "portable cargo container", "portable cargo containers", "shipping containers"]
A specialization of StorageConstruct. Each instance of LargePortableCargoContainer is a large (usually about 40' x 8' x 8') metal container used for shipping large quantities of goods across land (e.g., on a large truck) or overseas (e.g., on a cargo ship).
A Type of: storage device
Instance of: spatially disjoint object type, type of object
Subtypes:
Instances:
Same as:
http://umbel.org/umbel/sc/LargePortableCargoContainer
MAERSK SEALAND
BY

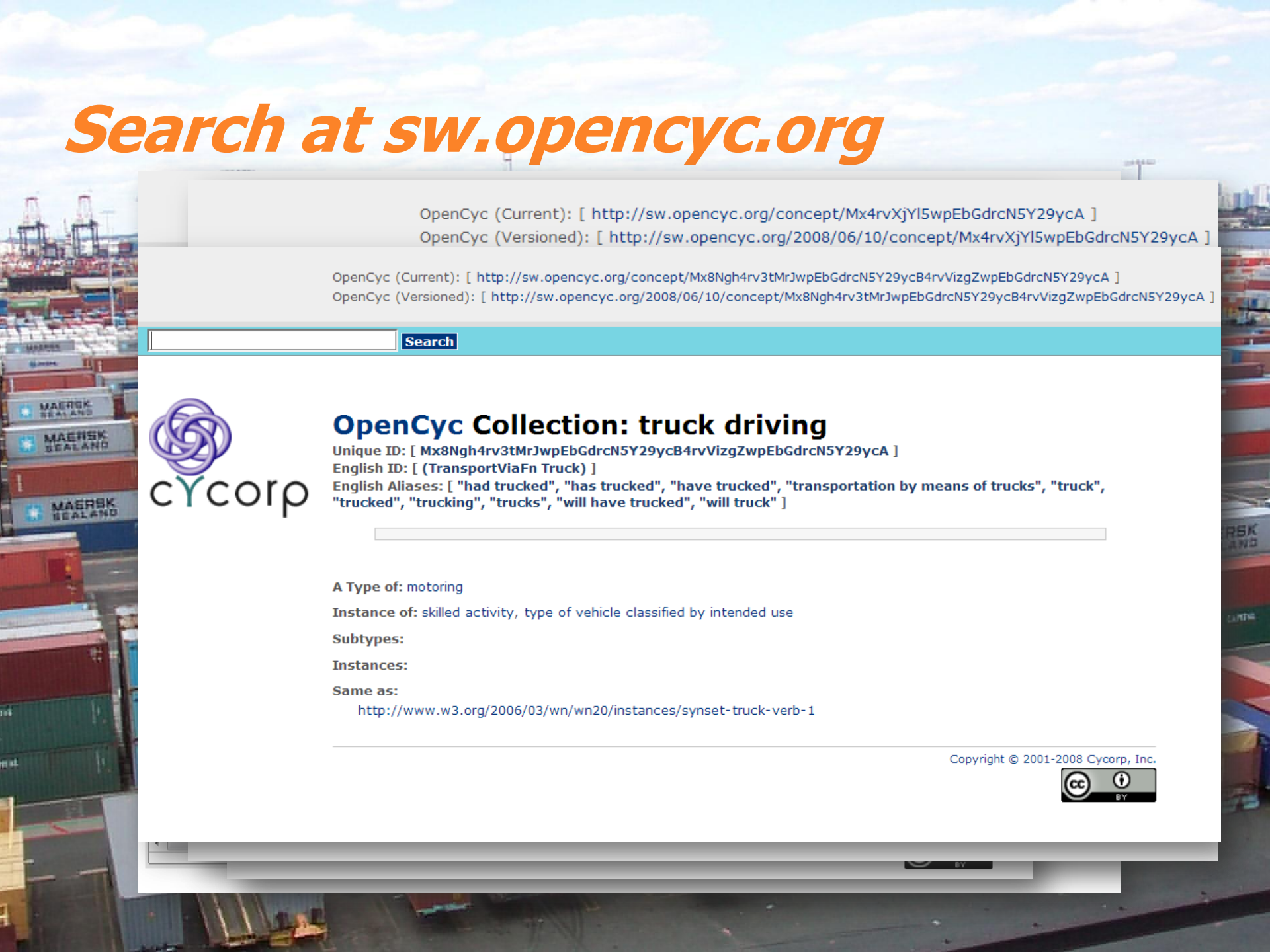
Search at sw.opencyc.org



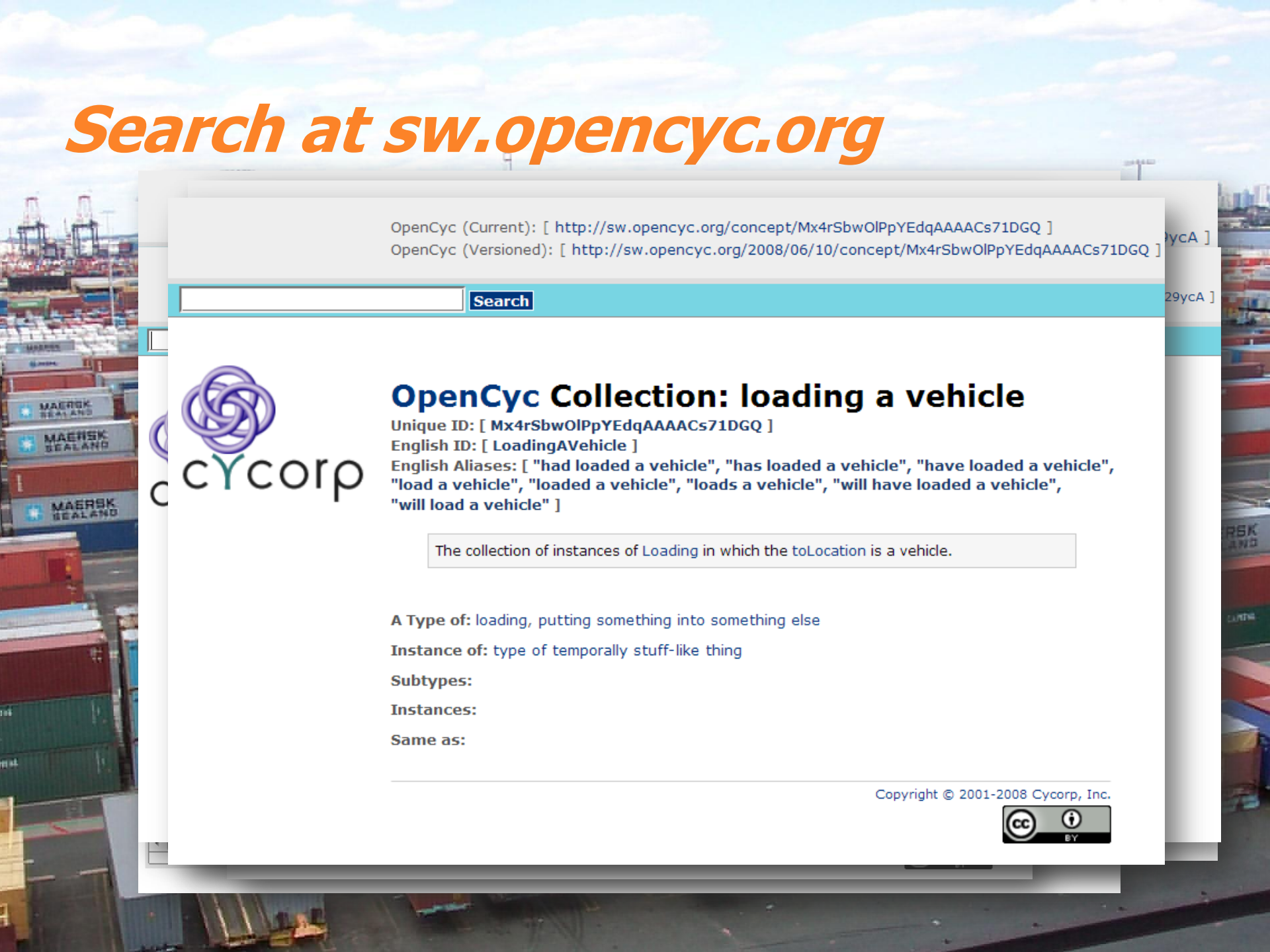
Search at sw.opencyc.org

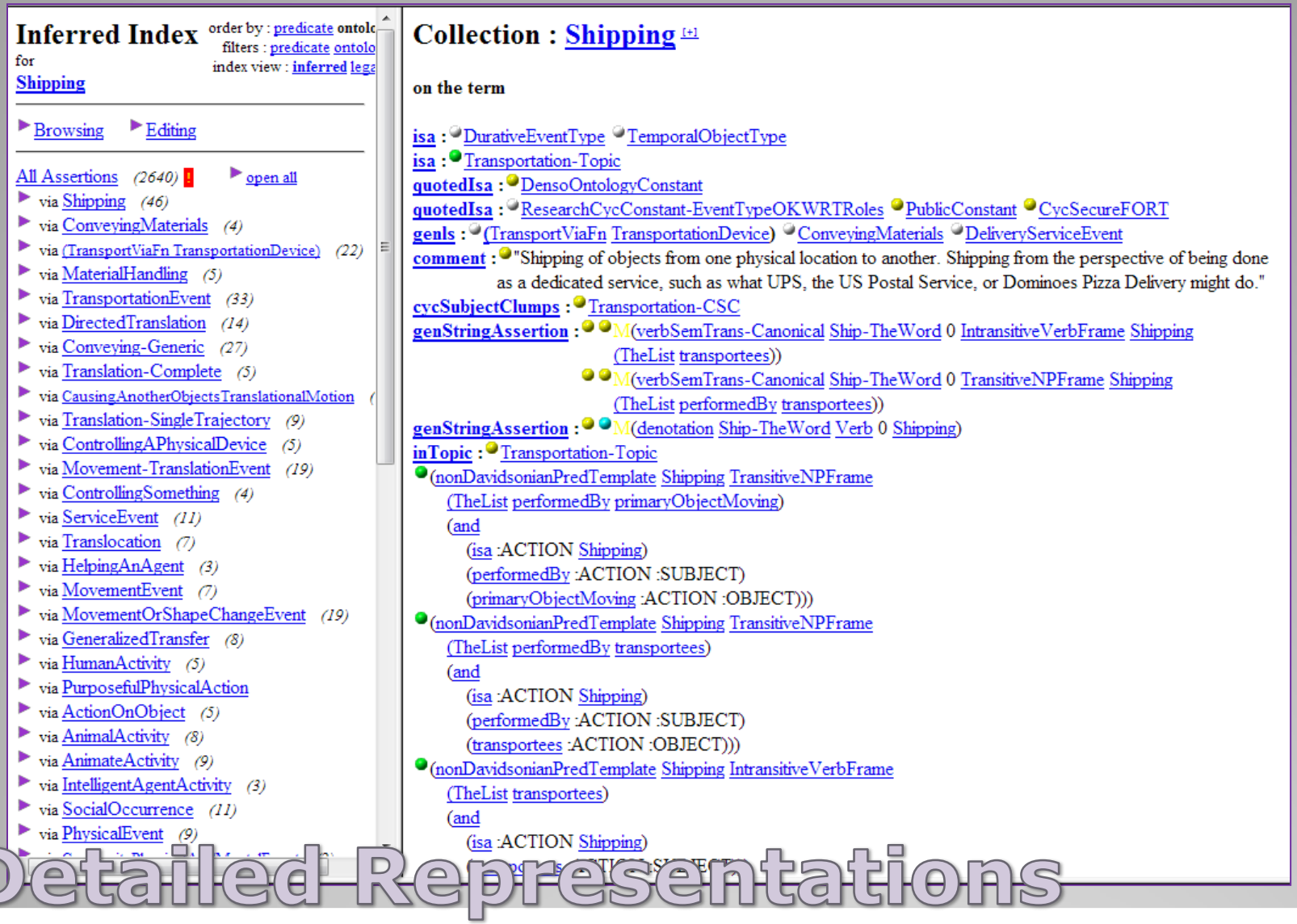
Search at sw.opencyc.org

Search at sw.opencyc.org

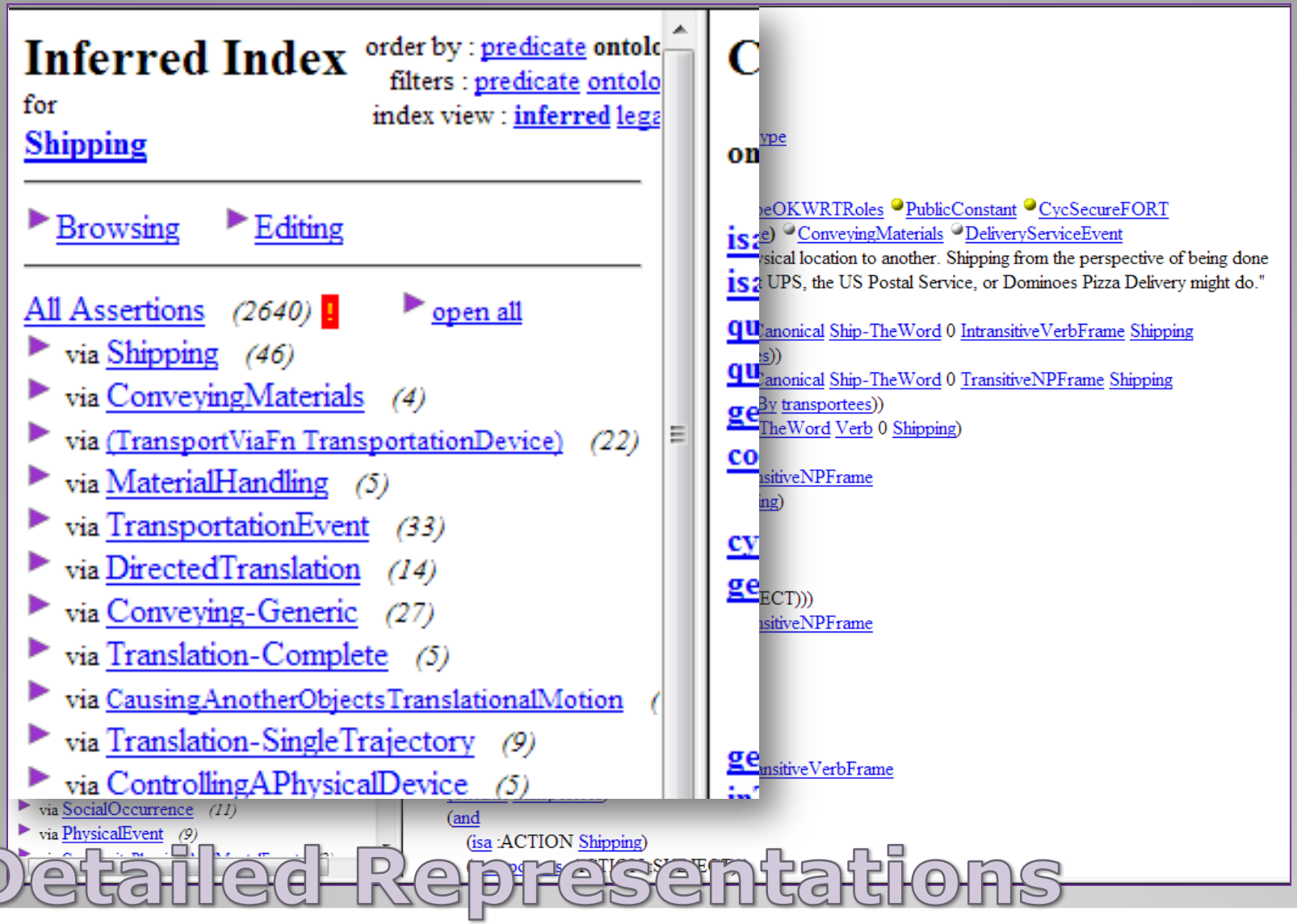


Search at sw.opencyc.org

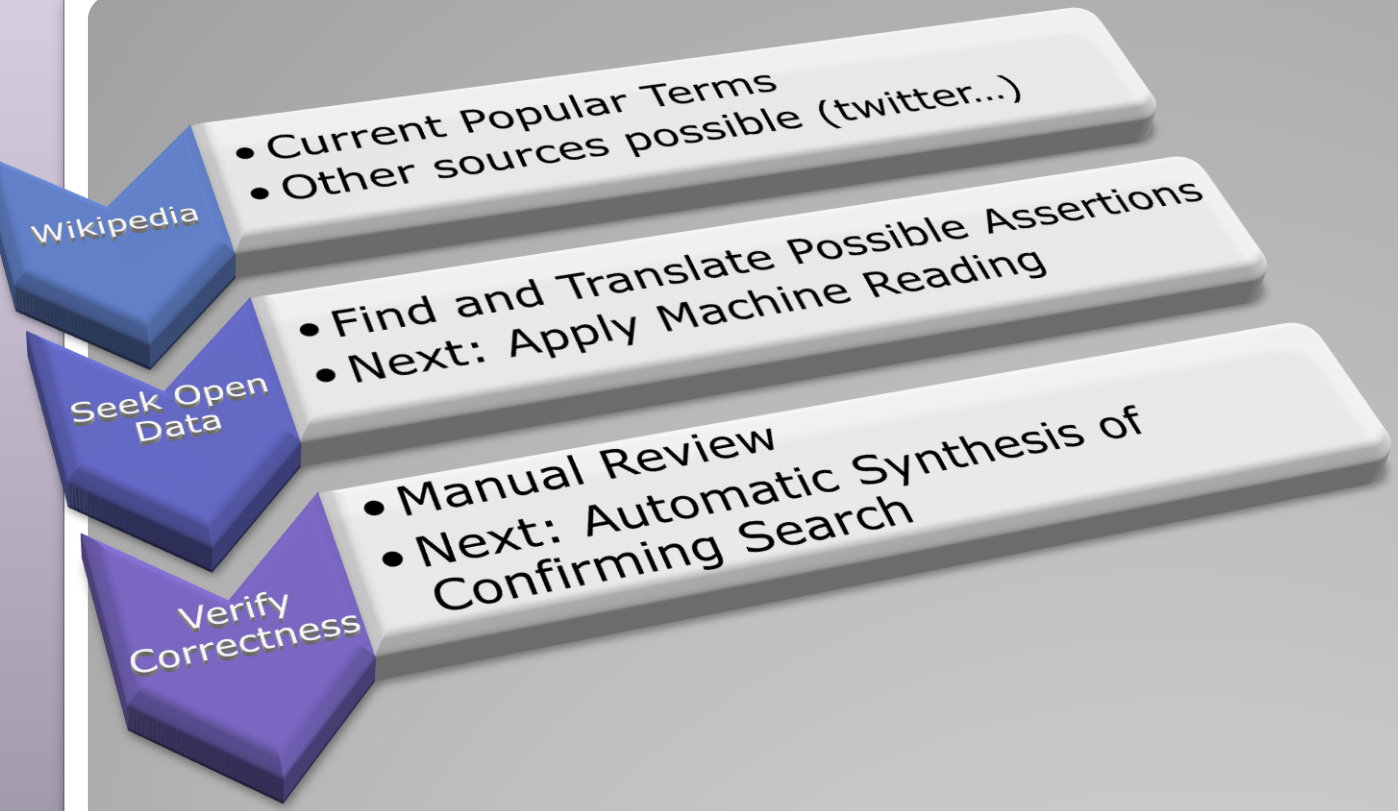




Detailed Representations



Detailed Representations



840 terms learned in 3 weeks

Automatic Term Learning

Individual : Franco-PrussianWar

on the term

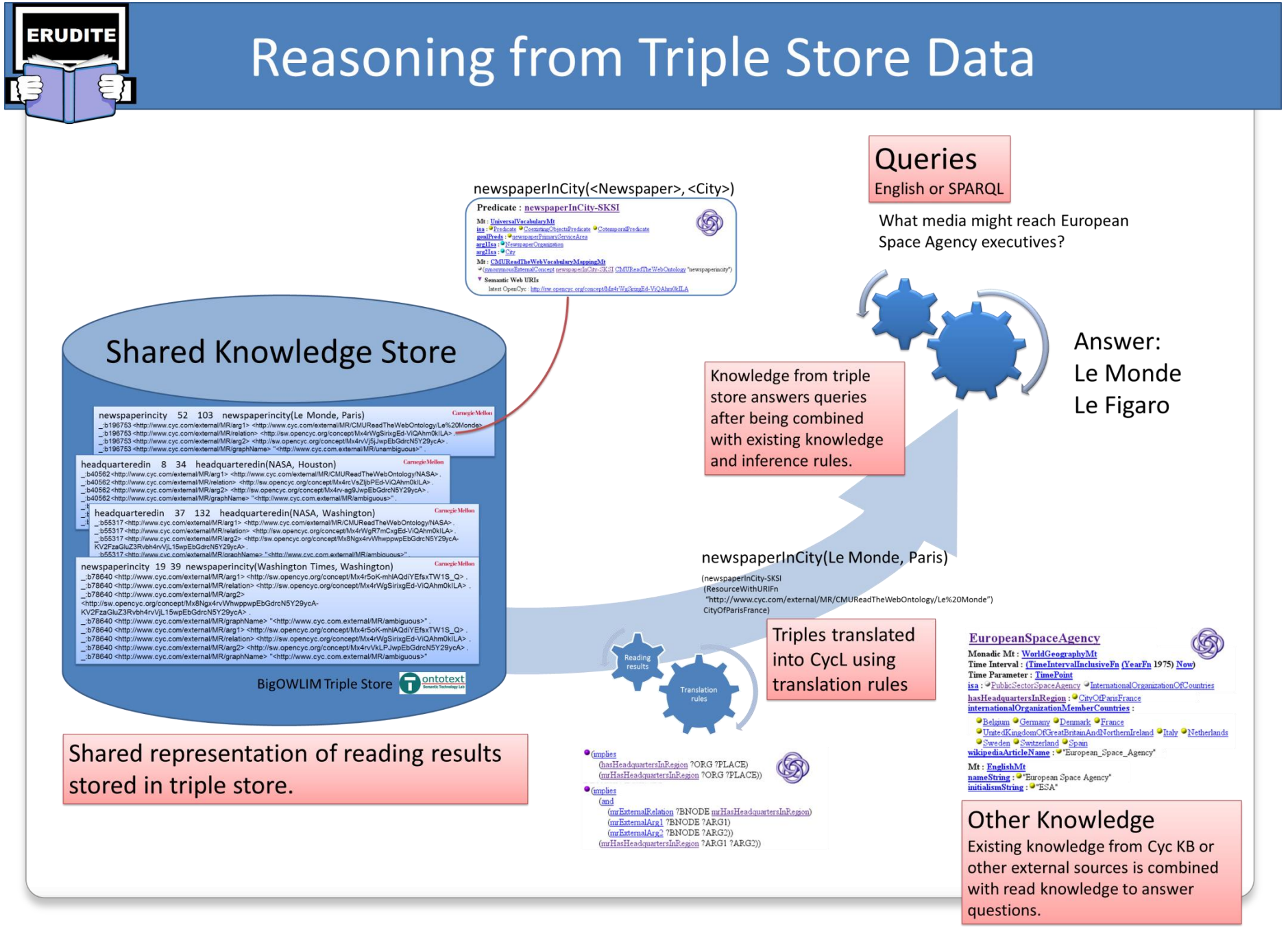
isa : TemporalThing
isa : MilitaryConflictEvent
(codeMapping DBPedia-CMLS "<http://dbpedia.org/resou
definiteDescriptions : M"the Franco-Prussian War"
nameString : M»Ranskan–Preussin sota«
nameString : M"Guerre franco-allemande (1870)"
nameString : M»Deutsch-Französischer Krieg«
nameString : M"Guerra franco-prussiana"
nameString : M»普法戰爭«
nameString : M"Frans-Duitse Oorlog
nameString : M»普仏戦争«
nameString : M"Den fransk-preussiske krig"
nameString : M"Wojna francusko-pruska"
nameString : M"Guerra franco-prussiana"
nameString : M»Франко-прусская война 1870—1871«
nameString : M"Guerra Franco-Prusiana"
nameString : M"Fransk-tyska kriget"
rdfURI : "http://dbpedia.org/resource/Franco-Prussian_War
(rdfURIInNamespace Franco-PrussianWar DBPediaResou
wikipediaArticleName : M"Franco-Prussian_War"

3 weeks

Automatic T

#$Warehouse13-TelevisionSeries
#$RyanReynolds-TheActor
#$DonRevie-SoccerCoach
#$BridgetPowers-ActorThatIsAlsoAnAdult
#$TheSuiteLifeOnDeck-TelevisionSeries
#$ChelseaFC
#$StormingOfTheBastille
#$TheColoradoKid-Book
#$EmileHeskey-SoccerPlayer
#$TravisWall-Person
#$BeezusAndRamona-Book
#$UFC116
#$CherylCole-TheMusician
#$JamesGammon-Actor
#$EdMiliband-ThePolitician
#$GeorgeSteinbrenner-FamousPerson
#$AleksandarKolarov-SoccerPlayer
#$SonsOfAnarchy-TelevisionSeries
#$ScottPilgrimVsTheWorld-Movie
#$PrettyLittleLiars-Book
#$VicenteDelBosque-SoccerCoach
#$MakeItOrBreakIt-TelevisionSeries
#$Adderall

Reasoning from Triple Store Data



inCyc beta

The Mississippi River

General:

The Arkansas River, the Red River, the Ohio River, the Tennessee River, the Missouri River, the St. Francis River, and the Wisconsin River are a tributary of the Mississippi River.

The Mississippi River is a large body of water and a river.

The Mississippi River is in North America and the United States. The Mississippi River is in the United States.

The Mississippi River empties into the Gulf of Mexico. The Mississippi River borders on St. Louis, MO.

Miscellaneous:

Comment: The chief river of the North American Continent and one of the worlds great rivers. The Mississippi River generally moves due south. It temporally contains the time period between 5001 B.C. and the Twenty-First Century A.D. Mississippi is named after the Mississippi River.

The Mississippi River has been adjacent to Louisiana State Penitentiary since 1880.

How was this page created?

inCyc beta

The Mississippi River

General:

The Arkansas River, the Red River, the Ohio River, the Tennessee River, the Missouri River, the St. Francis River, and the Wisconsin River are a tributary of the Mississippi River.

The Mississippi River is

The Mississippi River is States.

The Mississippi River e

Miscellaneous:

Comment: The chief riv Mississippi River gener the Twenty-First Centu

The Mississippi River h

inCyc beta

Carbon

Basic:

Carbon is a type of non-metallic element.

Documentation:

Comment: A piece of carbon; here on Earth, this is of course usually a solid, but it needn't necessarily be.

Structure:

Some carbon is a constituent of all steel and all gunpowder.

Every organic compound has some carbon as a proper physical part.

Miscellaneous:

A diamond, wood coal, and graphite are a type of carbon.

A possible valence of carbon is 4 and -4.

4 and 2 are possible oxidation numbers for carbon.

The atomic number of carbon is 6.

The atomic weight of carbon is 12.0107 atomic mass units. Every carbon metabolic event destroyed some carbon. Carbon 14 is isotopes of carbon.

The Mississippi River

General:

The Arkansas River, the Red River, the Ohio River, the Tennessee River, the Missouri River, the St. Francis River, and the Wisconsin River are a tributary of the Mississippi River.

The Mississippi River is

The Mississippi River is

The Roman Empire

Documentation:

Comment: The geopolitical entity known as the Roman Empire (27 BC -- 476 AD).

General:

The Roman Empire is an empire. The capital city of it was Rome, Italy. Lusitania is part of The Roman Empire.

Affiliations:

Lusitania is part of The Roman Empire.

Every ancient Roman is a citizen of The Roman Empire.

The capital city of The Roman Empire was Rome, Italy.

Miscellaneous:

Emperor Augustus is a citizen of The Roman Empire. The concept "Jesus of Nazareth" is conceptually related to the concept "The Roman Empire". It was made in all object of art from The Roman Empire. It ended in 476.

How was this page created?

be.

some carbon.

inCyc beta

Slovenia

General:

Ljubljana, Slovenia, Koper, Slovenia, Ljubliana, Slovenia, Portoroz, Slovenia, and Maribor, Slovenia are in Slovenia.

Slovenia borders on Italy, Croatia, Hungary, and Austria. Slovenia is northwest of Croatia.

Brezovica is a geopolitical subdivision of Slovenia. Slovenia has been a geopolitical subdivision of the European Union since the beginning of May 2004. Bohinj is a geopolitical subdivision of Slovenia. Bohinj and Brezovica are a geographical subregion of Slovenia.

Slovenia is an elected member of the Security Council, a Balkan country, and an eastern European country.

- Italy is west of Slovenia.
- Slovenia is west of Hungary.

Slovenia is northeast of Italy. The capital city of it is Ljublana. Slovenia is south of Austria. Slovenia was a geopolitical subdivision of Yugoslavia after 1922 and before 1992.

Group Membership:

Slovenia is a member of the United Nations.

Affiliations:

Maribor, Slovenia, Koper, Slovenia, Ljubljana, Slovenia, Portoroz, Slovenia, and Ljubliana, Slovenia are in Slovenia.

- Brezovica and Bohinj are a geopolitical subdivision of Slovenia.
- Slovenia has been a geopolitical subdivision of the European Union since the beginning of May 2004.
- Slovenia was a geopolitical subdivision of Yugoslavia after 1922 and before 1992.

The capital city of Slovenia is Ljublana. Slovenia is a member of the United Nations.

Miscellaneous:

Slovenia is inhabited by many Croats, Slovenes, and Serbians.

Slovenian is among the national languages of Slovenia. The concept "Slovenian" is conceptually related to the concept "Slovenia".

Slovenia's telephone country code is 386. Muslim people are one of the primary types of people inhabiting Slovenia. Slovenia is obliged to follow the Universal Declaration of Human Rights. Slovenia bought goods or services from Algeria in 1997.

From 1998 or earlier to at least November 1999, Slovenia was an elected member of the Security Council. Slovenia was an elected member of the Security Council after 1997 and before December 31, 1999.

incyc.cyc.com

person is the head of the United Arab Emirates.

inCyc beta

The United Arab Emirates

BASIC DATA		
PREDICATE	VALUE	DATE RANGE
Chief Ports	Dubai	always
Capital city	Abu Dhabi, the United Arab Emirates	always
Land Area Of Region	75,581 square kilometers	always
Predominant Language	Arabic	always
Government Type	federation government	always
Neighbor	Saudi Arabia	
Neighbor	Oman	
Neighbor	Qatar	

Abu Dhabi, Dubai, Ajman, Sharjah, Dubai, Ras al Khaymah, and al fujayrah are in the United Arab Emirates.

The United Arab Emirates is south of the Tumbs Islands, Qatar, Das Island, Abu Musa, and Qeshm. The United Arab

How was this page created?

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person is the head of the United Arab Emirates.

South Korea

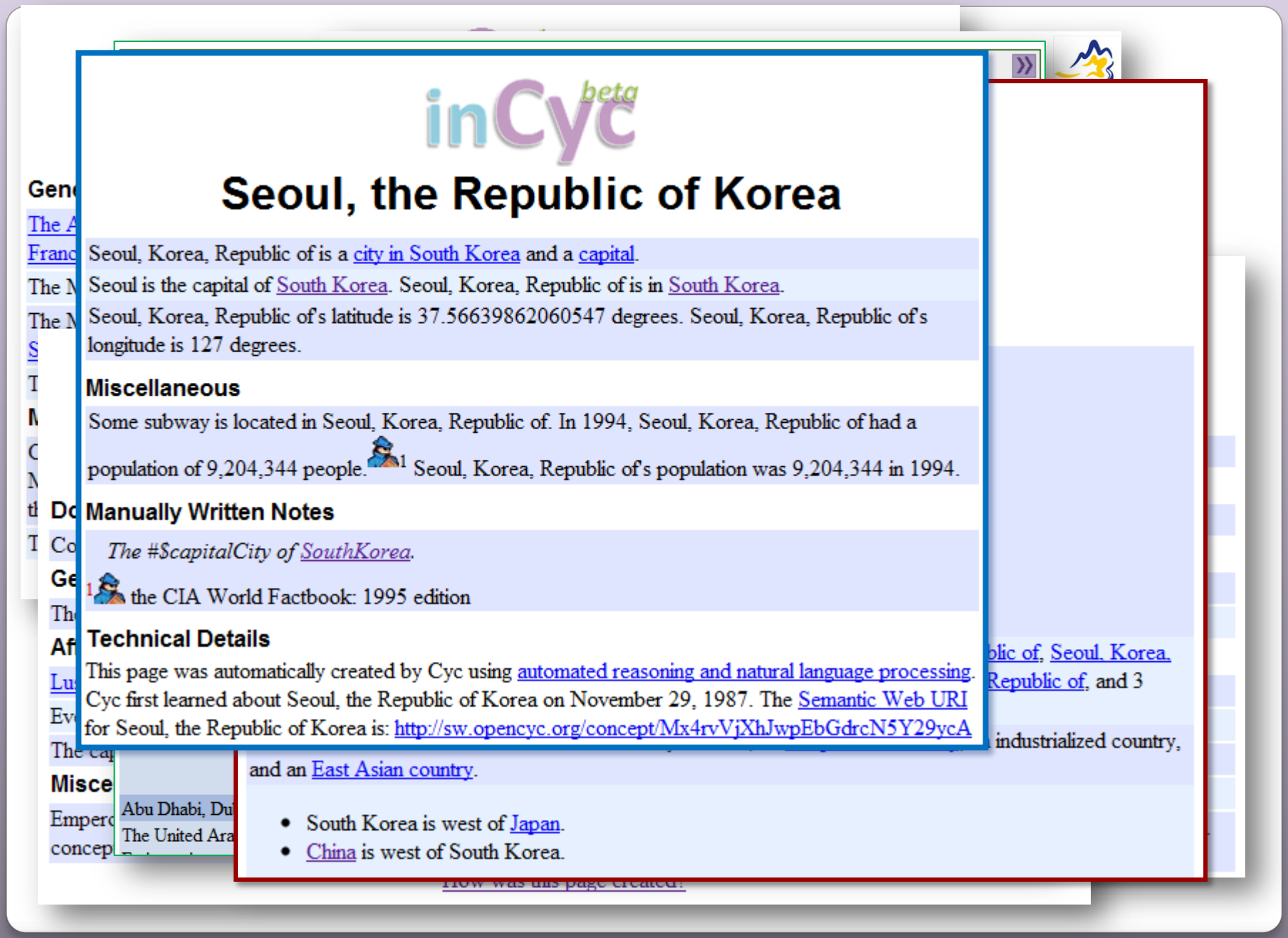
BASIC DATA		
PREDICATE	VALUE	DATE RANGE
Predominant Language	the Korean language	always
Neighbor	North Korea	always
Capital city	Seoul, the Republic of Korea	always

Pusan, Korea, Republic of, Taegu-jikhalsi, Korea, Republic of, Kunsan, Korea, Republic of, Seoul, Korea, Republic of, Mokpo, Korea, Republic of, Ulsan, Korea, Republic of, Inchon, Korea, Republic of, and 3 other cities in South Korea are in South Korea.

South Korea is an elected member of the Security Council, an independent country, an industrialized country, and an East Asian country.

- South Korea is west of Japan.
- China is west of South Korea.

incyc.cyc.com


inCyc beta
Seoul, the Republic of Korea
Seoul, Korea, Republic of is a city in South Korea and a capital.
Seoul is the capital of South Korea. Seoul, Korea, Republic of is in South Korea.
Seoul, Korea, Republic of's latitude is 37.56639862060547 degrees. Seoul, Korea, Republic of's longitude is 127 degrees.
Miscellaneous
Some subway is located in Seoul, Korea, Republic of. In 1994, Seoul, Korea, Republic of had a population of 9,204,344 people.[1] Seoul, Korea, Republic of's population was 9,204,344 in 1994.
Manually Written Notes
The #$CapitalCity of SouthKorea.
[1] the CIA World Factbook: 1995 edition
Technical Details
This page was automatically created by Cyc using automated reasoning and natural language processing. Cyc first learned about Seoul, the Republic of Korea on November 29, 1987. The Semantic Web URI for Seoul, the Republic of Korea is: http://sw.opencyc.org/concept/Mx4rvVjXhJwpEbGdrcN5Y29ycA
and an East Asian country.
South Korea is west of Japan.
China is west of South Korea.

inCyc beta

Republic of the Congo

BASIC DATA		
PREDICATE	VALUE	DATE RANGE
Predominant Language	French	always
Government Type	people's republic	always
Capital city	Brazzaville, Congo	always
Neighbor	Cameroon	always
Neighbor	Angola	
Neighbor	Gabon	
Neighbor	Democratic Republic of the Congo	
Neighbor	Central African Republic	

- Niari,
- Pool,
- Cuvette,
- Plateaux,
- and Brazzaville

are in Republic of the Congo.

Seoul, Korea
Seoul is the
Seoul, Korea
longitude is 1

Miscellane

Some subwa

population o

Manually

The #Scap

the CIA

Technical

This page wa
Cyc first lear
for Seoul, the

Abu Dhab
The United Ara

- China is west of South Korea.

How was this page created?

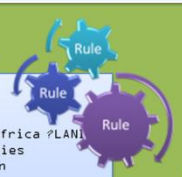
incyc.cyc.com

Facts and Rules (from 1998, 2003)

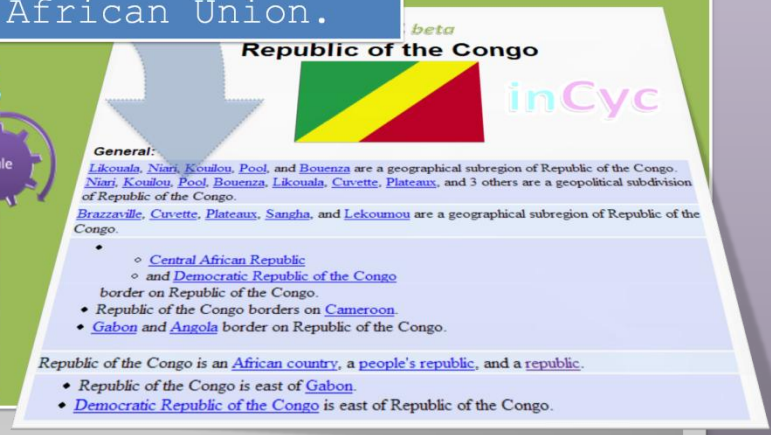
```
Mt : InternationalOrganizationDataMt
(internationalOrganizationMemberCountries
AfricanUnion Congo-Brazzaville)
(internationalOrganizationMemberCountries
UnitedNationsOrganization Congo-Brazzaville)

(implies  (and
      (isa ?COUNTRY IndependentCountry)
      (territoryOf ?COUNTRY ?LAND)
      (geographicalSubRegions ContinentOfAfrica
         ?LAND))
   (internationalOrganizationMemberCountries
OrganizationOfAfricanUnity ?COUNTRY))
```

Republic of the Congo is a member of Organization of African Unity, the United Nations, and African Union.

Automated Reasoning




```
(implies (and
   (isa ?COUNTRY IndependentCountry)
   (territoryOf ?COUNTRY ?LAND)
   (geographicalSubRegions ContinentOfAfrica ?LAND))
 (internationalOrganizationMemberCountries
OrganizationOfAfricanUnity ?COUNTRY)) in
InternationalOrganizationDataMt
(territoryOf Congo-Brazzaville
  TerritoryFn Congo-Brazzaville)) in
WorldPoliticalGeographyDataVocabularyMt
(properGeographicalSubRegions ContinentOfAfrica
  TerritoryFn Congo-Brazzaville)) in
WorldGeographyMt :GENLPREDS (genlPreds
properGeographicalSubRegions geographicalSubRegions)
in InternationalOrganizationDataMt
:ISA (isa Congo-Brazzaville IndependentCountry) in
InternationalOrganizationDataMt
```



Knowledge for People

People

- (isa occupation BioDataPredicate)
- (isa dateOfDeathEvent BioDataPredicate)
- (isa placeOfDeath BioDataPredicate)
- (isa citizens BioDataPredicate)
- (isa ethnicity BioDataPredicate)
- (isa birthPlace BioDataPredicate)
- (isa dateOfDeath BioDataPredicate)
- (isa birthDate BioDataPredicate)

Agent Location

Mt : BaseKB
Direction : Backward

```
M(implies
   (and
      (genlPreds ?SPEC hasBeenIn)
      (ist-Asserted ?MT
         (?SPEC ?ARG1 ?ARG2)))
   (agentLocationDataSentence ?ARG1
      (ist ?MT
         (?SPEC ?ARG1 ?ARG2))))
```

Agent Affiliation

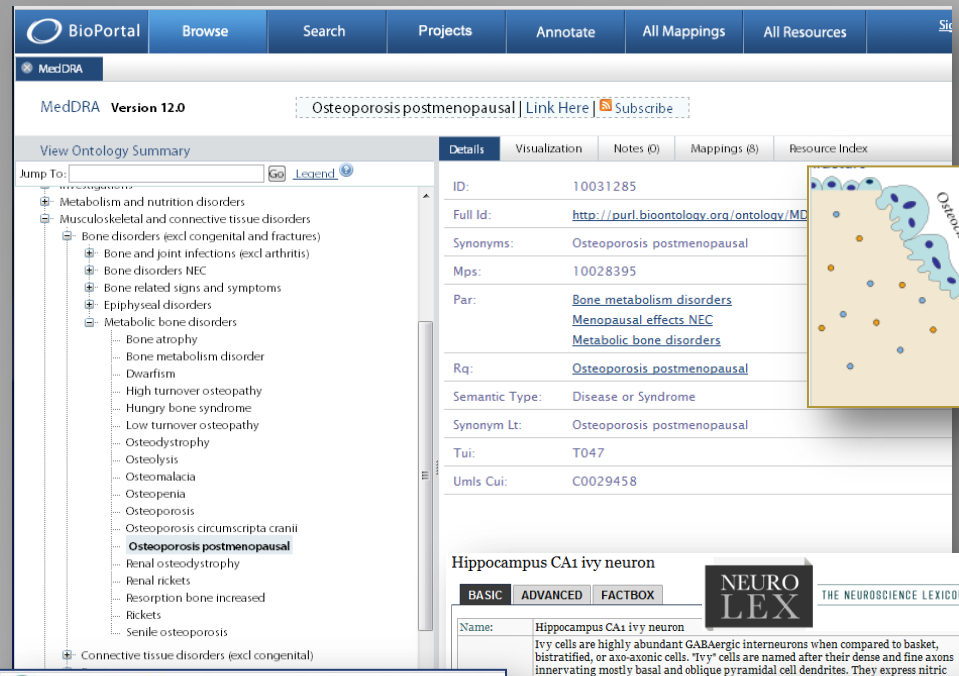
```
M(implies
   (and
      (genlPreds ?SPEC affiliatedWith)
      (ist-Asserted ?MT
         (?SPEC ?ARG1 ?ARG2)))
   (agentAffiliationDataSentence ?ARG2
      (ist ?MT
         (?SPEC ?ARG1 ?ARG2))))
M(implies
   (and
      (genlPreds ?SPEC affiliatedWith)
      (ist-Asserted ?MT
         (?SPEC ?ARG1 ?ARG2)))
   (agentAffiliationDataSentence ?ARG1
      (ist ?MT
         (?SPEC ?ARG1 ?ARG2))))
```

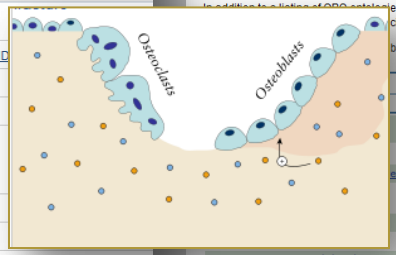
What goes on a inCyc Page?

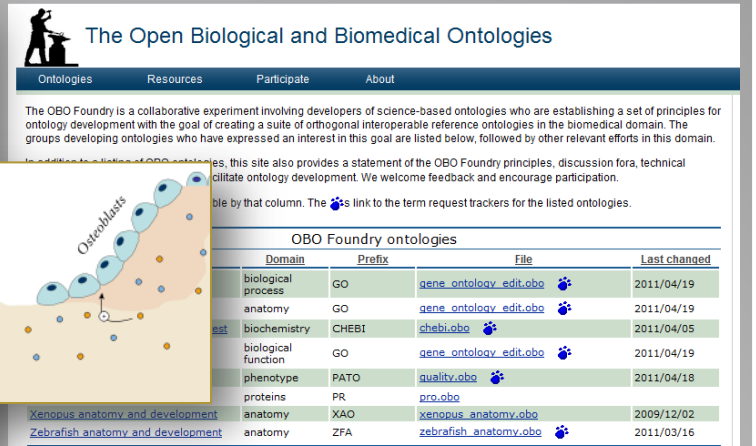
InCyc HTML Production Rules

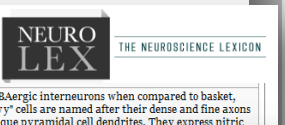
```
M(implies
  (and
    (isa ?PRED BasicDataPredicate)
    (miniFactSheetFlagHtml ?TOPIC ?FLAG-IMAGE-HTML)
    (?PRED ?TOPIC ?DATA)
    (evaluate ?FLAG-DATUM
      (HTMLTableDataFn
        (TheList
          (TheList Rowspan-HTMLTagAttribute 3)) ?FLAG-IMAGE-HTML))
    (evaluate ?ROW
      (HTMLTableRowFn TheEmptyList ?FLAG-DATUM ?ROW1))
    (evaluate ?ROW1
      (HTMLTableDataFn TheEmptyList
        (BasicDatumParaphraseFn
          (NthInListFn ?DATA 1) ?MT)))
    (evaluate ?ROW2
      (HTMLTableRowFn TheEmptyList
        (HTMLTableDataFn TheEmptyList
          (BasicDatumParaphraseFn
            (NthInListFn ?DATA 2) ?MT))))
    (evaluate ?ROW3
      (HTMLTableRowFn TheEmptyList
        (HTMLTableDataFn TheEmptyList
          (BasicDatumParaphraseFn
            (NthInListFn ?DATA 3) ?MT))))
    (evaluate ?TABLE
      (HTMLTableFn TheEmptyList ?ROW ?ROW2 ?ROW3)))
  (basicDataHTML ?TOPIC ?MT ?TABLE))
```

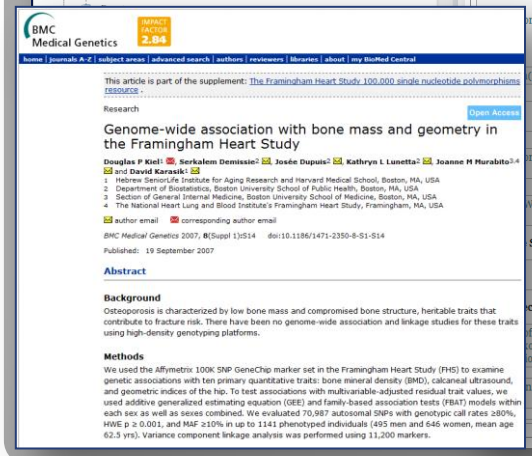
Use case – systems biology

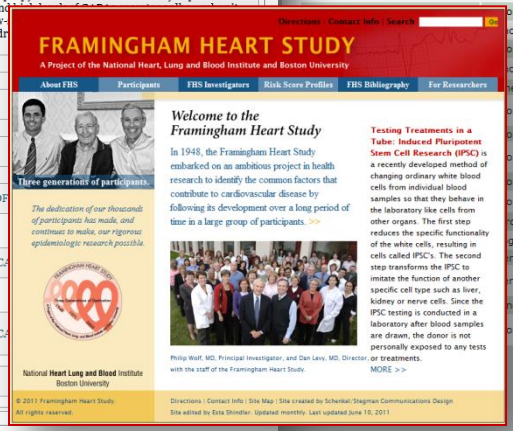


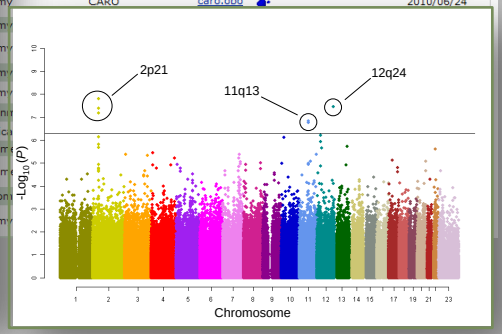




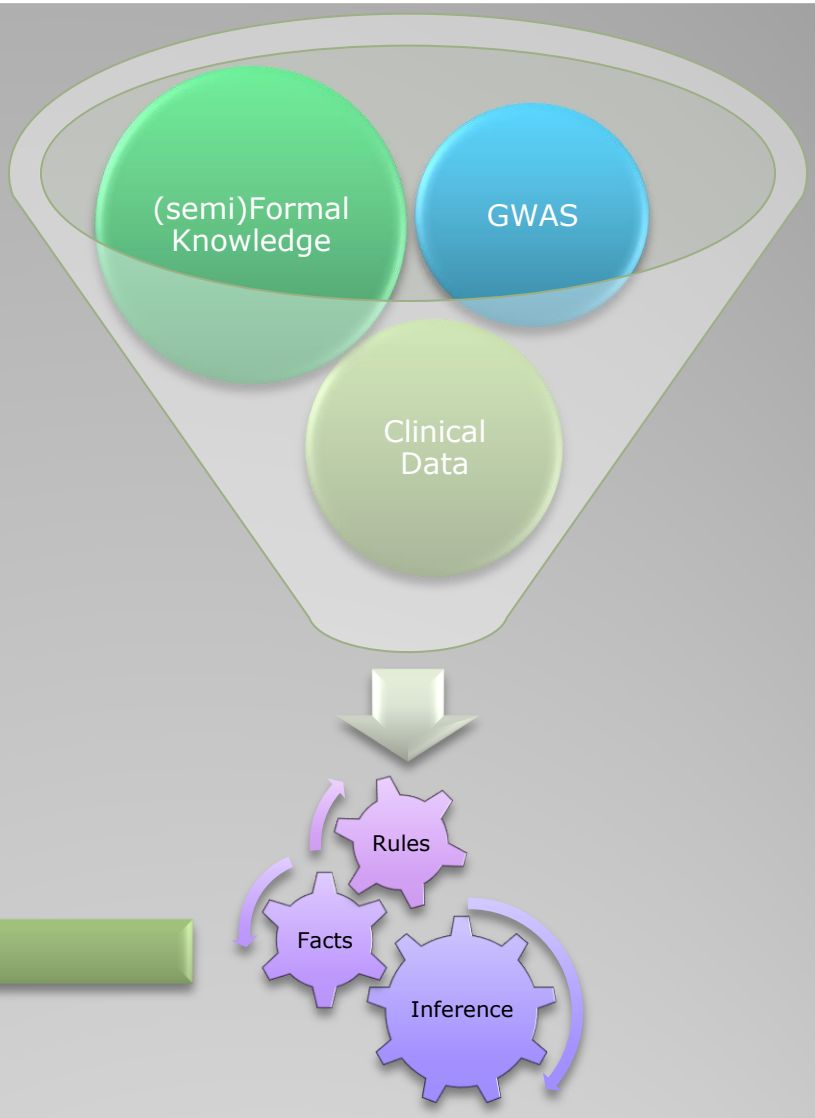






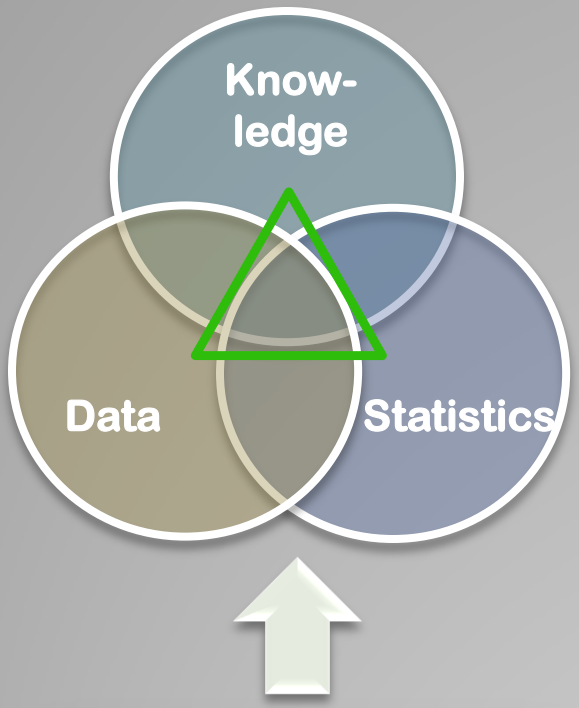


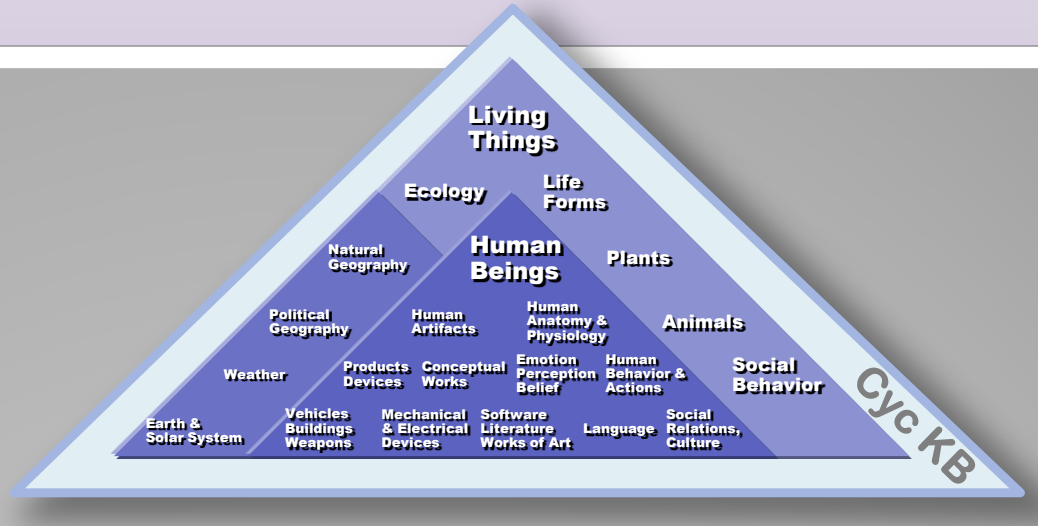
Overwhelming Biological Data

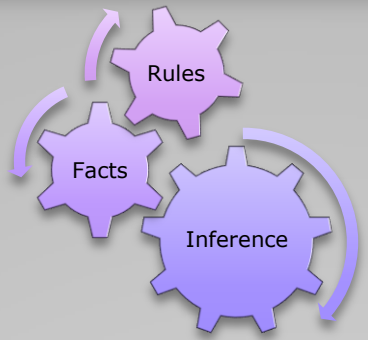


Clinical or Experimental Hypotheses

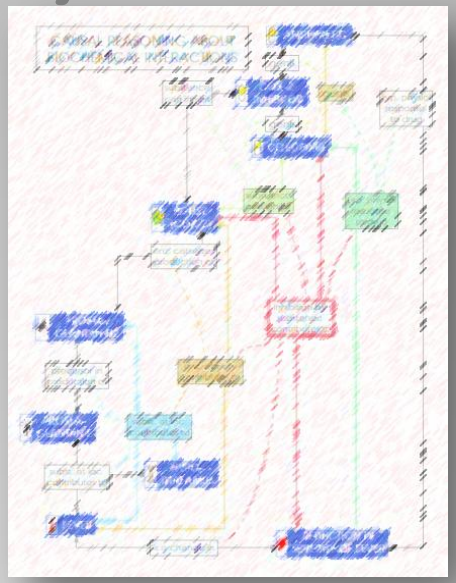
The Big Picture: AI assistance







Cyc Inference



linked life data

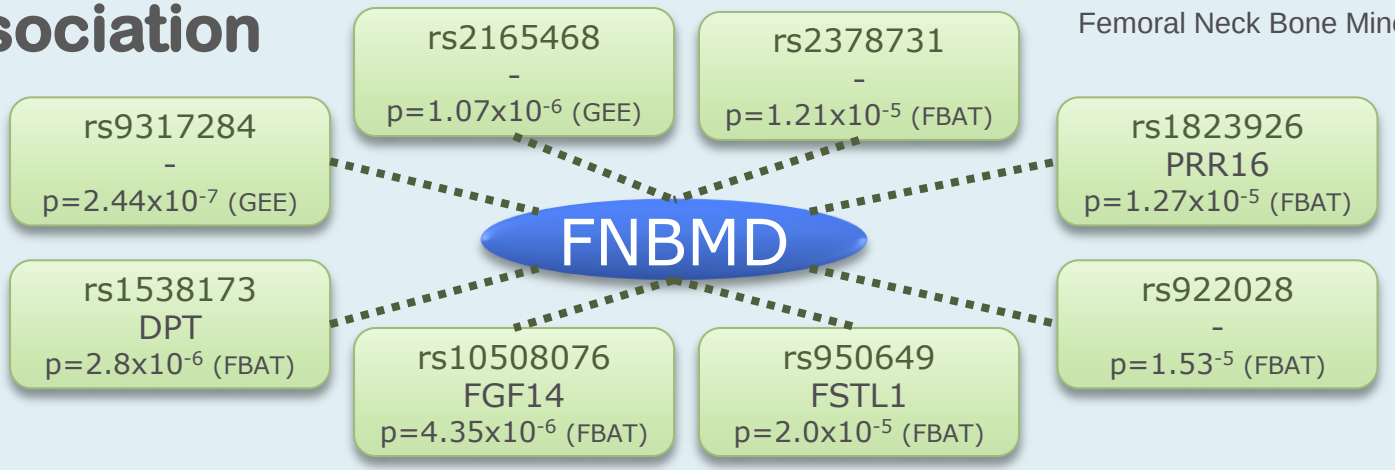
a semantic data integration platform for the biomedical domain

Focus: Osteoporosis and the Framingham Heart Study data

The Big Picture: AI assistance

Association

Femoral Neck Bone Mineral Density GWAS



Douglas P Kiel , Serkalem Demissie , Josée Dupuis , Kathryn L Lunetta , Joanne M Murabito and David Karasik Genome-wide association with bone mass and geometry in the Framingham Heart Study *BMC Medical Genetics* 2007, **8**(Suppl 1):S14

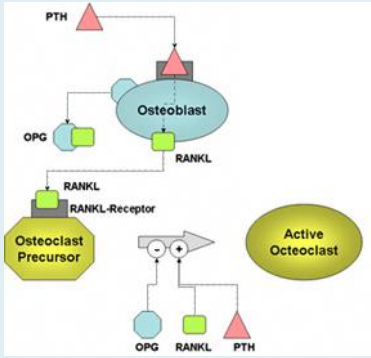
Weak Models

- term/document associations
- gene interactions
- label match in DB

Strong Models

Knowledge of constraints, temporal and spatial ordering, temporal and physical parts, preconditions, consequences, rates, etc.

- Molecular interactions
- Receptors, ligands, etc.
- Cell types, stages
- Cell macro, micro processes



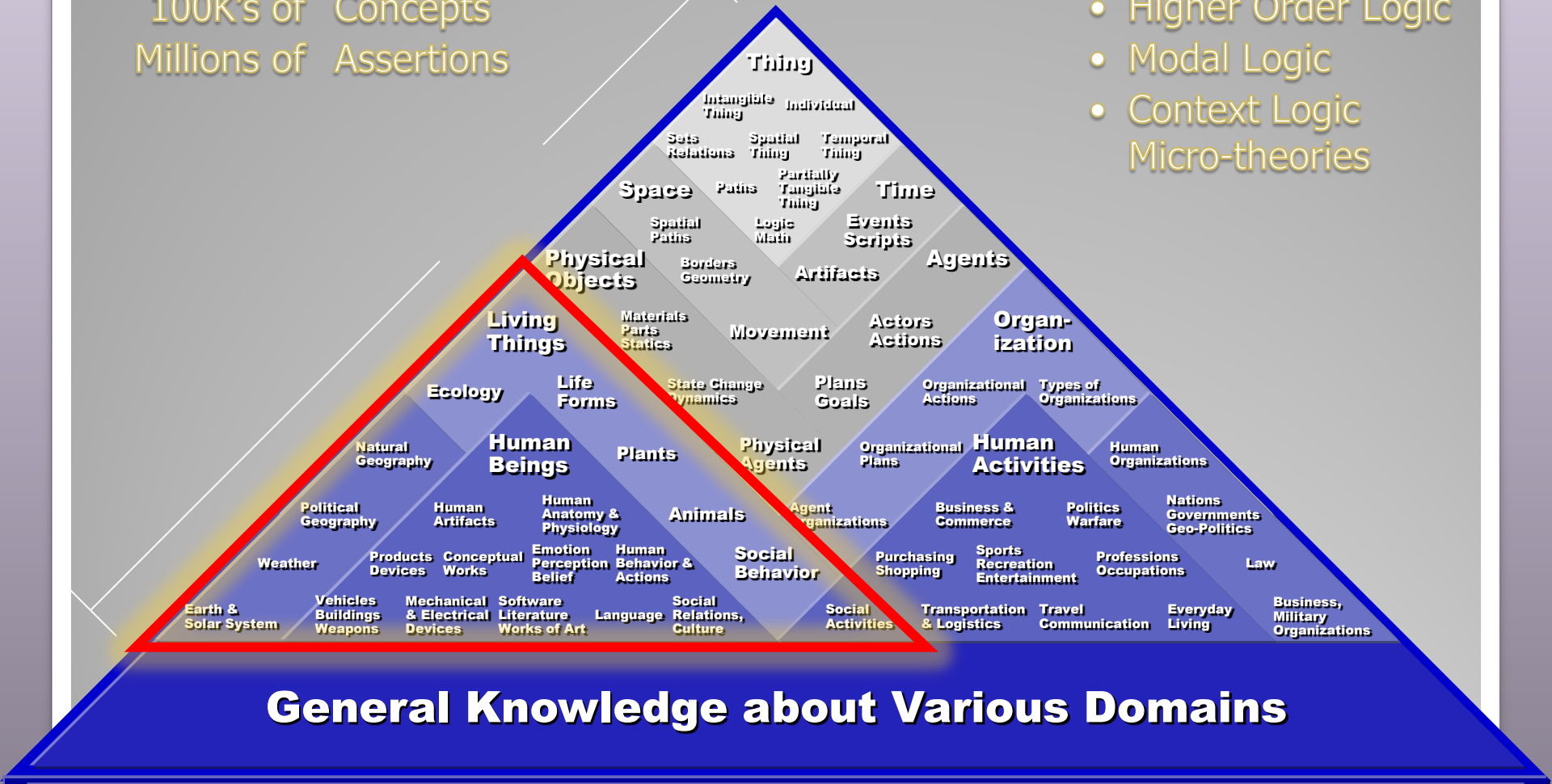
Types of Reasoning, Knowledge

Cyc contains:

10K's of Predicates
100K's of Concepts
Millions of Assertions

Represented in:

- First Order Logic
- Higher Order Logic
- Modal Logic
- Context Logic
  Micro-theories

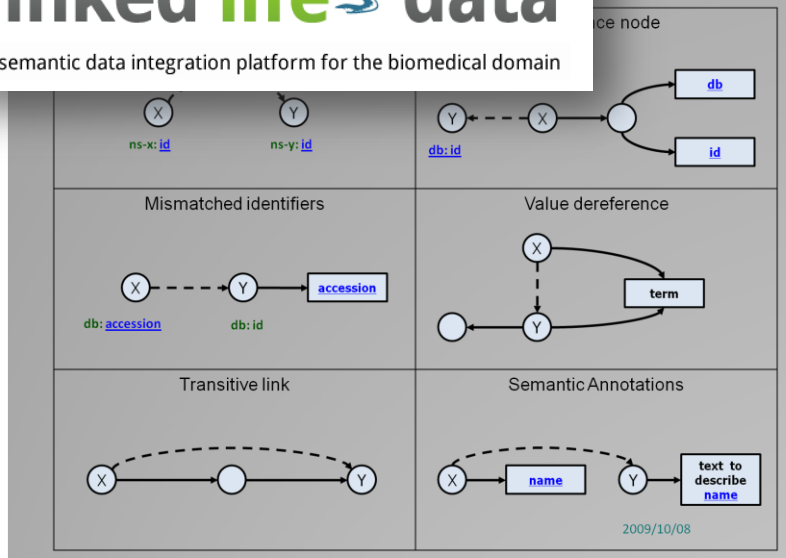


General Knowledge about Various Domains

Specific data, facts, and observations

linked life data

a semantic data integration platform for the biomedical domain



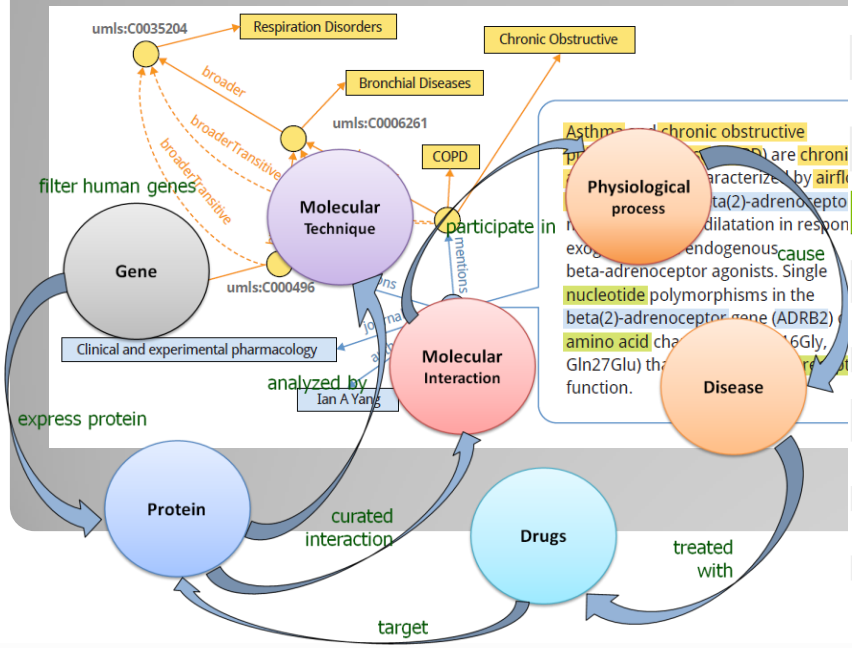
Number of Statements	5,512,293,218
Explicit statements	5,155,779,890
Inferred statements	356,523,328
Size on disk	~320GB
Unique users Jan-Aug 2010	10,226

27 sources

Data source	Named graph	Load date	Number of statements	Instances type
Disease Ontology (Reference, License)	http://linkedlifedata.com/resource/diseaseontology	21.10.10	144,541	diseaseontology:DiseaseOntologyConcept
LinkedCT (Reference, License)	http://linkedlifedata.com/resource/linkedct	14.10.10	[illegible],027,37[illegible]	[illegible]k[illegible]ct:[illegible]on[illegible]tion
Reactome (Reference, License)	http://linkedlifedata.com/resource/reactome	24.09.10	698,567	biopax-2:entity
HPRD (Reference, License)	http://linkedlifedata.com/resource/hprd	24.09.10	1,917,107	biopax-2:entity
DBPedia (Reference, License)	http://linkedlifedata.com/resource/dbpedia	20.07.10	496,360,473	skos:Concept
UniProt (Reference, License)	http://linkedlifedata.com/resource/uniprot	04.09.10	1,832,491,127	uniprot:Protein
CellMap (Reference, License)	http://linkedlifedata.com/resource/cell-map	24.09.10	148,346	biopax-2:entity
NCBI Entrez-Gene (Reference, License)	http://linkedlifedata.com/resource/entrezgene	18.10.10	140,024,275	entrezgene:Gene
UMLS	http://linkedlifedata.com/resource/umls	25.11.09	110,568,086	skos:Concept

29 types of link

Source dataset	Destination dataset	Linked Data Mapping Rule	Number of connections	Semantic relationship
BioPax Proteins	UniProt	Reference Node	148,941	skos:exactMatch
Drug from DrugBank	Disease from DISEASOME	Causality Relation Extraction	8,201	relationontology:treat
UniProt proteins	UniProt keywords	Causality Relation Extraction	9[illegible]4	relationontology:expressedInanamicalSystem
LinkedCT criteria	UMLS concepts	Semantic Annotation	844,390	relationontology:hasExclusionCriteria
UniProt GO terms	UMLS concepts (GO)	Mismatched Identifiers	51,024	skos:exactMatch
EntrezGene	UniProt	Causality Relation Extraction	4,923,807	relationontology:encodeProtein
UniProt proteins	GO terms	Causality Relation Extraction	5,053,151	relationontology:hasLocalization
BioPax GO	UMLS concepts (GO)	Reference Node	301,655	skos:relatedMatch
UMLS concepts (NCBI Taxonomy)	UniProt organisms	Value Dereference	412,297	skos:exactMatch
UMLS concepts (MeSH)	PubMed MeSH terms	Value Dereference	25,306	skos:exactMatch
UniProt proteins	GO terms	Causality Relation Extraction	4,000,000	relationontology:participateInBiologicalProcess



First Order

```
(isa AVPR2-Human-GIS GeneTypeBySpeciesAndProductFamily)
(gene-GISTypeCodesForType AVPR2-Human-GIS VasopressinV2Receptor)
```

With Context

```
In Mt : VertebratePhysiologyMt
(relationExistsAll outputsCreated IntramembranousBoneGrowthAndDevelopment FlatBone)
```

Each *vertebrate* flat bone was created by intramembranous bone development.

Rule

```
In Mt: MolecularBiologyMt
(implies
   (isa ?MOLECULE-TYPE TranscriptionFactor)
   (behaviorCapable ?MOLECULE-TYPE
         (ChemicalBindingEventTypeWithTypesFn TranscriptionFactor DNAMolecule)
         objectOfAttachment))
```

Transcription factors can bind with DNA.

Exceptions

```
(implies (and (isa ?MUT GeneticMutationEvent-Cellular)
     (locusOfCellularProcess-Cell ?MUT ?ANCESTOR)
     (isa ?ANCESTOR Cell)
     (subEvents ?REPRO ?MUT))
   (abnormal (TheList ?REPRO ?PROGENY ?ANCESTOR)
     (implies(and
            (isa ?REPRO AsexualReproductionEvent)
            (outputsCreated ?REPRO ?PROGENY)
            (isa ?PROGENY BiologicalLivingObject)
            (doneBy ?REPRO ?ANCESTOR))
        (geneticallyIdentical ?ANCESTOR ?PROGENY))))
```

Normally, the progeny of asexual reproduction are genetically identical to the parent; however, if the parent is a cell in which a mutation has occurred, this rule doesn't apply.

Syntactic Power

1. Douglas P Kiel , Serkalem Demissie , Josée Dupuis , Kathryn L Lunetta , Joanne M Murabito and David Karasik. **Genome-wide association with bone mass** and geometry in the Framingham Heart Study *BMC Medical Genetics* 2007, **8**(Suppl 1):S14

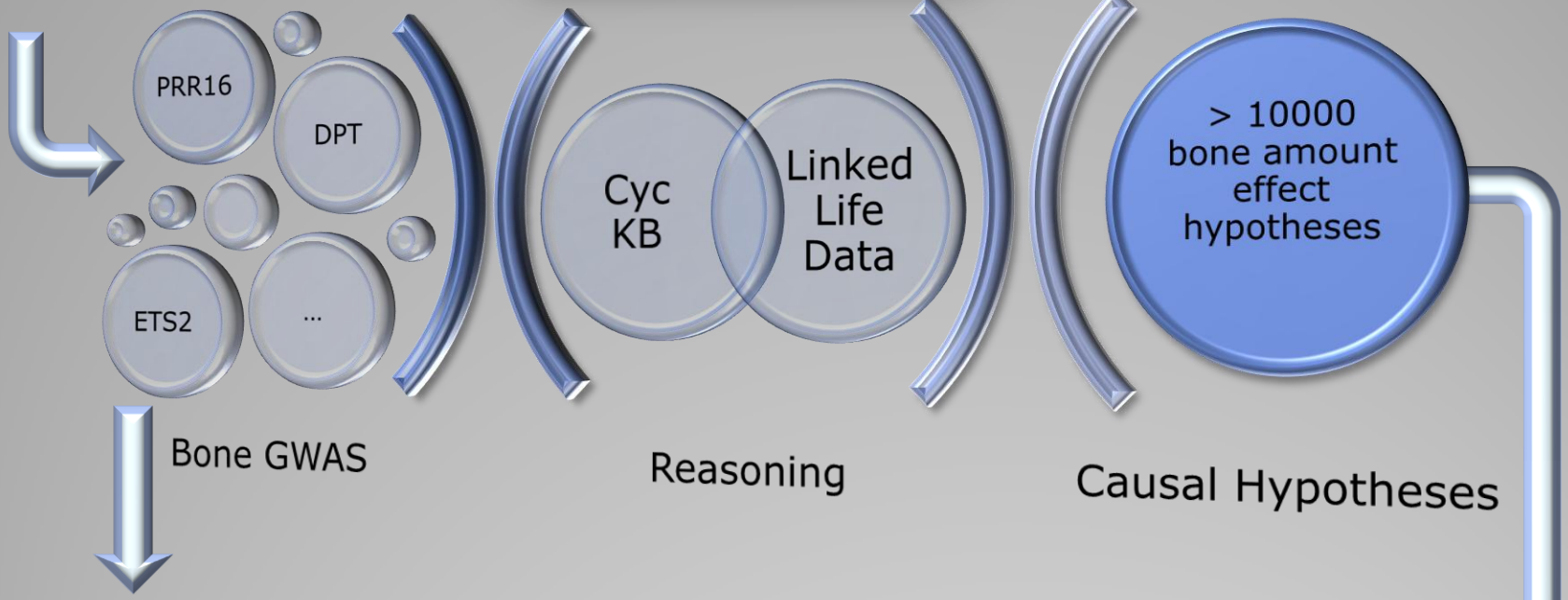
2. **Hsu Y-H, Zillikens MC, Wilson SG, Farber CR, Demissie S, et al. (2010)** An Integration of **Genome-Wide Association Study** and Gene Expression Profiling to Prioritize the Discovery of Novel Susceptibility Loci **for Osteoporosis-Related Traits**. PLoS Genet 6(6): e1000977.

TestQueryFnLLGeneImpactBoneTest2FnETS2-Human-GIS4

What values of *ITEM0*, *ITEM1*, *ITEM2*, and *ITEM3* are there such that

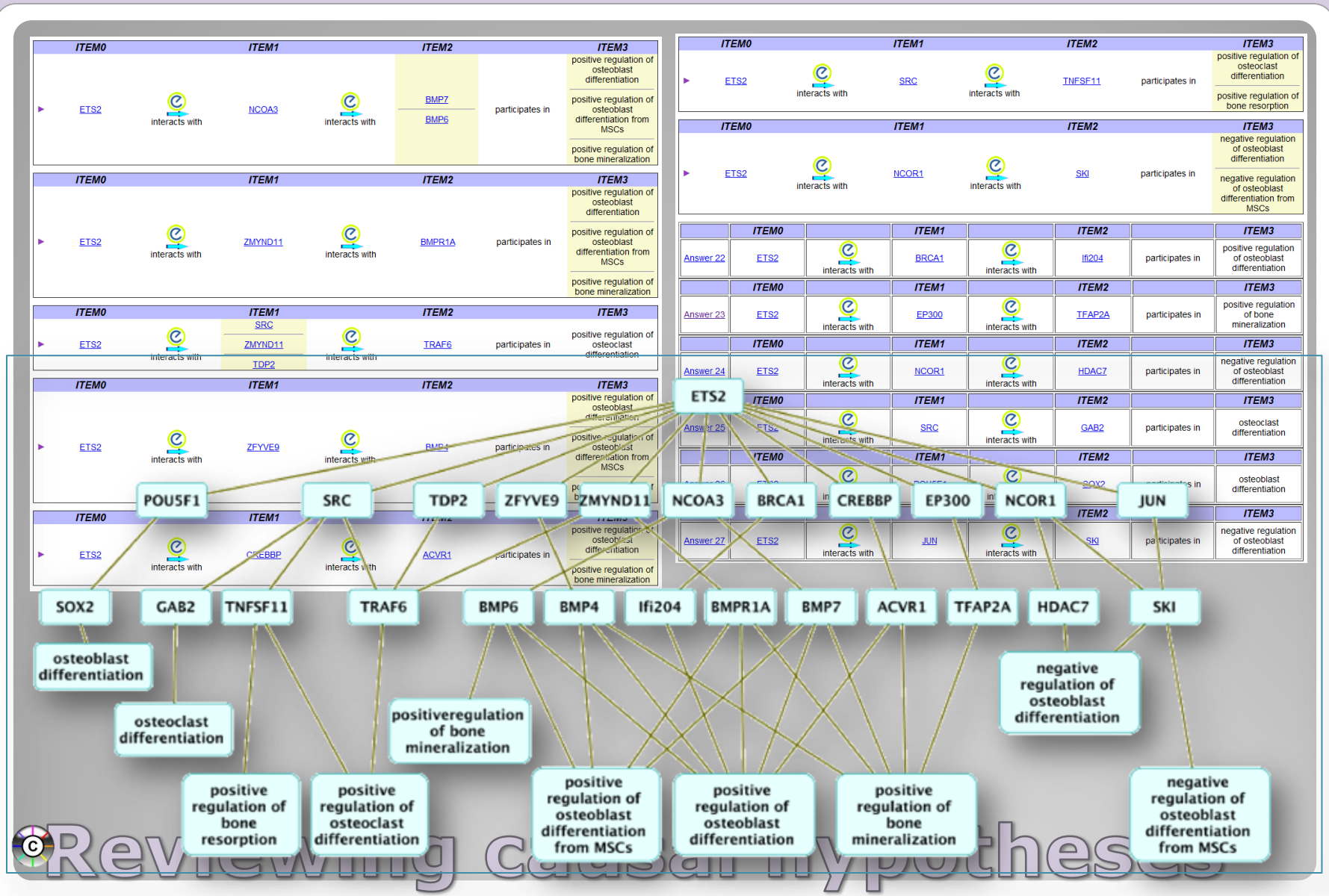
- *ITEM0* and ETS2 are identical symbols,
- there is some evidence that *ITEM0* affects *ITEM1*,
- there is some evidence that *ITEM1* affects *ITEM2*,
- there is some evidence that *ITEM2* affects *ITEM3*,
- there is some evidence that *ITEM3* affects the quantity of bone tissue present,
- and *ITEM0* is not *ITEM1*, *ITEM2*, or *ITEM3*?

Logic Query



ITEM0		ITEM1		ITEM2		ITEM3
ETS2	interacts with	NCOA3	interacts with	BMP7	participates in	positive regulation of osteoblast differentiation
				BMP6		positive regulation of osteoblast differentiation from MSCs
						positive regulation of bone mineralization

Pilot experiment: GWAS-bone


ITEM0 ITEM1 ITEM2 ITEM3
ETS2 interacts with NCOA3 interacts with BMP7 BMP6 participates in positive regulation of osteoblast differentiation | positive regulation of osteoblast differentiation from MSCs | positive regulation of bone mineralization
ETS2 interacts with ZMYND11 interacts with BMPR1A participates in positive regulation of osteoblast differentiation | positive regulation of osteoblast differentiation from MSCs | positive regulation of bone mineralization
ETS2 interacts with SRC ZMYND11 TDP2 interacts with TRAF6 participates in positive regulation of osteoclast differentiation
ETS2 interacts with ZFYVE9 interacts with BMP4 participates in positive regulation of osteoblast differentiation | positive regulation of osteoblast differentiation from MSCs | positive regulation of bone mineralization
ETS2 interacts with CREBBP interacts with ACVR1 participates in positive regulation of osteoblast differentiation | positive regulation of bone mineralization
ETS2 interacts with SRC interacts with TNFSF11 participates in positive regulation of osteoclast differentiation | positive regulation of bone resorption
ETS2 interacts with NCOR1 interacts with SKI participates in negative regulation of osteoblast differentiation | negative regulation of osteoblast differentiation from MSCs
Answer 22 ETS2 interacts with BRCA1 interacts with Ifi204 participates in positive regulation of osteoblast differentiation
Answer 23 ETS2 interacts with EP300 interacts with TFAP2A participates in positive regulation of bone mineralization
Answer 24 ETS2 interacts with NCOR1 interacts with HDAC7 participates in negative regulation of osteoblast differentiation
Answer 25 ETS2 interacts with SRC interacts with GAB2 participates in osteoclast differentiation
Answer 27 ETS2 interacts with JUN interacts with SKI participates in negative regulation of osteoblast differentiation
ETS2
POU5F1 SRC TDP2 ZFYVE9 ZMYND11 NCOA3 BRCA1 CREBBP EP300 NCOR1 JUN
SOX2 GAB2 TNFSF11 TRAF6 BMP6 BMP4 Ifi204 BMPR1A BMP7 ACVR1 TFAP2A HDAC7 SKI
osteoblast differentiation
osteoclast differentiation
positiveregulation of bone mineralization
negative regulation of osteoblast differentiation
positive regulation of bone resorption
positive regulation of osteoclast differentiation
positive regulation of osteoblast differentiation from MSCs
positive regulation of osteoblast differentiation
positive regulation of bone mineralization
negative regulation of osteoblast differentiation from MSCs
Reviewing causal hypotheses

Answer:

ITEM0: ETS2
ITEM1: NCOA3
ITEM2: BMP7
ITEM3: positive regulation of osteoblast differentiation

Because: | Detailed Justification: | Linear Justification:

Detailed Justification:

- There is some evidence that ETS2 affects NCOA3.
- There is some evidence that BMP7 affects positive regulation of osteoblast differentiation.
  - If the evidence given for a type of biological process having a type of chemical object as a participant is experimental evidence (as opposed to evidence based on structural similarity or computer matching), and a particular gene codes for that chemical object type, then conclude that instances of the process type typically have the product of that gene as participants.
  - Inferred from direct assay is a type of experimental evidence.[1]
  - The evidence for Bone morphogenetic protein 7's participation in the positive regulation of osteoblast differentiation was provided by direct assay.
  - BMP7 codes for Bone morphogenetic protein 7.
    - If, according to EntrezGene, a gene has a particular term in UniProt as its "uniprotAccession", that gene codes for the type of peptide molecule represented by the UniProt term.

      According to EntrezGene, "BMP7" codes for Bone morphogenetic protein 7.
- There is some evidence that NCOA3 affects BMP7.
- Inferred from direct assay is a type of experimental evidence.[1]
- There is some evidence that positive regulation of osteoblast differentiation affects the quantity of bone tissue present.

  Positive regulation of osteoblast differentiation is more specific than biological processes.

External Sources:

[1]Linked Life Ontology

Human-Readable Explanations

Because: | Detailed Justification: | Linear Justification:

Detailed Justification:

There is some evidence that ETS2 affects NCOA3.

```
(couldImpact-BackchainRequired ETS2-Human-GIS
    (SchemaObjectFn BioOWLCodeMapping "gene:8202"))
```

There is some evidence that BMP7 affects positive regulation of osteoblast differentiation.

```
(couldImpact-BackchainRequired
    (SchemaObjectFn BioOWLCodeMapping "gene:655")
    (PositiveRegulationOfTypeFn OsteoblastDifferentiation))
```

There is some evidence that NCOA3 affects BMP7.

```
(couldImpact-BackchainRequired
    (SchemaObjectFn BioOWLCodeMapping "gene:8202")
    (SchemaObjectFn BioOWLCodeMapping "gene:655"))
```

If, according to EntrezGene, gene A has an interaction in which gene B is the interactant, then then molecular products of genes A and B interact.

```
M(implies
      (and
          (interactant-EntrezGene ?INTERACTION ?GENE2)
          (interaction-EntrezGene ?GENE1 ?INTERACTION))
      (productsOfGene-GISTypesInteract ?GENE2 ?GENE1)) in BioOWLBridgingMt
```

According to EntrezGene, "NCOA3" is the interactant in http://linkedlifedata.com/resource/entrezgene/interaction/655-8202.

```
:SKSI (interactant-EntrezGene
        (SchemaObjectFn BioOWLCodeMapping "<http://linkedlifedata.com/resource/entrezgene/interaction/655-8202>")
        (SchemaObjectFn BioOWLCodeMapping "gene:8202"))
      in (ContentMtFn BioOWLIMLinkedLifeTripleStoreKS)
```

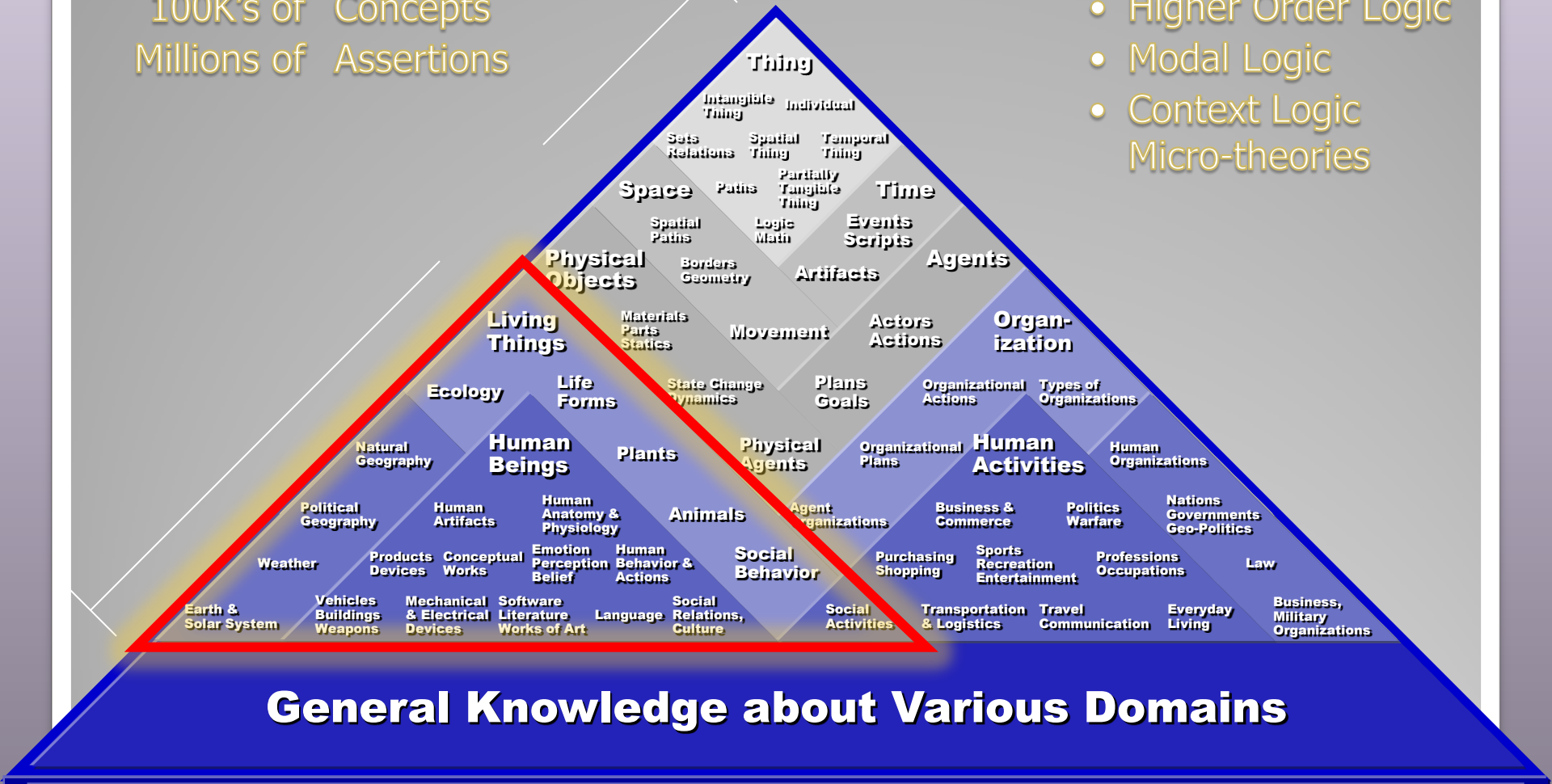
Clearer than logic

Cyc contains:

10K's of Predicates
100K's of Concepts
Millions of Assertions

Represented in:

- First Order Logic
- Higher Order Logic
- Modal Logic
- Context Logic
  Micro-theories



General Knowledge about Various Domains

Specific data, facts, and observations

First Order

```
(isa AVPR2-Human-GIS GeneTypeBySpeciesAndProductFamily)
(gene-GISTypeCodesForType AVPR2-Human-GIS VasopressinV2Receptor)
```

With Context

```
In Mt : VertebratePhysiologyMt
(relationExistsAll outputsCreated IntramembranousBoneGrowthAndDevelopment FlatBone)
```

Each *vertebrate* flat bone was created by intramembranous bone development.

Rule

```
In Mt: MolecularBiologyMt
(implies
   (isa ?MOLECULE-TYPE TranscriptionFactor)
   (behaviorCapable ?MOLECULE-TYPE
         (ChemicalBindingEventTypeWithTypesFn TranscriptionFactor DNAMolecule)
         objectOfAttachment))
```

Transcription factors can bind with DNA.

Exceptions

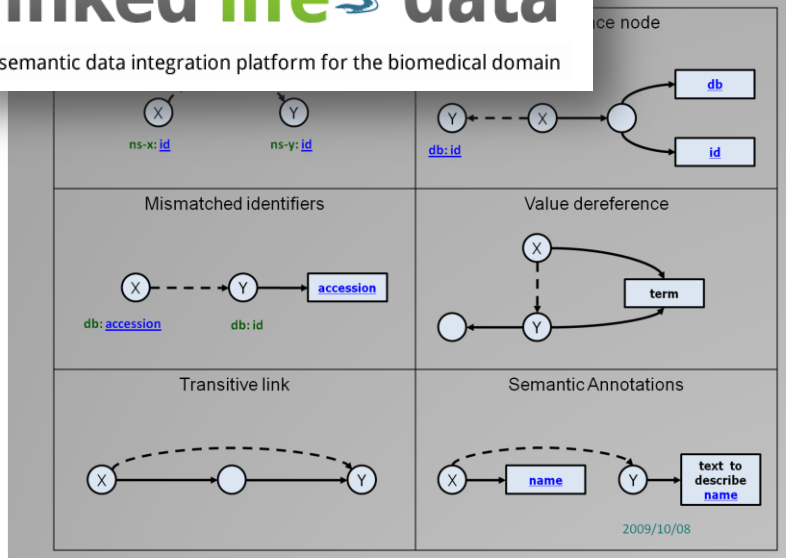
```
(implies (and (isa ?MUT GeneticMutationEvent-Cellular)
     (locusOfCellularProcess-Cell ?MUT ?ANCESTOR)
     (isa ?ANCESTOR Cell)
     (subEvents ?REPRO ?MUT))
   (abnormal (TheList ?REPRO ?PROGENY ?ANCESTOR)
     (implies(and
            (isa ?REPRO AsexualReproductionEvent)
            (outputsCreated ?REPRO ?PROGENY)
            (isa ?PROGENY BiologicalLivingObject)
            (doneBy ?REPRO ?ANCESTOR))
        (geneticallyIdentical ?ANCESTOR ?PROGENY))))
```

Normally, the progeny of asexual reproduction are genetically identical to the parent; however, if the parent is a cell in which a mutation has occurred, this rule doesn't apply.

Syntactic Power

linked life data

a semantic data integration platform for the biomedical domain



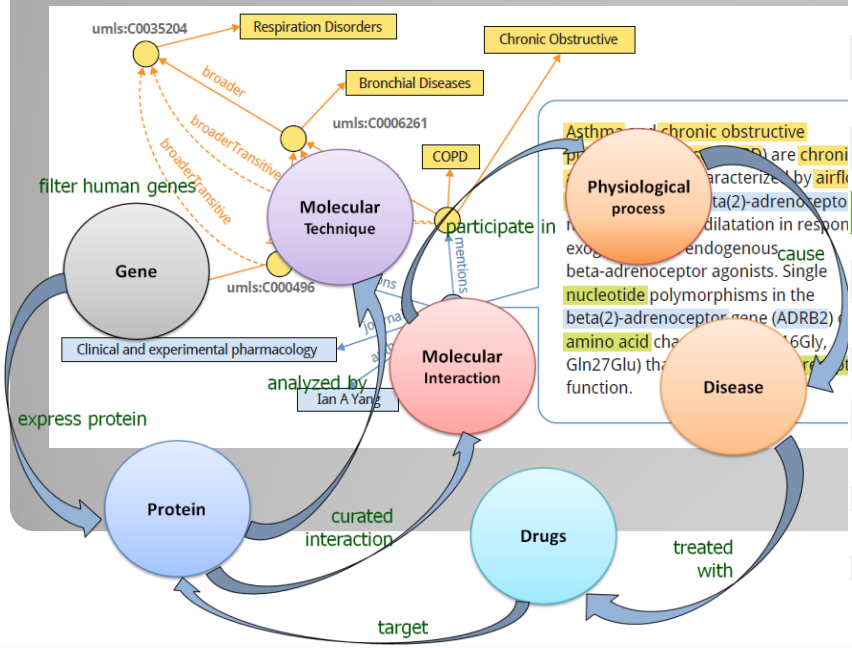
Number of Statements	5,512,293,218
Explicit statements	5,155,779,890
Inferred statements	356,523,328
Size on disk	~320GB
Unique users Jan-Aug 2010	10,226

27 sources

Data source	Named graph	Load date	Number of statements	Instances type
Disease Ontology (Reference, License)	http://linkedlifedata.com/resource/diseaseontology	21.10.10	144,541	diseaseontology:DiseaseOntologyConcept
LinkedCT (Reference, License)	http://linkedlifedata.com/resource/linkedct	14.10.10	[illegible],027,37[illegible]	[illegible]k[illegible]ct:[illegible]on[illegible]tion
Reactome (Reference, License)	http://linkedlifedata.com/resource/reactome	24.09.10	698,567	biopax-2:entity
HPRD (Reference, License)	http://linkedlifedata.com/resource/hprd	24.09.10	1,917,107	biopax-2:entity
DBPedia (Reference, License)	http://linkedlifedata.com/resource/dbpedia	20.07.10	496,360,473	skos:Concept
UniProt (Reference, License)	http://linkedlifedata.com/resource/uniprot	04.09.10	1,832,491,127	uniprot:Protein
CellMap (Reference, License)	http://linkedlifedata.com/resource/cell-map	24.09.10	148,346	biopax-2:entity
NCBI Entrez-Gene (Reference, License)	http://linkedlifedata.com/resource/entrezgene	18.10.10	140,024,275	entrezgene:Gene
UMLS	http://linkedlifedata.com/resource/umls	25.11.09	110,568,086	skos:Concept

29 types of link

Source dataset	Destination dataset	Linked Data Mapping Rule	Number of connections	Semantic relationship
BioPax Proteins	UniProt	Reference Node	148,941	skos:exactMatch
Drug from DrugBank	Disease from DISEASOME	Causality Relation Extraction	8,201	relationontology:treat
UniProt proteins	UniProt keywords	Causality Relation Extraction	9[illegible]4	relationontology:expressedInanamicalSystem
LinkedCT criteria	UMLS concepts	Semantic Annotation	844,390	relationontology:hasExclusionCriteria
UniProt GO terms	UMLS concepts (GO)	Mismatched Identifiers	51,024	skos:exactMatch
EntrezGene	UniProt	Causality Relation Extraction	4,923,807	relationontology:encodeProtein
UniProt proteins	GO terms	Causality Relation Extraction	5,053,151	relationontology:hasLocalization
BioPax GO	UMLS concepts (GO)	Reference Node	301,655	skos:relatedMatch
UMLS concepts (NCBI Taxonomy)	UniProt organisms	Value Dereference	412,297	skos:exactMatch
UMLS concepts (MeSH)	PubMed MeSH terms	Value Dereference	25,306	skos:exactMatch
UniProt proteins	GO terms	Causality Relation Extraction	4,000,000	relationontology:participateInBiologicalProcess



1. Douglas P Kiel , Serkalem Demissie , Josée Dupuis , Kathryn L Lunetta , Joanne M Murabito and David Karasik. **Genome-wide association with bone mass** and geometry in the Framingham Heart Study *BMC Medical Genetics* 2007, **8**(Suppl 1):S14

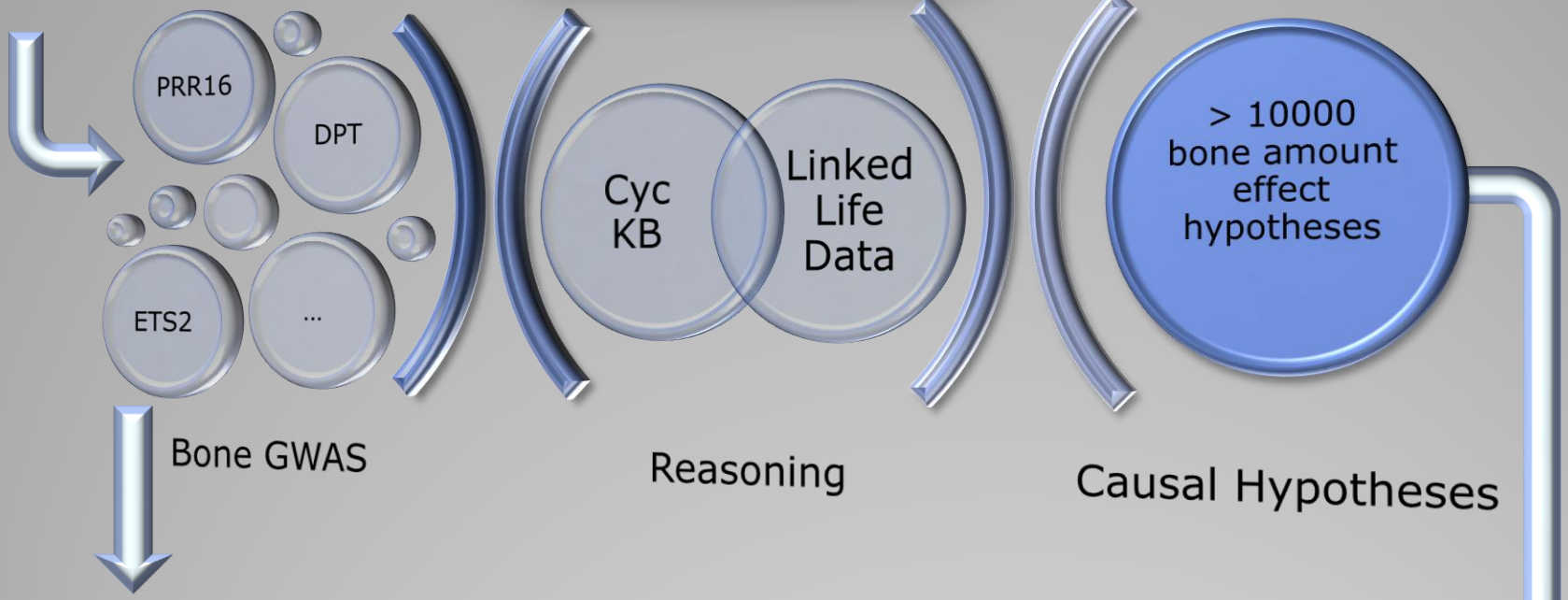
2. **Hsu Y-H, Zillikens MC, Wilson SG, Farber CR, Demissie S, et al. (2010)** An Integration of **Genome-Wide Association Study** and Gene Expression Profiling to Prioritize the Discovery of Novel Susceptibility Loci **for Osteoporosis-Related Traits**. PLoS Genet 6(6): e1000977.

TestQueryFnLLGeneImpactBoneTest2FnETS2-Human-GIS4

What values of *ITEM0*, *ITEM1*, *ITEM2*, and *ITEM3* are there such that

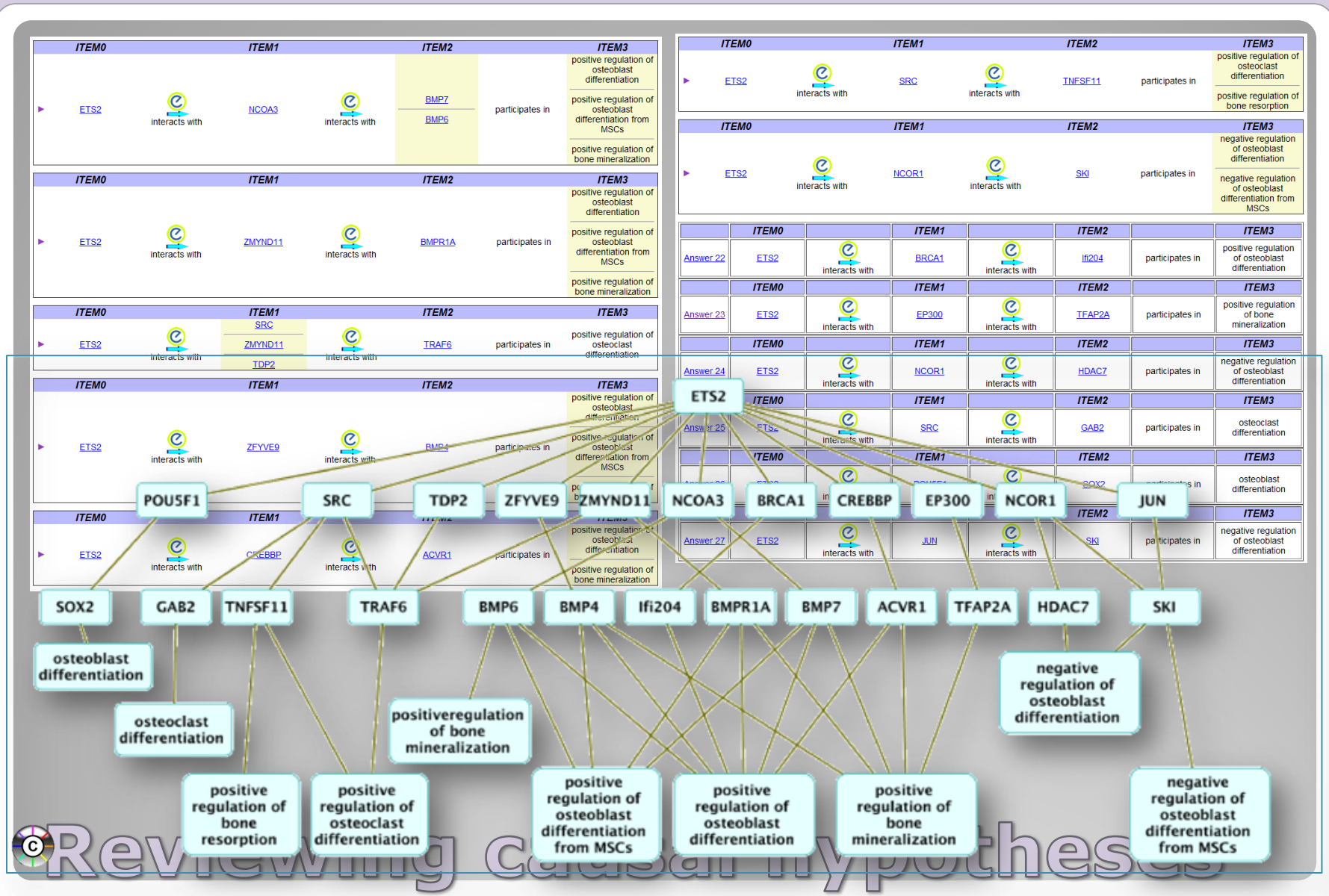
- *ITEM0* and ETS2 are identical symbols,
- there is some evidence that *ITEM0* affects *ITEM1*,
- there is some evidence that *ITEM1* affects *ITEM2*,
- there is some evidence that *ITEM2* affects *ITEM3*,
- there is some evidence that *ITEM3* affects the quantity of bone tissue present,
- and *ITEM0* is not *ITEM1*, *ITEM2*, or *ITEM3*?

Logic Query



ITEM0		ITEM1		ITEM2		ITEM3
ETS2	interacts with	NCOA3	interacts with	BMP7	participates in	positive regulation of osteoblast differentiation
				BMP6		positive regulation of osteoblast differentiation from MSCs
						positive regulation of bone mineralization

Pilot experiment: GWAS-bone


ITEM0 ITEM1 ITEM2 ITEM3
ETS2 interacts with NCOA3 interacts with BMP7 BMP6 participates in positive regulation of osteoblast differentiation | positive regulation of osteoblast differentiation from MSCs | positive regulation of bone mineralization
ETS2 interacts with ZMYND11 interacts with BMPR1A participates in positive regulation of osteoblast differentiation | positive regulation of osteoblast differentiation from MSCs | positive regulation of bone mineralization
ETS2 interacts with SRC ZMYND11 TDP2 interacts with TRAF6 participates in positive regulation of osteoclast differentiation
ETS2 interacts with ZFYVE9 interacts with BMP4 participates in positive regulation of osteoblast differentiation | positive regulation of osteoblast differentiation from MSCs | positive regulation of bone mineralization
ETS2 interacts with CREBBP interacts with ACVR1 participates in positive regulation of osteoblast differentiation | positive regulation of bone mineralization
ETS2 interacts with SRC interacts with TNFSF11 participates in positive regulation of osteoclast differentiation | positive regulation of bone resorption
ETS2 interacts with NCOR1 interacts with SKI participates in negative regulation of osteoblast differentiation | negative regulation of osteoblast differentiation from MSCs
Answer 22 ETS2 interacts with BRCA1 interacts with Ifi204 participates in positive regulation of osteoblast differentiation
Answer 23 ETS2 interacts with EP300 interacts with TFAP2A participates in positive regulation of bone mineralization
Answer 24 ETS2 interacts with NCOR1 interacts with HDAC7 participates in negative regulation of osteoblast differentiation
Answer 25 ETS2 interacts with SRC interacts with GAB2 participates in osteoclast differentiation
Answer 27 ETS2 interacts with JUN interacts with SKI participates in negative regulation of osteoblast differentiation
ETS2
POU5F1 SRC TDP2 ZFYVE9 ZMYND11 NCOA3 BRCA1 CREBBP EP300 NCOR1 JUN
SOX2 GAB2 TNFSF11 TRAF6 BMP6 BMP4 Ifi204 BMPR1A BMP7 ACVR1 TFAP2A HDAC7 SKI
osteoblast differentiation
osteoclast differentiation
positiveregulation of bone mineralization
negative regulation of osteoblast differentiation
positive regulation of bone resorption
positive regulation of osteoclast differentiation
positive regulation of osteoblast differentiation from MSCs
positive regulation of osteoblast differentiation
positive regulation of bone mineralization
negative regulation of osteoblast differentiation from MSCs
Reviewing causal hypotheses

Answer:

ITEM0: ETS2
ITEM1: NCOA3
ITEM2: BMP7
ITEM3: positive regulation of osteoblast differentiation

Because: | Detailed Justification: | Linear Justification:

Detailed Justification:

- There is some evidence that ETS2 affects NCOA3.
- There is some evidence that BMP7 affects positive regulation of osteoblast differentiation.
  - If the evidence given for a type of biological process having a type of chemical object as a participant is experimental evidence (as opposed to evidence based on structural similarity or computer matching), and a particular gene codes for that chemical object type, then conclude that instances of the process type typically have the product of that gene as participants.
  - Inferred from direct assay is a type of experimental evidence.[1]
  - The evidence for Bone morphogenetic protein 7's participation in the positive regulation of osteoblast differentiation was provided by direct assay.
  - BMP7 codes for Bone morphogenetic protein 7.
    - If, according to EntrezGene, a gene has a particular term in UniProt as its "uniprotAccession", that gene codes for the type of peptide molecule represented by the UniProt term.

      According to EntrezGene, "BMP7" codes for Bone morphogenetic protein 7.
- There is some evidence that NCOA3 affects BMP7.
- Inferred from direct assay is a type of experimental evidence.[1]
- There is some evidence that positive regulation of osteoblast differentiation affects the quantity of bone tissue present.

  Positive regulation of osteoblast differentiation is more specific than biological processes.

External Sources:

[1]Linked Life Ontology

Human-Readable Explanations

Because: | Detailed Justification: | Linear Justification:

Detailed Justification:

There is some evidence that ETS2 affects NCOA3.

```
(couldImpact-BackchainRequired ETS2-Human-GIS
    (SchemaObjectFn BioOWLCodeMapping "gene:8202"))
```

There is some evidence that BMP7 affects positive regulation of osteoblast differentiation.

```
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    (SchemaObjectFn BioOWLCodeMapping "gene:655")
    (PositiveRegulationOfTypeFn OsteoblastDifferentiation))
```

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```
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If, according to EntrezGene, gene A has an interaction in which gene B is the interactant, then then molecular products of genes A and B interact.

```
M(implies
      (and
          (interactant-EntrezGene ?INTERACTION ?GENE2)
          (interaction-EntrezGene ?GENE1 ?INTERACTION))
      (productsOfGene-GISTypesInteract ?GENE2 ?GENE1)) in BioOWLBridgingMt
```

According to EntrezGene, "NCOA3" is the interactant in http://linkedlifedata.com/resource/entrezgene/interaction/655-8202.

```
:SKSI (interactant-EntrezGene
        (SchemaObjectFn BioOWLCodeMapping "<http://linkedlifedata.com/resource/entrezgene/interaction/655-8202>")
        (SchemaObjectFn BioOWLCodeMapping "gene:8202"))
      in (ContentMtFn BioOWLIMLinkedLifeTripleStoreKS)
```

Clearer than logic

	ITEM0		ITEM1		ITEM2		ITEM3
Answer 26	ETS2	interacts with	POU5F1	interacts with	SOX2	participates in	osteoblast differentiation

Down-rank novelty

Papers mention all three genes together

BMC Genomics

BioMed Central

Research article

Open Access

Identification of *Pou5f1*, *Sox2*, and *Nanog* downstream target genes with statistical confidence by applying a novel algorithm to time course microarray and genome-wide chromatin immunoprecipitation data

Alexei A Sharov[1], Shinji Masui[2], Lioudmila V Sharova[1], Yulan Piao[1], Kazuhiro Aiba[1], Ryo Matoba[1], Li Xin[1], Hitoshi Niwa[2] and Minoru SH Ko*[1]

Genes	Suppression of Pou5f1	Sox2	Nanog	Genes	Suppression of Pou5f1	Sox2	Nanog
Dppa5, Epha1, Epha4, Fbxo15, Ncor1, Socs3, Tcf3, Tcfe3, Utf1	⇩	No effect	No effect	Gli2, Inhbb, Lrrc2	⇩	⇧	⇩
Arid5b, Oas1f, Ptger2, Zic2	No effect	⇩	No effect	Dppa3, Gja1, Trh	⇩	⇩	⇧
Brd2, Ccdc5, Fbxo2, Fgf17, Foxp1, Fzd5, Itpr3, Mid1, Rara, Rarg, Sall1	No effect	No effect	⇩	Lefty1, Nodal	⇩	⇧	⇧
				Fgfbp1, Id3, Klf5, Myc, Sall4,	⇩	No effect	⇧
Dazl, Dnmt3b, Etv1, Foxd3, Gbx2, Id4, Jmjd2c, Klf2, Mkrn1, Morc1, Mup4, Mycn, Notch1, Otx2, Pou5f1, Sap30, Set, Suz12, Terf1, Tle1, Upp1, Zic3	⇩	⇩	No effect	Ccng2, Egln3, Scd1	⇧	⇧	⇩
				Cdc42ep3, Six1, Six4, Smad7	⇩	⇧	No effect
Myb, Yes1, Zic5	No effect	⇩	⇩	Arrb1, Cidea, Dmrt1, Eomes, Qk, Smarca2, Tec	⇧	⇧	No effect
Ccnb1, Erf, Esrrb, Fgf4, Jak3, Mras, Mtss1, Mybl2, Ptch1, Rest, Sfrp1, Sgk, Spred2, Tdgf1, Trps1, Tcfcp2l1, Zfp42	⇩	No effect	⇩	Cdx2, Fat1	⇧	No effect	⇧
				Dusp4, Hs6st2	No effect	⇩	⇧
				Ets2, Foxh1, Prickle1	No effect	No effect	⇧

Figure 6
Examples of tentative target genes responding differentially to the suppression of *Pou5f1*, *Sox2*, and *Nanog*.

CSH PRESS GENOME RESEARCH

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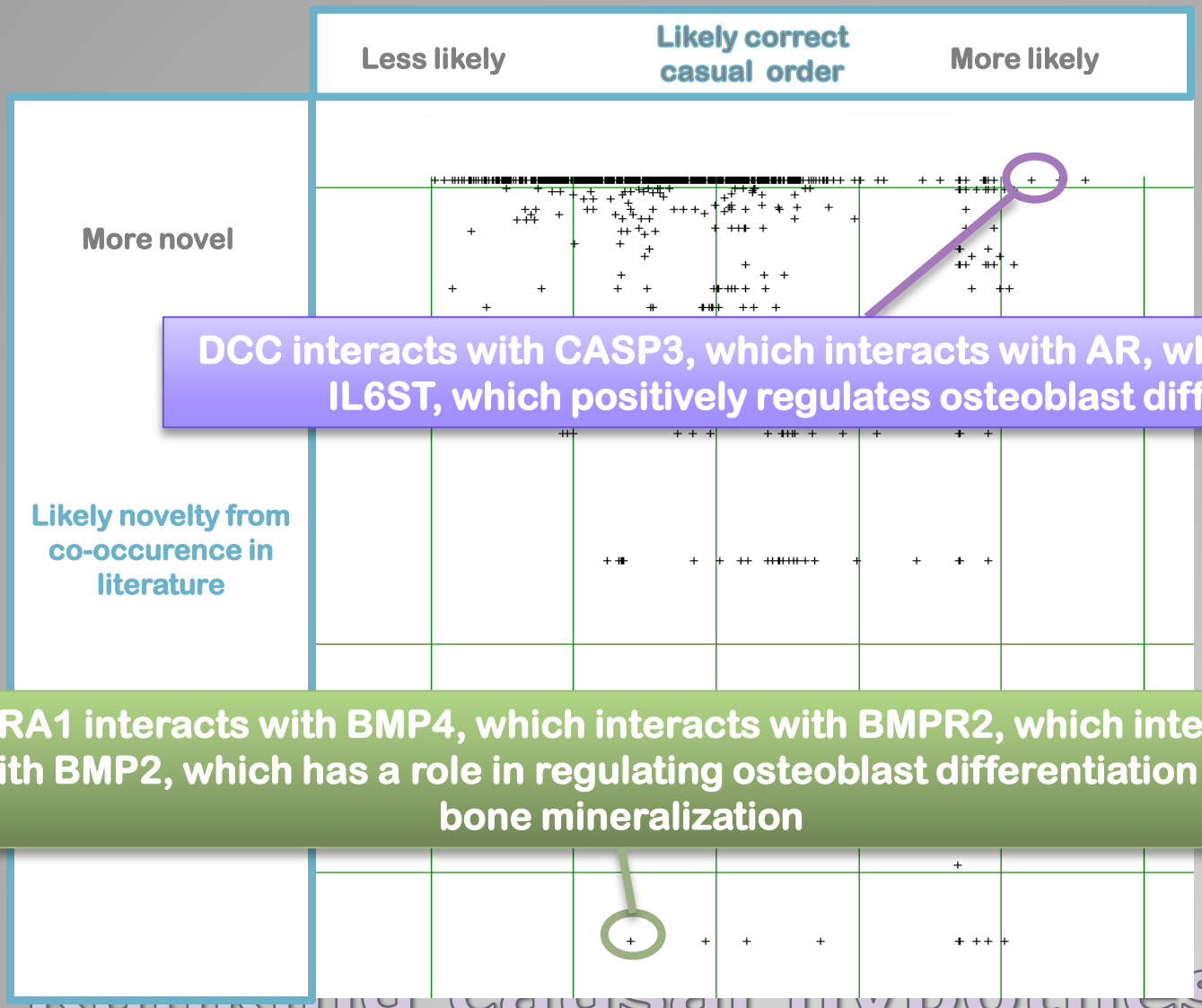
Examination of transcriptional networks reveals an important role for TCFAP2C, SMARCA4, and EOMES in trophoblast stem cell maintenance

Benjamin L. Kidder[1] and Stephen Palmer

transcription factors (TFs) POU5F1 (formerly known as OCT4), SOX2, and NANOG (Nichols et al. 1998; Avilion et al. 2003; Chambers et al. 2003), while TS cell self-renewal and multipotency require TFs such as TCFAP2C, CDX2, EOMES, ESRRB, ETS2, SOX2, and TEAD4 (Chawengsaksophak et al. 1997; Luo et al. 1997; Russ et al. 2000; Auman et al. 2002; Avilion et al. 2003; Wen et al. 2007; Nishioka et al. 2008). Recently, it has been shown that forced expression of *Pou5f1*, *Sox2*, *Klf4*, and *Myc* (formerly known as *c-Myc*) is sufficient to reprogram mouse and human fibroblasts into pluripotent cells (Takahashi et al. 2007a,b; Wernig et al. 2007). It

Weak knowledge: path ranking



DCC interacts with CASP3, which interacts with AR, which interacts with IL6ST, which positively regulates osteoblast differentiation

HTRA1 interacts with BMP4, which interacts with BMPR2, which interacts with BMP2, which has a role in regulating osteoblast differentiation and bone mineralization

Ranking causal hypotheses

(triggeringSubEventType TranscriptionFactorActivatedTranscription
(ChemicalBindingEventWithTypesFn Gene-DNARegion TranscriptionFactor))
Binding to a DNA region triggers activation of transcription by a transcription factor molecule.

(implies (triggeringSubEventTypes ?EVT-TYPE ?SUB-TYPE)
(and (sufficientTriggeringSubEventTypes ?EVT-TYPE ?SUB-TYPE)
(firstSubEventTypes ?EVT-TYPE ?SUB-TYPE))
Triggering sub-events are the first sub-events of the event as a whole, and are sufficient to begin it.

(firstSubEventTypes TranscriptionFactorActivatedTranscription
(ChemicalBindingEventWithTypesFn Gene-DNARegion TranscriptionFactor))
Activation of transcription by a factor molecule starts with the binding of that transcription factor to the some region of DNA.

Transcription factors activate transcription. Coactivators can bind with the transcription factors to upregulate the transcription, which increases the expression of the gene.

Richly represented knowledge

```
(implies (coactivatesTranscriptionOfTypeInitiatedByType
            ?COAC-TYPE ?GIS-TYPE ?TF-TYPE)
         (causes-SitTypeSitType
            (ChemicalBindingEventTypeWithTypesFn
               ?COAC-TYPE ?TF-TYPE)
            (UpregulationOfTypeFn
               (ChemicalBindingEventWithTypesFn
               (DNARegionForGeneFn ?GIS-TYPE) ?TF-TYPE)))
```

When a molecule is known to act as a coactivator with a certain transcription factor in the transcription of a gene, binding of the coactivator to the transcription factor causes an upregulation of the transcription factor's binding to the DNA region for that gene.

```
(implies
   (triggeringSubEventType ?EVENT-TYPE ?SUB-TYPE)
   (causes-SitTypeSitType
         (UpregulationOfTypeFn?TRIGGER-UPREG-TYPE)
         (UpregulationOfTypeFn ?UPREG-TYPE))
```

Upregulation of a triggering sub-event causes [illegible]ation of the overall event type.

Transcription factors activate transcription. Coactivators can bind with the transcription factors to upregulate the transcription, which increases the expression of the gene.

Richly represented knowledge

This can be used to explain an "interaction" between a gene and a coactivator.

	ITEM0		ITEM1		ITEM2		ITEM3
Answer 22	ETS2	interacts with	BRCA1	interacts with	Ifi204	participates in	positive regulation of osteoblast differentiation
	ITEM0		**ITEM1**		**ITEM2**		**ITEM3**
Answer 23	ETS2	interacts with	EP300	interacts with	TFAP2A	participates in	positive regulation of bone mineralization
	ITEM0		**ITEM1**		**ITEM2**		**ITEM3**
Answer 24	ETS2	interacts with	NCOR1	interacts with	HDAC7	participates in	negative regulation of osteoblast differentiation
	ITEM0		**ITEM1**		**ITEM2**		**ITEM3**
Answer 25	ETS2	interacts with	SRC	interacts with	GAB2	participates in	osteoclast differentiation
	ITEM0		**ITEM1**		**ITEM2**		**ITEM3**
Answer 26	ETS2	interacts with	POU5F1	interacts with	SOX2	participates in	osteoblast differentiation
	ITEM0		**ITEM1**		**ITEM2**		**ITEM3**
Answer 27	ETS2	interacts with	JUN	interacts with	SKI	participates in	negative regulation of osteoblast differentiation

Applying richer knowledge

	ITEM0		ITEM1		ITEM2		ITEM3
Answer 23	ETS2	interacts with	EP300	interacts with	TFAP2A	participates in	positive regulation of bone mineralization

transcription factors and the p53 protooncogene.

Pastorcic M, Das HK.

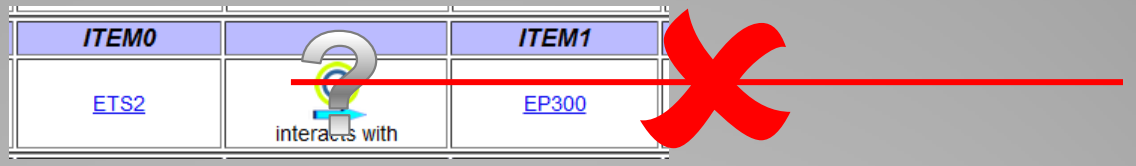
Department of Pharmacology and Neuroscience and Department of Molecular Biology and Immunology, University of North Texas Health Science Center, Fort Worth, Texas 76107, USA. mpastorc@hsc.unt.edu

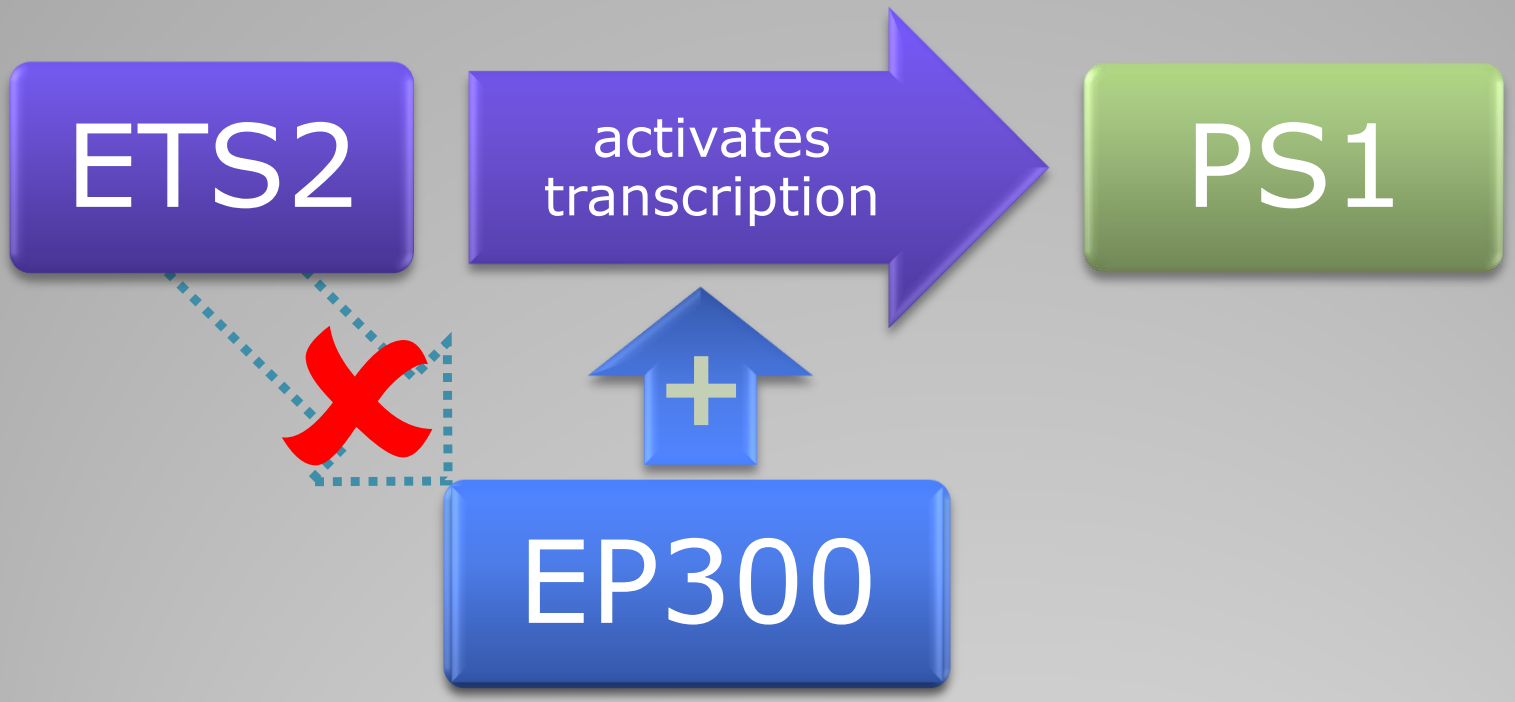
Abstract

The expression of the human presenilin-1 cellular gene is suppressed by the p53 protooncogene. The rapid kinetic of the down-regulation has suggested that it may result from a primary mechanism. We show here that p53 also suppresses the transcription of a presenilin-1 promoter-chloramphenicol acetyltransferase reporter synthetic gene in transient infection assays in neuroblastoma (SK-N-SH) and hepatoma (HepG2) cell lines. Only a minimum promoter including sequences from -35 to + 6 from the transcription initiation is sufficient to confer down-regulation. We have previously defined a crucial DNA element controlling 90% of the expression of the gene within the same short area, and the identification of the transcription factors involved should also provide insights into the regulation of PS1 by p53. This region contains an Ets transcription factor binding motif, and a 2-base pair alteration within the core sequence (GGAA to TTAA) of the Ets consensus also reduced transcription by more than 90%. We now show that Ets1 and Ets2 indeed transactivate a PS1 promoter-chloramphenicol acetyltransferase reporter including the (-35 to +6) fragment. Furthermore, in vitro translated Ets2 binds specifically to the -10 Ets motif in electrophoretic mobility shift assays. Therefore, Ets1/2 factors bind specifically to the -10 Ets element and activate PS1 transcription. We also show that the coactivator p300 enhances the activation by Ets1 and Ets2 as well as the repression by p53. p300 is known to interact with p53 as well as with Ets1 and Ets2. We show that p53 does not bind directly to the PS1 promoter. Hence the repression of PS1 transcription by p53 is likely to be mediated through protein-protein interactions.

PMID: 10942770 [PubMed - indexed for MEDLINE] **Free full text**

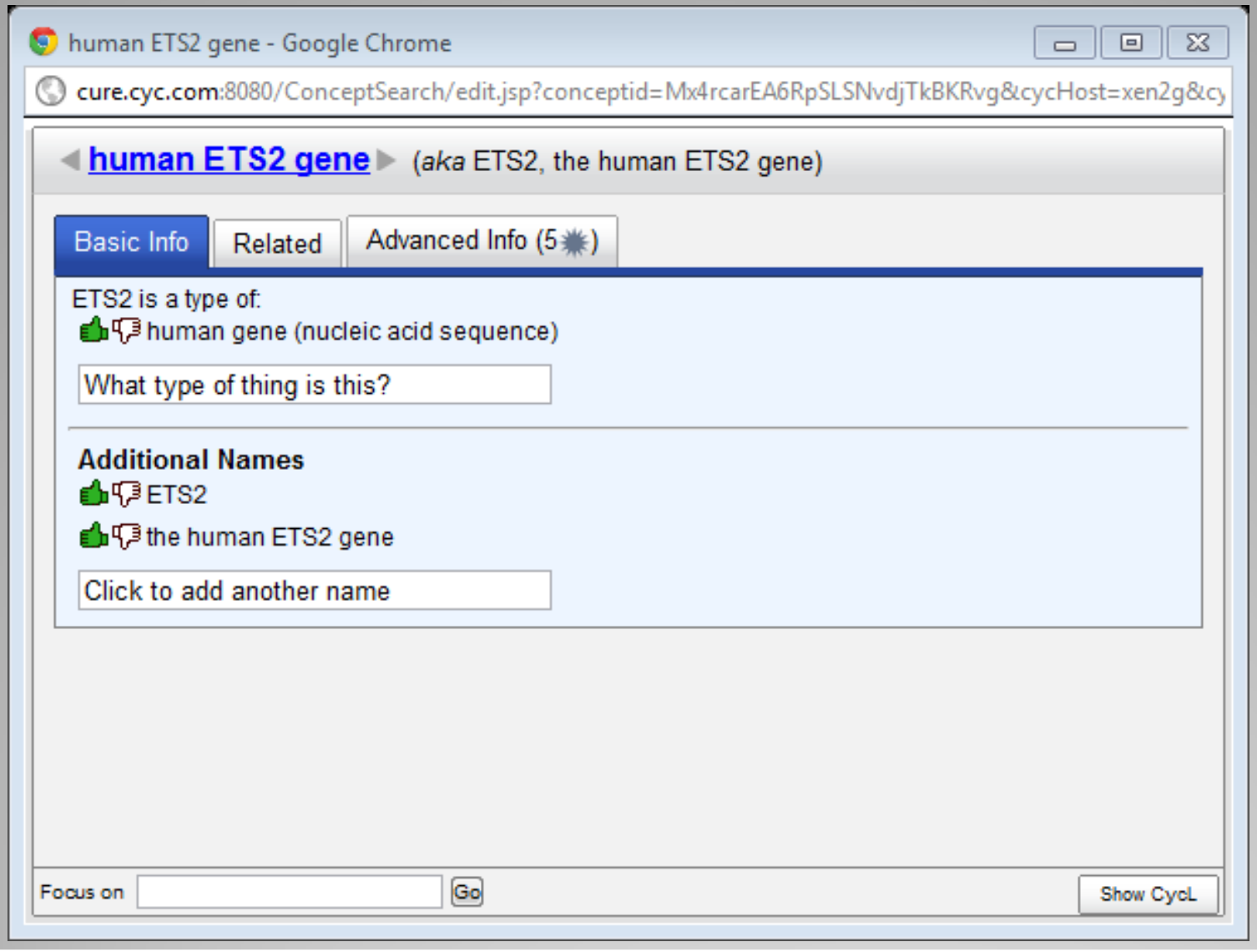
Is the pathway justified



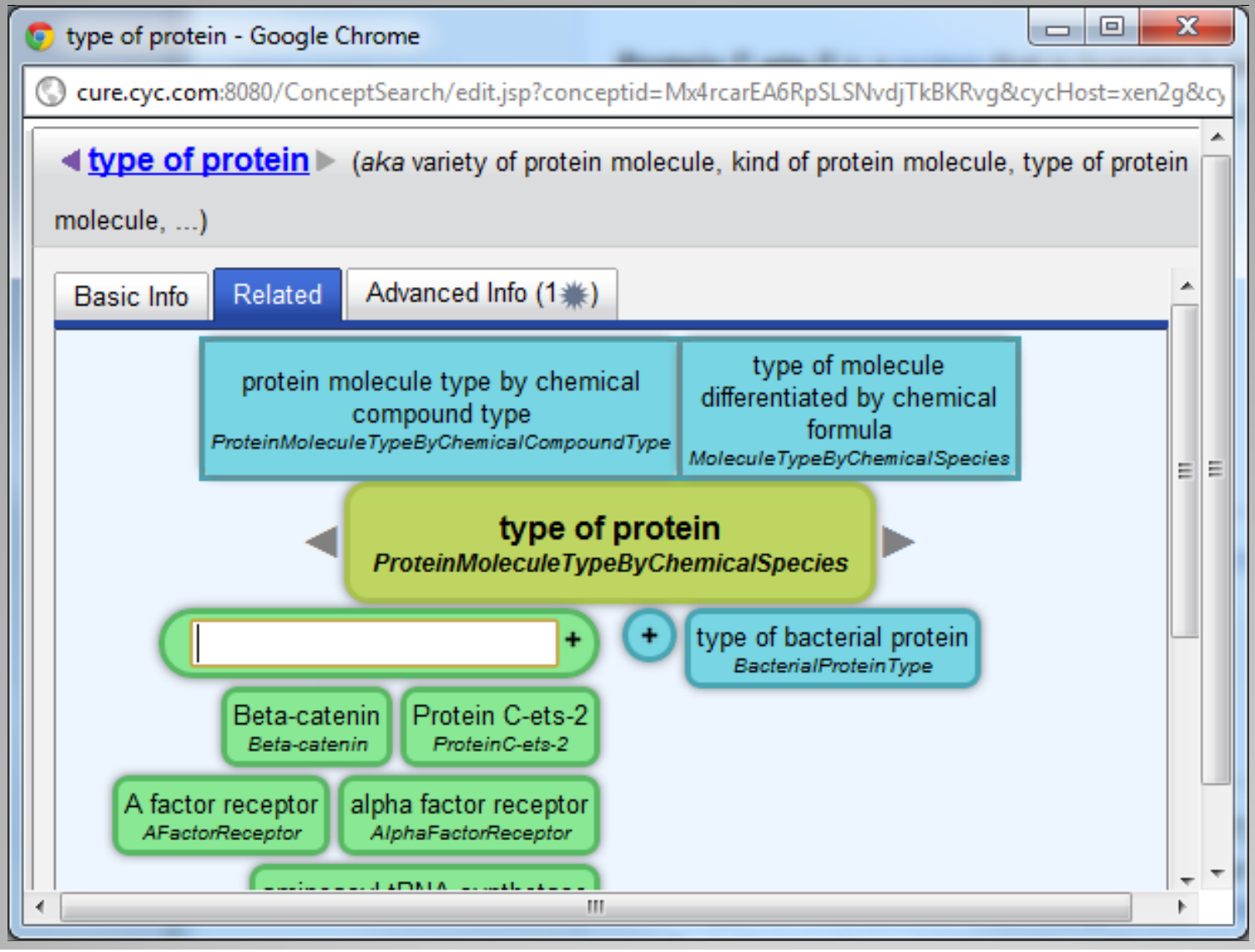


More detailed model

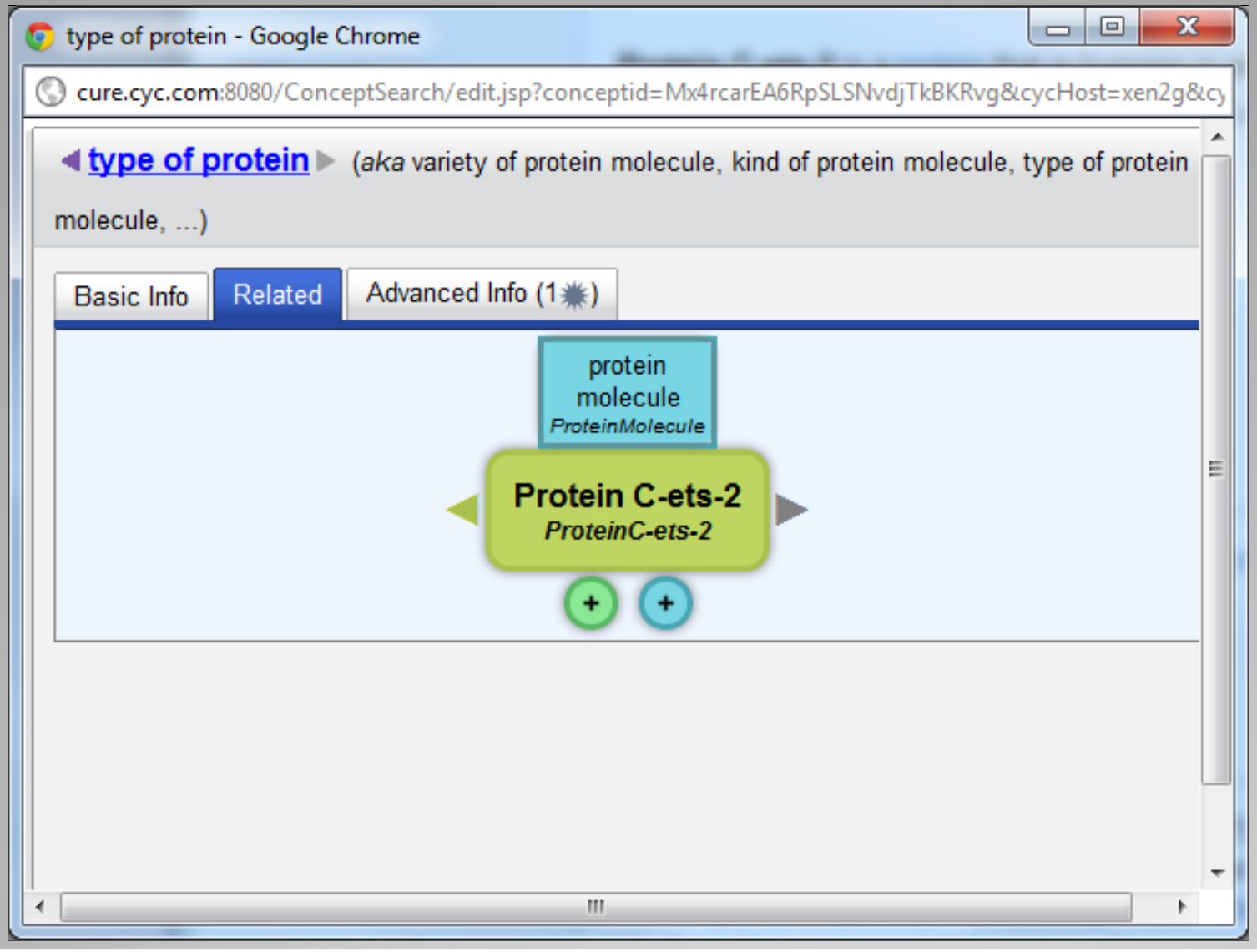
Collaborative Knowledge Creation



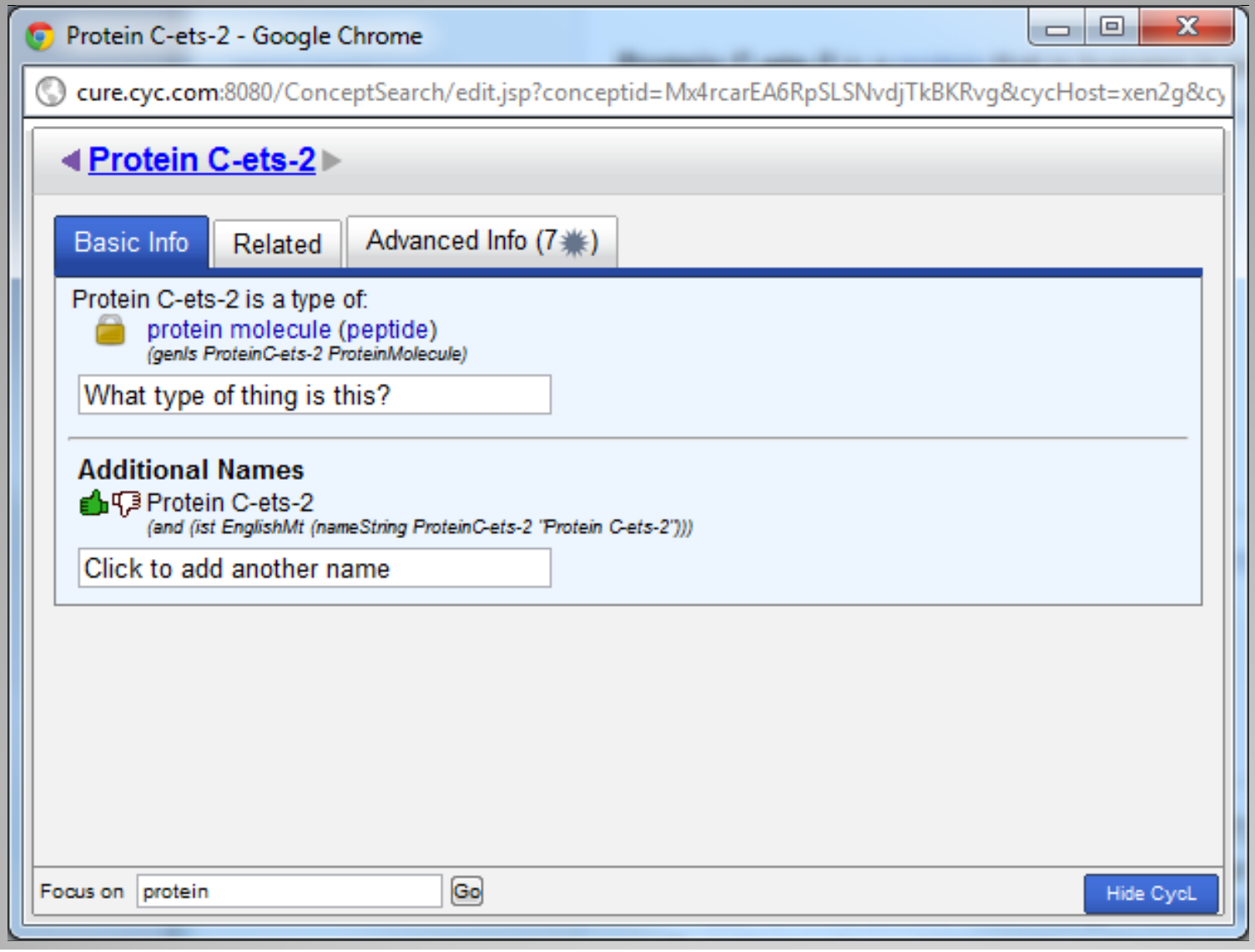
Collaborative Knowledge Creation



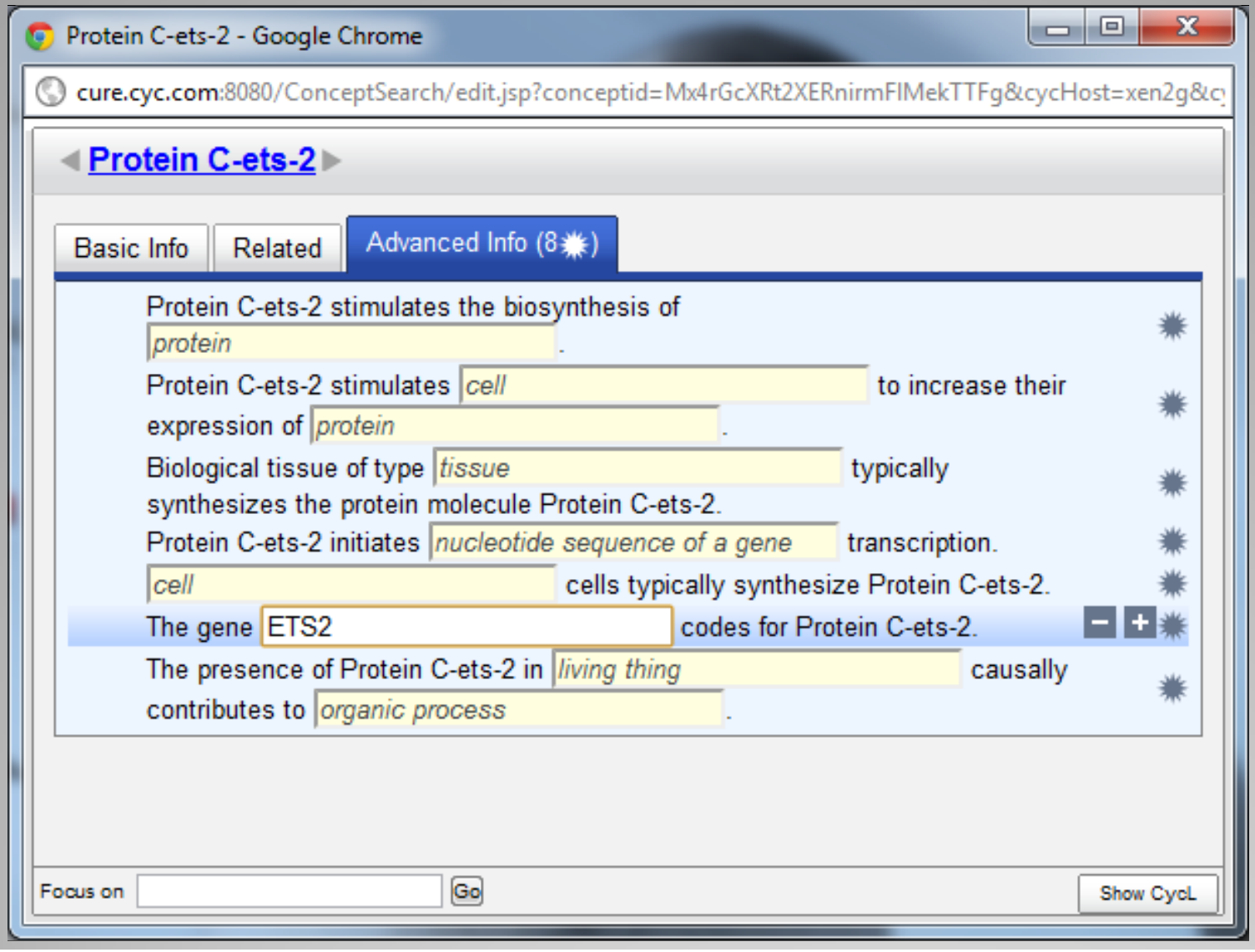
Collaborative Knowledge Creation



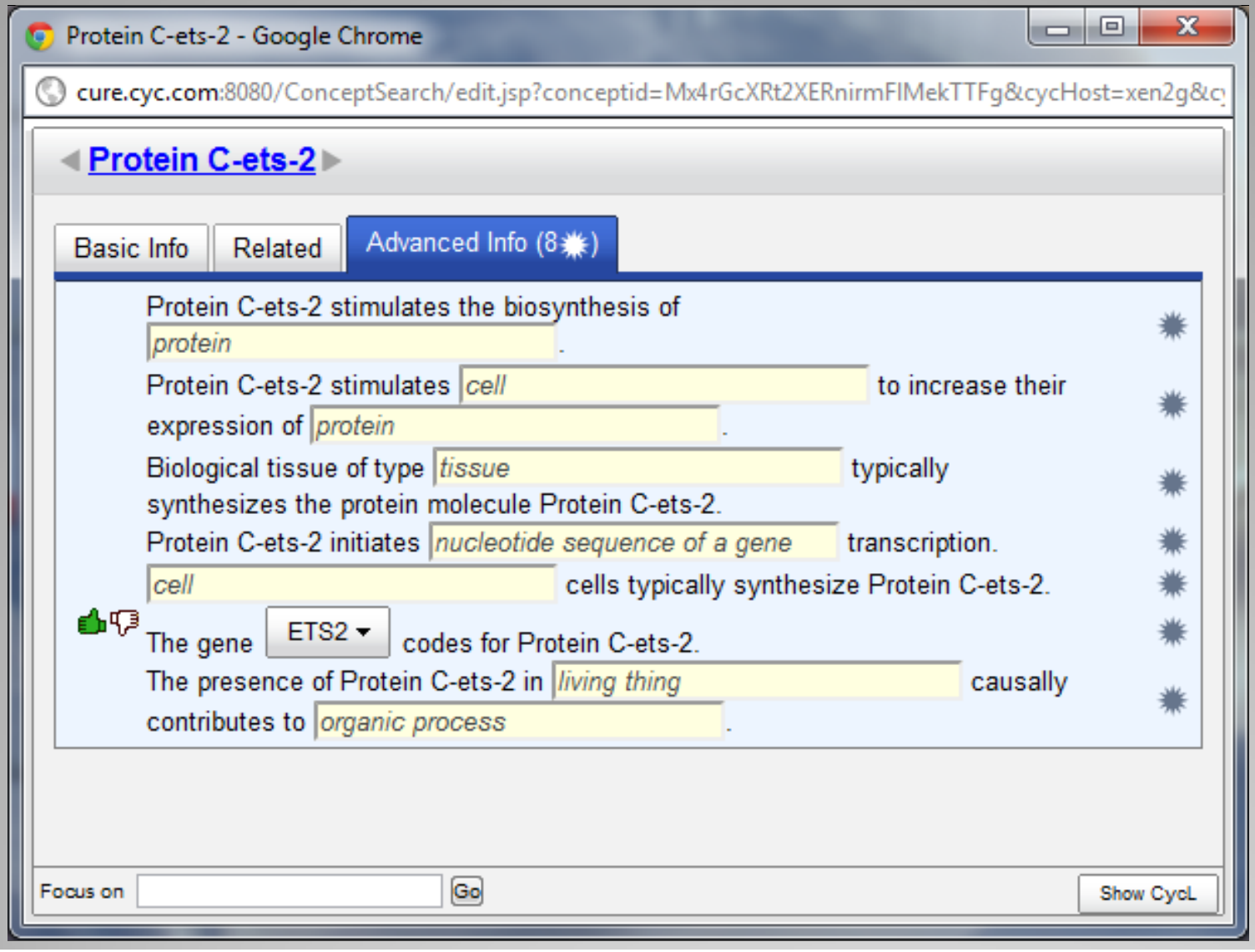
Collaborative Knowledge Creation



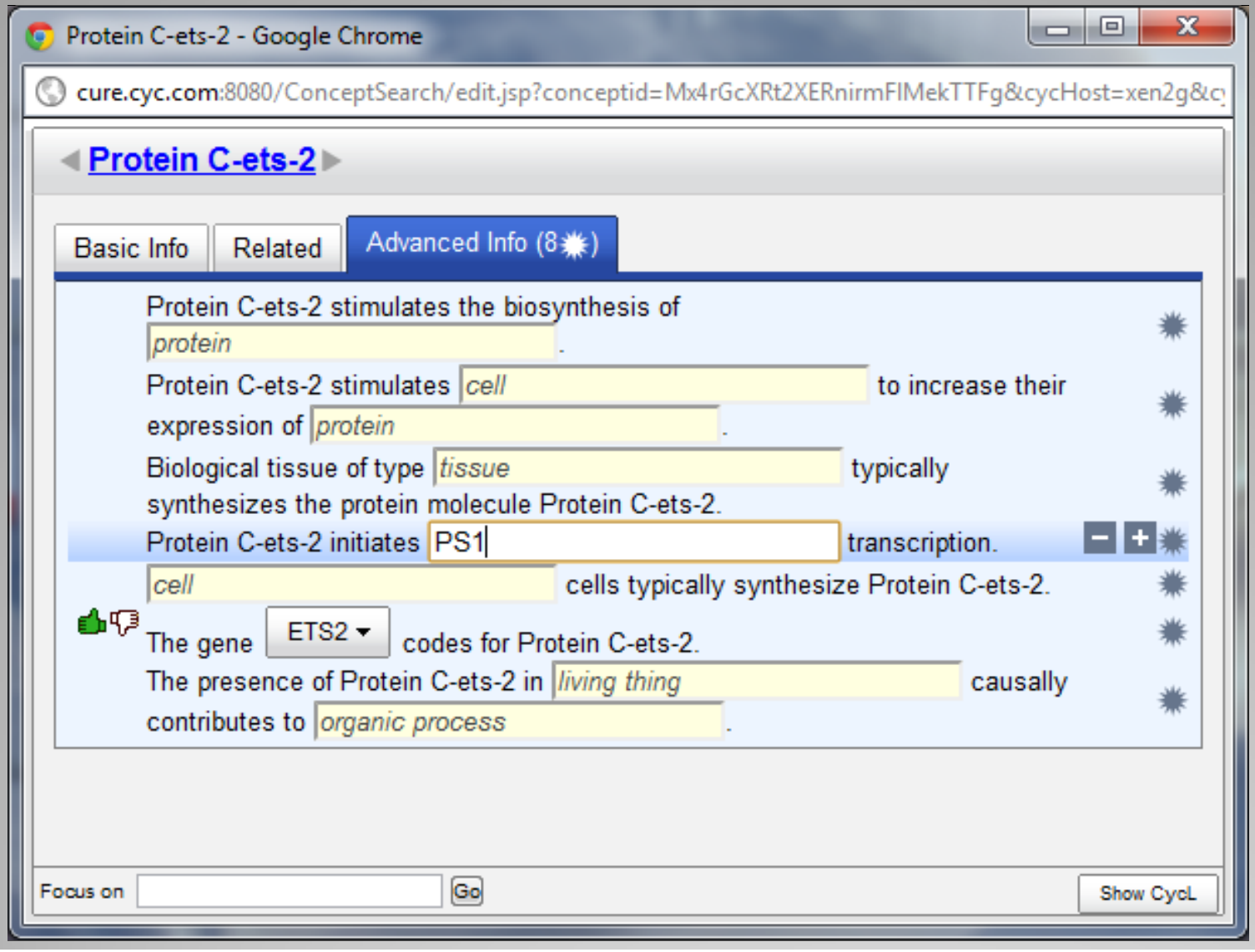
Collaborative Knowledge Creation



Collaborative Knowledge Creation



Collaborative Knowledge Creation



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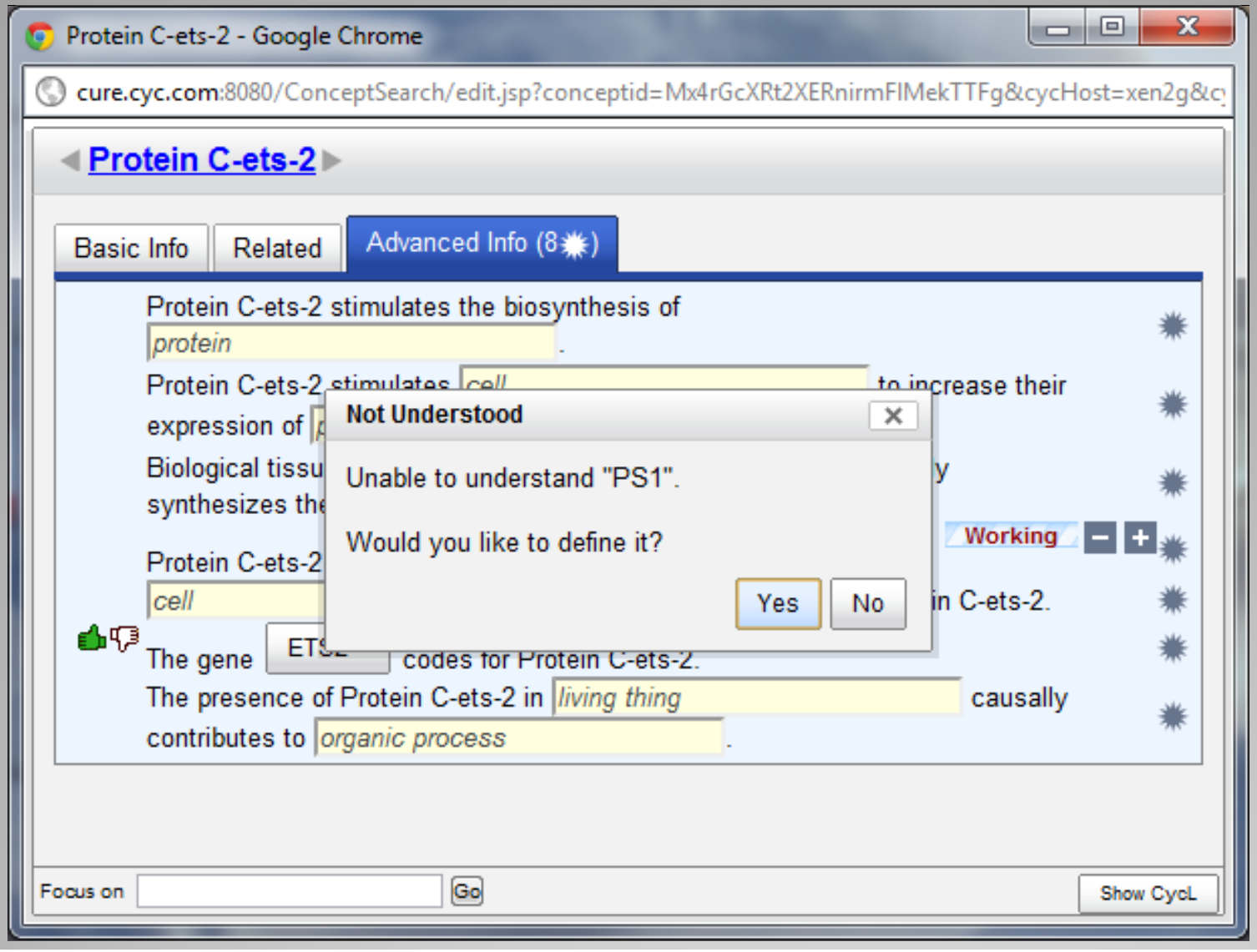
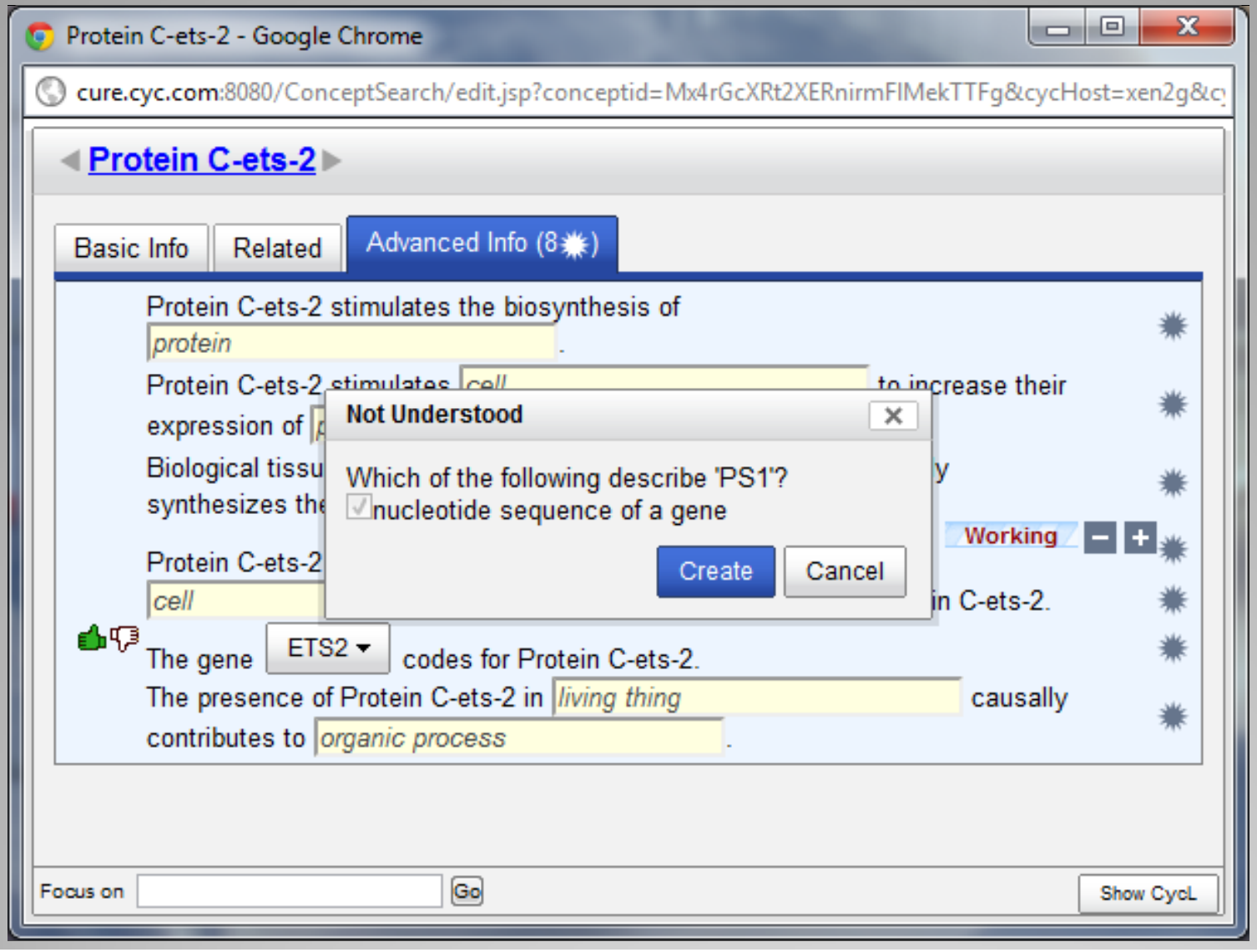
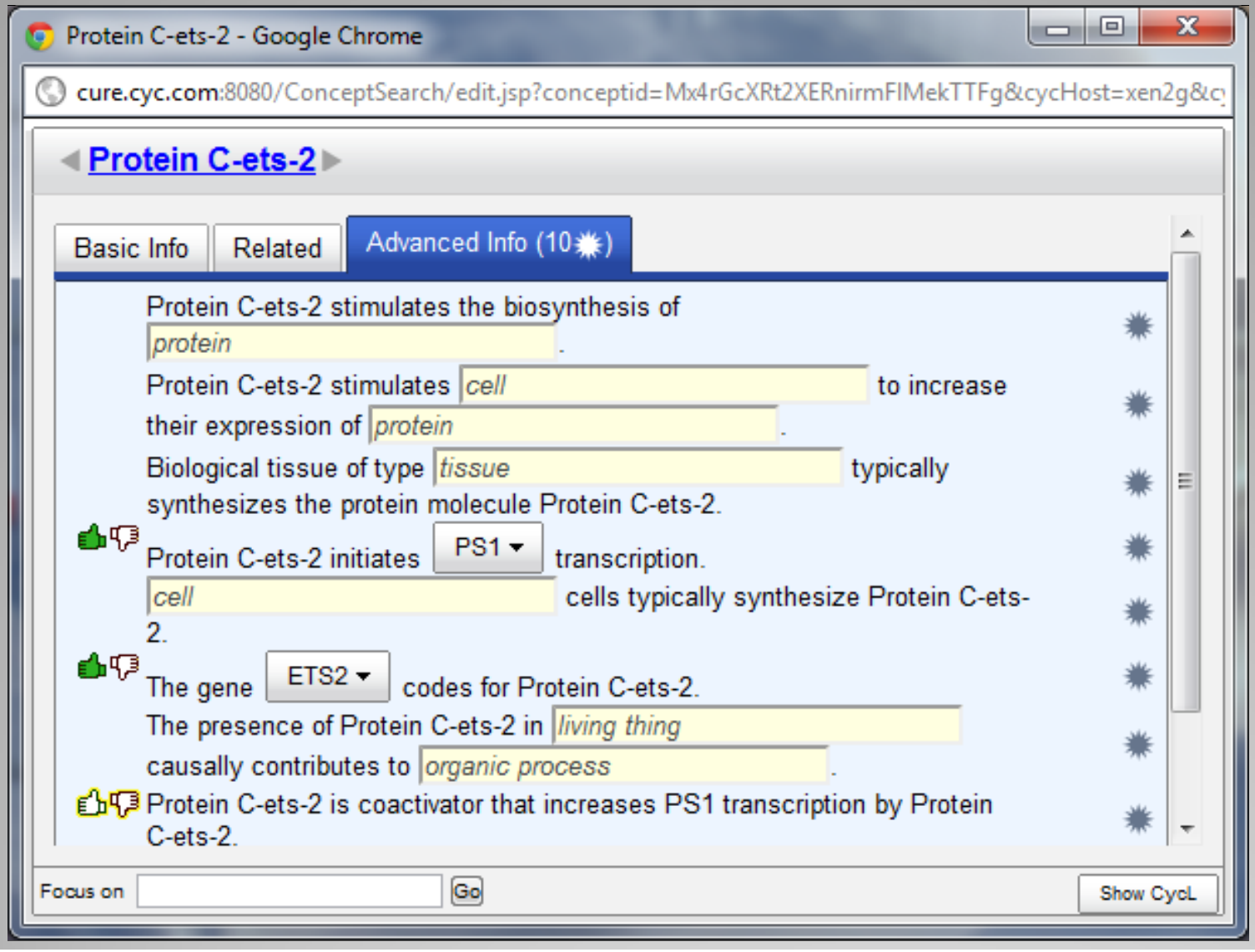


Collaborative Knowledge Creation



Collaborative Knowledge Creation



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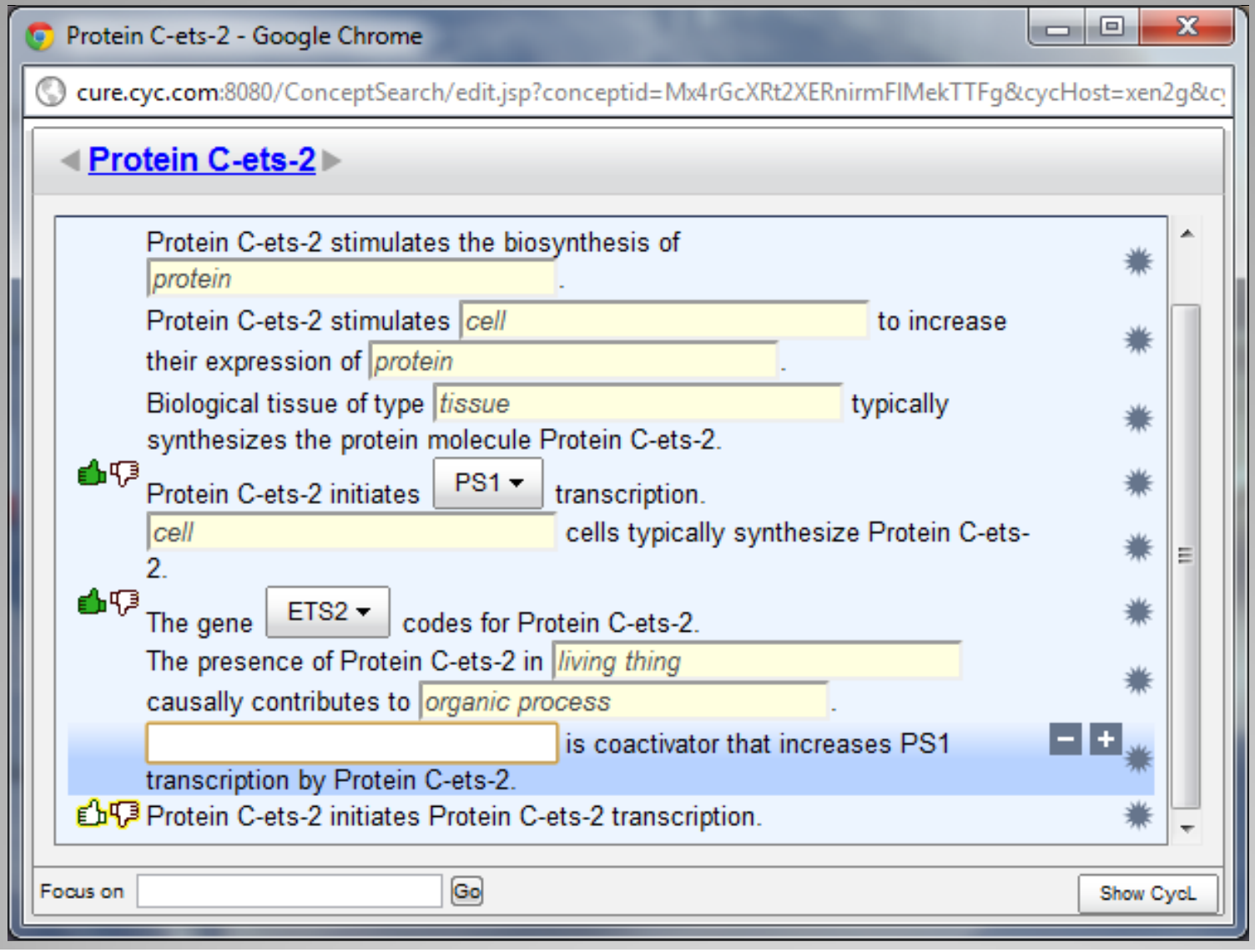
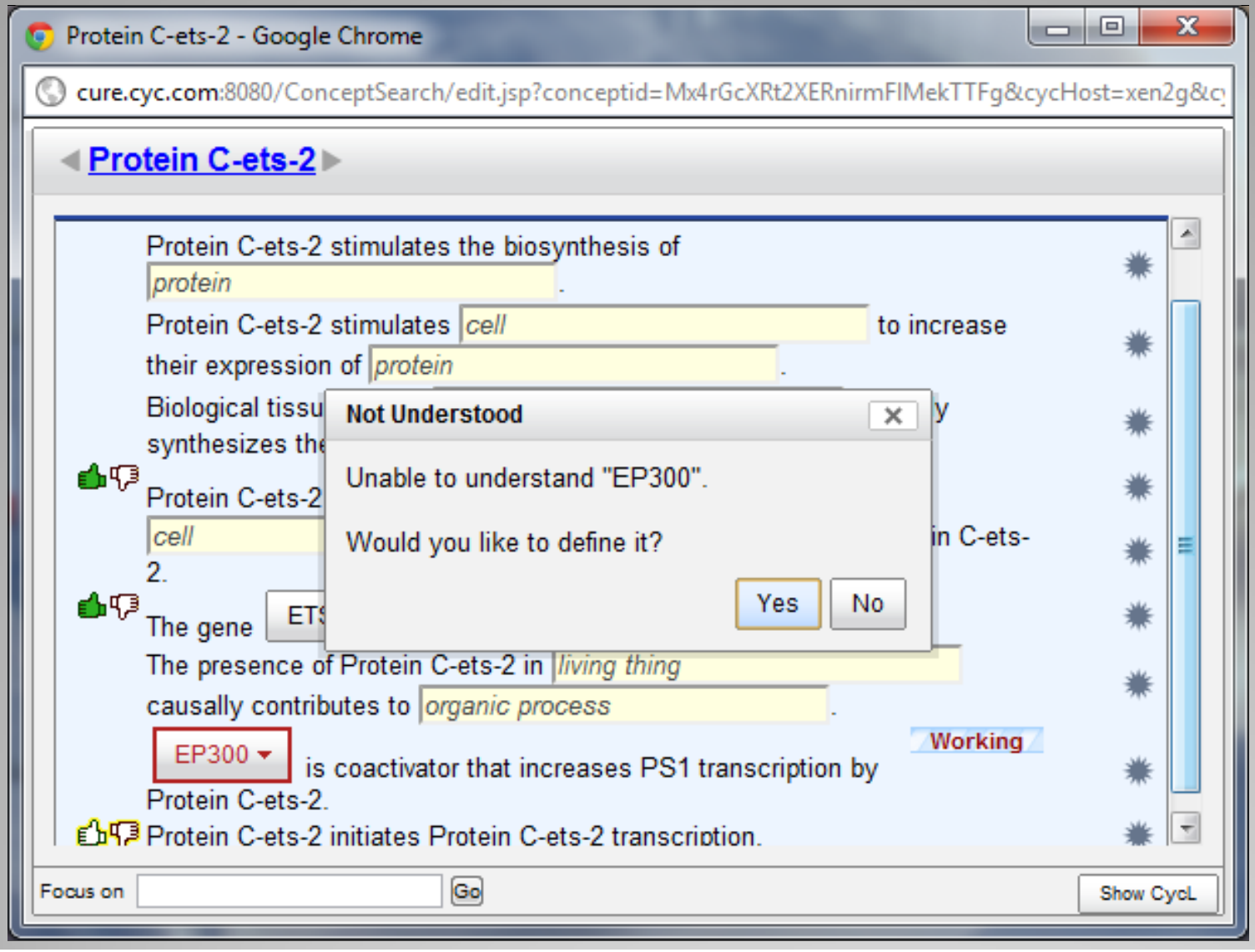
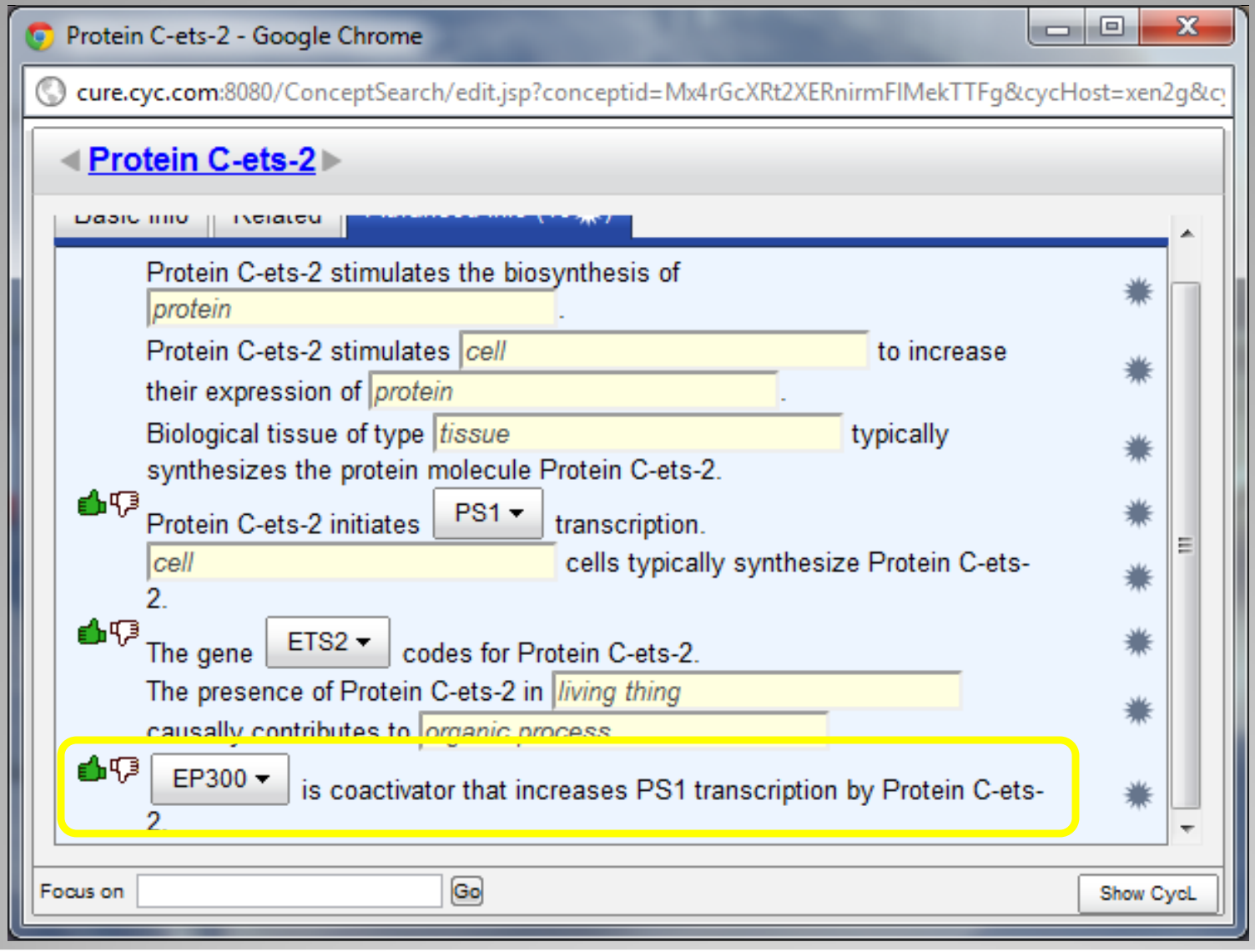


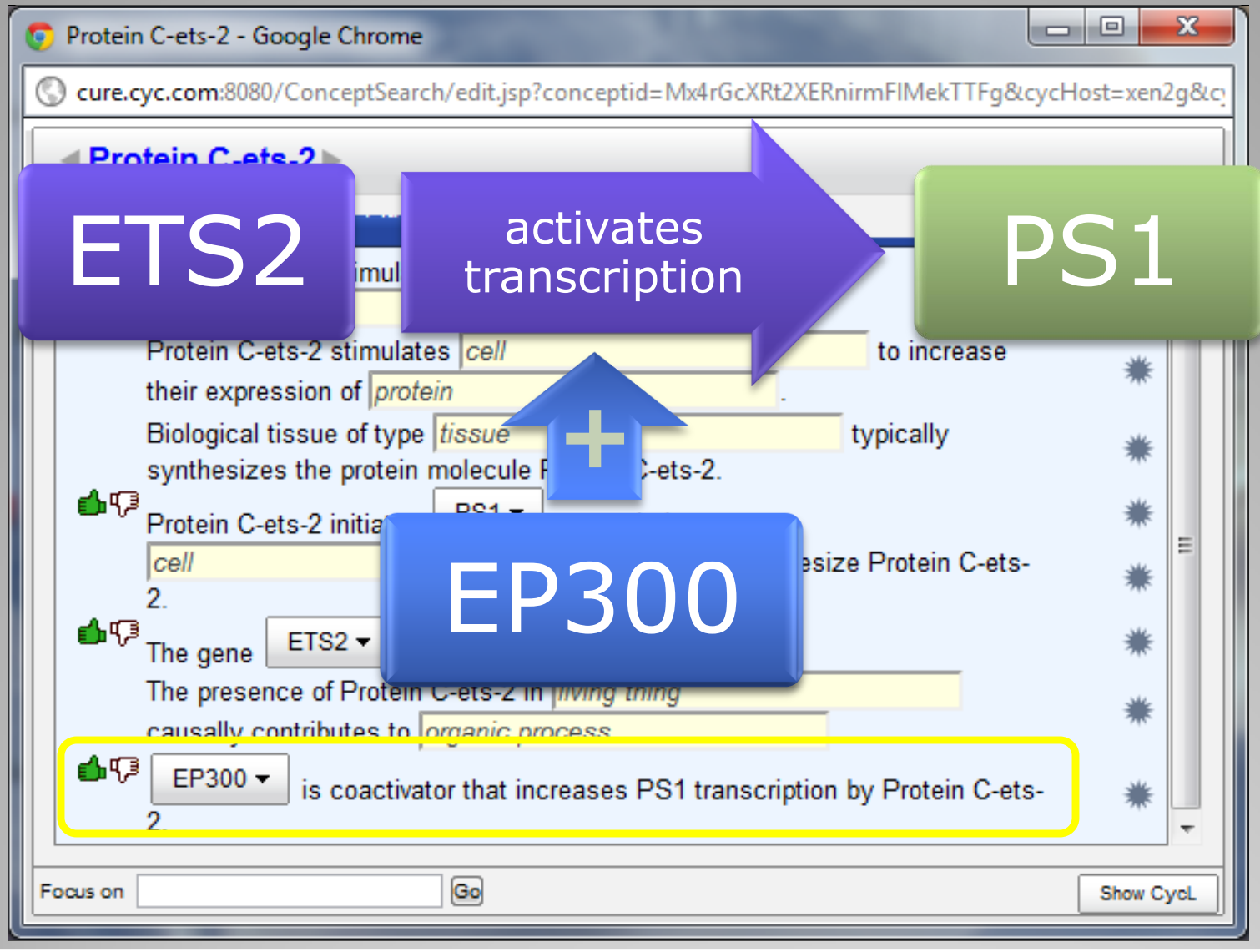
Collaborative Knowledge Creation



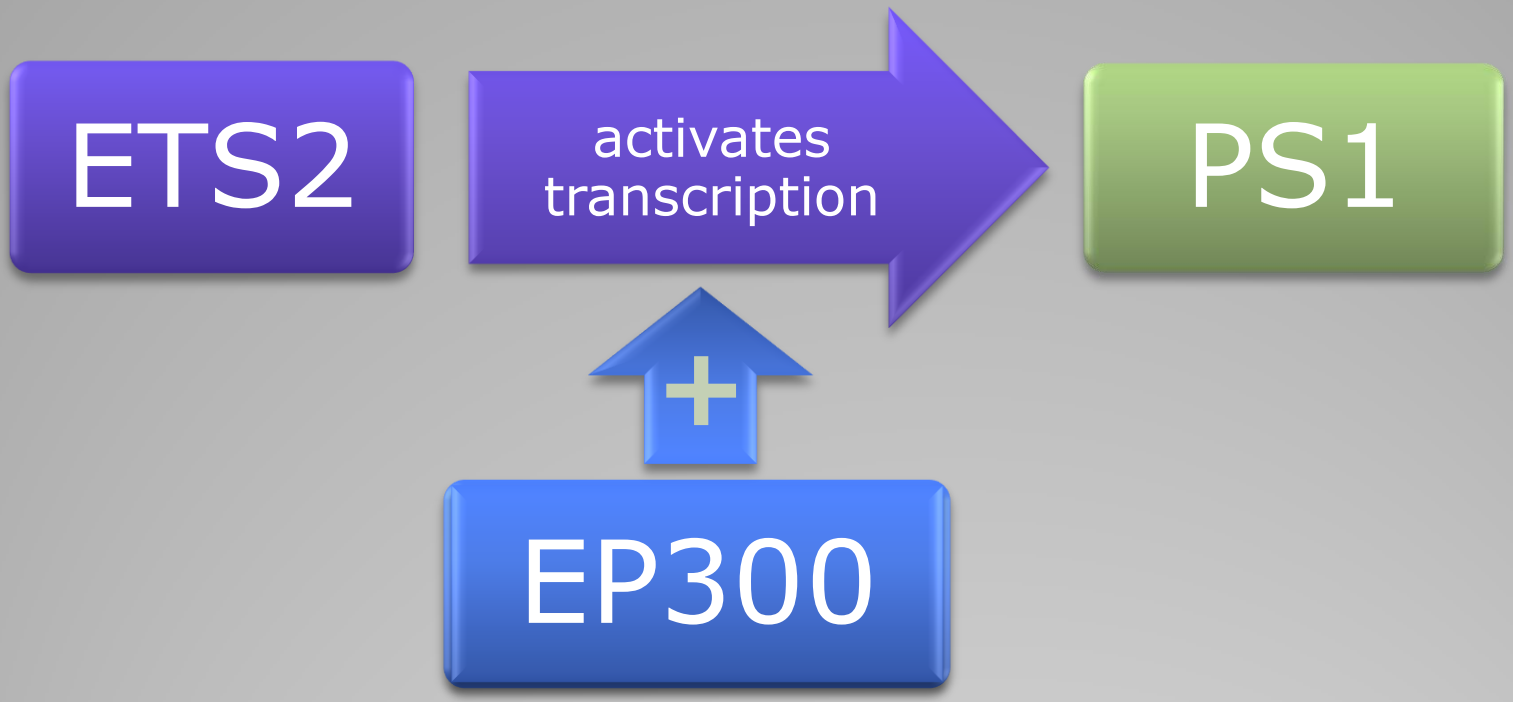
Collaborative Knowledge Creation



Collaborative Knowledge Creation



Collaborative Knowledge Creation



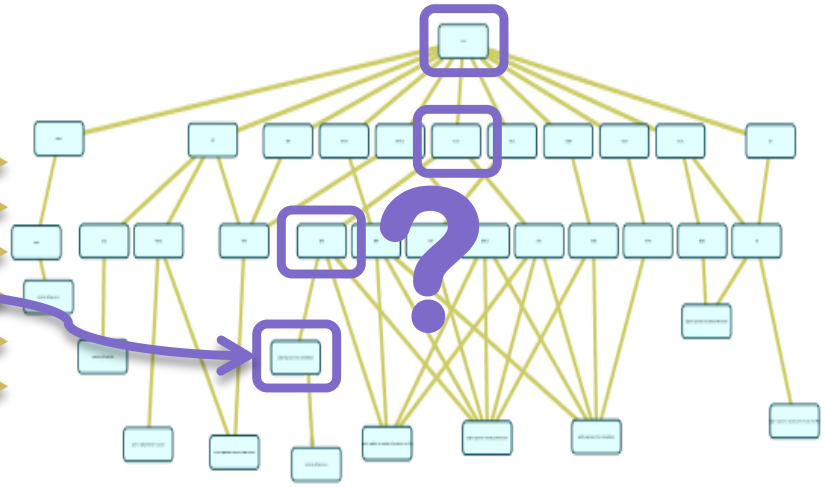
EP300 is coactivator that increases PS1 transcription by Protein C-ets-2.

Collaborative Knowledge Creation

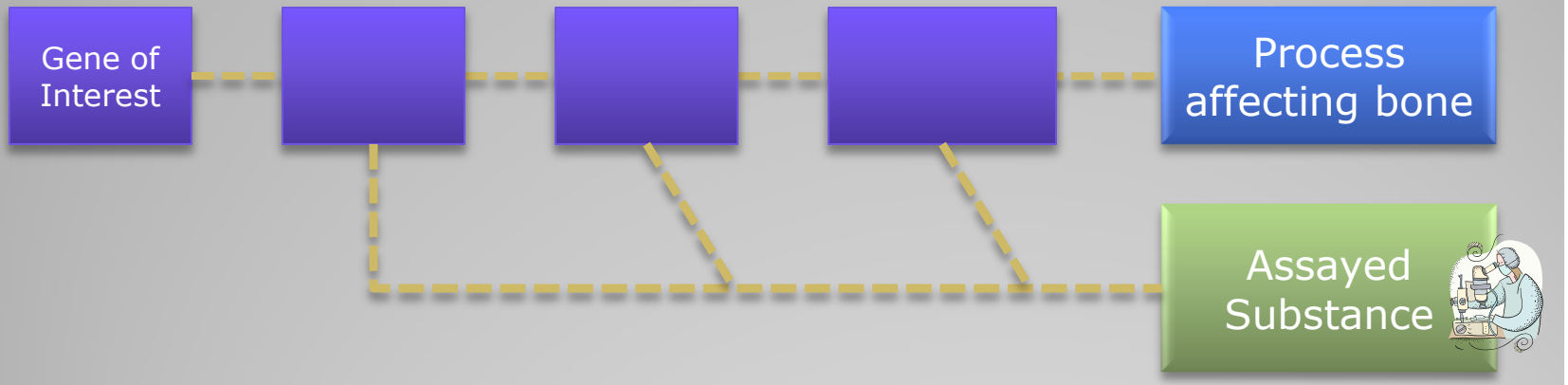
Framingham SHARe

dbGaP GENOTYPES and PHENOTYPES

- . . . .
- CD40 ligand from plasma, ng/ml — CD40L
- TNF alpha, pg/ml — TNF
- Osteoprotegerin from plasma, pmol/L — TNFRSF11B
- Vitamin D, ng/l — CYP27B1
- Cystatin C, mg/L — CST3
- P-selectin from plasma, ng/ml — SELP
- . . . . hundreds more



What data is available to test hypothesis plausibility?

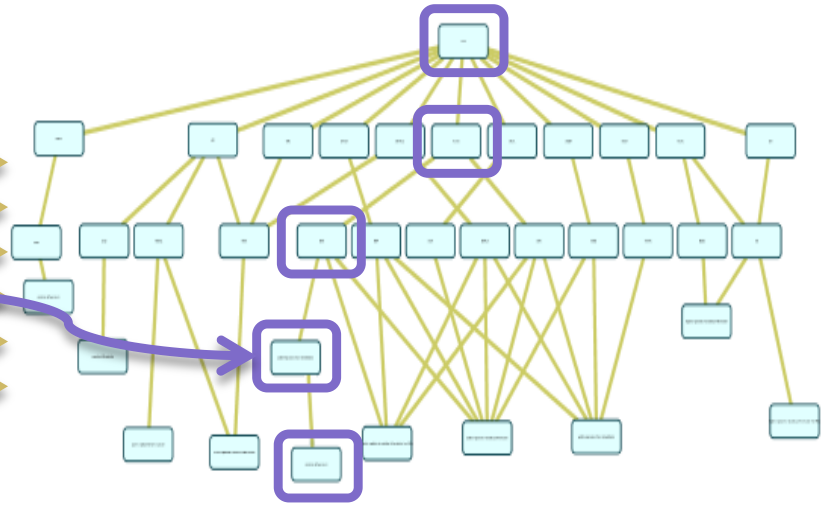


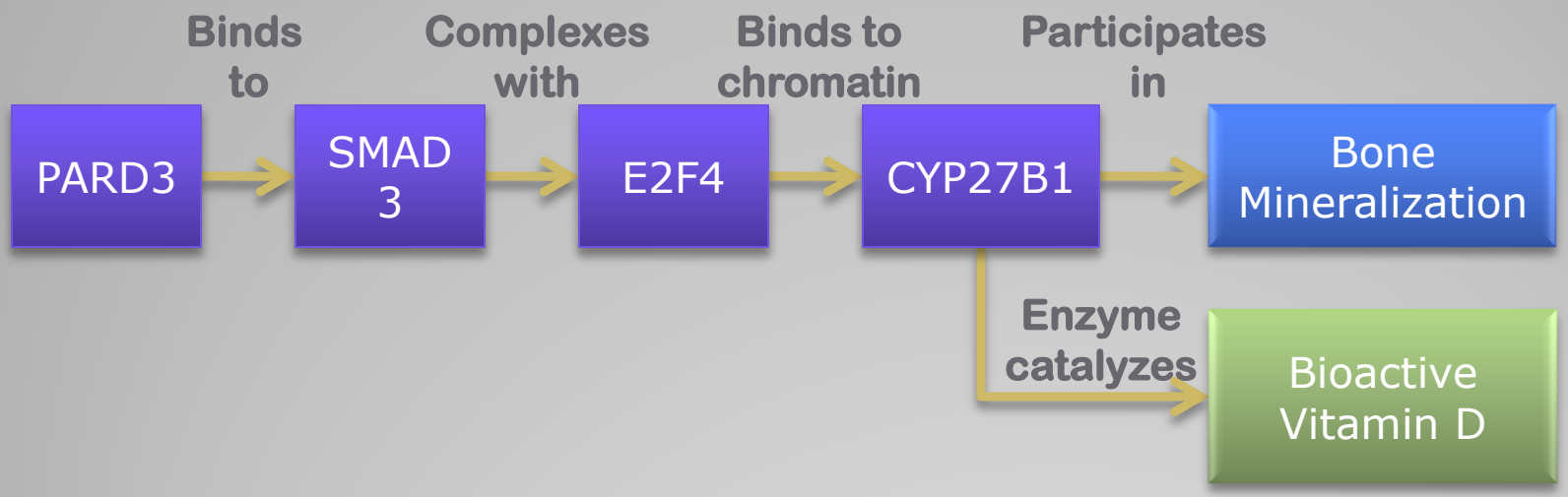
Patient Data: Metabolic Products

Framingham SHARe

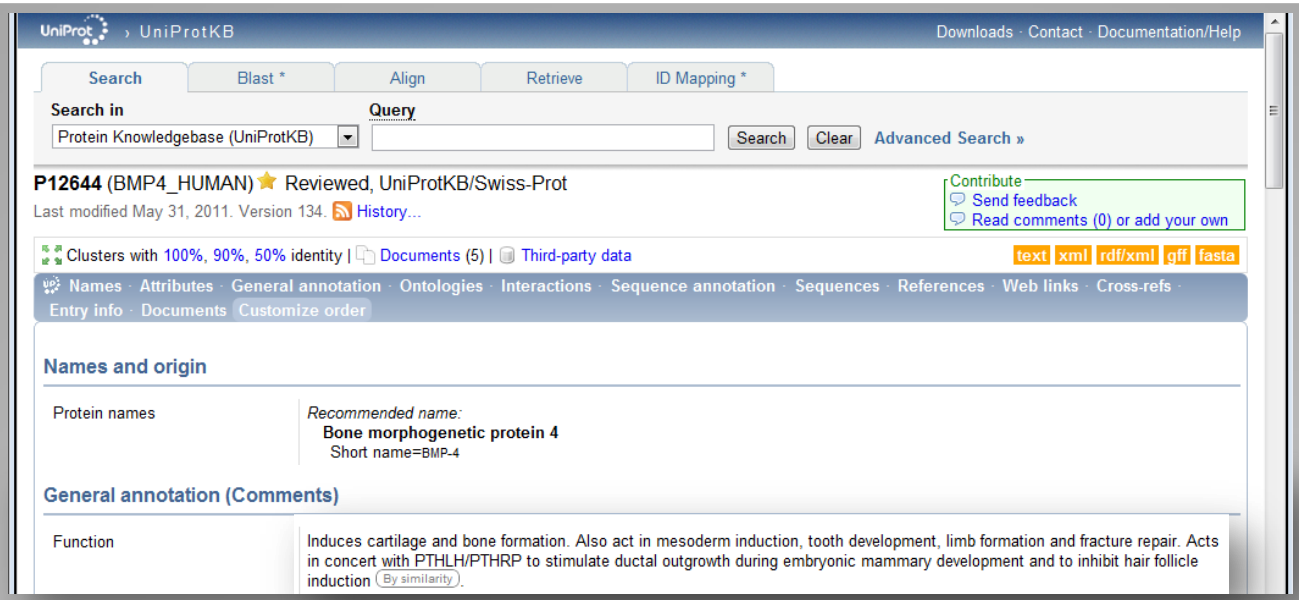
dbGaP GENOTYPES and PHENOTYPES

- . . . .
- CD40 ligand from plasma, ng/ml — CD40L
- TNF alpha, pg/ml — TNF
- Osteoprotegerin from plasma, pmol/L — TNFRSF11B
- Vitamin D, ng/l — CYP27B1
- Cystatin C, mg/L — CST3
- P-selectin from plasma, ng/ml — SELP
- . . . . hundreds more



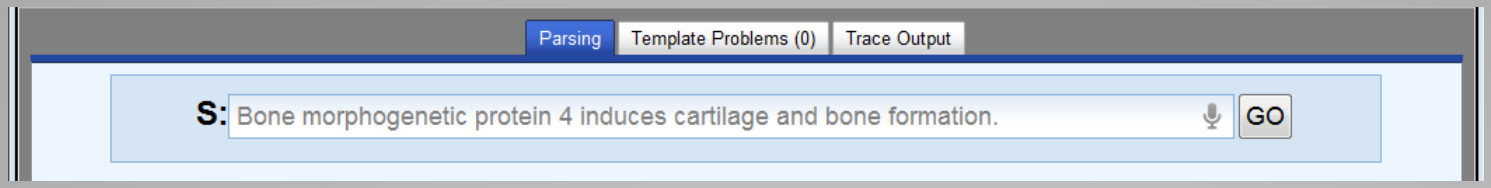


Patient Data: Metabolic Products



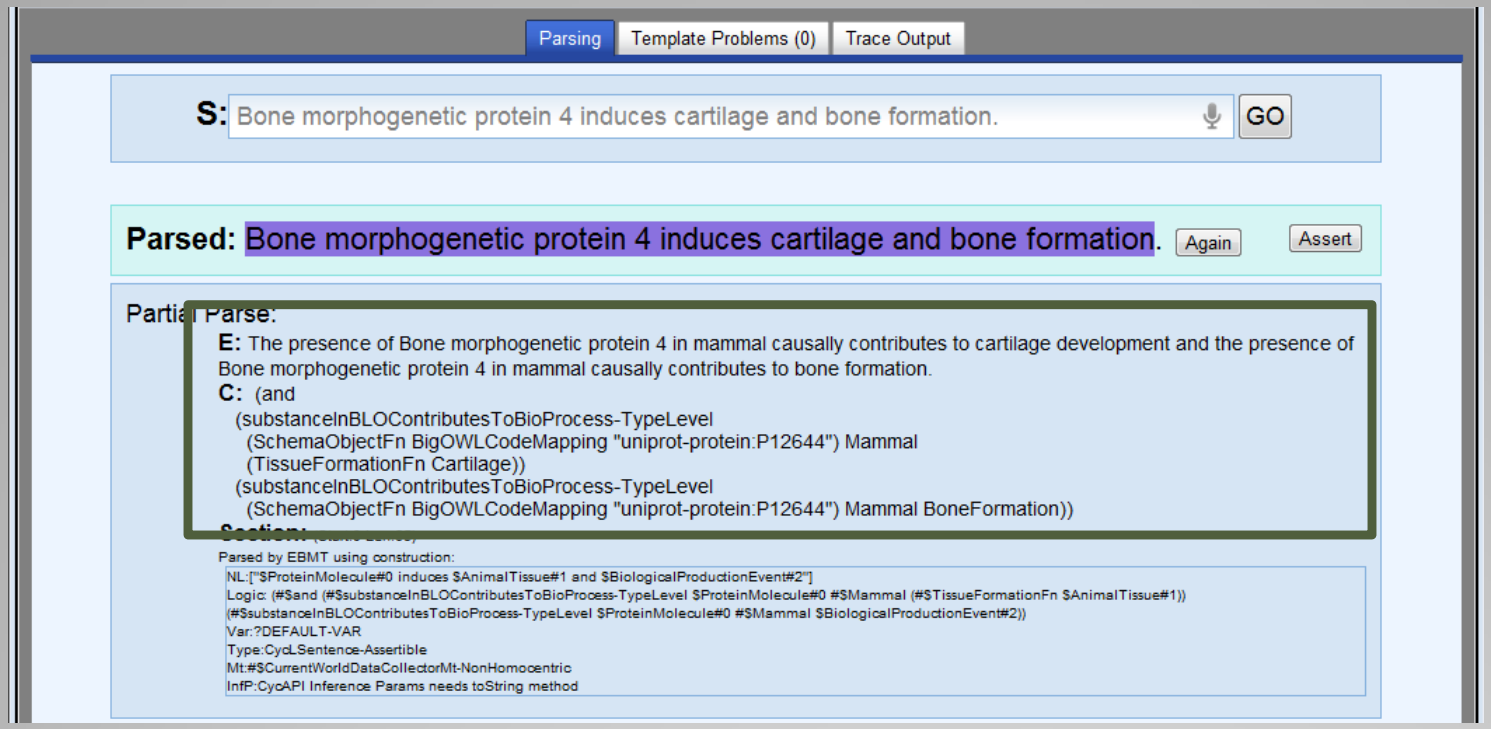
Richer Data, Richer Knowledge

Induces cartilage and bone formation. Also act in mesoderm induction, tooth development, limb formation and fracture repair. Acts in concert with PTHLH/PTHRP to stimulate ductal outgrowth during embryonic mammary development and to inhibit hair follicle induction By similarity.



Richer Data, Richer Knowledge

Induces cartilage and bone formation. Also act in mesoderm induction, tooth development, limb formation and fracture repair. Acts in concert with PTHLH/PTHRP to stimulate ductal outgrowth during embryonic mammary development and to inhibit hair follicle induction By similarity.



Richer Data, Richer Knowledge

- Technology Steps
  - Use all current structured interaction, chemical, pathway *etc* knowledge
  - Model and elicit, and read increasing variety of high precision (causal, explanatory) knowledge
  - Improve display and explanation of causal hypotheses
  - Improve hypothesis ranking techniques, learn from user responses to hypotheses
- Data steps
  - Apply to more GWAS studies
  - Comprehensive knowledge of possible and performed assays, starting with Framingham Heart Study
- Community Steps
  - Insert human-computer collaborative knowledge elicitation and curation into existing workflows
    - first into KB workflows, then into research and publication

Scaling out and scaling up

Palm, Inc.

From Wikipedia, the free encyclop

Palm, Inc. is a personal digital
headquartered in Sunnyvale,
products such as the Zire, Tun
LifeDrive. Previous product line
and Palm VII. While their older
of the Treo run Windows Mobil
operating system, Palm webOS
Palm OS Garnet.[2]

Contents [hide]

1 History
2 List of PDA models
  2.1 Current models
  2.2 Upcoming models
  2.3 Discontinued models
3 Environmental Record
4 See also
5 References
6 External links

History

Palm Co
Hawkins,
and Ed C
invention of the Palm Pilot. The company was started

Palm, Inc. (*aka* Palm)

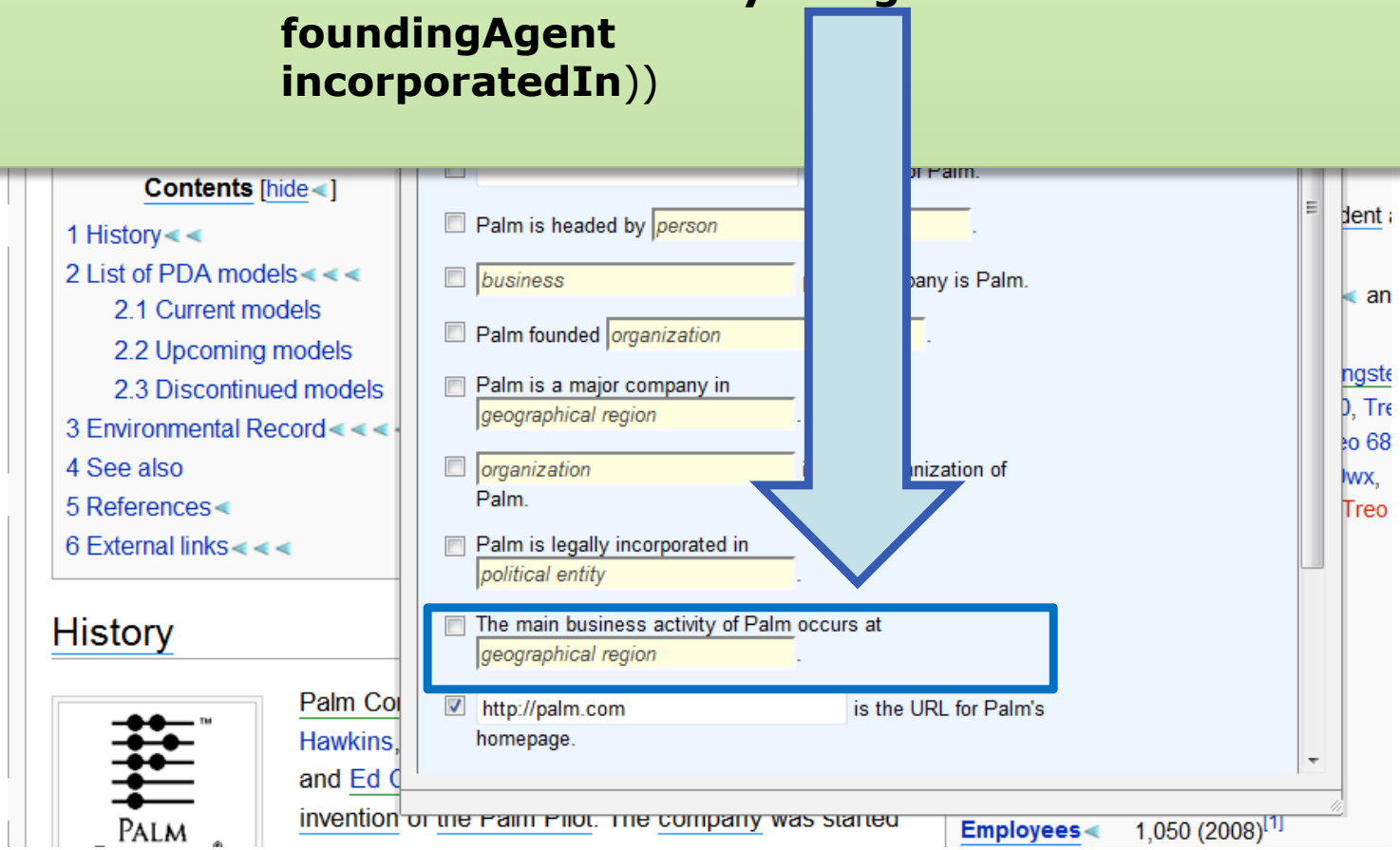
About | Basic Info | Documentation | Advanced Info | Affiliations

- [x] Ed Colligan is Palm's CEO.
- [ ] *person* is the COO of Palm.
- [ ] *person* is the CFO of Palm.
- [x] Jeff Hawkins founded Palm.
- [x] Donna Dubinsky founded Palm.
- [ ] is a leader of Palm.
- [ ] Palm is headed by *person*.
- [ ] *business* parent company is Palm.
- [ ] Palm founded *organization*.
- [ ] Palm is a major company in *geographical region*.
- [ ] *organization* is a suborganization of Palm.
- [ ] Palm is legally incorporated in *political entity*.
- [ ] The main business activity of Palm occurs at *geographical region*.
- [x] http://palm.com is the URL for Palm's homepage.

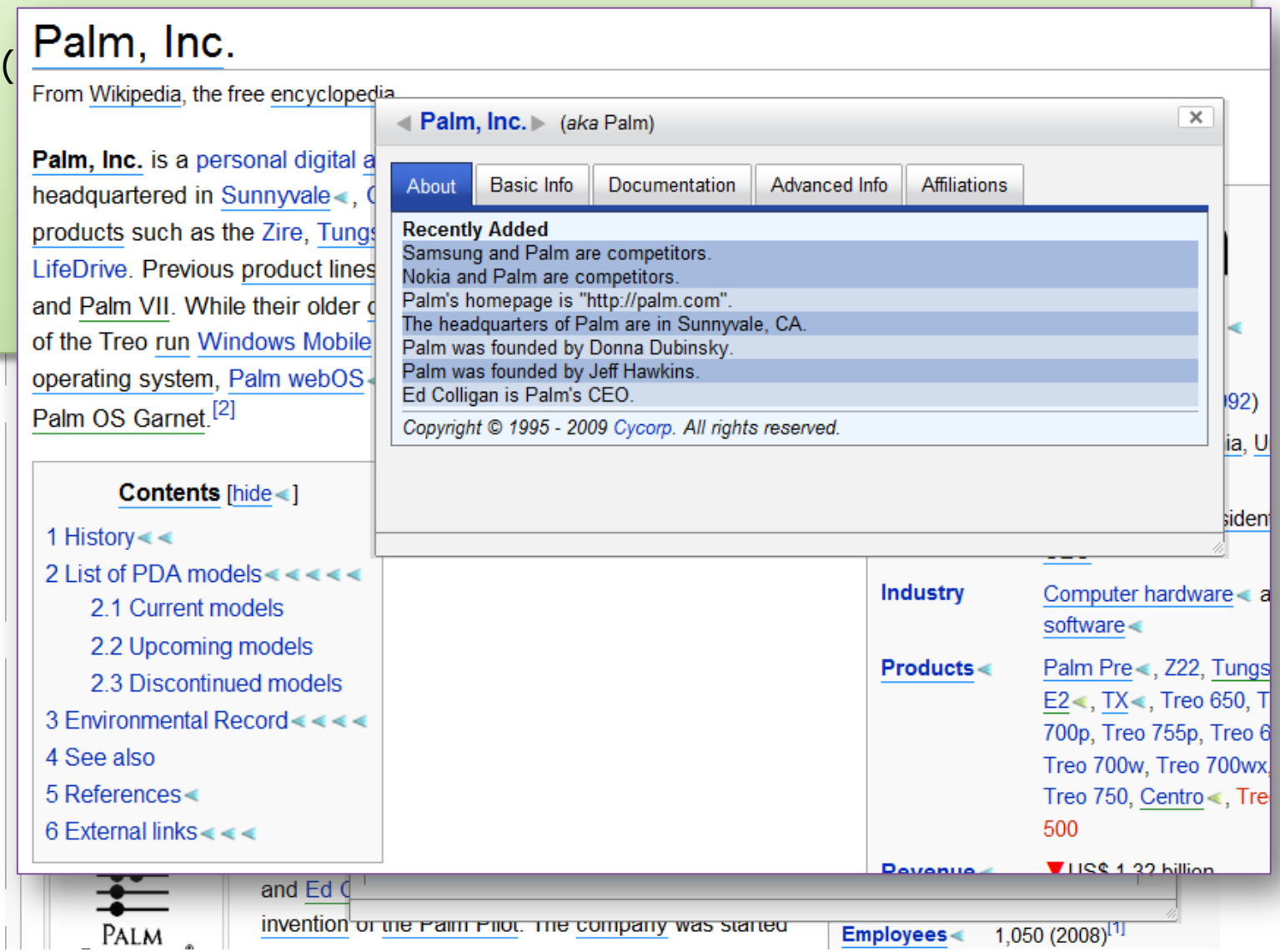
Employees 1,050 (2008)[1]

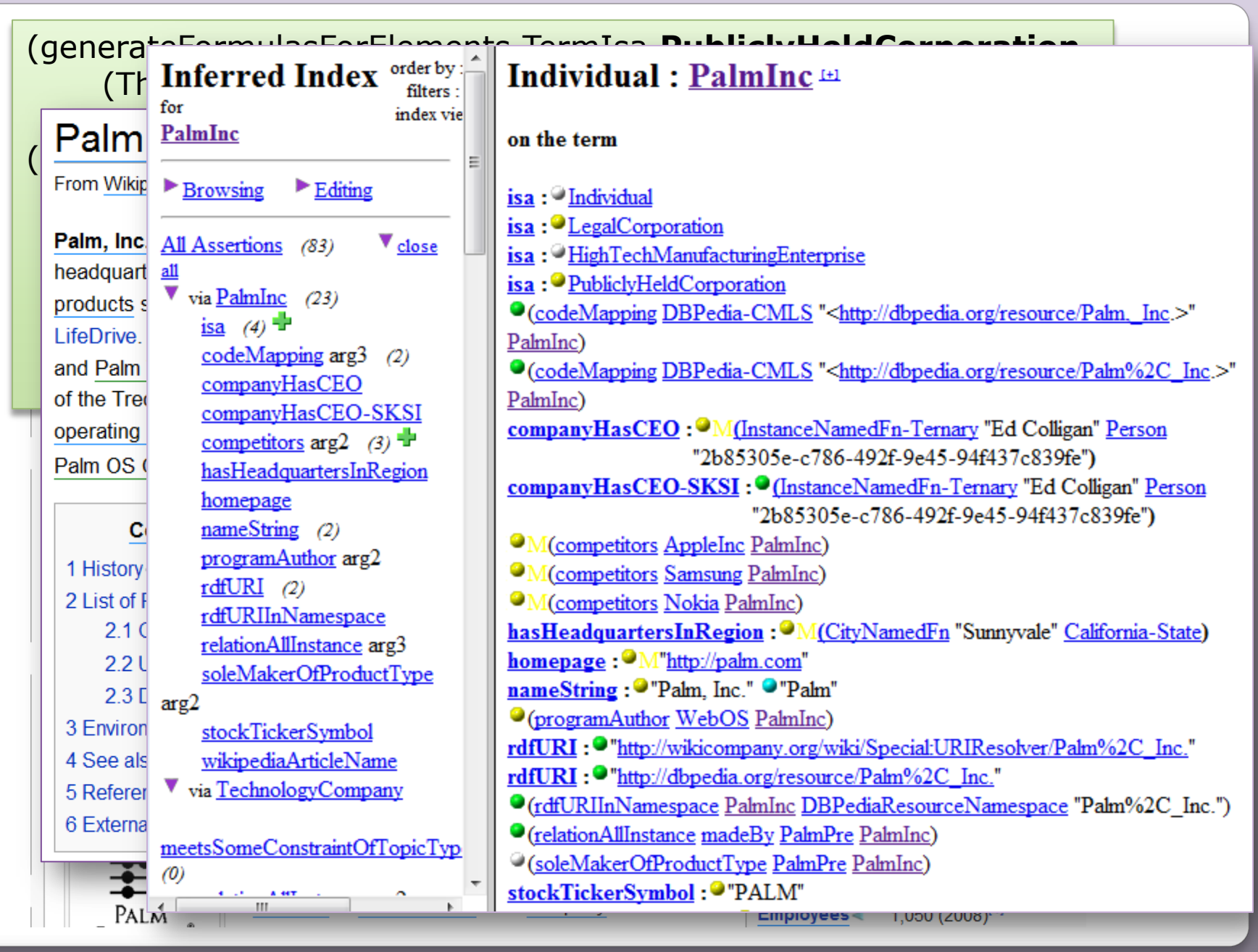
(generateFormulasForElements-TermIsa **PubliclyHeldCorporation**
(TheSet **stockTickerSymbol**))

(generateFormulasForElements-TermIsa **CommercialOrganization**
(TheSet **importantCompany**
subOrganizations
mainBusinessActivityOfOrgOccursAt
foundingAgent
incorporatedIn))



(generateFormulasForElements-TermIsa **PubliclyHeldCorporation**
(TheSet **stockTickerSymbol**))




(generate
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Palm
From Wikip
Palm, Inc.
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LifeDrive.
and Palm
of the Tre
operating
Palm OS
C
1 History
2 List of F
2.1 C
2.2 U
2.3 D
3 Environ
4 See als
5 Referer
6 Externa
Inferred Index
order by :
filters :
index vie
for
PalmInc
Browsing
Editing
All Assertions (83)
close
all
via PalmInc (23)
isa (4)
codeMapping arg3 (2)
companyHasCEO
companyHasCEO-SKSI
competitors arg2 (3)
hasHeadquartersInRegion
homepage
nameString (2)
programAuthor arg2
rdfURI (2)
rdfURIInNamespace
relationAllInstance arg3
soleMakerOfProductType
arg2
stockTickerSymbol
wikipediaArticleName
via TechnologyCompany
meetsSomeConstraintOfTopicTyp
(0)
Individual : PalmInc [+]
on the term
isa : Individual
isa : LegalCorporation
isa : HighTechManufacturingEnterprise
isa : PubliclyHeldCorporation
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PalmInc)
(codeMapping DBPedia-CMLS "<http://dbpedia.org/resource/Palm%2C_Inc.>"
PalmInc)
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"2b85305e-c786-492f-9e45-94f437c839fe")
companyHasCEO-SKSI : (InstanceNamedFn-Ternary "Ed Colligan" Person
"2b85305e-c786-492f-9e45-94f437c839fe")
M(competitors AppleInc PalmInc)
M(competitors Samsung PalmInc)
M(competitors Nokia PalmInc)
hasHeadquartersInRegion : M(CityNamedFn "Sunnyvale" California-State)
homepage : M"http://palm.com"
nameString : "Palm, Inc." "Palm"
(programAuthor WebOS PalmInc)
rdfURI : "http://wikicompany.org/wiki/Special:URIResolver/Palm%2C_Inc."
rdfURI : "http://dbpedia.org/resource/Palm%2C_Inc."
(rdfURIInNamespace PalmInc DBPediaResourceNamespace "Palm%2C_Inc.")
(relationAllInstance madeBy PalmPre PalmInc)
(soleMakerOfProductType PalmPre PalmInc)
stockTickerSymbol : "PALM"

- Home
- Contact us
- Reservation
- History
- Banquet
- Brussels
- Hotels & Acces

Main courses
(with choice)

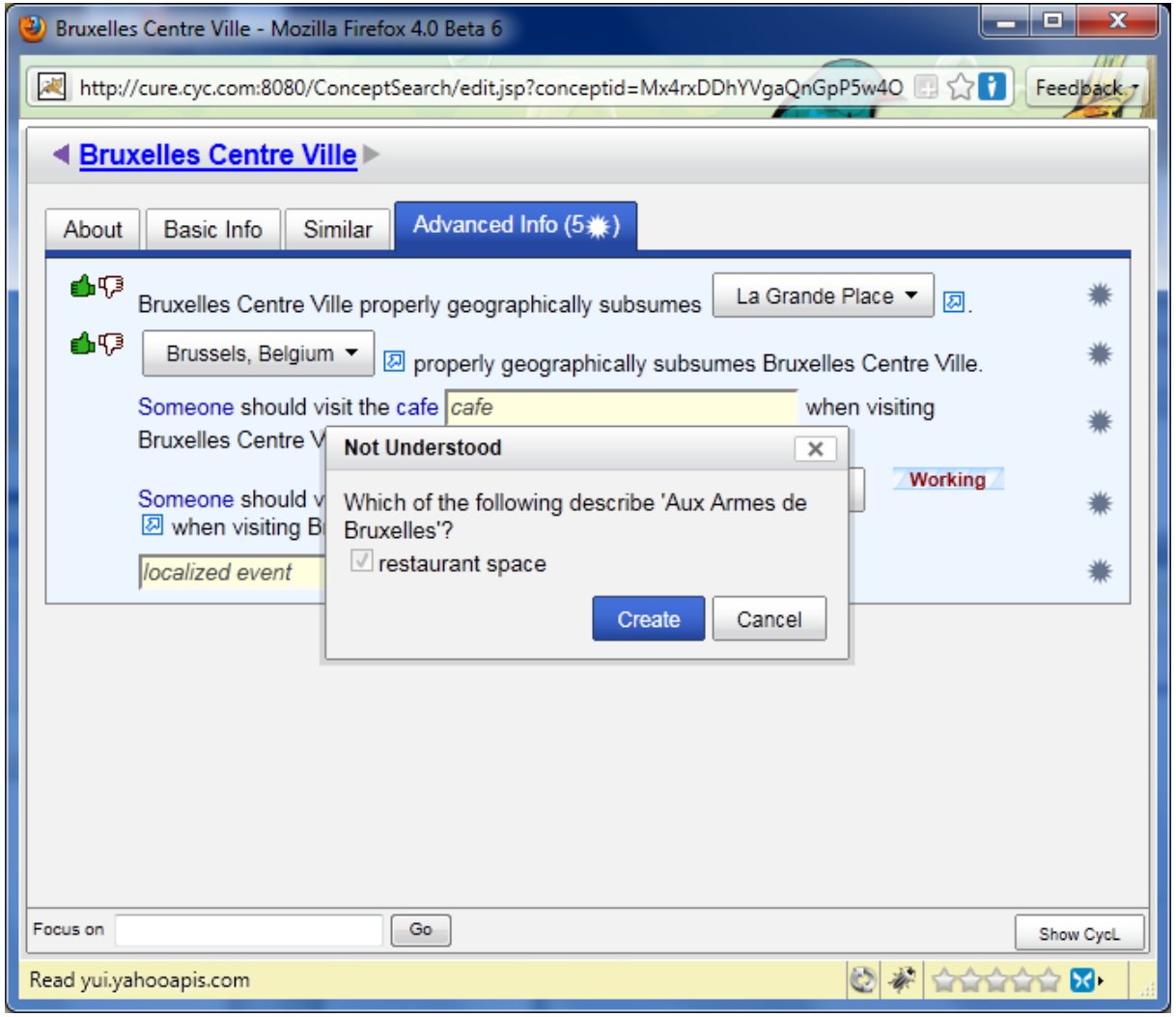
Dish of the day

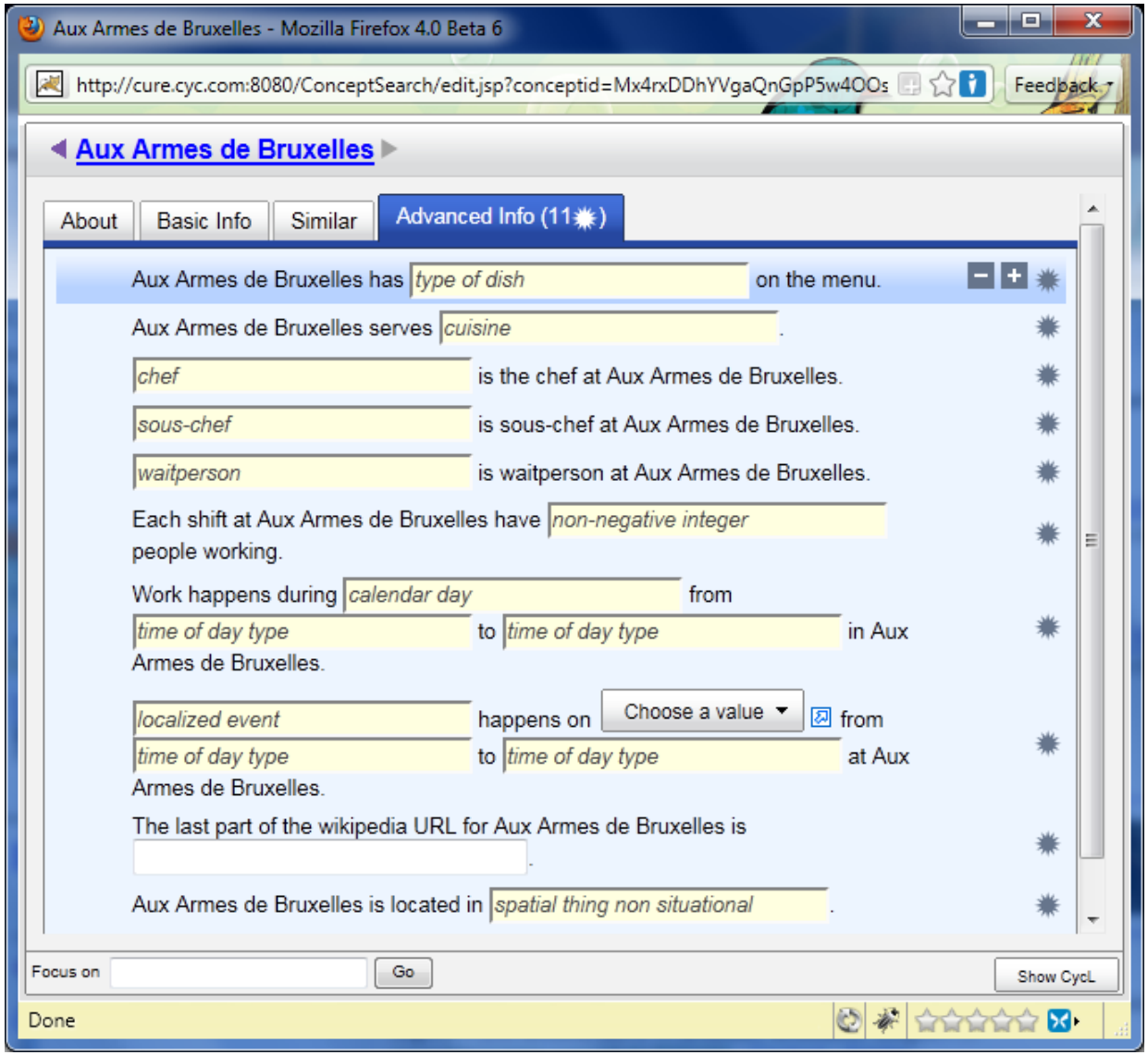
or Tartar steak, frites

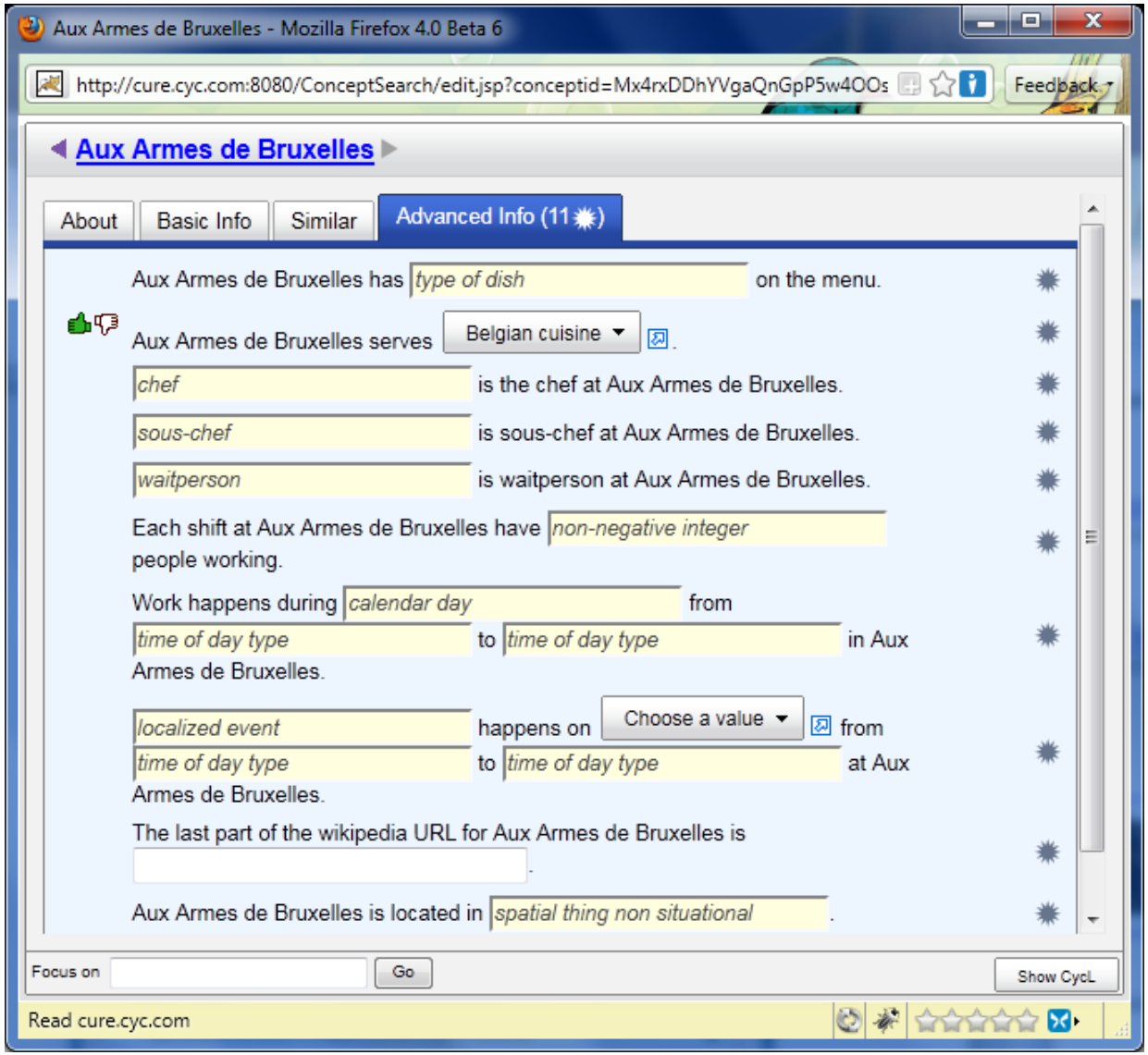
or Stewed beef with gueuze sauce and frites

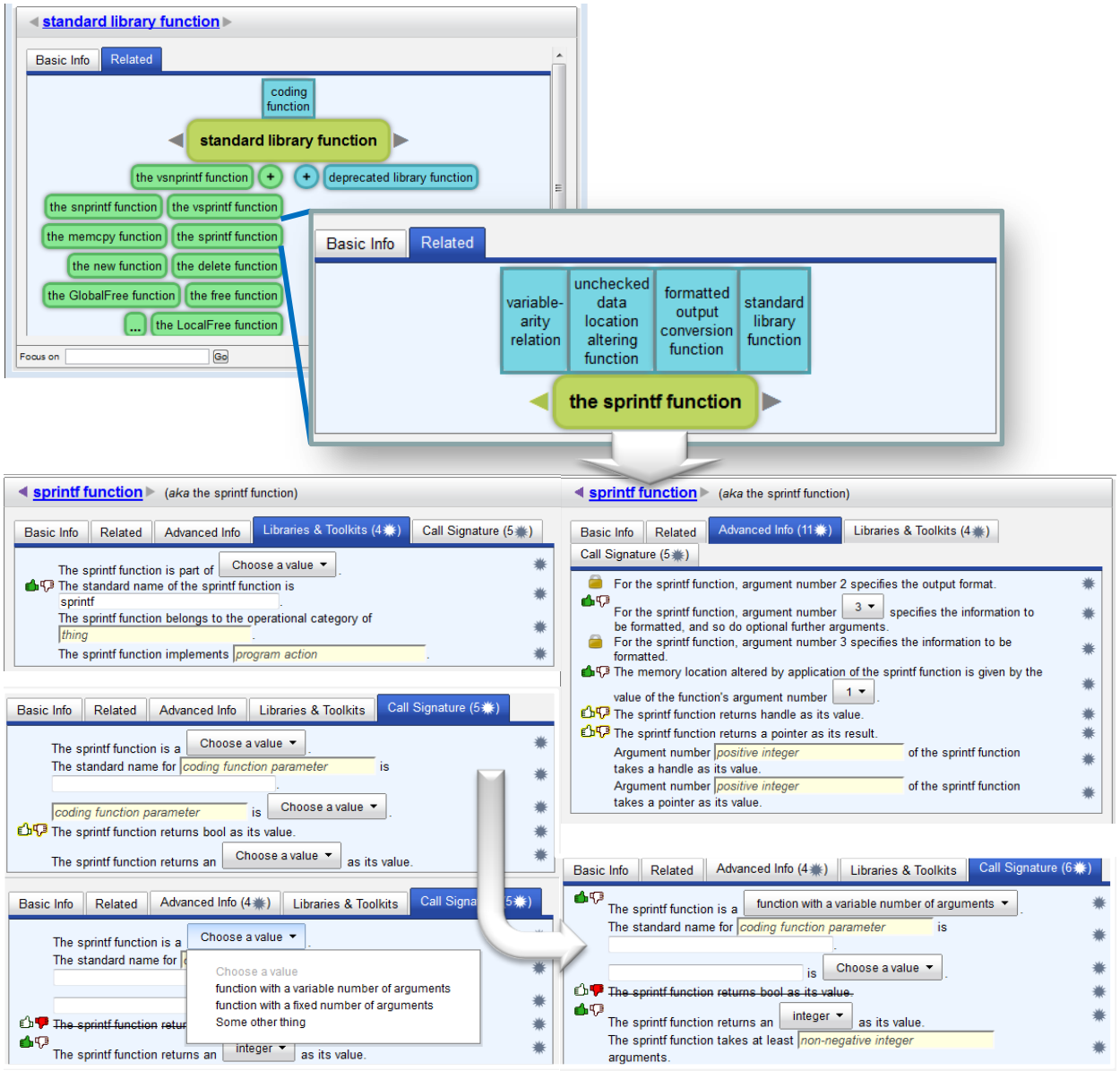
or Grilled salmon béarnaise

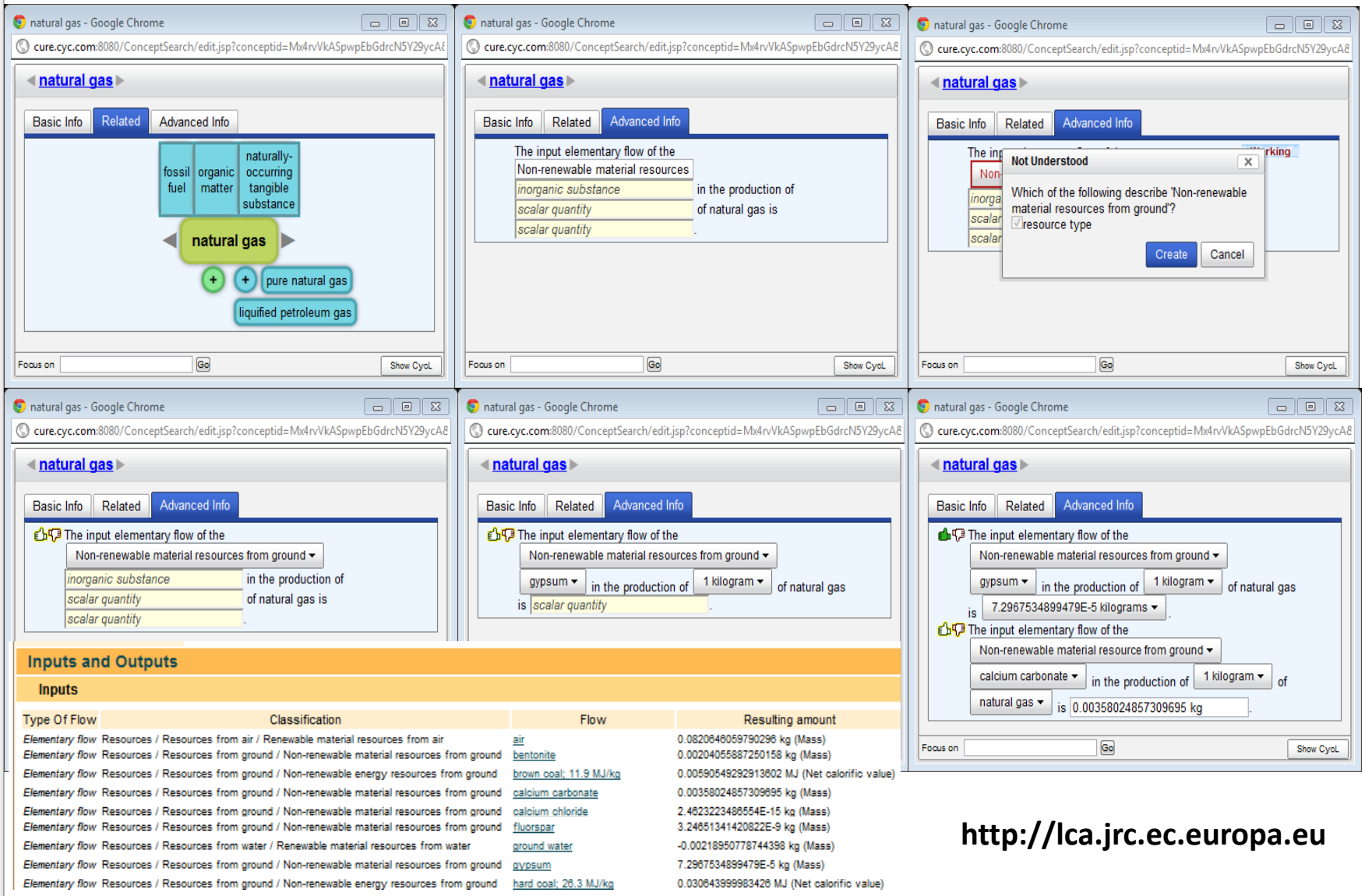
or Mussels in casserole, frites (in season, 600g)


Bruxelles Centre Ville - Mozilla Firefox 4.0 Beta 6
http://cure.cyc.com:8080/ConceptSearch/edit.jsp?conceptid=Mx4rxDDhYVgaQnGpP5w4O
Feedback
Bruxelles Centre Ville
About
Basic Info
Similar
Advanced Info (5)
Bruxelles Centre Ville properly geographically subsumes
La Grande Place
Brussels, Belgium
properly geographically subsumes Bruxelles Centre Ville.
Someone should visit the cafe
cafe
when visiting
Bruxelles Centre V
Working
Someone should v
when visiting B
localized event
Not Understood
Which of the following describe 'Aux Armes de Bruxelles'?
restaurant space
Create
Cancel
Focus on
Go
Show CycL
Read yui.yahooapis.com

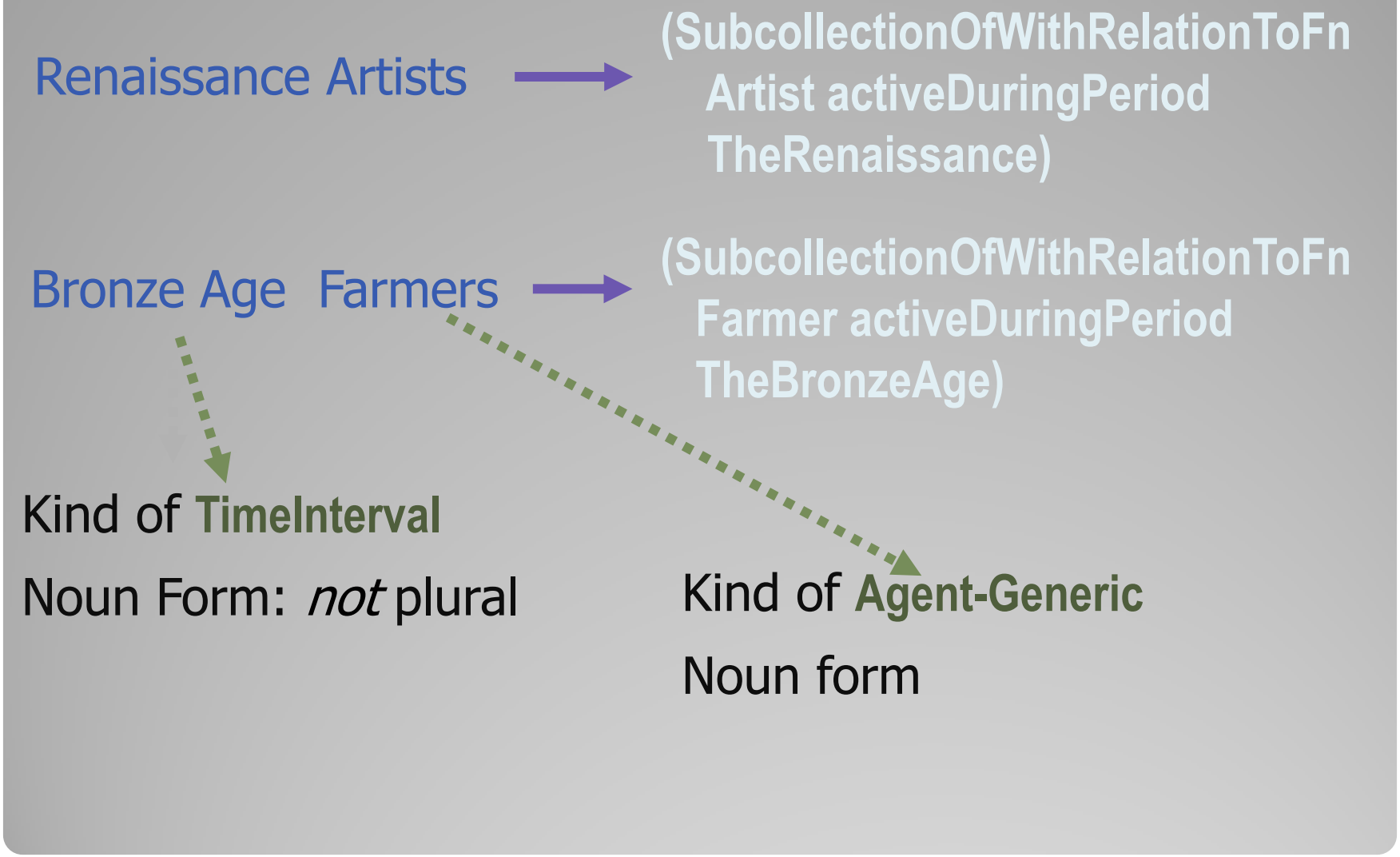

Aux Armes de Bruxelles - Mozilla Firefox 4.0 Beta 6
http://cure.cyc.com:8080/ConceptSearch/edit.jsp?conceptid=Mx4rxDDhYVgaQnGpP5w4OOs
Feedback
Aux Armes de Bruxelles
About
Basic Info
Similar
Advanced Info (11)
Aux Armes de Bruxelles has type of dish on the menu.
Aux Armes de Bruxelles serves cuisine .
chef is the chef at Aux Armes de Bruxelles.
sous-chef is sous-chef at Aux Armes de Bruxelles.
waitperson is waitperson at Aux Armes de Bruxelles.
Each shift at Aux Armes de Bruxelles have non-negative integer people working.
Work happens during calendar day from time of day type to time of day type in Aux Armes de Bruxelles.
localized event happens on Choose a value from time of day type to time of day type at Aux Armes de Bruxelles.
The last part of the wikipedia URL for Aux Armes de Bruxelles is .
Aux Armes de Bruxelles is located in spatial thing non situational .
Focus on
Go
Show CycL
Done


Aux Armes de Bruxelles - Mozilla Firefox 4.0 Beta 6
http://cure.cyc.com:8080/ConceptSearch/edit.jsp?conceptid=Mx4rxDDhYVgaQnGpP5w4OOs
Feedback
Aux Armes de Bruxelles
About
Basic Info
Similar
Advanced Info (11)
Aux Armes de Bruxelles has type of dish on the menu.
Aux Armes de Bruxelles serves Belgian cuisine .
chef is the chef at Aux Armes de Bruxelles.
sous-chef is sous-chef at Aux Armes de Bruxelles.
waitperson is waitperson at Aux Armes de Bruxelles.
Each shift at Aux Armes de Bruxelles have non-negative integer people working.
Work happens during calendar day from time of day type to time of day type in Aux Armes de Bruxelles.
localized event happens on Choose a value from time of day type to time of day type at Aux Armes de Bruxelles.
The last part of the wikipedia URL for Aux Armes de Bruxelles is .
Aux Armes de Bruxelles is located in spatial thing non situational .
Focus on
Go
Show CycL
Read cure.cyc.com


standard library function
Basic Info
Related
coding function
standard library function
the vsnprintf function
deprecated library function
the snprintf function
the vsprintf function
the memcpy function
the sprintf function
the new function
the delete function
the GlobalFree function
the free function
...
the LocalFree function
Focus on
Go
variable-arity relation
unchecked data location altering function
formatted output conversion function
standard library function
the sprintf function
sprintf function
(aka the sprintf function)
Advanced Info
Libraries & Toolkits (4)
Call Signature (5)
The sprintf function is part of
Choose a value
The standard name of the sprintf function is
sprintf
The sprintf function belongs to the operational category of
thing
The sprintf function implements
program action
Libraries & Toolkits
Call Signature (5)
The sprintf function is a
The standard name for
coding function parameter
is
The sprintf function returns bool as its value.
The sprintf function returns an
as its value.
Advanced Info (4)
Call Signa
5)
Choose a value
function with a variable number of arguments
function with a fixed number of arguments
Some other thing
integer
Advanced Info (11)
Call Signature (5)
For the sprintf function, argument number 2 specifies the output format.
For the sprintf function, argument number
3
specifies the information to be formatted, and so do optional further arguments.
For the sprintf function, argument number 3 specifies the information to be formatted.
The memory location altered by application of the sprintf function is given by the value of the function's argument number
1
The sprintf function returns handle as its value.
The sprintf function returns a pointer as its result.
Argument number
positive integer
of the sprintf function takes a handle as its value.
Argument number
positive integer
of the sprintf function takes a pointer as its value.
Call Signature (6)
function with a variable number of arguments
The sprintf function takes at least
non-negative integer
arguments.



http://lca.jrc.ec.europa.eu



Noun Compound Parsing

Attributive Adjective & Noun

Yellow Submarine → (SubcollectionWithRelationToFn Submarine mainColorOfObject Yellow)

Sick Child → (SubcollectionWithRelationToFn HumanChild stateOfHealth Sick)

Supporting Lexical Assertions:

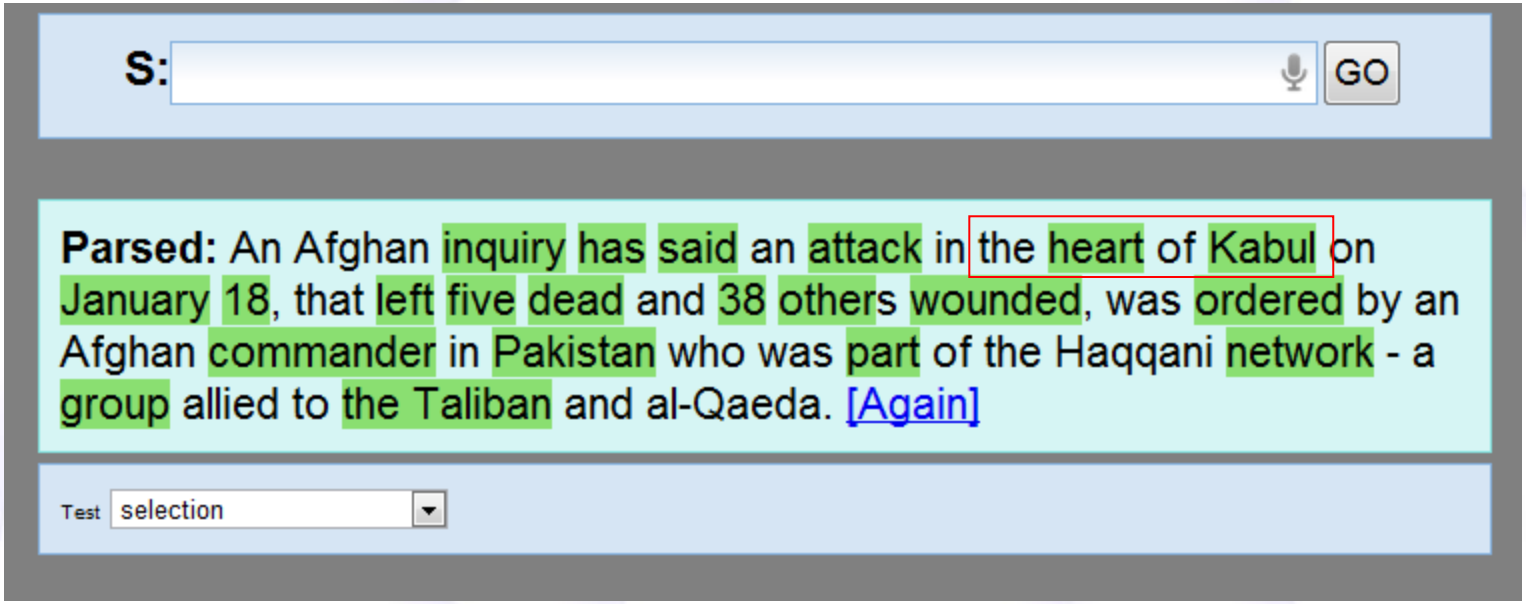
(adjSemTrans Yellow-TheWord 0 RegularAdjFrame
(mainColorOfObject :NOUN YellowColor))

(adjSemTrans Sick-TheWord 0 RegularAdjFrame
(stateOfHealth :NOUN Sick))

Noun Phrase Parsing

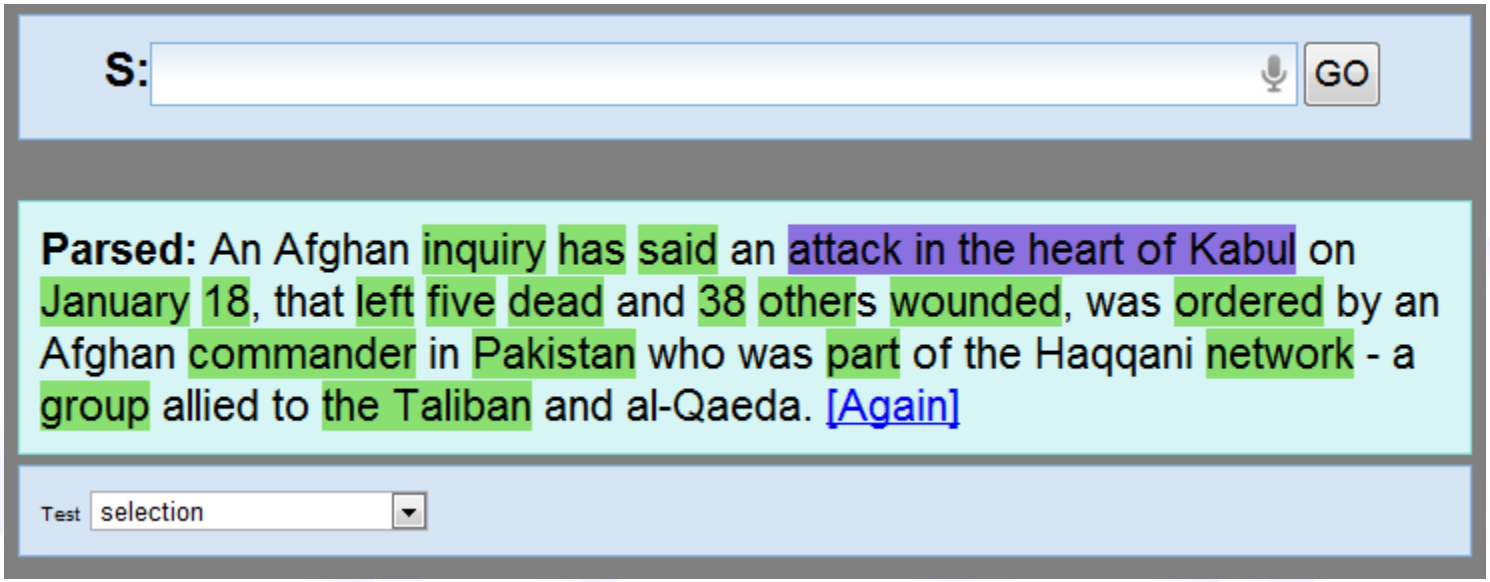
S:
An Afghan inquiry has said an attack in the heart of Kabul on Januar
GO
Test
selection

cYcorp

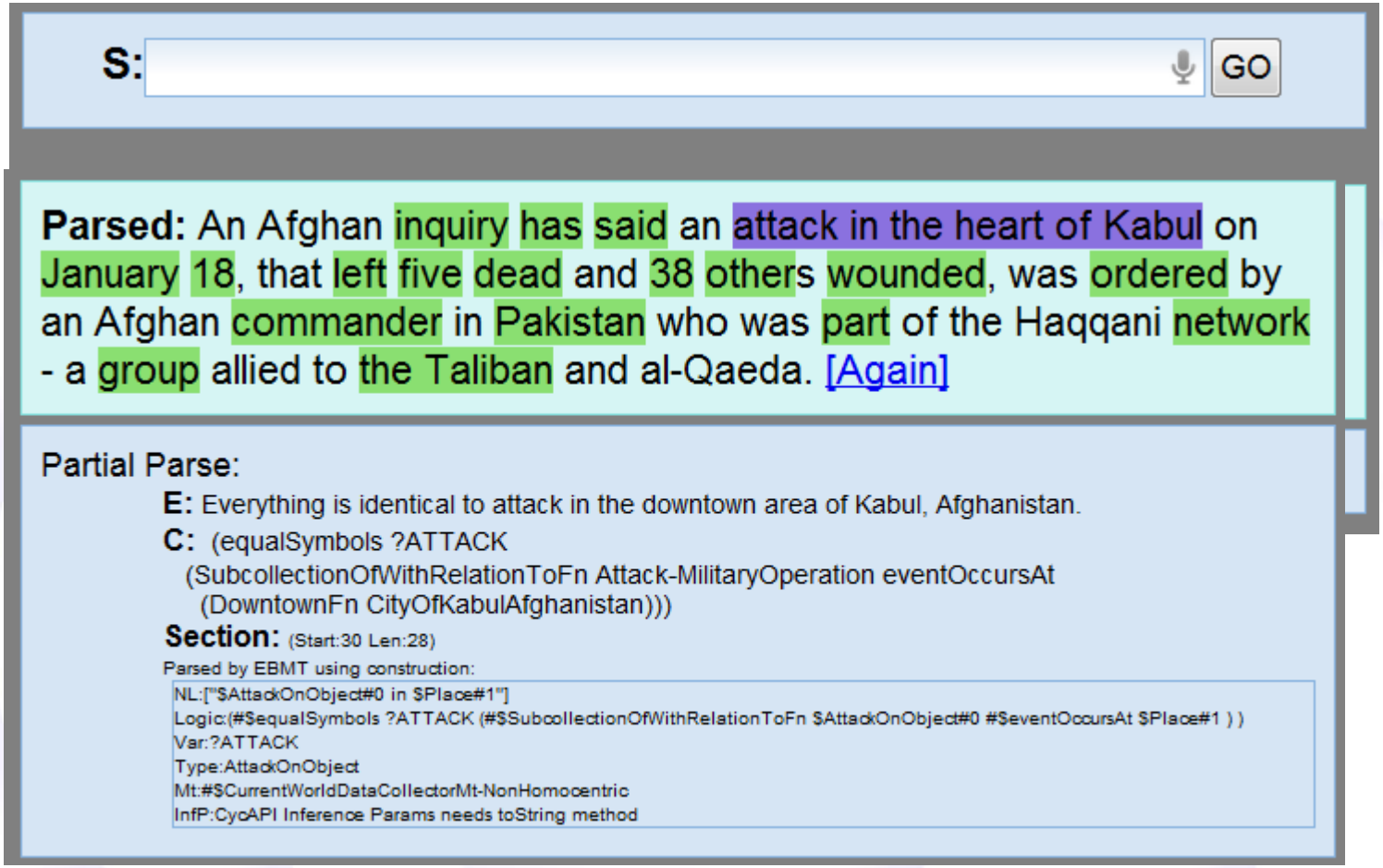



```
<template>
  <nlPattern class="140080">the heart of $City#0</nlPattern>
  <cyclPattern>
      (#$equalSymbols ?D (#$DowntownFn $City#0))
  </cyclPattern>
  <variable>?D</variable>
  <type>#$Downtown</type>
</template>
```

cYcorp


S:
GO
Parsed: An Afghan inquiry has said an attack in the heart of Kabul on January 18, that left five dead and 38 others wounded, was ordered by an Afghan commander in Pakistan who was part of the Haqqani network - a group allied to the Taliban and al-Qaeda. [Again]
Test
selection

cYcorp


S:
GO
Parsed: An Afghan inquiry has said an attack in the heart of Kabul on January 18, that left five dead and 38 others wounded, was ordered by an Afghan commander in Pakistan who was part of the Haqqani network - a group allied to the Taliban and al-Qaeda. [Again]
Partial Parse:
E: Everything is identical to attack in the downtown area of Kabul, Afghanistan.
C: (equalSymbols ?ATTACK
(SubcollectionOfWithRelationToFn Attack-MilitaryOperation eventOccursAt
(DowntownFn CityOfKabulAfghanistan)))
Section: (Start:30 Len:28)
Parsed by EBMT using construction:
NL:["$AttackOnObject#0 in $Place#1"]
Logic:(#$equalSymbols ?ATTACK (#$SubcollectionOfWithRelationToFn $AttackOnObject#0 #$eventOccursAt $Place#1))
Var:?ATTACK
Type:AttackOnObject
Mt:#$CurrentWorldDataCollectorMt-NonHomocentric
InfP:CycAPI Inference Params needs toString method

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Taking Advantage of Paraphrases

an attack in the heart of Kabul on January 18, that left five dead and 38 others wounded,

AttackOnObject, that left five dead and 38 others wounded,

c.f. *AttackOnObject* has killed five people and injured 38

```
<template>
  <nlPattern class="140060">$AttackOnObject#0 has killed $NonNegativeInteger#2 people and injured $NonNegativeInteger#3</nlPattern>
  <cyclPattern>(#$thereExists ?ATTACK
              (#$and
                (#$isa ?ATTACK $AttackOnObject#0)
                 (#$relationInstanceExistsCount #$animalInjuredIn ?ATTACK #$Person $NonNegativeInteger#3)
                (#$relationInstanceExistsCount #$organismKilled ?ATTACK #$Person $NonNegativeInteger#2)   )    )
  </cyclPattern>
  <type>#$CycLSentence-Assertible</type>
  <microTheory>#$CurrentWorldDataCollectorMt-NonHomocentric</microTheory>
  <inferenceMode type=":MINIMAL"/>
 </template>
```

```
<template>
  <nlPattern class="140060">$AttackOnObject#0 , that left $NonNegativeInteger#2 dead and $NonNegativeInteger#3 others wounded
        </nlPattern>
  <cyclPattern>(#$thereExists ?ATTACK
              (#$and
                (#$isa ?ATTACK $AttackOnObject#0)
                 (#$relationInstanceExistsCount #$animalWoundedIn ?ATTACK #$Person $NonNegativeInteger#3)
                (#$relationInstanceExistsCount #$organismKilled ?ATTACK #$Person $NonNegativeInteger#2)  )   )
  </cyclPattern>
  <type>#$CycLSentence-Assertible</type>
  <microTheory>#$CurrentWorldDataCollectorMt-NonHomocentric</microTheory>
  <inferenceMode type=":MINIMAL"/>
 </template>
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cYcorp

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  </cyclPattern>
  <type>#$CycLSentence-Assertible</type>
  <microTheory>#$CurrentWorldDataCollectorMt-NonHomocentric</microTheory>
  <inferenceMode type=":MINIMAL"/>
 </template>
```

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<template>
  <nlPattern class="140060">$AttackOnObject#0 , that left $NonNegativeInteger#2 dead and $NonNegativeInteger#3 others wounded
        </nlPattern>
```

Parsed: An Afghan inquiry has said an attack in the heart of Kabul, that left five dead and 38 others wounded, was ordered by an Afghan commander in Pakistan who was part of the Haqqani network - a group allied to the Taliban and al-Qaeda. [Again]

```
  <microTheory>#$CurrentWorldDataCollectorMt-NonHomocentric</microTheory>
  <inferenceMode type=":MINIMAL"/>
 </template>
```

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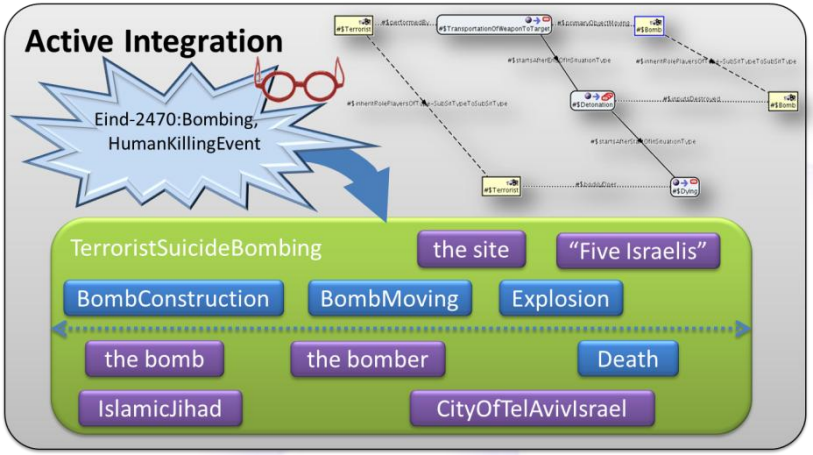

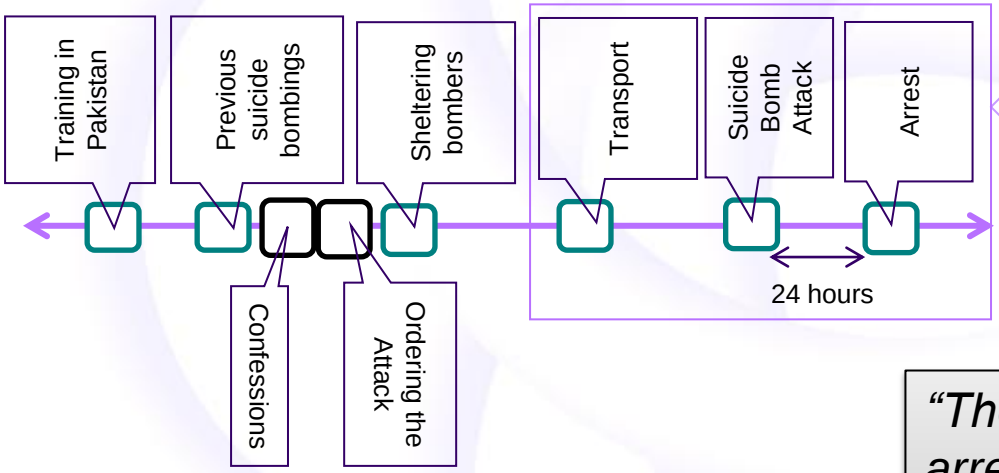

to prove: the transport in the bombing happened before the attack

"Their evidence comes from a man arrested 24-hours after the assault, who admitted he sheltered the suicide bombers and took them to some of their targets in Kabul"

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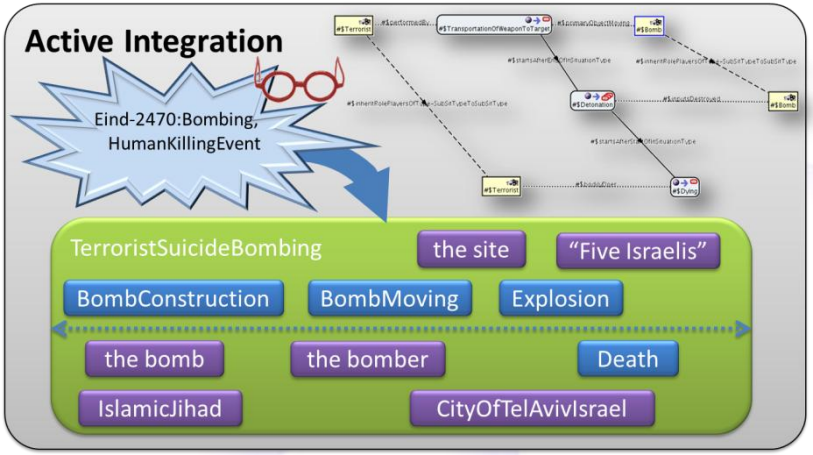

Rules

- **Transport** of something to a place happens before the end of the thing transported (so, not after the attack).
- If there is one transport, of some X, as a sub-situation, and that X plays a required role in some other sub-situation, and the destination of the transport is near the location of the other sub-situation, then the transport happens before (in this case, the other sub-situation is the attack)

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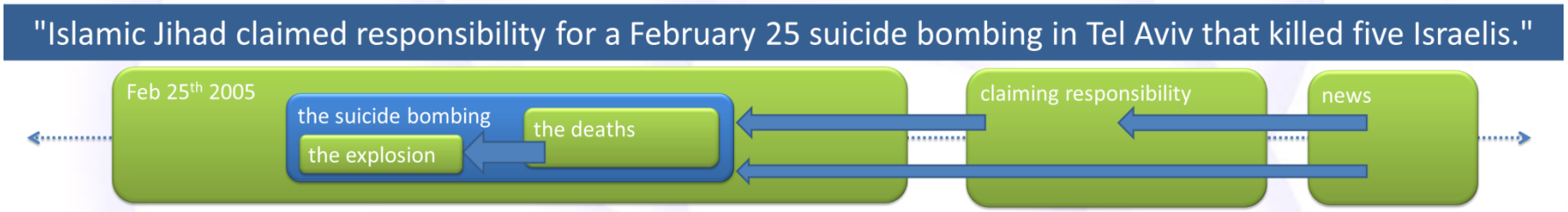
Existing Content

(properSubEventTypes TerroristSuicideBombing TransportationOfWeaponToTarget)
(properSubEventTypes TerroristSuicideBombing Detonation)
(properSubEventTypes TerroristSuicideBombing Dying)

(startsAfterEndOfInSituationType TerroristSuicideBombing Dying Detonation)
(startsAfterEndOfInSituationType TerroristSuicideBombing Detonation TransportationOfWeaponToTarget)
(startsAfterEndOfInSituationType TerroristSuicideBombing Detonation TransportationOfWeaponToTarget)

(inheritRolePlayers-SitTypeToSubSitType TerroristSuicideBombing perpetrator Dying bodilyDoer)
(inheritRolePlayersOfType-SubSitTypeToSubSitType TerroristSuicideBombing TransportationOfWeaponToTarget performedBy Dying bodilyDoer Terrorist)
(inheritRolePlayers-SitTypeToSubSitType TerroristSuicideBombing perpetrator TransportationOfWeaponToTarget doneBy)



Similar: Needed

(startsAfterEndOfInSituationType Bombing ClaimingResponsibility Detonation)

Causal Constraints:

(causes-SubSitTypeSubSitType Bombing Detonaton Dying)
(requiresForRole Bombing Bomb deviceUsed)
(requiresForRole Detonation Bomb inputsDestroyed)
(requiresForRole TerroristSuicideBombing Person bodilyDoer)

We need these constraints, can they be read or learned?

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Needs-based Ontology Extension

Role	Types	Examples
personKilled	People	vacationer, newlywed, bus rider, mouseketeer
eventOccursAt	Places	Police station, army recruiting center, souk, marquee
deviceUsed	Weapons	Suicide vest, boomerang, crossbow, bus bomb, shaped charge
killers	Agent	Somali youth, pirates, military doctor, rebel recruit

Haqqani network

From Wikipedia, the free encyclopedia

The **Haqqani network** is an independent insurgent group in Afghanistan and Pakistan that is closely allied with the Taliban.[1] Maulvi Jalaluddin Haqqani along with his son Sirajuddin Haqqani lead the Haqqani network which is based in North Waziristan, Pakistan. The network is thought[*by whom?*] to present one of the biggest threats to NATO and United States forces in Afghanistan. [2] Following *Wikileaks* July 2010 publication of 75,000 classified documents the public learned that Siraj Haqqani was in the tier one of the International Security Assistance Force's Joint Prioritized Effects List -- its *"kill or capture"* list.[3]

- Techniques:
  - **Acquire candidates:**
  - Automatically acquire from dbPedia, or
  - Read from Wikipedia, or
  - Import from macro-readers, or
  - Fillers of templates, where there is evidence for effectiveness for type inference
  - **Confirmation** by human beings, or
  - by generate and test

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CYC