Bridging Ontologies and Text Mining

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Biolexicon, Bioterminologies and related resources

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Overview

- An example
- Types of resources for mining biomedical text
- Three types of resources
  - Lexical resources
  - Terminological resources
  - Ontological resources

An example

Neurofibromatosis 2

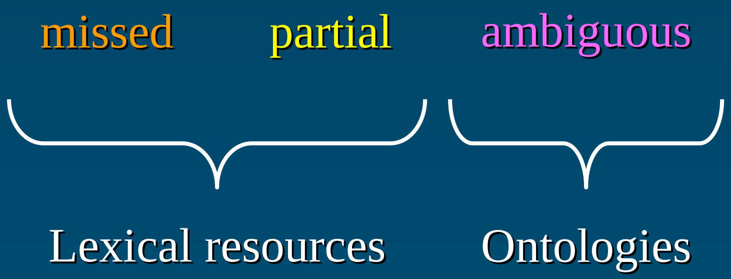
Neurofibromatosis 2

Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis. NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas. NF2 results from a mutation in the gene named merlin, located on chromosome 22.

[Uppal, S., and A. P. Coatesworth. "Neurofibromatosis Type 2." *Int J Clin Pract*, 57, no. 8, 2003, pp. 698-703.]

Entity recognition

Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis. NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas. NF2 results from a mutation in the gene named merlin, located on chromosome 22.



missed partial ambiguous

Lexical resources Ontologies

Relation extraction

Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis. NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas. NF2 results from a mutation in the gene named merlin, located on chromosome 22.

- vestibular schwannomas *manifestation of* neurofibromatosis 2
- neurofibromatosis 2 *associated with* mutation of NF2 gene
- NF2 gene *located on* chromosome 22

Types of resources
for mining biomedical text

Types of resources

- Lexical resources
  - Collections of lexical items
  - Additional information
    - Part of speech
    - Spelling variants
  - Useful for entity recognition
  - UMLS SPECIALIST Lexicon, WordNet

- Ontological resources
  - Collections of
    - kinds of entities (substances, qualities, processes)
    - relations among them
  - Useful for relation extraction
  - UMLS Semantic Network, BioTop

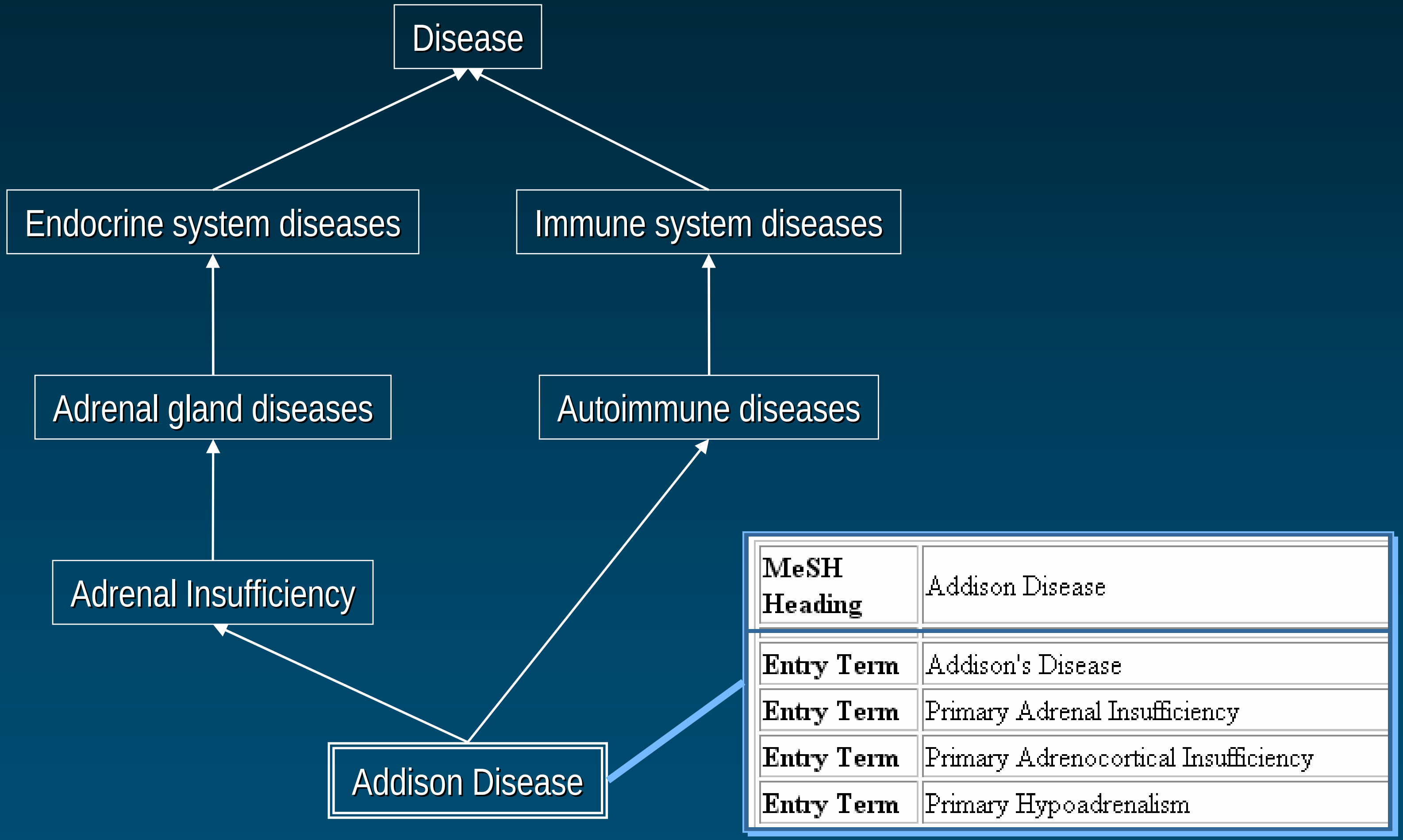
- Terminological resources
  - Collections lexical items + identifiers
  - Useful for entity resolution
  - UMLS Metathesaurus

Types of resources (revisited)

- Lexical and terminological resources
  - Mostly collections of names for biomedical entities
  - Often have some kind or hierarchical organization (e.g., relations)
- Ontological resources
  - Mostly collections of relations among biomedical entities
  - Sometimes also collect names

Lexical / Ontological MeSH

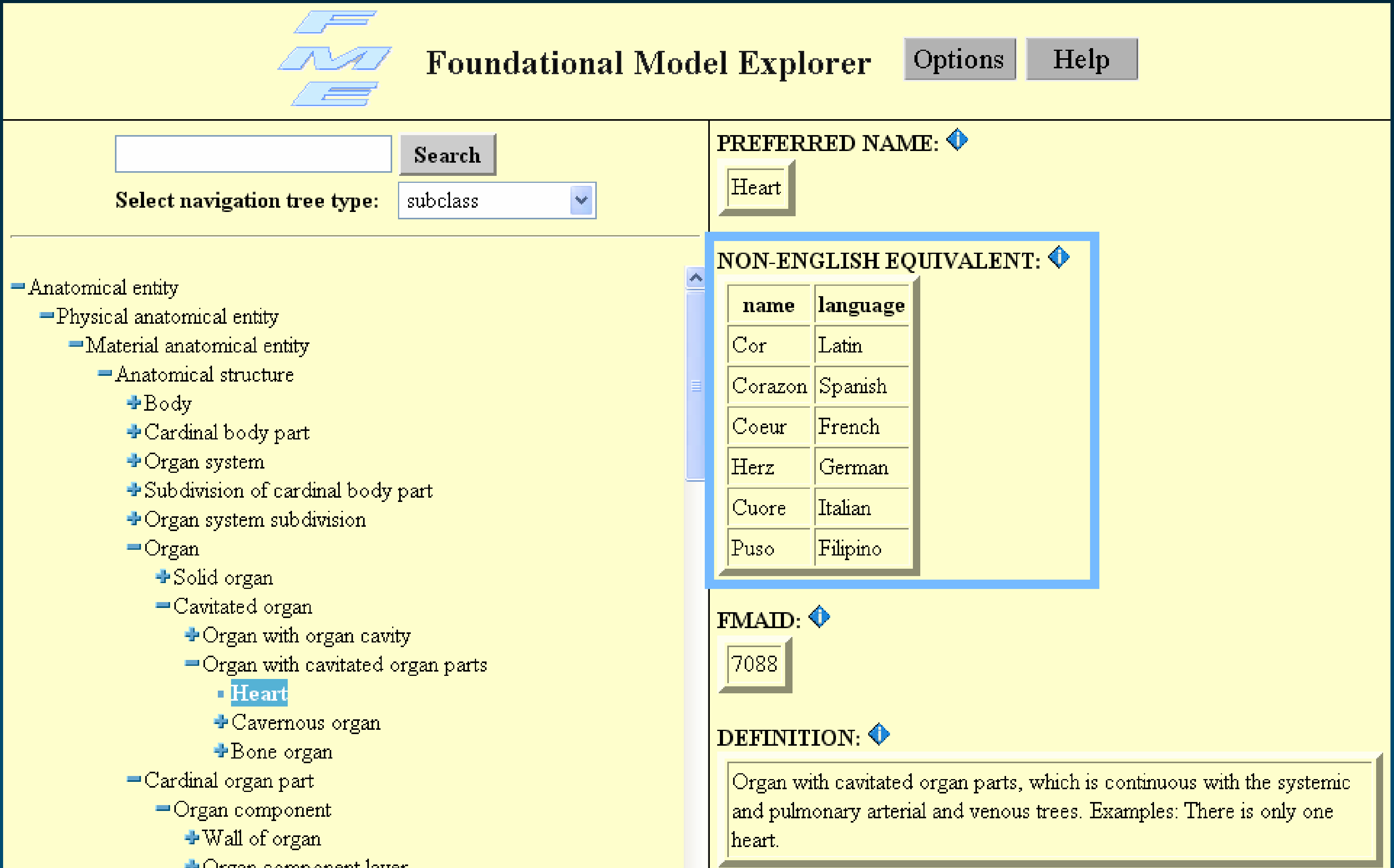
http://www.nlm.nih.gov/mesh/2007/MBrowser.html



MeSH Heading	Addison Disease
Entry Term	Addison's Disease
Entry Term	Primary Adrenal Insufficiency
Entry Term	Primary Adrenocortical Insufficiency
Entry Term	Primary Hypoadrenalism

Lexical / Ontological FMA

http://fme.biostr.washington.edu/index.html



Select navigation tree type: subclass

- − Anatomical entity
  - − Physical anatomical entity
    - − Material anatomical entity
      - − Anatomical structure
        - + Body
        - + Cardinal body part
        - + Organ system
        - + Subdivision of cardinal body part
        - + Organ system subdivision
        - − Organ
          - + Solid organ
          - − Cavitated organ
            - + Organ with organ cavity
            - − Organ with cavitated organ parts
              - ▪ Heart
            - + Cavernous organ
            - + Bone organ
        - − Cardinal organ part
          - − Organ component
            - + Wall of organ
            - + Organ component layer

PREFERRED NAME:

Heart

NON-ENGLISH EQUIVALENT:

name	language
Cor	Latin
Corazon	Spanish
Coeur	French
Herz	German
Cuore	Italian
Puso	Filipino

FMAID:

7088

DEFINITION:

Organ with cavitated organ parts, which is continuous with the systemic and pulmonary arterial and venous trees. Examples: There is only one heart.

Unified Medical Language System

- SPECIALIST Lexicon
  - 360,000 lexical items
  - Part of speech and variant information
- Metathesaurus
  - 6M names from over 100 terminologies
  - 1.5M concepts
  - 8M relations
- Semantic Network
  - 135 high-level categories
  - 7000 relations among them

Lexical resources

LVG / Norm

Terminological resources

MetaMap

Ontological resources

SemRep

Lexical resources

SPECIALIST Lexicon and lexical tools

Lexical Systems Group

http://umlslex.nlm.nih.gov/

SPECIALIST Lexicon

- Content
  - English lexicon
  - Many words from the biomedical domain
- 360,000 lexical items
- Word properties
  - morphology
  - orthography
  - syntax
- Used by the lexical tools

Morphology

- Inflection

noun	nucleus, nuclei
verb	cauterize, cauterizes, cauterized, cauterizing
adjective	red, redder, reddest

- Derivation

verb	↔	noun	cauterize -- cauterization
adjective	↔	noun	red -- redness

Orthography

- Spelling variants

oe/e	oesophagus - esophagus
ae/e	anaemia - anemia
ise/ize	cauterise - cauterize
genitive mark	Addison's disease Addison disease Addisons disease

Syntax

- Complementation
  - verbs
    - intransitive   I'll treat.
    - transitive   He treated the patient.
    - ditransitive   He treated the patient with a drug.
  - nouns
    - prepositional phrase

      Valve of coronary sinus
- Position for adjectives

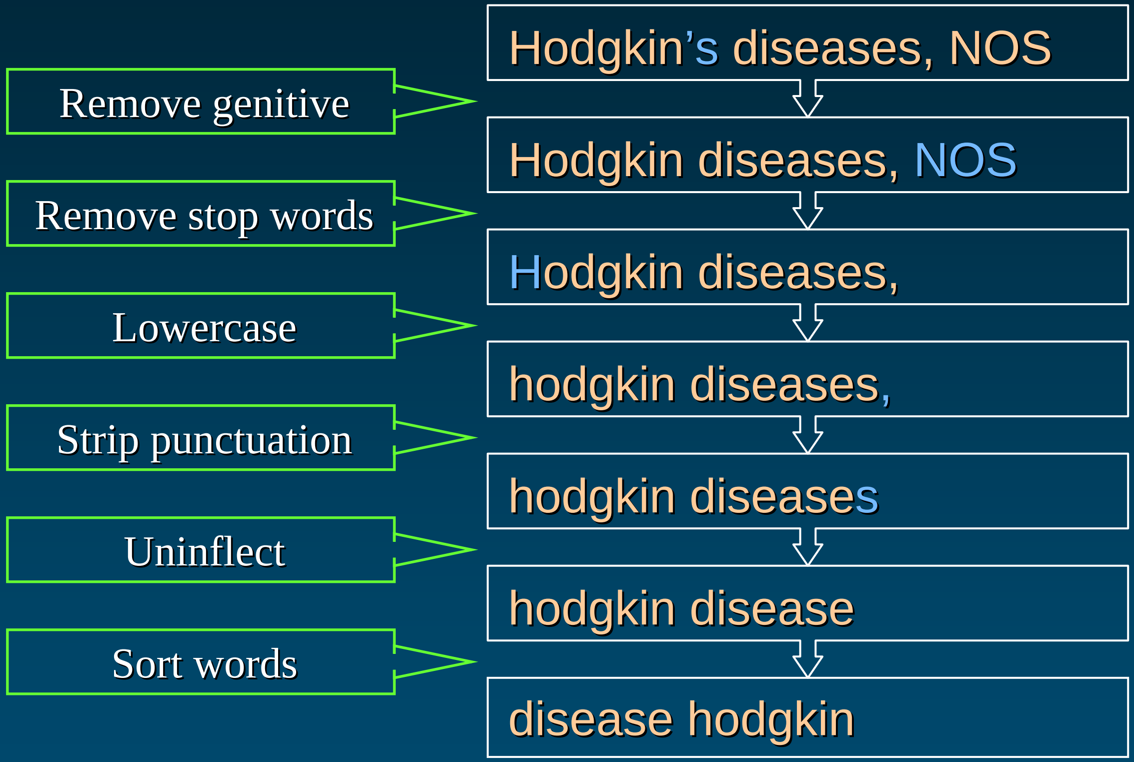
SPECIALIST Lexicon record

```
{
  base=hemoglobin       (base form)
  spelling_variant=haemoglobin
  entry=E0031208        (identifier)
  cat=noun              (part of speech)
  variants=uncount      (no plural)
  variants=reg          (plural: hemoglobins, hemoglobins)
}
```

Lexical tools

- To manage lexical variation in biomedical terminologies
- Major tools
  - Normalization
  - Indexes
  - Lexical Variant Generation program (lvg)
- Based on the SPECIALIST Lexicon
- Used by noun phrase extractors, search engines

Normalization



Hodgkin’s diseases, NOS

Remove genitive

Hodgkin diseases, NOS

Remove stop words

Hodgkin diseases,

Lowercase

hodgkin diseases,

Strip punctuation

hodgkin diseases

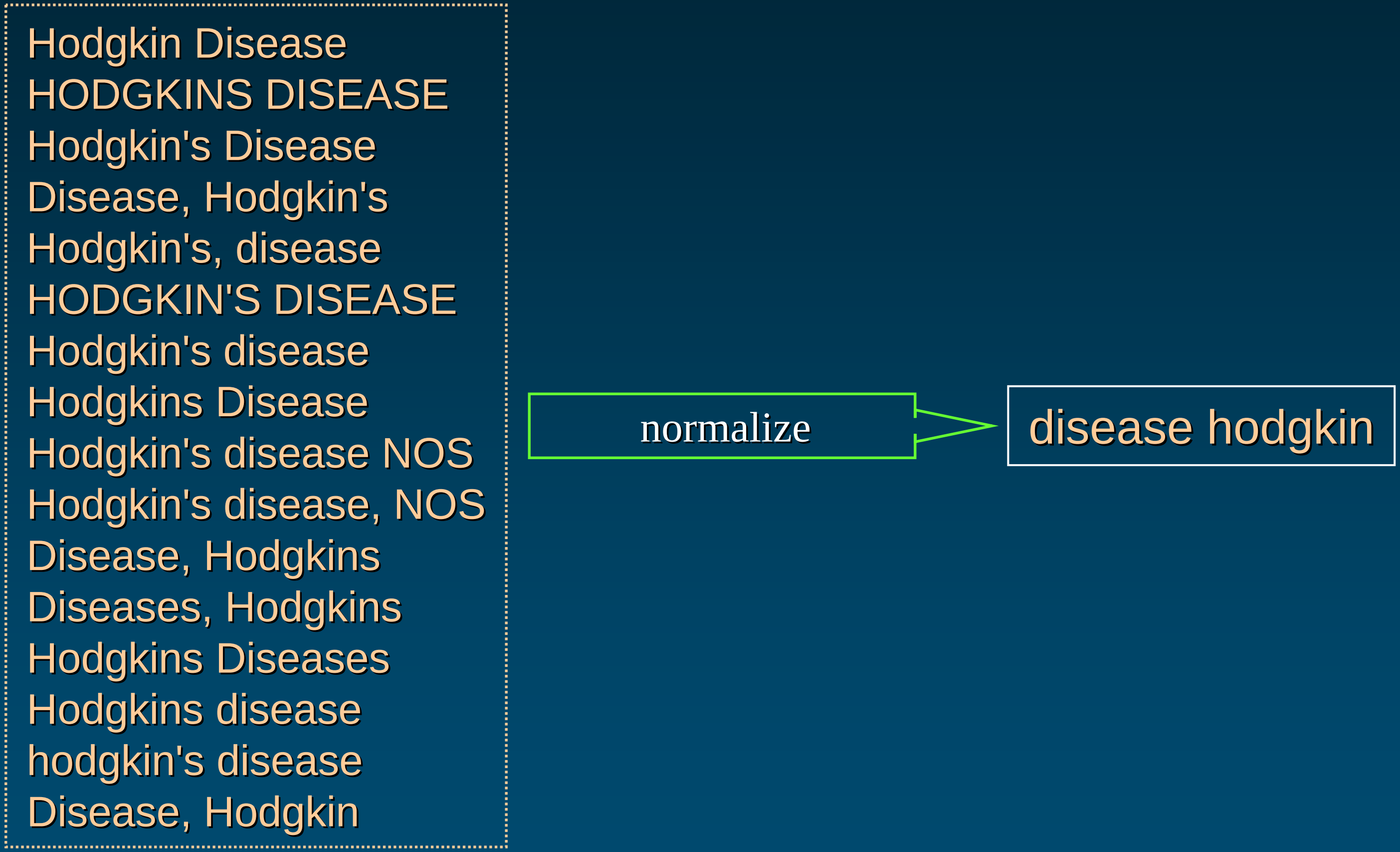
Uninflect

hodgkin disease

Sort words

disease hodgkin

Normalization: Example



Hodgkin Disease
HODGKINS DISEASE
Hodgkin's Disease
Disease, Hodgkin's
Hodgkin's, disease
HODGKIN'S DISEASE
Hodgkin's disease
Hodgkins Disease
Hodgkin's disease NOS
Hodgkin's disease, NOS
Disease, Hodgkins
Diseases, Hodgkins
Hodgkins Diseases
Hodgkins disease
hodgkin's disease
Disease, Hodgkin

normalize

disease hodgkin

Normalization Applications

- Model for lexical resemblance
- Help find lexical variants for a term
  - Terms that normalize the same usually share the same LUI
- Help find candidates to synonymy among terms
- Help map input terms to UMLS concepts

Indexes

- Word index
  - word to Metathesaurus strings
  - one word index per language
- Normalized word index
  - normalized word to Metathesaurus strings
  - English only
- Normalized string index
  - normalized term to Metathesaurus strings
  - English only

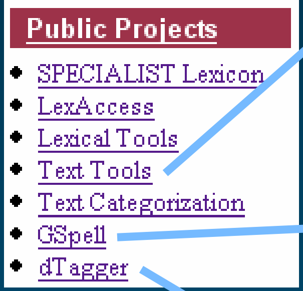
Lexical Variant Generation program

- Tool for specialists (linguists)
- Performs atomic lexical transformations
  - generating inflectional variants
  - lowercase
  - …
- Performs sequences of atomic transformations
  - a specialized sequence of transformations provides the normalized form of a term (the *norm* program)

Related NLM tools

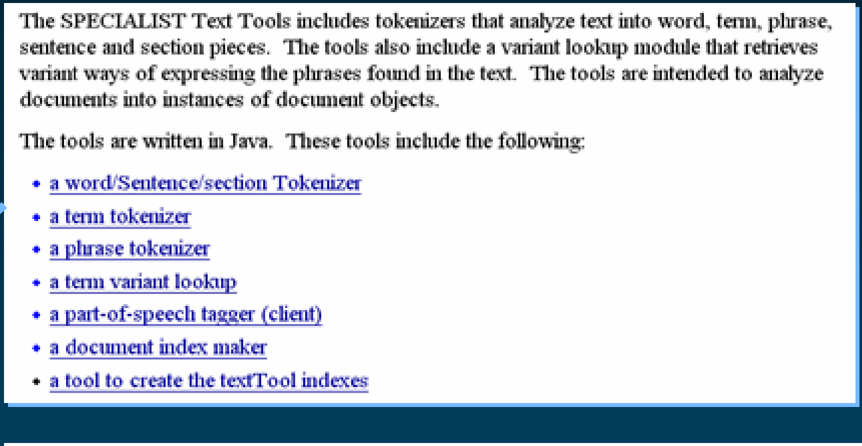
Lexical Systems Group

http://umlslex.nlm.nih.gov/



Public Projects

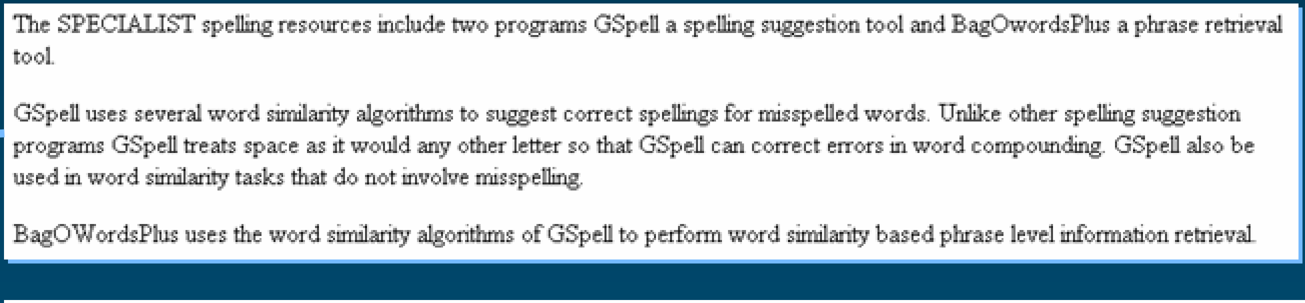
- SPECIALIST Lexicon
- LexAccess
- Lexical Tools
- Text Tools
- Text Categorization
- GSpell
- dTagger



The SPECIALIST Text Tools includes tokenizers that analyze text into word, term, phrase, sentence and section pieces. The tools also include a variant lookup module that retrieves variant ways of expressing the phrases found in the text. The tools are intended to analyze documents into instances of document objects.

The tools are written in Java. These tools include the following:

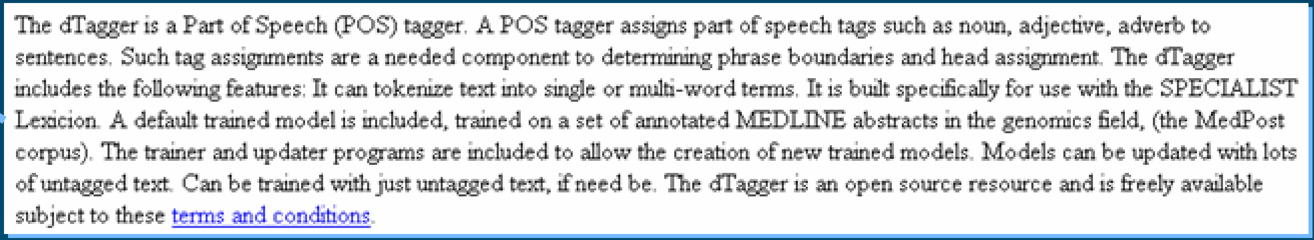
- a word/Sentence/section Tokenizer
- a term tokenizer
- a phrase tokenizer
- a term variant lookup
- a part-of-speech tagger (client)
- a document index maker
- a tool to create the textTool indexes



The SPECIALIST spelling resources include two programs GSpell a spelling suggestion tool and BagOwordsPlus a phrase retrieval tool.

GSpell uses several word similarity algorithms to suggest correct spellings for misspelled words. Unlike other spelling suggestion programs GSpell treats space as it would any other letter so that GSpell can correct errors in word compounding. GSpell also be used in word similarity tasks that do not involve misspelling.

BagOWordsPlus uses the word similarity algorithms of GSpell to perform word similarity based phrase level information retrieval.



The dTagger is a Part of Speech (POS) tagger. A POS tagger assigns part of speech tags such as noun, adjective, adverb to sentences. Such tag assignments are a needed component to determining phrase boundaries and head assignment. The dTagger includes the following features: It can tokenize text into single or multi-word terms. It is built specifically for use with the SPECIALIST Lexicion. A default trained model is included, trained on a set of annotated MEDLINE abstracts in the genomics field, (the MedPost corpus). The trainer and updater programs are included to allow the creation of new trained models. Models can be updated with lots of untagged text. Can be trained with just untagged text, if need be. The dTagger is an open source resource and is freely available subject to these terms and conditions.

Lexical resources

Other resources

Need for additional resources

- More generic
  - WordNet
- More specific
  - Lexical items specific to specialized subdomains
    - Not listed in biolexicons
    - Not amenable to normalization
  - Examples
    - Genes, proteins
      - MAPK3 / Mapk3 / mapk3
    - Chemicals
      - 5’-3’ exonuclease / 3’-5’ exonuclease
    - Drugs
    - Acronyms

Gene and protein names

- Additional resources

Genew	http://www.gene.ucl.ac.uk/nomenclature/
Entrez Gene	http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=gene
UniProt	http://www.ebi.uniprot.org/index.shtml

- Additional identification methods
  - e.g., ABGene (Tanabe & Wilbur, NCBI)
  - BioCreAtIvE
    - Gene mention identification
    - Gene normalization

BioCreAtIvE

Critical Assessment for Information Extraction in Biology

Chemical names

- Additional resources

PubChem	http://pubchem.ncbi.nlm.nih.gov/
ChemIDplus	http://chem.sis.nlm.nih.gov/chemidplus/chemidlite.jsp
ChEBI	http://www.ebi.ac.uk/chebi/

Drug names

- Covered by UMLS
- Specialized resource: RxNorm
  - Branded names / generic names
  - Various levels of aggregation
    - Ingredient
    - Ingredient + dose
    - Ingredient + form
    - Ingredient + dose + form
  - Codes in various reference systems
- Mostly US drugs, no “over-the-counter” drugs

Acronyms

- Many resources available
  - AcroMine http://www.nactem.ac.uk/software/acromine/
  - ARGH: Biomedical Acronym Resolver http://lethargy.swmed.edu/ARGH/argh.asp
  - Stanford Biomedical Abbreviation Server http://bionlp.stanford.edu/abbreviation/
  - AcroMed http://medstract.med.tufts.edu/acro1.1/index.htm
  - SaRAD http://www.hpl.hp.com/research/idl/projects/abbrev.html

Terminological resources

UMLS Metathesaurus

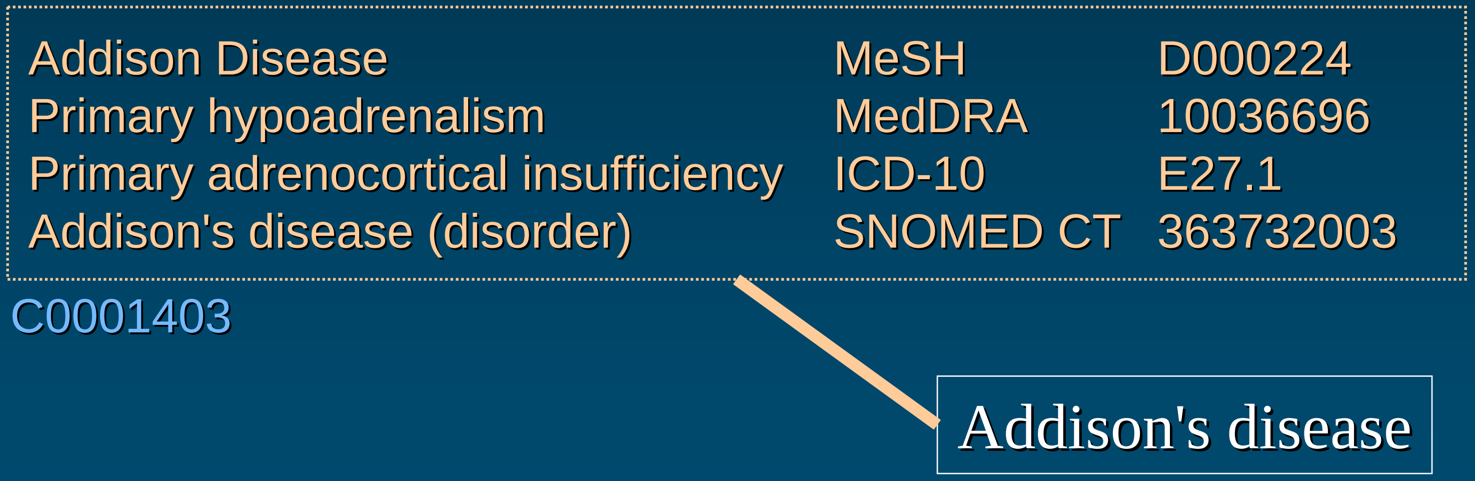
http://www.nlm.nih.gov/research/umls/

Source Vocabularies (2007AB)

- 143 source vocabularies
  - 17 languages
- Broad coverage of biomedicine
  - 5.9M names
  - 1.4M concepts
  - 16M relations
- Common presentation

Organize terms

- Synonymous terms clustered into a concept
- Preferred term
- Unique identifier (CUI)



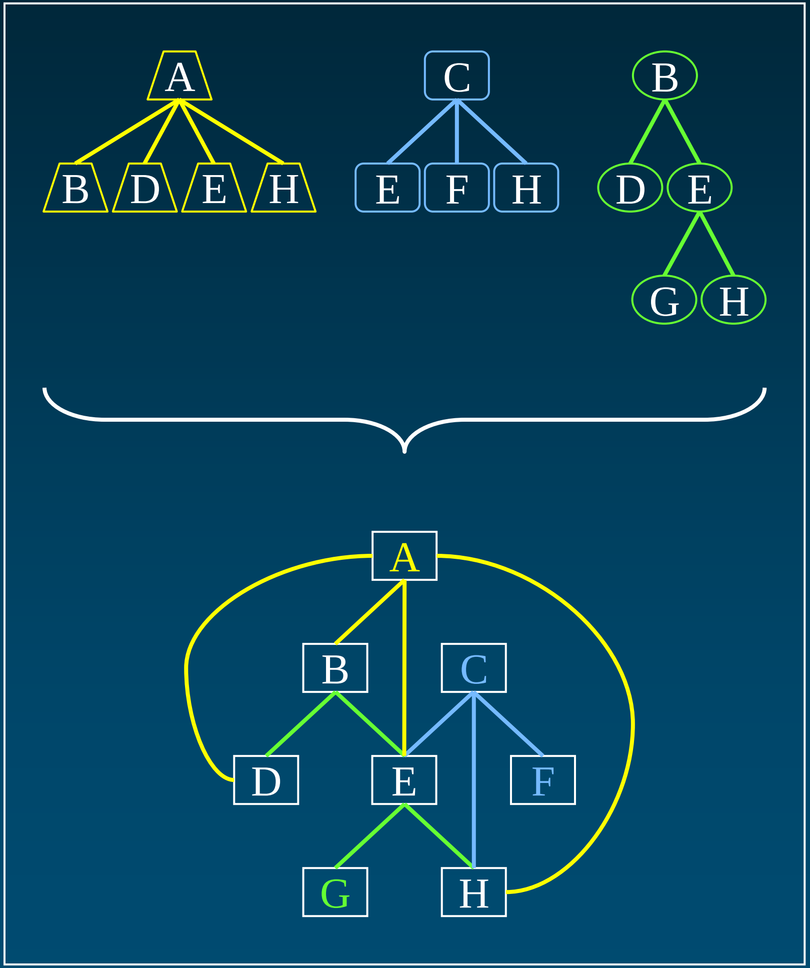
Addison Disease	MeSH	D000224
Primary hypoadrenalism	MedDRA	10036696
Primary adrenocortical insufficiency	ICD-10	E27.1
Addison's disease (disorder)	SNOMED CT	363732003

C0001403

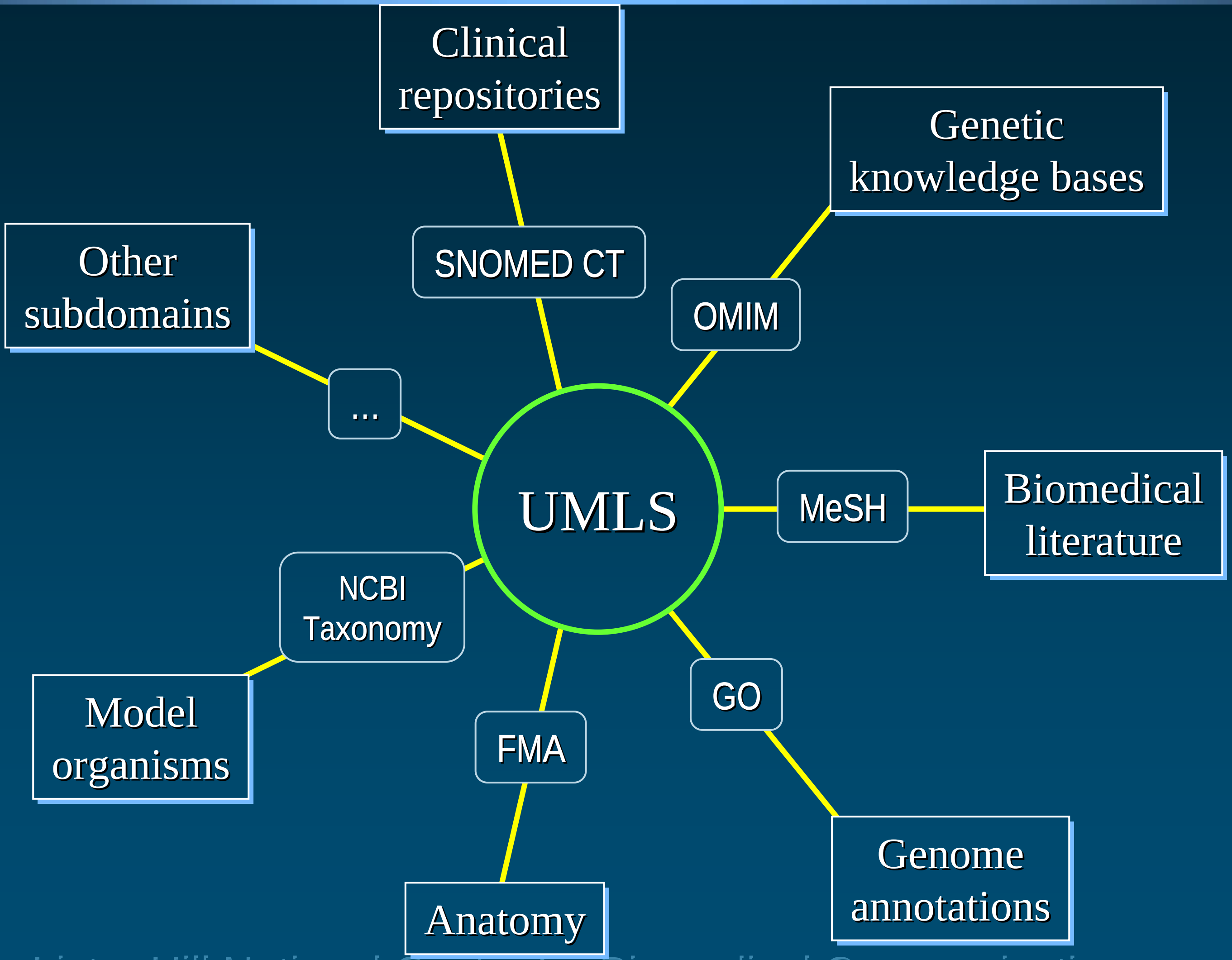
Addison's disease

Organize concepts

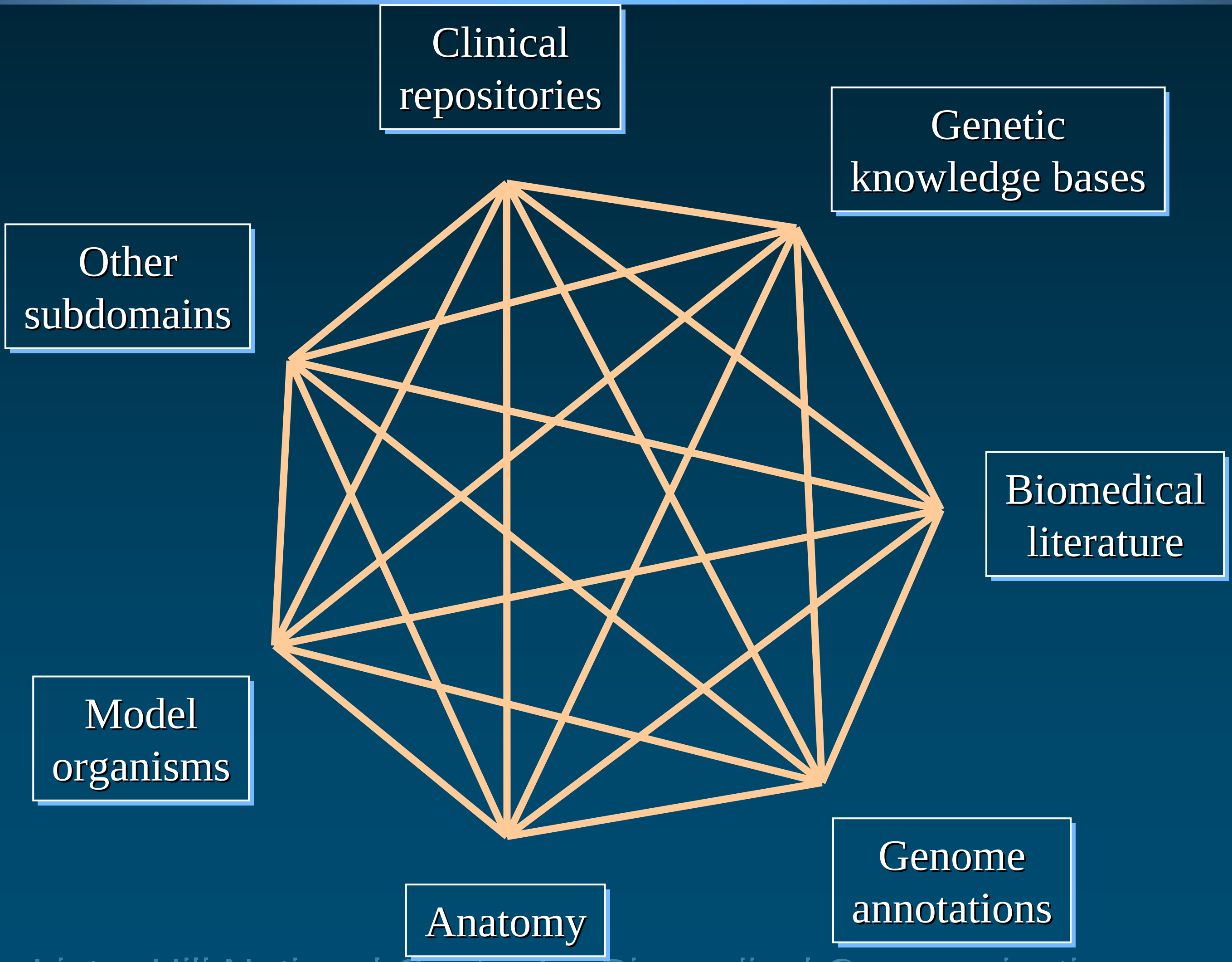
- Inter-concept relationships: hierarchies from the source vocabularies
- Redundancy: multiple paths
- One graph instead of multiple trees (multiple inheritance)



Integrating subdomains



Integrating subdomains



Clinical repositories

Genetic knowledge bases

Other subdomains

Biomedical literature

Model organisms

Genome annotations

Anatomy

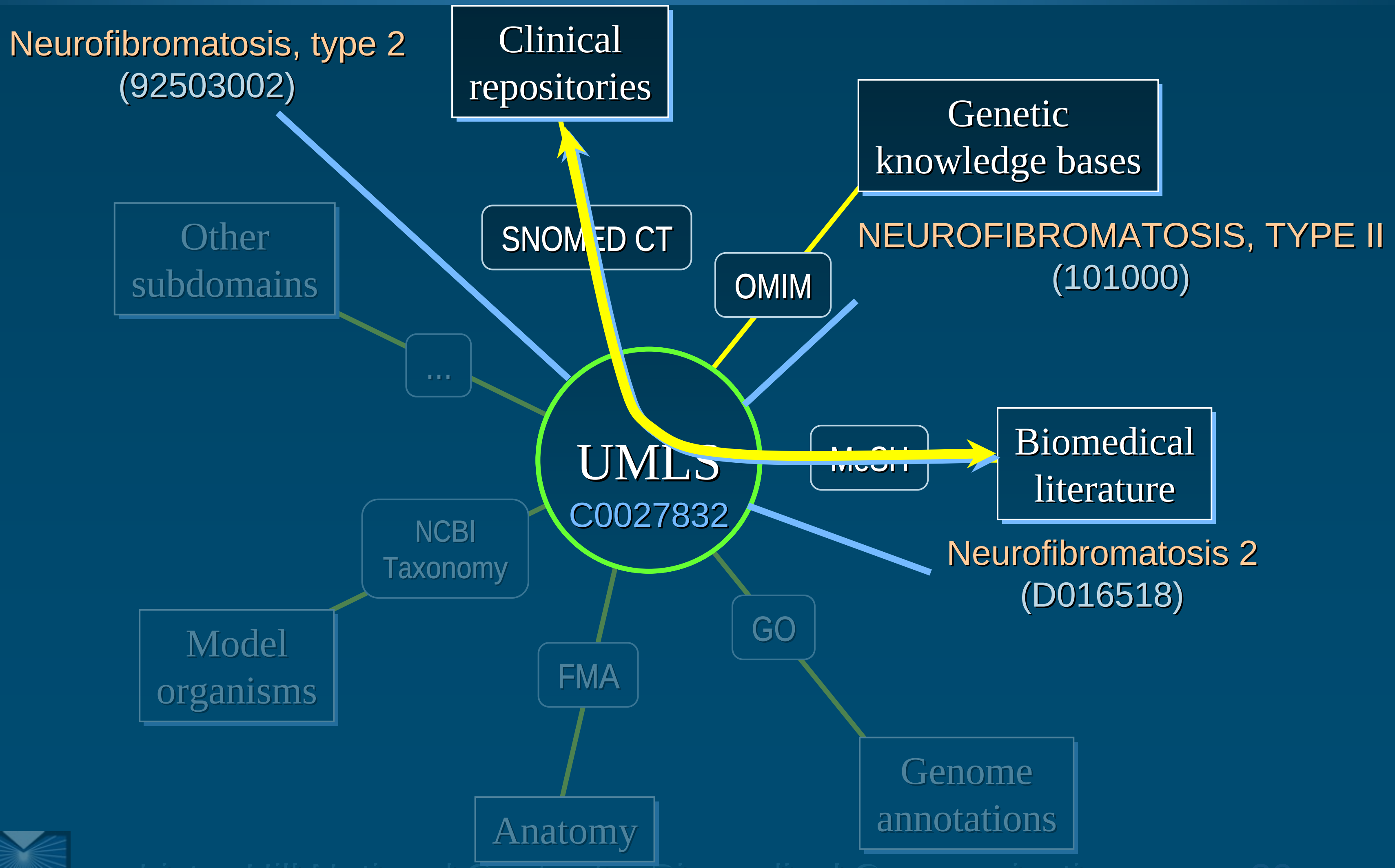
Entity mention vs. resolution

Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis. NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas. NF2 results from a mutation in the gene named merlin, located on chromosome 22.

UMLS:C0027832
MeSH:D016518
SNOMEDCT:92503002
OMIM:101000

UMLS:C0254123
EG:4771
HGNC:7773
UniProt:P35240

Trans-namespace resolution (1)



Neurofibromatosis, type 2
(92503002)

Clinical repositories

SNOMED CT

Genetic knowledge bases

OMIM

NEUROFIBROMATOSIS, TYPE II
(101000)

Other subdomains

...

UMLS
C0027832

MeSH

Biomedical literature

Neurofibromatosis 2
(D016518)

NCBI Taxonomy

Model organisms

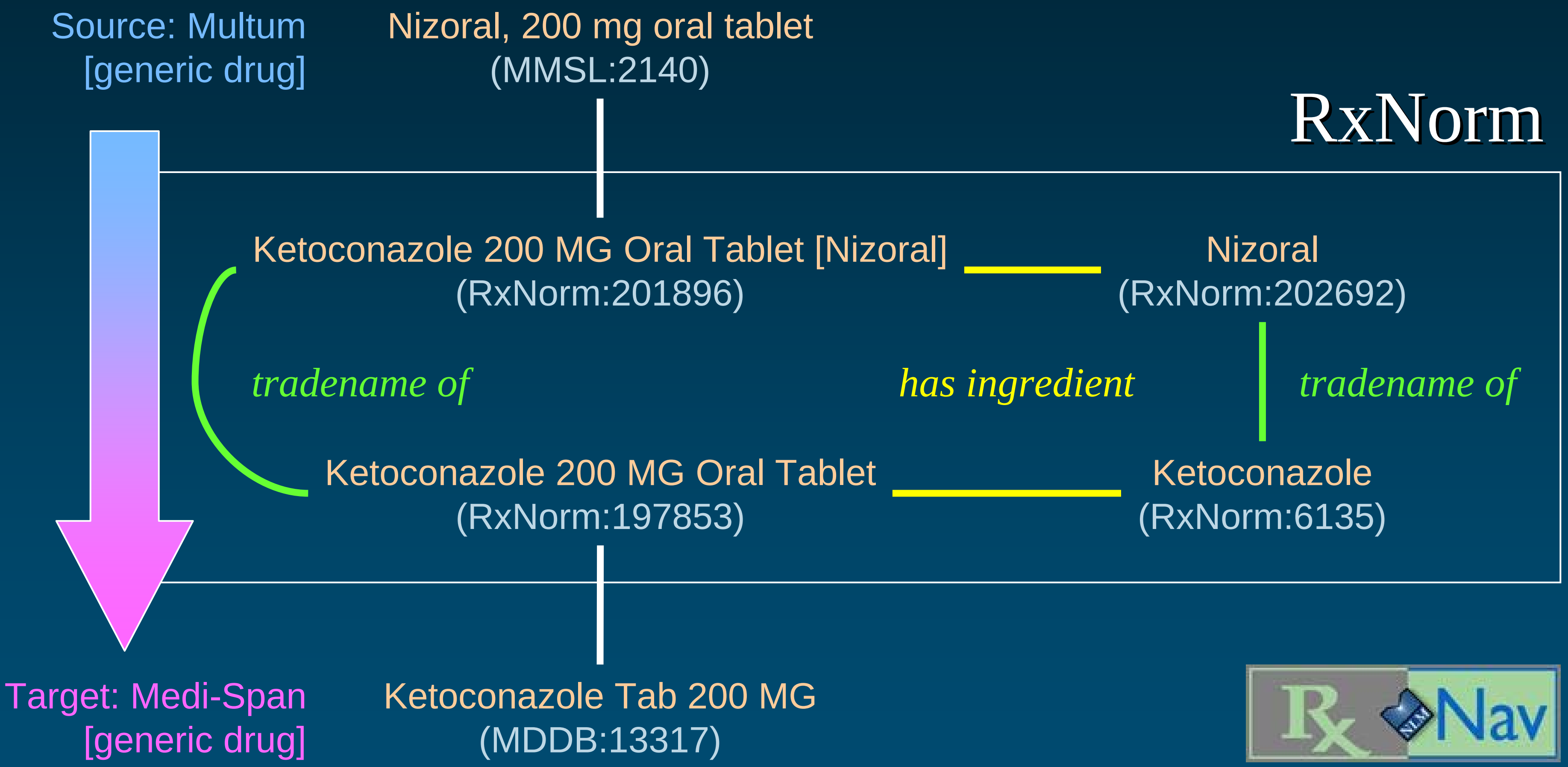
FMA

Anatomy

GO

Genome annotations

Trans-namespace resolution (2)



Source: Multum
[generic drug]

Nizoral, 200 mg oral tablet
(MMSL:2140)

RxNorm

Ketoconazole 200 MG Oral Tablet [Nizoral]
(RxNorm:201896)

Nizoral
(RxNorm:202692)

tradename of

has ingredient

tradename of

Ketoconazole 200 MG Oral Tablet
(RxNorm:197853)

Ketoconazole
(RxNorm:6135)

Target: Medi-Span
[generic drug]

Ketoconazole Tab 200 MG
(MDDB:13317)

http://mor.nlm.nih.gov/download/rxnav/

Terminological resources

MetaMap

Indexing Initiative

http://ii.nlm.nih.gov/

MetaMap

- UMLS-based entity recognition system
  - Linguistically motivated
  - Exploits both the SPECIALIST lexicon and Metathesaurus
- In practice, used to identify UMLS concepts in biomedical text
- Freely available (UMLS license)
- Two versions
  - Web-based
  - Standalone (MMTx)

MetaMap Example

Neurofibromatosis type 2 C0027832 (NF2 C0027832) is often not recognised as a distinct entity from peripheral neurofibromatosis C0027831. NF2 C0027832 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas C0027859. NF2 C0027832 results from a mutation C0026882 in the gene named merlin C0254123, located on chromosome 22 C0008665.

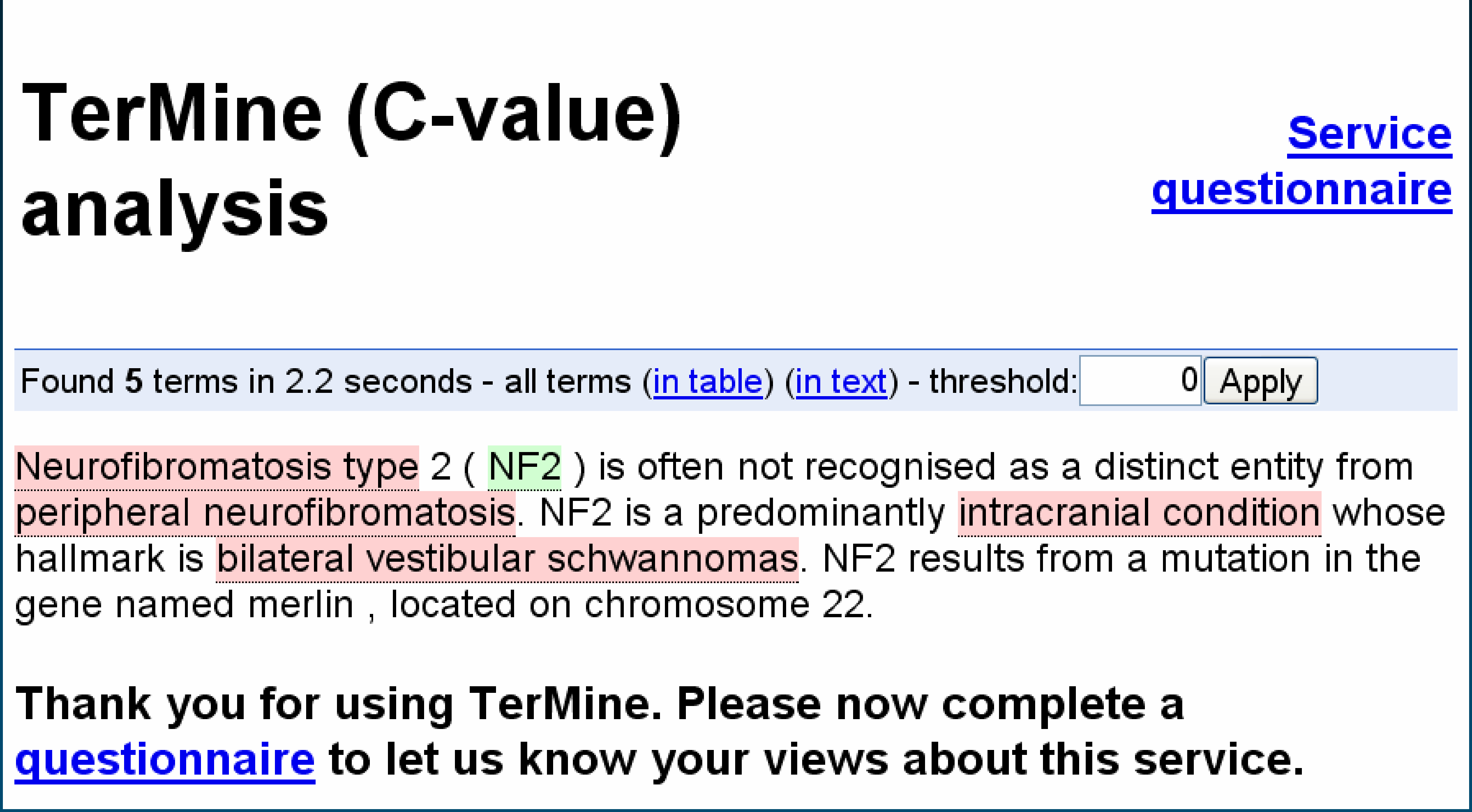
C0254123

Neurofibromin 2	MeSH
Merlin	SNOMED CT
Schwannomin	MeSH
Schwannomerlin	NCI Thesaurus

Terminological resources

Other resources

Other NER systems TerMine



TerMine (C-value) analysis

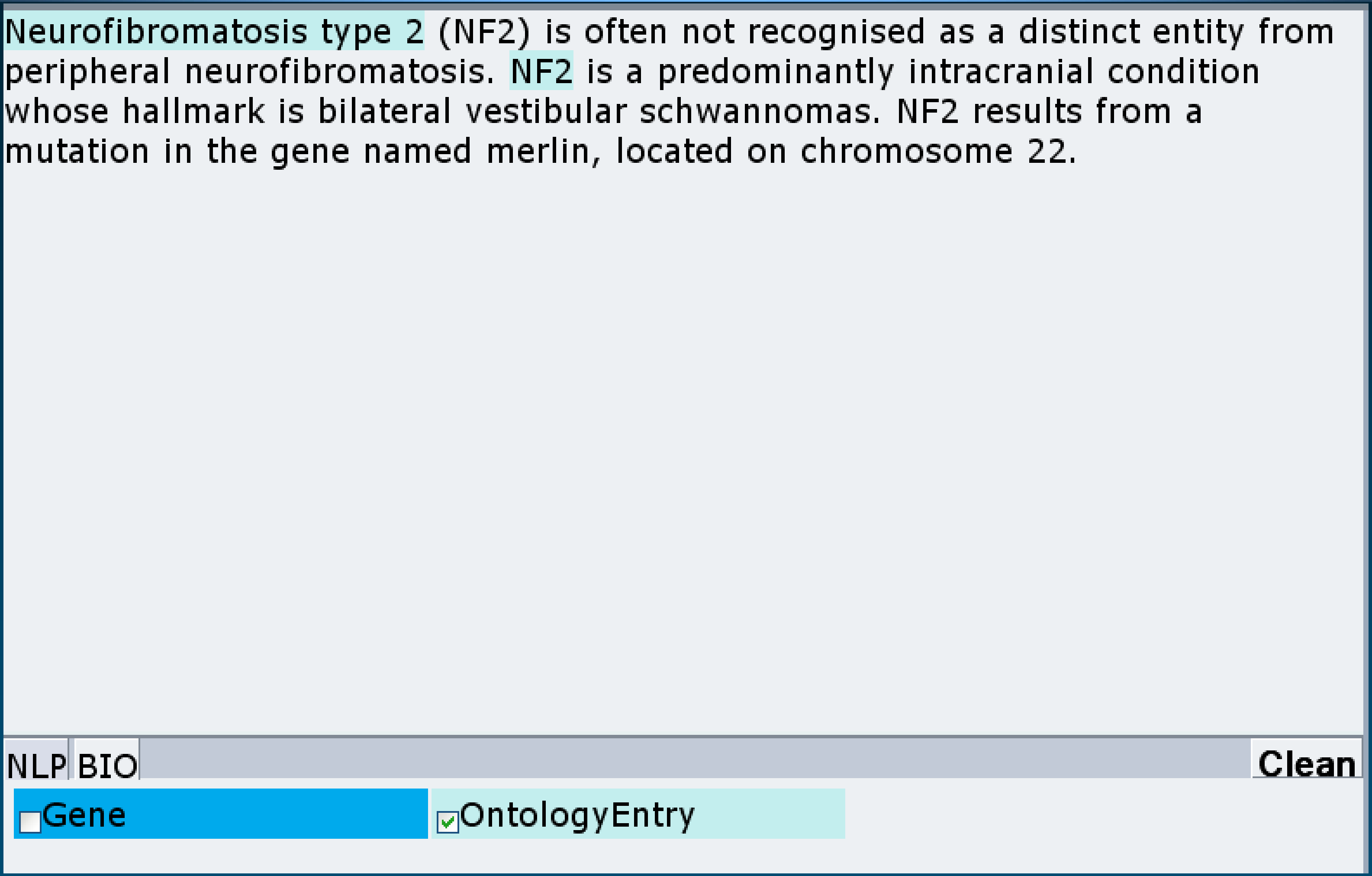
Service questionnaire

Found **5** terms in 2.2 seconds - all terms (in table) (in text) - threshold: 0 Apply

Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis. NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas. NF2 results from a mutation in the gene named merlin , located on chromosome 22.

Thank you for using TerMine. Please now complete a questionnaire to let us know your views about this service.

Other NER systems DocProWI (Beta)

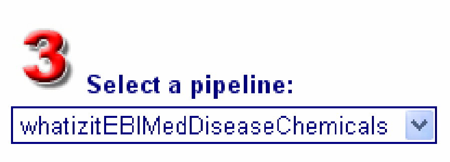


Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis. NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas. NF2 results from a mutation in the gene named merlin, located on chromosome 22.

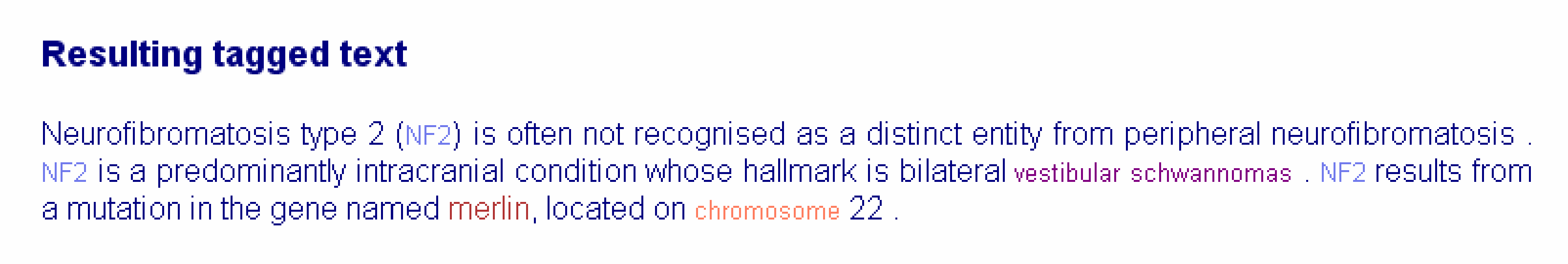
□ Gene ☑ OntologyEntry

Other NER systems Whatizit

Whatizit


3 Select a pipeline:

whatizitEBIMedDiseaseChemicals


Resulting tagged text

Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis . NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas . NF2 results from a mutation in the gene named merlin, located on chromosome 22 .

Ontological resources

Ontological resources

- Provide background knowledge
  - For resolving ambiguity in entity recognition
    - Merlin: Protein or Bird?
  - For relation extraction
    - Template relations between high-level concepts
    - Used in combination with clues from linguistic phenomena in text

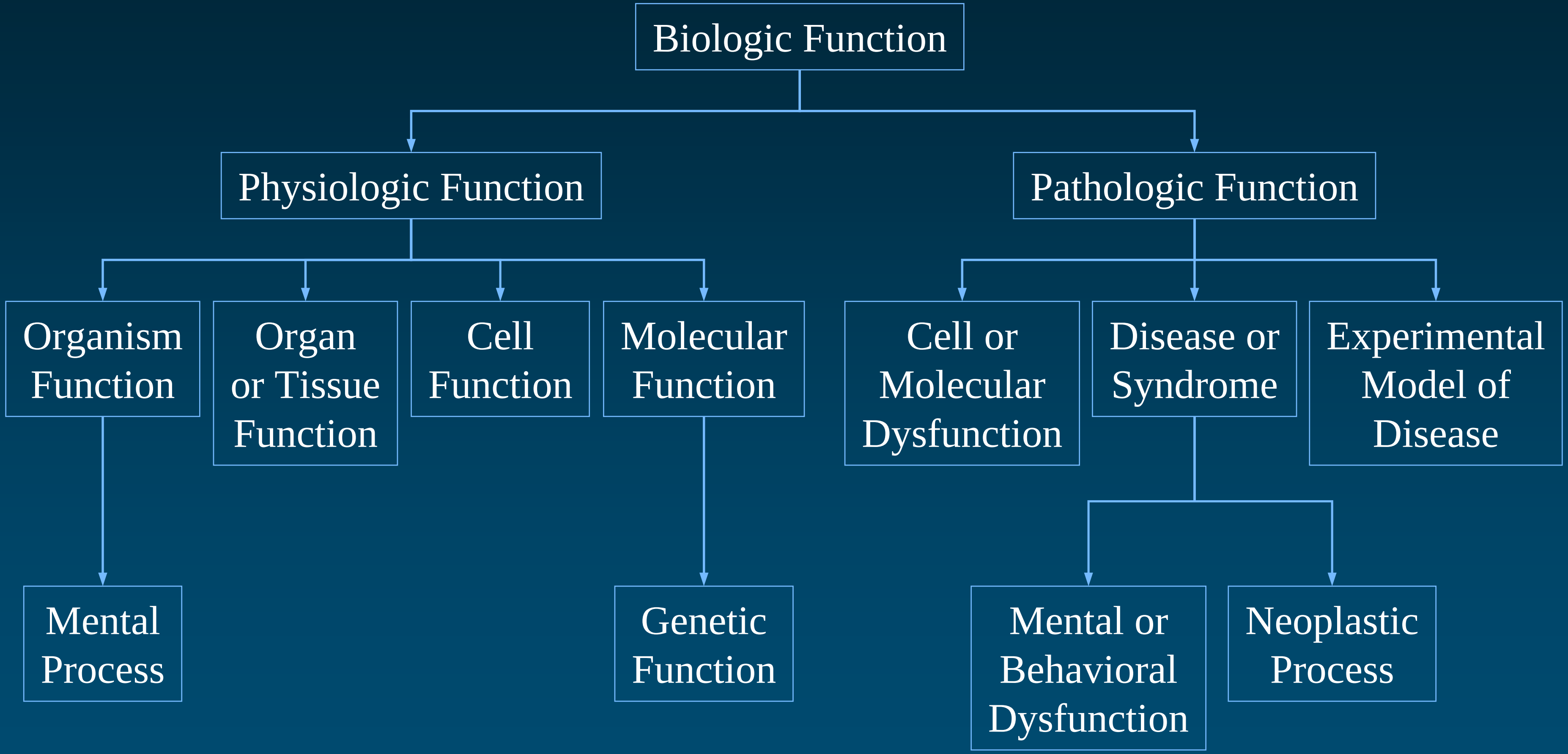
Ontological resources

- Various level of formality
  - Formal top-level ontologies (e.g., BioTop)
  - Informal top-level ontologies (e.g., UMLS Semantic Network)
  - Domain-Range constraints for roles in DL-based terminologies (e.g., SNOMED CT, NCI Thesaurus)
  - Relations in terminologies
- Various level of granularity
  - UMLS Smeantic Network: 135 types
  - Foundational Model of Anatomy: 70,000 classes

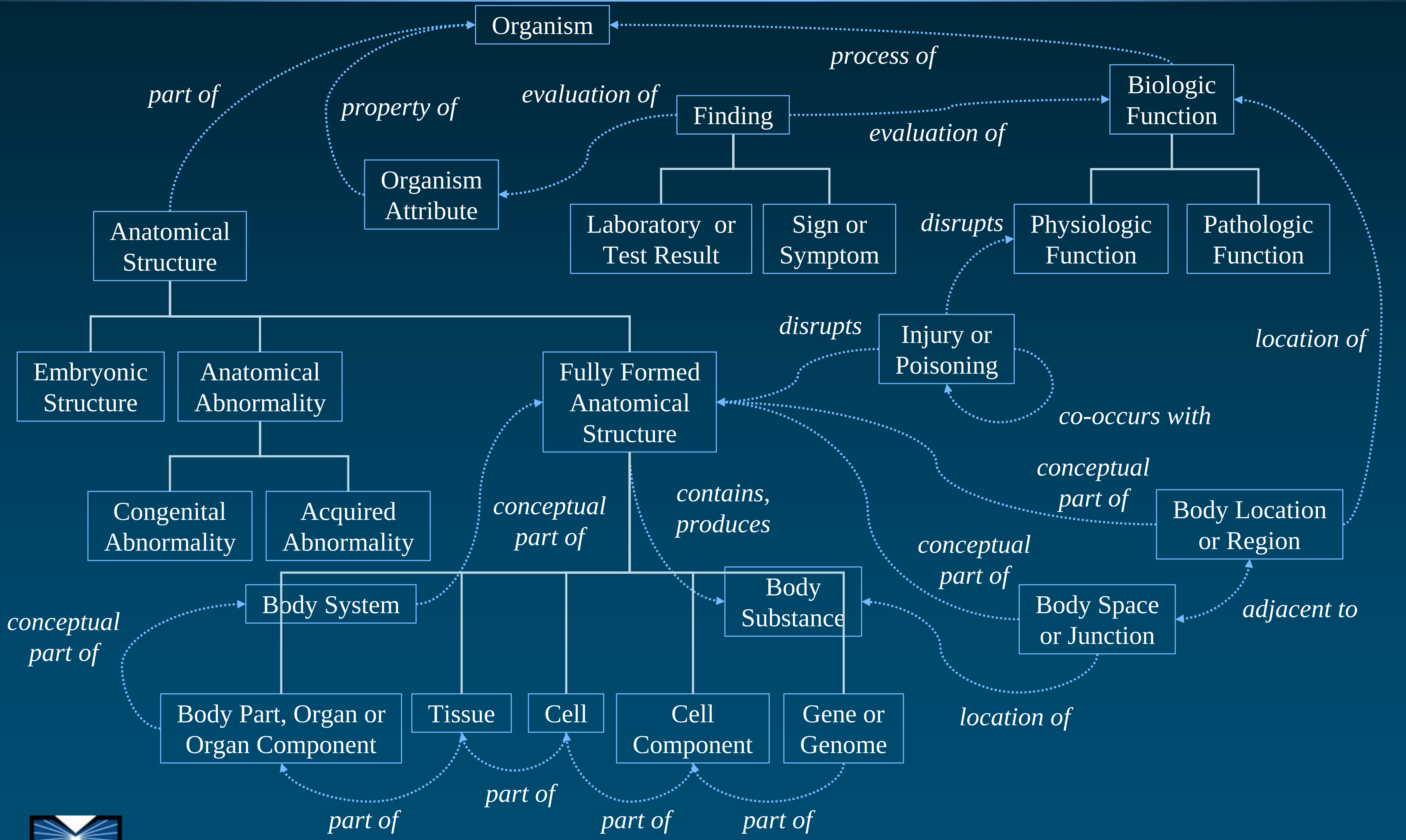
Ontological resources

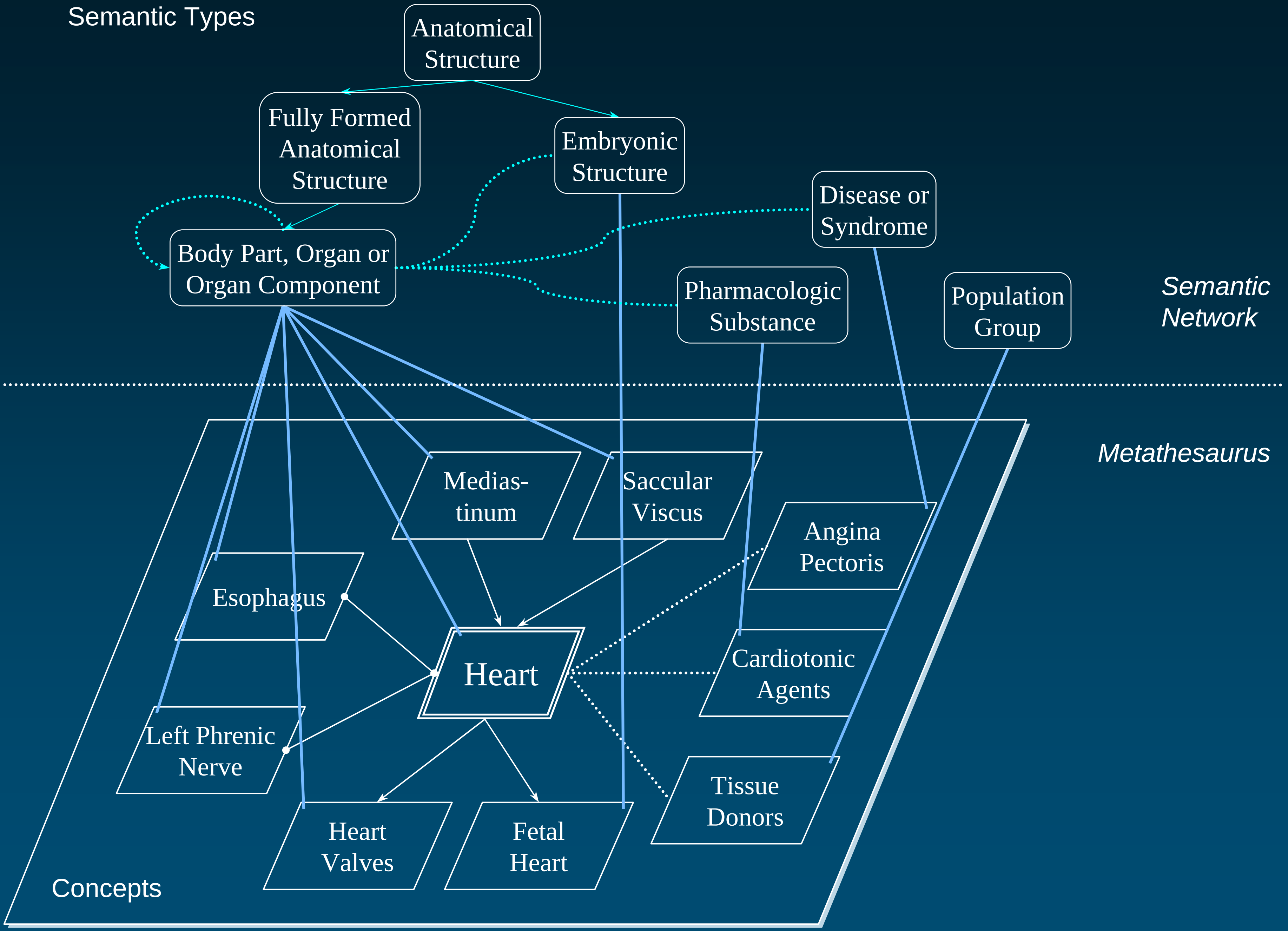
UMLS Semantic Network

“Biologic Function” hierarchy (isa)



Associative (non-isa) relationships

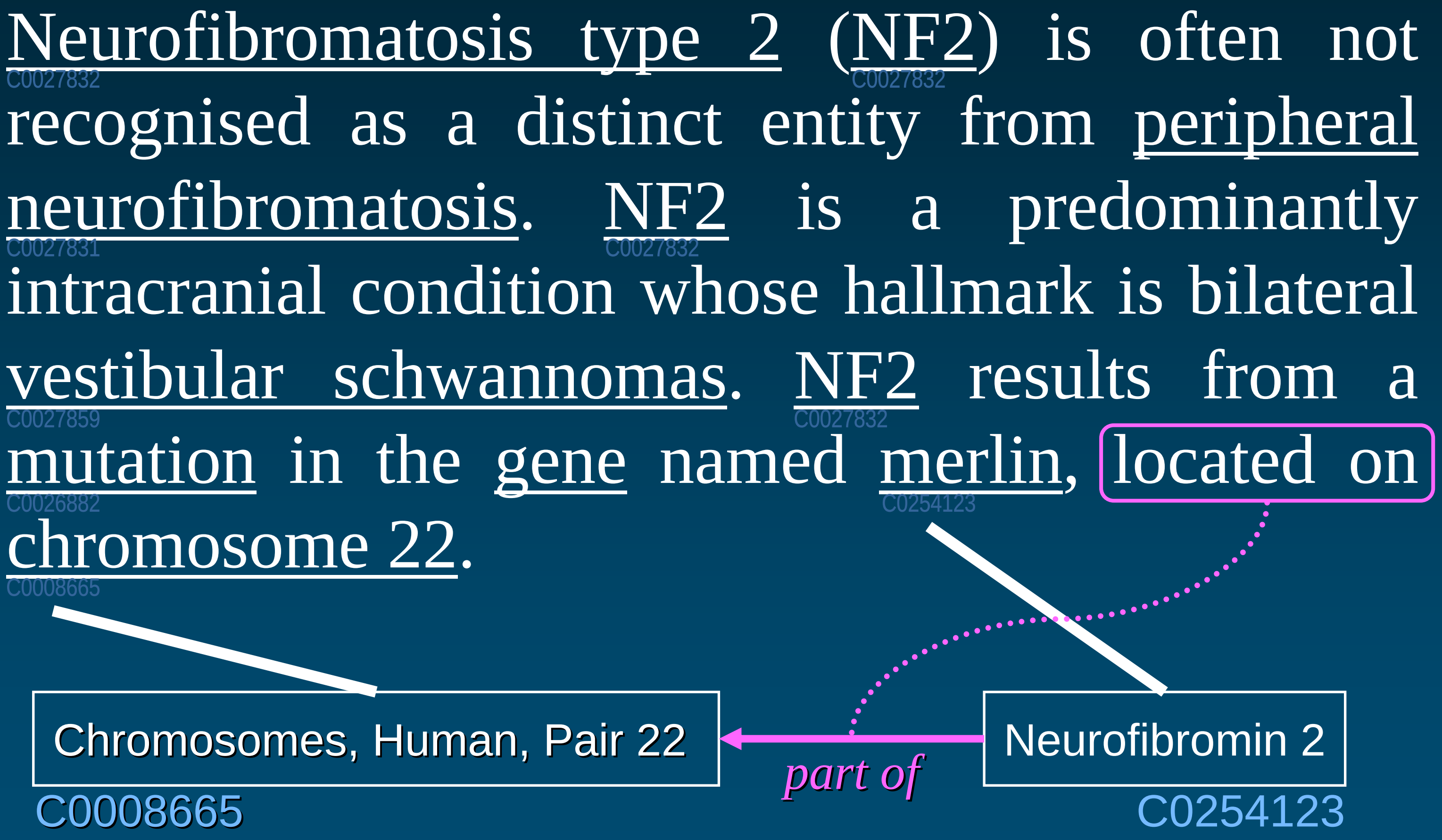



Semantic Types
Anatomical Structure
Fully Formed Anatomical Structure
Embryonic Structure
Body Part, Organ or Organ Component
Disease or Syndrome
Pharmacologic Substance
Population Group
Semantic Network
Metathesaurus
Medias- tinum
Saccular Viscus
Angina Pectoris
Esophagus
Heart
Cardiotonic Agents
Left Phrenic Nerve
Tissue Donors
Heart Valves
Fetal Heart
Concepts

Ontological resources

SemRep

SemRep Relation extraction



Neurofibromatosis type 2 (NF2) is often not recognised as a distinct entity from peripheral neurofibromatosis. NF2 is a predominantly intracranial condition whose hallmark is bilateral vestibular schwannomas. NF2 results from a mutation in the gene named merlin, located on chromosome 22.

Ontological resources

Other resources

Other ontological resources

- Ontologies
  - Top-level ontologies (e.g., BioTop)
  - Domain ontologies (e.g., FMA, SNOMED CT, NCI Thesaurus)
- Many information extraction systems available
  - Specialized
    - Protein-protein interaction (e.g., Info-PubMed, TextPresso, …)
    - BioCreAtIvE (task 2)
  - More generic (e.g., MedLEE / BioMedLEE)
  - Commercial systems (TeSSI, Linguamatics, …)

Conclusions

Conclusions

- Lexical and terminological resources enable entity recognition
  - Terminological resources enable entity *resolution*
- Terminological and ontological resources enable relation extraction

But…

- Text mining techniques can also benefit
  - Specialized lexicons: NER based on machine learning techniques
  - Terminologies: term extraction / computational terminology
  - Ontologies: ontology population

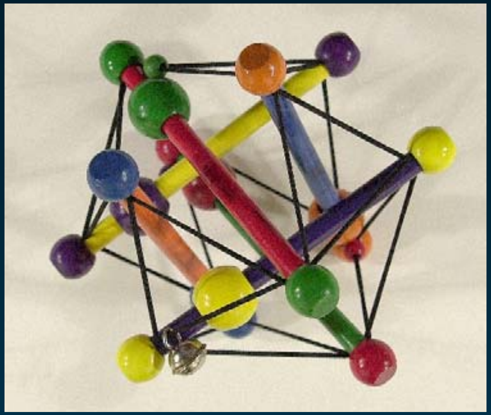
Future directions

- Information integration
  - Knowledge extracted from text
  - Knowledge in structured knowledge bases
- Ontologies for relations
  - In complement to ontologies for entities
  - To support reasoning

- W3C Health Care and Life Sciences Interest Group (Semantic Web)
  - http://www.w3.org/2001/sw/hcls/

References

- Bodenreider O. *Lexical, terminological and ontological resources for biological text mining.* In: Ananiadou S, McNaught J, editors. Text mining for biology and biomedicine: Artech House; 2006. p. 43-66.



Medical Ontology Research

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for Biomedical Communications
Bethesda, Maryland - USA

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