LHC Board of Scientific Counselors

September 12, 2013

RxNav, the RxNorm API and RxMix

Browsing and enabling complex queries to drug information sources

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U.S. National Library of Medicine

Acknowledgments

- Developers
  - Lee Peters
  - Thang Nguyen
- Former collaborators
  - Kelly Zeng
  - Ramez Ghazzaoui
  - Alex Skovorodnev
  - Jonathan Mortensen
- RxNorm
  - John Kilbourne

Outline

- RxNorm
  - Drug vocabulary integration
  - Drug vocabulary normalization
- Visualizing drug information: RxNav
- Processing drug information: RxNorm API
- Integrating drug information sources
  - Sister APIs (RxTerms, NDF-RT, RxImageAccess)
- Enabling complex queries: RxMix
- Usage and applications

RxNorm

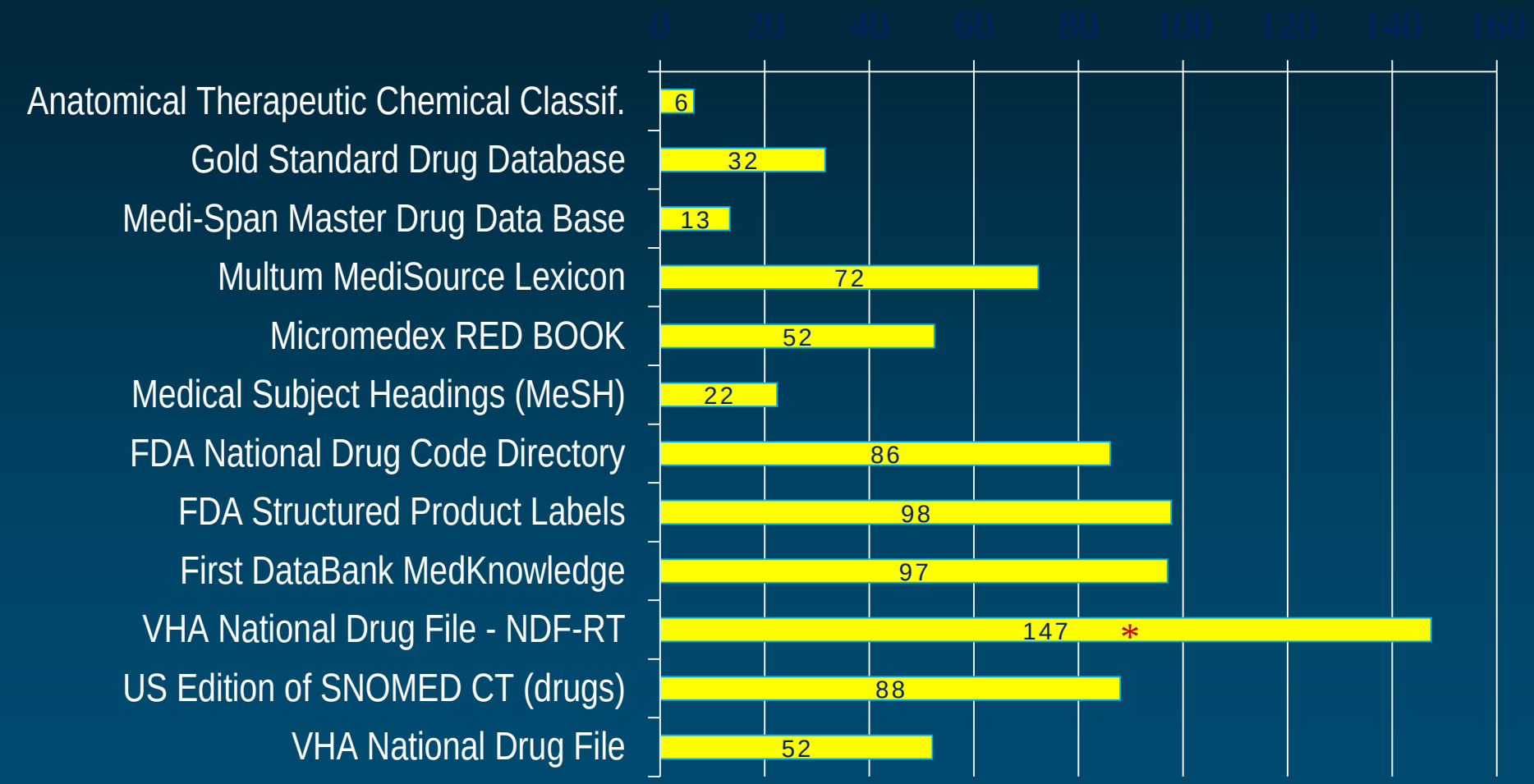
Overview

UMLS-like approach

- 12 source vocabularies
- Synonymous names grouped into an RxNorm concept
- Unique identifiers (RxCUI)
- RRF format

- Differences
  - RxNorm creates its own names
  - Principled use of names relationships
  - Limited scope: drug names
  - Monthly updates (and weekly additions)

Source vocabularies in RxNorm



(terms in thousands, as of Sept. 2013)

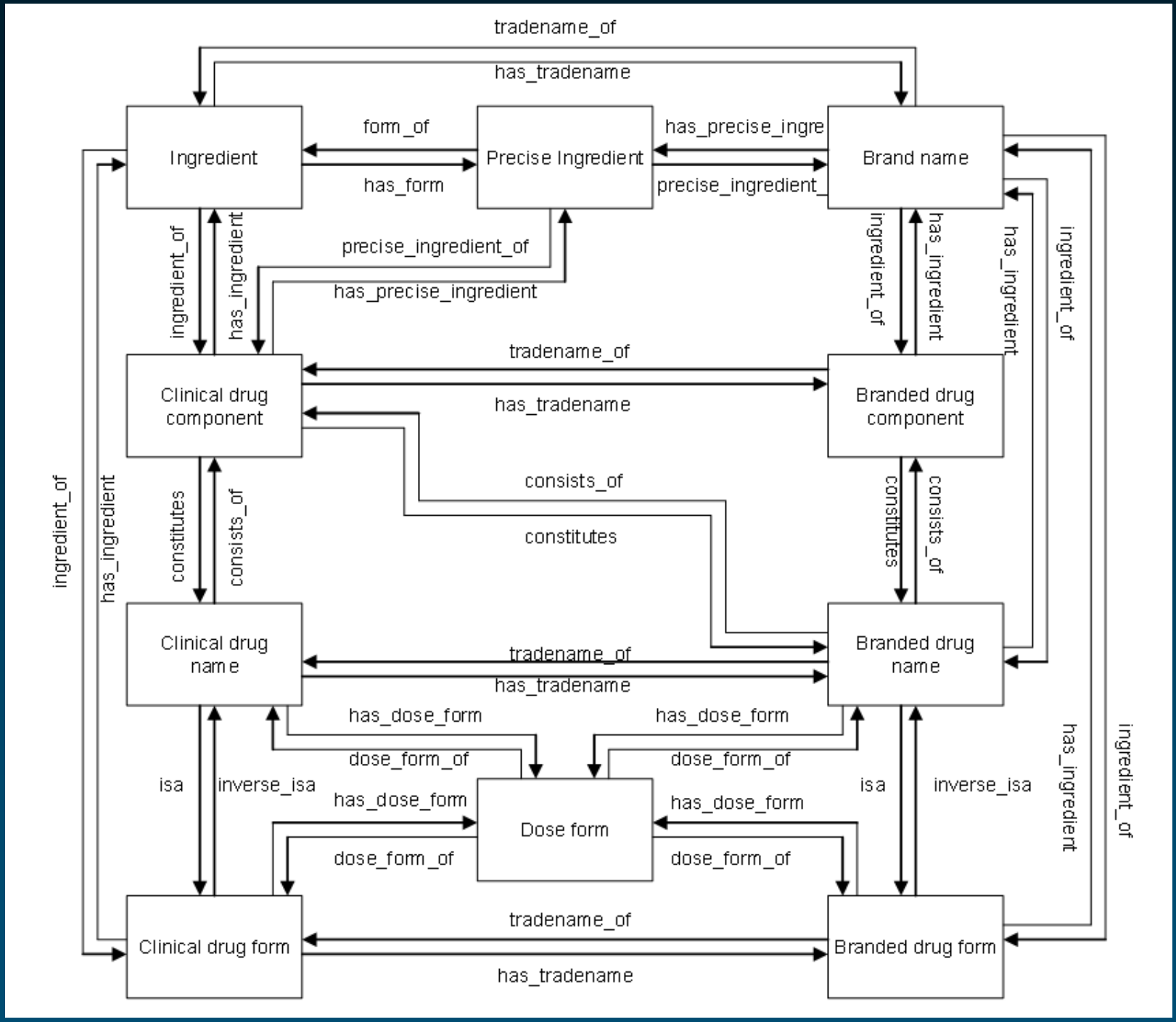
Normalization Lexical level

GS	Digoxin 0.25mg/1mL Solution for injection
GS	Digoxin 500mcg/2mL Solution for injection
MDDB	'Digoxin Inj 0.25 MG/ML
MMSL	digoxin 250 mcg/mL (0.25 mg/mL) injectable solution
MMSL	Digoxin, 250 mcg/mL (0.25 mg/mL) injectable solution
MMX	Digoxin 0.25 MG/ML Injection Solution
MTHFDA	DIGOXIN 0.25 MG INTRAMUSCULAR INJECTION, SOLUTION
MTHFDA	DIGOXIN 250 MCG INTRAMUSCULAR INJECTION
MTHFDA	DIGOXIN 250 MCG INTRAVENOUS INJECTION
MTHSPL	digoxin 0.25 MILLIGRAM In 1.0 MILLILITER INTRAVENOUS INJECTION
MTHSPL	Digoxin 250 MICROGRAM In 1 MILLILITER INTRAVENOUS INJECTION, SOLUTION
NDDF	DIGOXIN 250 mcg/mL INJECTION AMPUL (ML)
NDDF	DIGOXIN 250 mcg/mL INJECTION DISPOSABLE SYRINGE (ML)
NDDF	DIGOXIN@250 mcg/mL@INJECTION@AMPUL (ML)
SNOMEDCT	Digoxin 250micrograms/mL injection solution 2mL ampule
SNOMEDCT	Digoxin 500micrograms/2mL injection
VANDF	DIGOXIN 0.25MG/ML INJ
[…]	[…]

→ Digoxin 0.25 MG/ML Injectable Solution

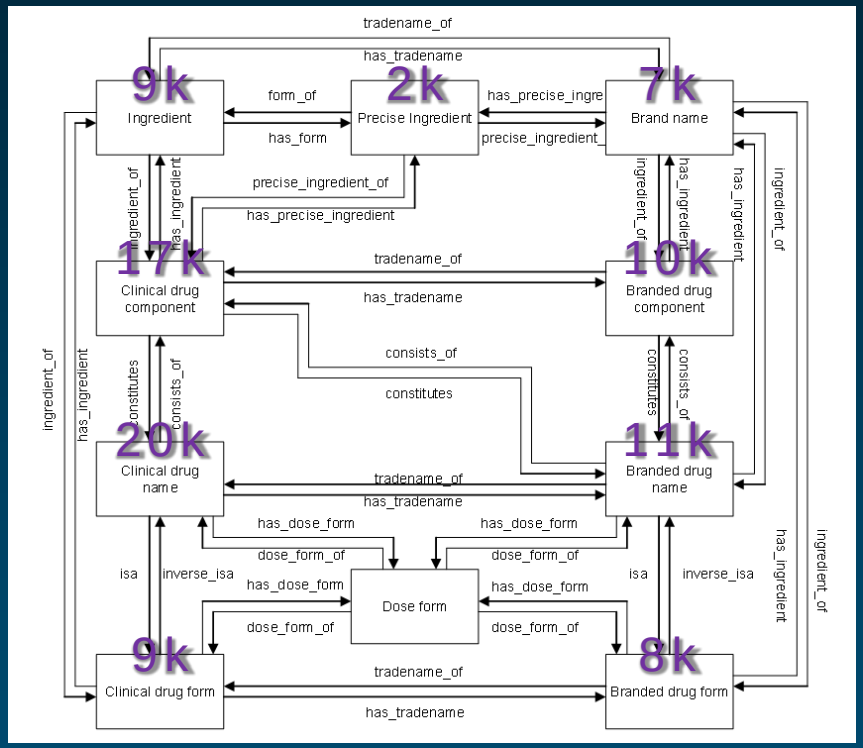
Normalization Structural level

- Structural level
  - Atomic elements
    - Ingredient (fluoxetine)
    - Strength (10 MG)
    - Dose form (oral tablet)
  - Generic vs. Brand names (fluoxetine vs. Prozac)
  - Principle set of relationships among the different types


tradename_of
has_tradename
Ingredient
form_of
has_form
Precise Ingredient
has_precise_ingre
precise_ingredient_
Brand name
ingredient_of
has_ingredient
precise_ingredient_of
has_precise_ingredient
ingredient_of
has_ingredient
has_ingredient
ingredient_of
tradename_of
has_tradename
Clinical drug component
Branded drug component
consists_of
constitutes
constitutes
consists_of
ingredient_of
has_ingredient
constitutes
consists_of
Clinical drug name
Branded drug name
tradename_of
has_tradename
has_dose_form
has_dose_form
dose_form_of
dose_form_of
isa
inverse_isa
has_dose_form
has_dose_form
Dose form
dose_form_of
dose_form_of
isa
inverse_isa
has_ingredient
ingredient_of
tradename_of
has_tradename
Clinical drug form
Branded drug form

Drug entities in RxNorm

- Content
  - 11,434 ingredients (P/IN)
  - 7,000 brand names
  - 20,100 clinical drugs
  - 11,080 branded drugs
  - 16,661 clinical drug comp.
  - 10,458 branded drug comp.
  - 8,735 clinical drug forms
  - 8,214 branded drug forms
  - 337 generic packs
  - 413 branded packs
  - 104 dose forms
- 120,115 drug entities overall



(active concepts, as of Sept. 2013)

Visualizing drug information

RxNav

RxNav

- Visualization and navigation
  - RxNorm browser
    - Search on names and codes (including proprietary)
      - Auto-completion and spelling correction
    - Display all non-proprietary information
      - Graph
      - Tabular format
    - Integrate information beyond RxNorm
      - RxTerms, NDF-RT, Pill images, MeSH and ATC classes
      - Link out to DailyMed, MedlinePlus, NLM Drug Info. Portal
  - Standalone online application
    - Latest RxNorm database at NLM
    - Leverages the RxNorm API
- First release: September 2004

RxNav demo

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

RxNav

Launch RxNav

Content:

- Overview
- Starting RxNav
- Using RxNav
- RxNav Views
- RxNav new features (updated 8/05/2013)

Overview

RxNav is a browser for several drug information sources, including RxNorm, RxTerms and NDF-RT. RxNav finds drugs in RxNorm from the names and codes in its constituent vocabularies. RxNav displays links from clinical drugs, both branded and generic, to their active ingredients, drug components and related brand names. RxNav also provides lists of NDC codes and links to package inserts in DailyMed. The RxTerms record for a given drug can be accessed through RxNav, as well as clinical information from NDF-RT, including pharmacologic classes, mechanisms of action, physiologic effects and drug-drug interactions.

Starting RxNav

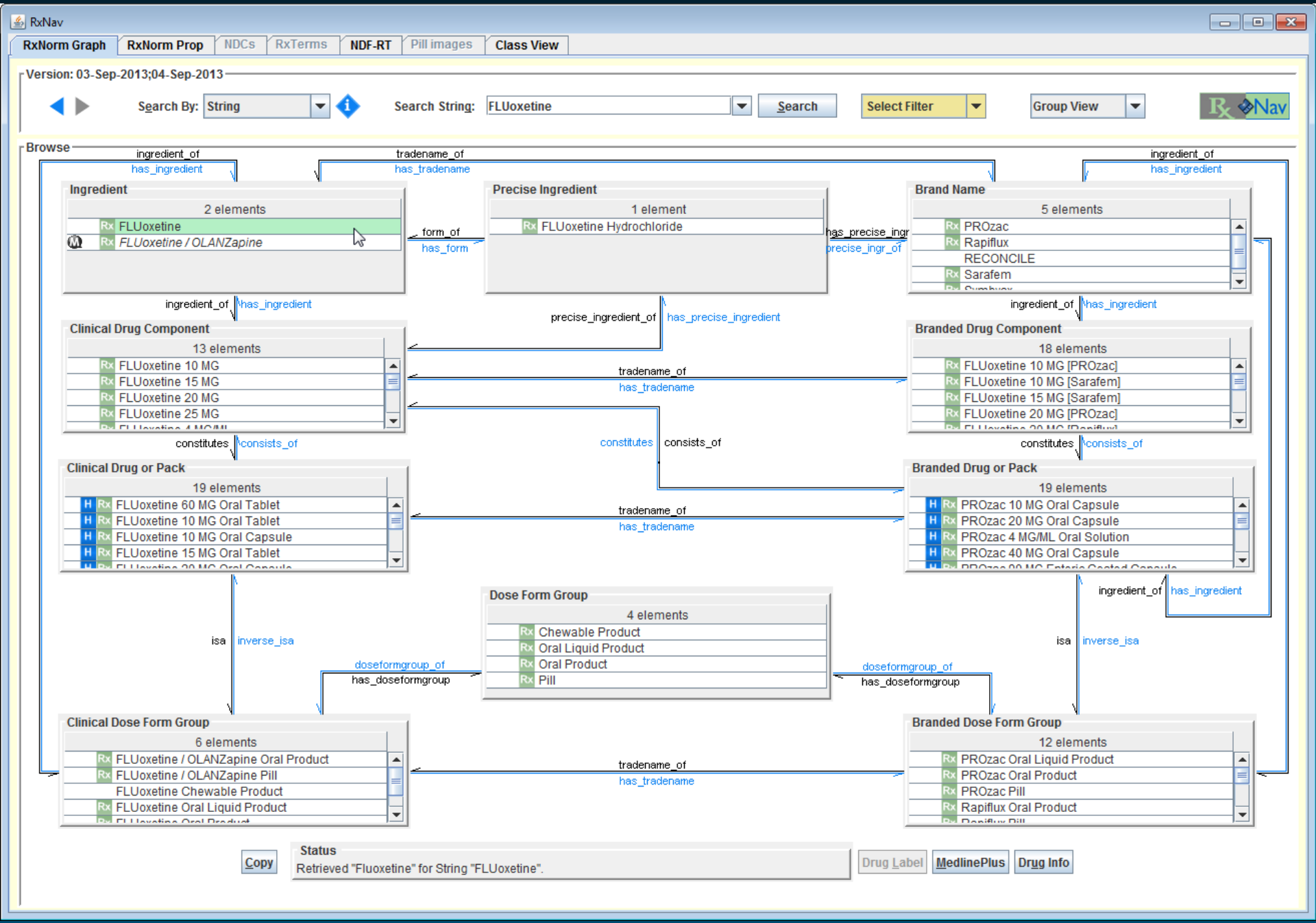
To start RxNav, click on "Launch RxNav" if the link is present; Otherwise, click on "Download and install the lastest JRE and RxNav". You will arrive at the Sun download homepage, browse to find the JRE download link, and install it. Then return to this RxNav home page, where the link now should read "Launch RxNav" and RxNav installation will be automatically launched. During installation, you can elect to have the shortcut on your desktop.

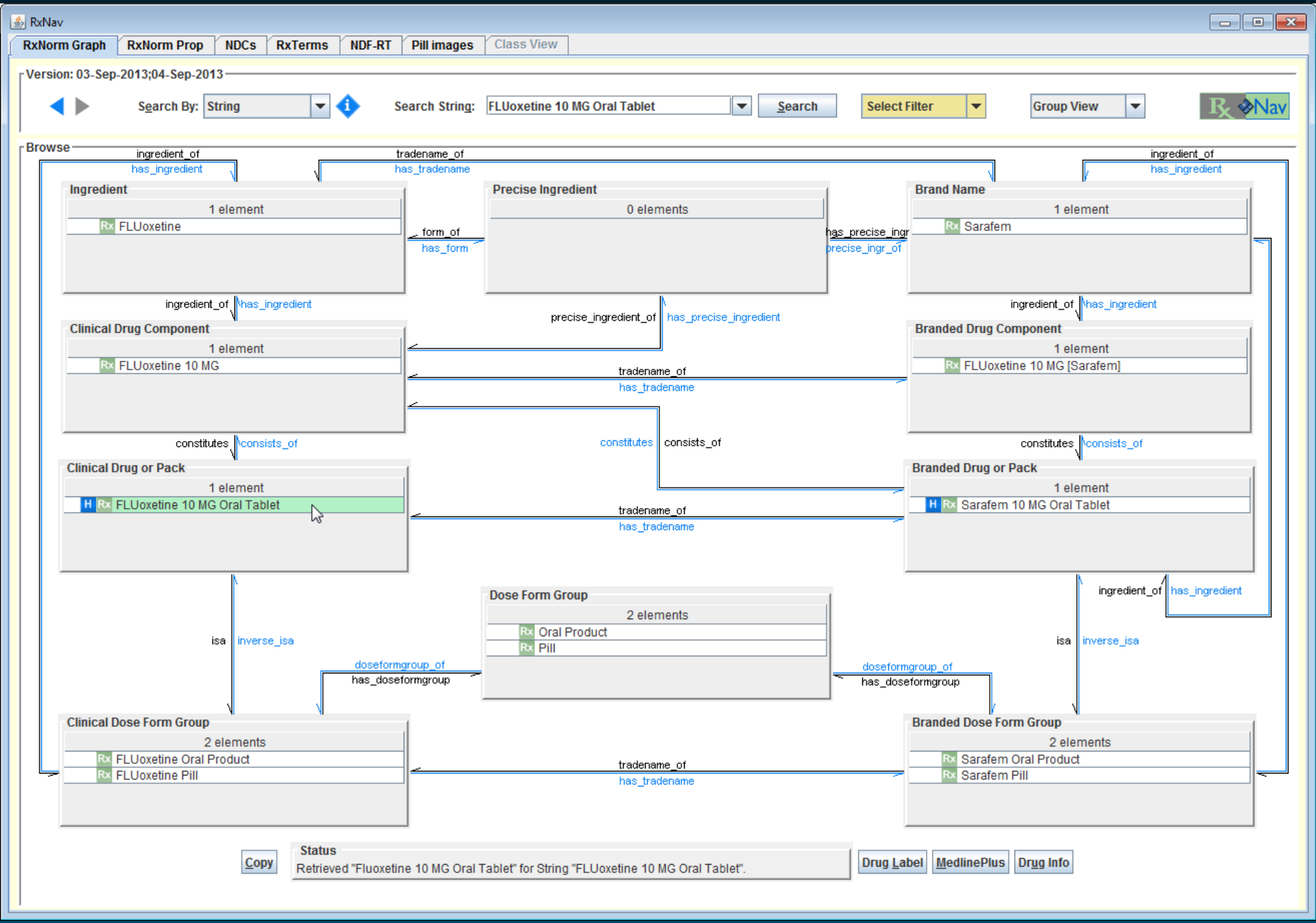
For Firefox users, open with Java Web Start Launcher.

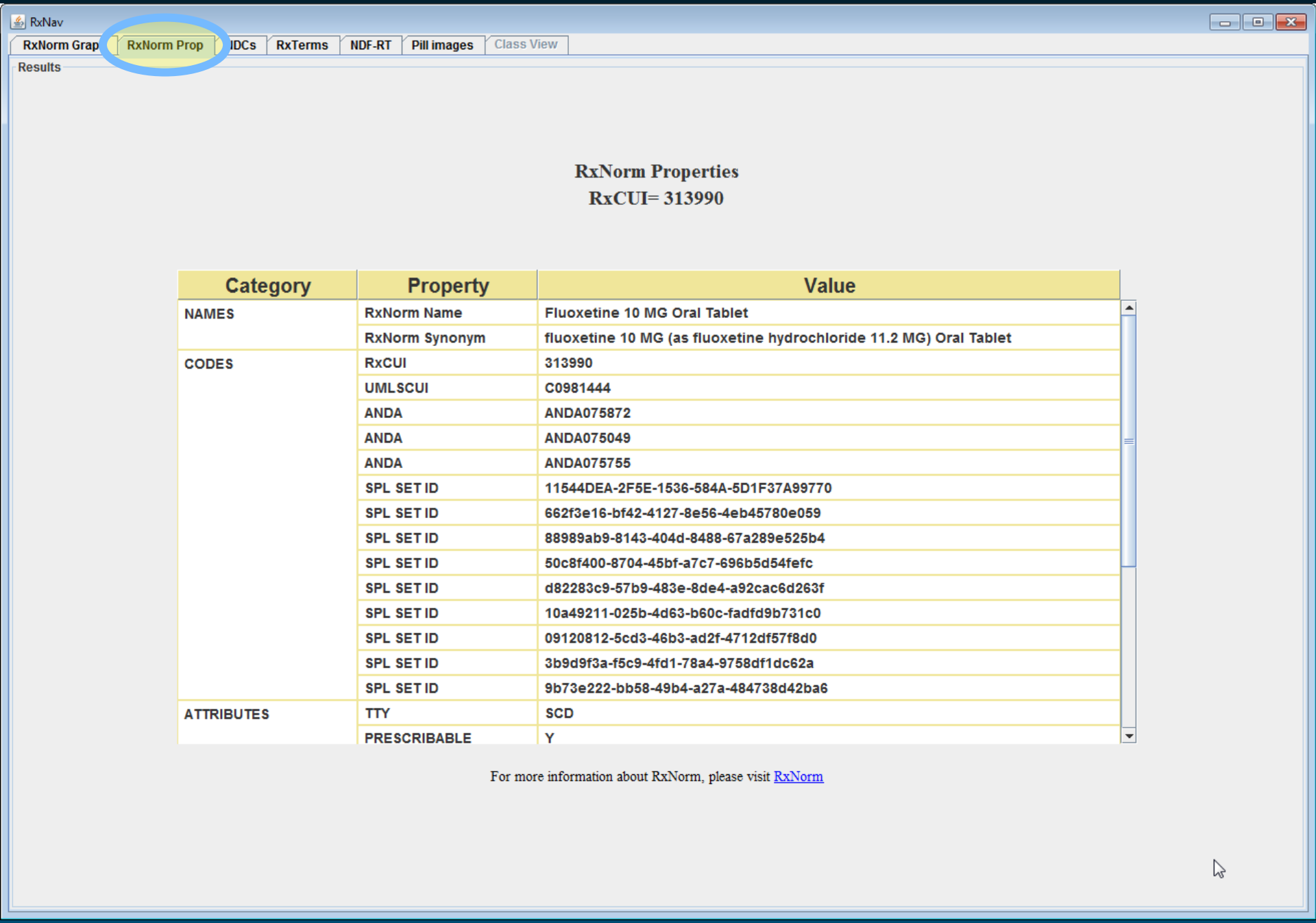
RxNav code is digitally signed. You need to accept its security certificate to launch the browser.

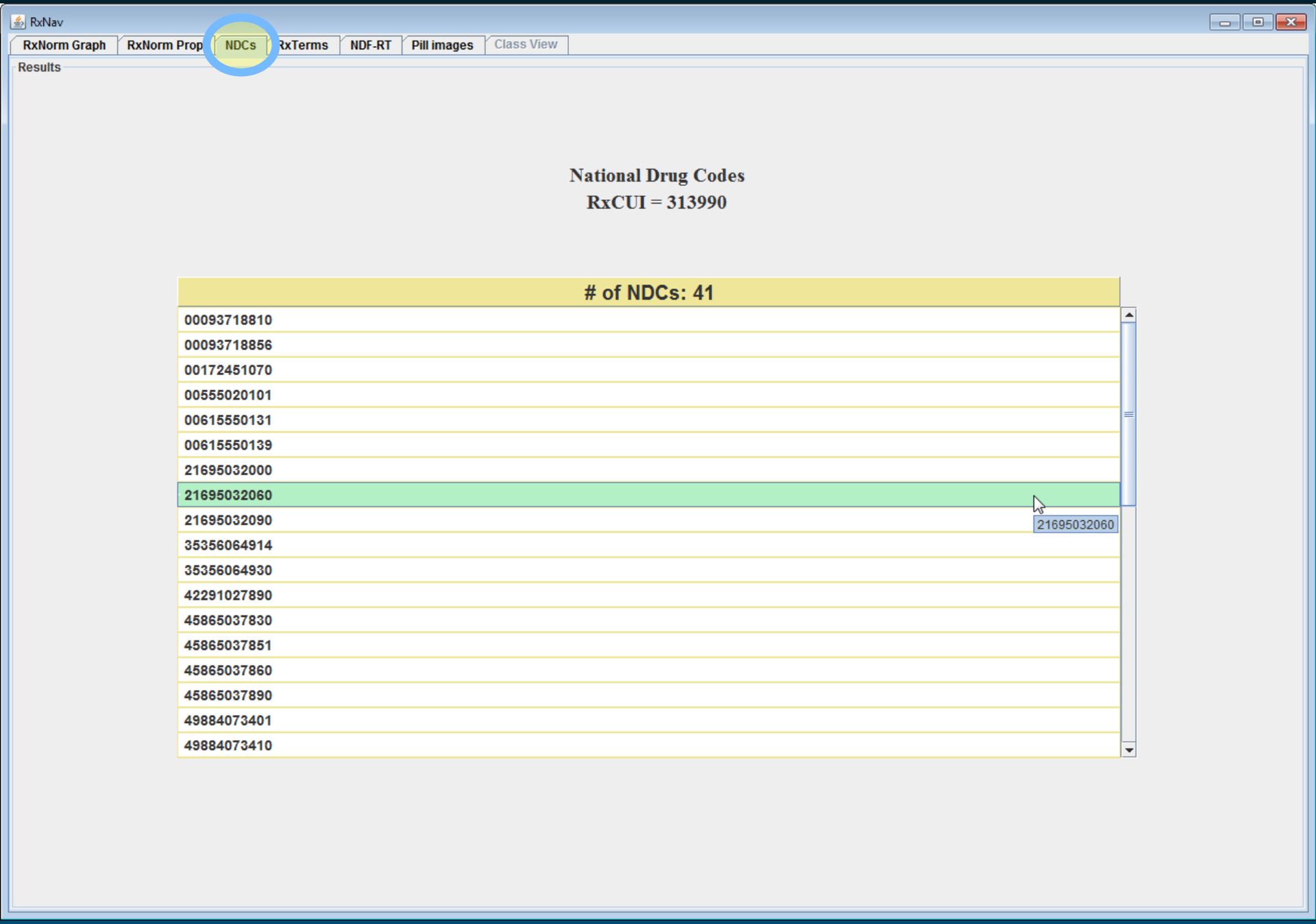
RxNav uses Java Web Start Technology and requires JRE 1.6 or higher.

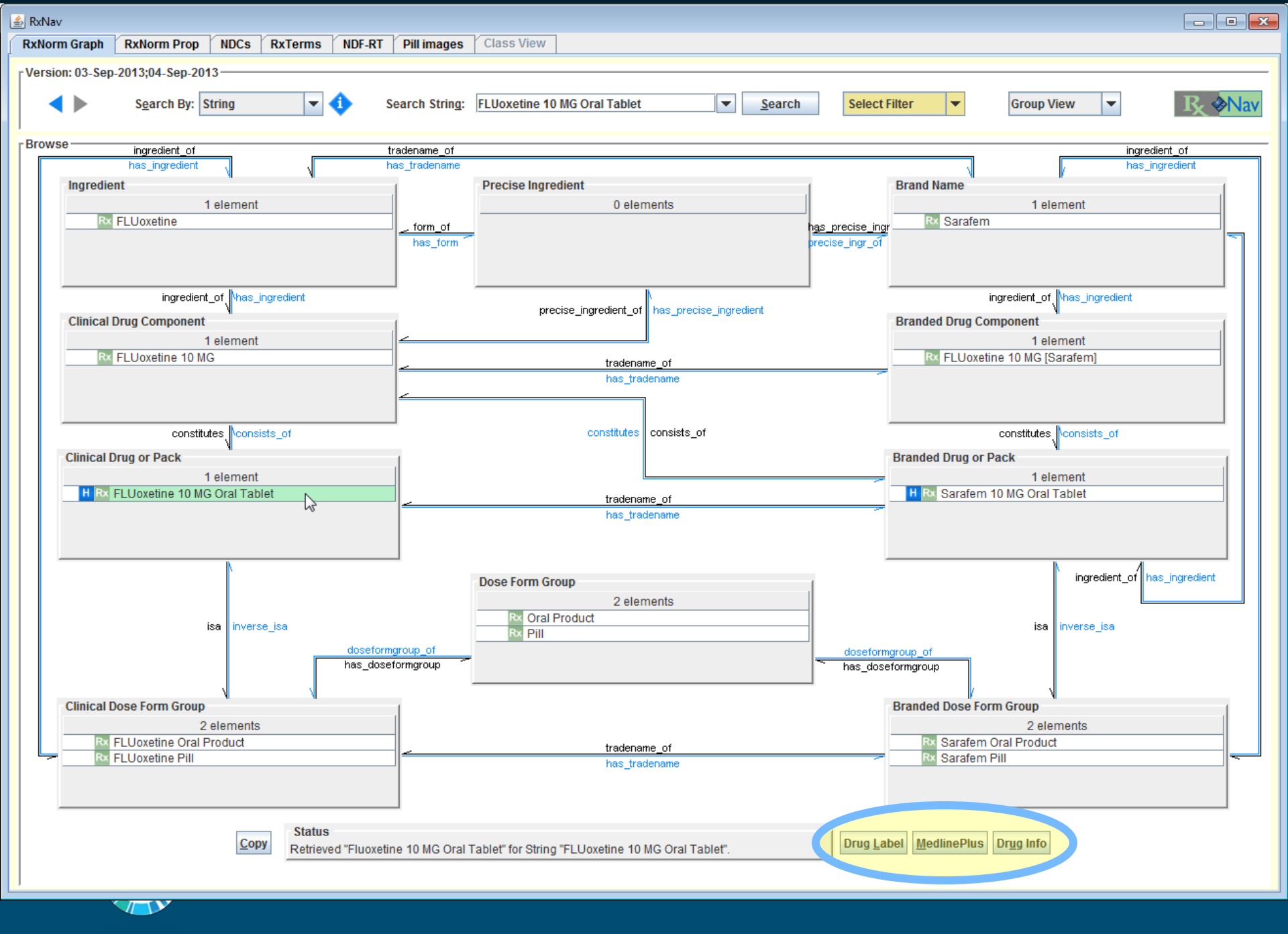
Using RxNav


RxNav
RxNorm Graph
RxNorm Prop
NDCs
RxTerms
NDF-RT
Pill images
Class View
Version: 03-Sep-2013;04-Sep-2013
Search By: String
Search String: FLUoxetine
Search
Select Filter
Group View
Browse
ingredient_of
has_ingredient
tradename_of
has_tradename
Ingredient
2 elements
FLUoxetine
FLUoxetine / OLANZapine
form_of
has_form
Precise Ingredient
1 element
FLUoxetine Hydrochloride
has_precise_ingr
precise_ingr_of
Brand Name
5 elements
PROzac
Rapiflux
RECONCILE
Sarafem
precise_ingredient_of
has_precise_ingredient
Clinical Drug Component
13 elements
FLUoxetine 10 MG
FLUoxetine 15 MG
FLUoxetine 20 MG
FLUoxetine 25 MG
Branded Drug Component
18 elements
FLUoxetine 10 MG [PROzac]
FLUoxetine 10 MG [Sarafem]
FLUoxetine 15 MG [Sarafem]
FLUoxetine 20 MG [PROzac]
constitutes
consists_of
Clinical Drug or Pack
19 elements
FLUoxetine 60 MG Oral Tablet
FLUoxetine 10 MG Oral Tablet
FLUoxetine 10 MG Oral Capsule
FLUoxetine 15 MG Oral Tablet
Branded Drug or Pack
19 elements
PROzac 10 MG Oral Capsule
PROzac 20 MG Oral Capsule
PROzac 4 MG/ML Oral Solution
PROzac 40 MG Oral Capsule
isa
inverse_isa
Dose Form Group
4 elements
Chewable Product
Oral Liquid Product
Oral Product
Pill
doseformgroup_of
has_doseformgroup
Clinical Dose Form Group
6 elements
FLUoxetine / OLANZapine Oral Product
FLUoxetine / OLANZapine Pill
FLUoxetine Chewable Product
FLUoxetine Oral Liquid Product
Branded Dose Form Group
12 elements
PROzac Oral Liquid Product
PROzac Oral Product
PROzac Pill
Rapiflux Oral Product
Copy
Status
Retrieved "Fluoxetine" for String "FLUoxetine".
Drug Label
MedlinePlus
Drug Info


RxNav
RxNorm Graph
RxNorm Prop
NDCs
RxTerms
NDF-RT
Pill images
Class View
Version: 03-Sep-2013;04-Sep-2013
Search By: String
Search String: FLUoxetine 10 MG Oral Tablet
Search
Select Filter
Group View
Browse
Ingredient
1 element
FLUoxetine
Precise Ingredient
0 elements
Brand Name
1 element
Sarafem
Clinical Drug Component
1 element
FLUoxetine 10 MG
Branded Drug Component
1 element
FLUoxetine 10 MG [Sarafem]
Clinical Drug or Pack
1 element
FLUoxetine 10 MG Oral Tablet
Branded Drug or Pack
1 element
Sarafem 10 MG Oral Tablet
Dose Form Group
2 elements
Oral Product
Pill
Clinical Dose Form Group
2 elements
FLUoxetine Oral Product
FLUoxetine Pill
Branded Dose Form Group
2 elements
Sarafem Oral Product
Sarafem Pill
ingredient_of
has_ingredient
tradename_of
has_tradename
form_of
has_form
has_precise_ingr
precise_ingr_of
precise_ingredient_of
has_precise_ingredient
constitutes
consists_of
isa
inverse_isa
doseformgroup_of
has_doseformgroup
Copy
Status
Retrieved "Fluoxetine 10 MG Oral Tablet" for String "FLUoxetine 10 MG Oral Tablet".
Drug Label
MedlinePlus
Drug Info


RxNav
RxNorm Grap
RxNorm Prop
IDCs
RxTerms
NDF-RT
Pill images
Class View
Results
RxNorm Properties
RxCUI= 313990
Category
Property
Value
NAMES
RxNorm Name
Fluoxetine 10 MG Oral Tablet
RxNorm Synonym
fluoxetine 10 MG (as fluoxetine hydrochloride 11.2 MG) Oral Tablet
CODES
RxCUI
313990
UMLSCUI
C0981444
ANDA
ANDA075872
ANDA
ANDA075049
ANDA
ANDA075755
SPL SET ID
11544DEA-2F5E-1536-584A-5D1F37A99770
SPL SET ID
662f3e16-bf42-4127-8e56-4eb45780e059
SPL SET ID
88989ab9-8143-404d-8488-67a289e525b4
SPL SET ID
50c8f400-8704-45bf-a7c7-696b5d54fefc
SPL SET ID
d82283c9-57b9-483e-8de4-a92cac6d263f
SPL SET ID
10a49211-025b-4d63-b60c-fadfd9b731c0
SPL SET ID
09120812-5cd3-46b3-ad2f-4712df57f8d0
SPL SET ID
3b9d9f3a-f5c9-4fd1-78a4-9758df1dc62a
SPL SET ID
9b73e222-bb58-49b4-a27a-484738d42ba6
ATTRIBUTES
TTY
SCD
PRESCRIBABLE
Y
For more information about RxNorm, please visit RxNorm


RxNav
RxNorm Graph
RxNorm Prop
NDCs
RxTerms
NDF-RT
Pill images
Class View
Results
National Drug Codes
RxCUI = 313990
# of NDCs: 41
00093718810
00093718856
00172451070
00555020101
00615550131
00615550139
21695032000
21695032060
21695032090
21695032060
35356064914
35356064930
42291027890
45865037830
45865037851
45865037860
45865037890
49884073401
49884073410


RxNav
RxNorm Graph
RxNorm Prop
NDCs
RxTerms
NDF-RT
Pill images
Class View
Version: 03-Sep-2013;04-Sep-2013
Search By:
String
Search String:
FLUoxetine 10 MG Oral Tablet
Search
Select Filter
Group View
Browse
ingredient_of
has_ingredient
tradename_of
has_tradename
Ingredient
1 element
FLUoxetine
form_of
has_form
Precise Ingredient
0 elements
has_precise_ingr
precise_ingr_of
Brand Name
1 element
Sarafem
precise_ingredient_of
has_precise_ingredient
Clinical Drug Component
1 element
FLUoxetine 10 MG
Branded Drug Component
1 element
FLUoxetine 10 MG [Sarafem]
constitutes
consists_of
Clinical Drug or Pack
1 element
FLUoxetine 10 MG Oral Tablet
Branded Drug or Pack
1 element
Sarafem 10 MG Oral Tablet
isa
inverse_isa
Dose Form Group
2 elements
Oral Product
Pill
doseformgroup_of
has_doseformgroup
Clinical Dose Form Group
2 elements
FLUoxetine Oral Product
FLUoxetine Pill
Branded Dose Form Group
2 elements
Sarafem Oral Product
Sarafem Pill
Copy
Status
Retrieved "Fluoxetine 10 MG Oral Tablet" for String "FLUoxetine 10 MG Oral Tablet".
Drug Label
MedlinePlus
Drug Info

Firefox

dailymed.nlm.nih.gov/dailymed/rxcui.cfm?rxcui=313990

DailyMed: Drug Labels List

Skip to content | Skip to Drug Search

DailyMed Current Medication Information

DailyMed provides high quality information about marketed drugs.
Drug labeling on this Web site is the most recent submitted to the Food and Drug Administration (FDA) and currently in use; it may include, for example, strengthened warnings undergoing FDA review or minor editorial changes. These labels have been reformatted to make them easier to read.

Options

- Home
- E-mail Label Information
- Downloads
- Archives
- Notify of Updates
- Contact Us
- Help
- Web Services
- Browse Drug Classes NEW

Additional Resources

- SPLIMAGE Specification Version 3.0.2
- Report Adverse Event
- SPL Format Previewer for Label Authors
- Product Identification System

At the present time this Web site does not contain a complete listing of labels for approved prescription drugs. Currently this Web site contains 54420 drugs.

Search : GO Advanced Search

Limits: Drug Name NDC Code Drug Class SetId

Label Type: Human Drugs Animal Drugs

Search results for

`Fluoxetine 10 MG Oral Tablet`

Total Results Found: [Count:20]

FLUOXETINE (fluoxetine hydrochloride) tablet
[Dr. Reddy's Laboratories Limited]

FLUOXETINE (fluoxetine hydrochloride) tablet
[Dr. Reddy's Laboratories Limited]

FLUOXETINE (fluoxetine hydrochloride) tablet, film coated
[Teva Pharmaceuticals USA Inc]

FLUOXETINE (fluoxetine hydrochloride) tablet, film coated
[Teva Pharmaceuticals USA Inc]

FLUOXETINE HYDROCHLORIDE (fluoxetine hydrochloride) tablet, film coated
[AvKARE, Inc.]

FLUOXETINE HYDROCHLORIDE (fluoxetine hydrochloride) tablet, film coated

MedlinePlus
Trusted Health Information for You

A service of the U.S. National Library of Medicine
NIH National Institutes of Health

Fluoxetine

(floo ox' e teen)

Why is this medication prescribed?
How should this medicine be used?
Other uses for this medicine
What special precautions should I follow?
What should I do if I forget a dose?
What side effects can this medication cause?
What should I know about storage and disposal of this medication?
In case of emergency/overdose
What other information should I know?
Brand names
Brand names of combination products

IMPORTANT WARNING:

A small number of children, teenagers, and young adults (up to 24 years of age) who took antidepressants ('mood elevators') such as fluoxetine during clinical studies became suicidal (thinking about harming or killing oneself or planning or trying to do so). Children, teenagers, and young adults who take antidepressants to treat depression or other mental illnesses may be more likely to become suicidal than children, teenagers, and young adults who do not take antidepressants to treat these conditions. However, experts are not sure about how great this risk is and how much it should be considered in deciding whether a child or teenager should take an antidepressant.

You should know that your mental health may change in unexpected ways when you take fluoxetine or other antidepressants even if you are an adult over 24 years of age. You may become suicidal, especially at the beginning of your treatment and any time that your dose is increased or decreased. You, your family, or your caregiver should call your doctor right away if you experience any of the following symptoms: new or worsening depression; thinking about harming or killing yourself, or planning or trying to do so; extreme worry; agitation; panic attacks; difficulty falling asleep or staying asleep; aggressive behavior; irritability; acting without thinking; severe restlessness; and frenzied abnormal excitement. Be sure that your family or caregiver knows which symptoms may be serious so they can call the doctor if you are unable to seek treatment on your own.

Your healthcare provider will want to see you often while you are taking fluoxetine, especially at the beginning of your treatment. Be sure to keep all appointments for office visits with your doctor.

The doctor or pharmacist will give you the manufacturer's patient information sheet (Medication Guide) when you begin treatment with fluoxetine. Read the information carefully and ask your doctor or pharmacist if you have any questions. You also can obtain the Medication Guide from the FDA website: http://www.fda.gov/Drugs/DrugSafety/InformationbyDrugClass/UCM096273.

Firefox
druginfo.nlm.nih.gov/drugportal/ProxyServlet?mergeData=true&objectHandle=DBMaint&APPLICATION_NAME=drugportal&actionHandle=d
Google
FLUOXETINE - Drug Information Portal -...

Drug Information Portal

Quick Access to Quality Drug Information

United States National Library of Medicine
National Institutes of Health

Search DRUG INFORMATION PORTAL

By Name By Category

FLUOXETINE 10 MG ORAL TABLET Go

Go back to previous page.

No exact matches were found for this search
Record(s) were found for : FLUOXETINE

Search Results

Drug Name: Fluoxetine [USAN:INN:BAN] [show more names] [show structure]
Search Term: FLUOXETINE 10 MG ORAL TABLET
Description: The first highly specific serotonin uptake inhibitor. It is used as an antidepressant and often has a more acceptable side-effects profile than traditional antidepressants.
Categories: Antidepressive Agents [show more categories]

Summary

- Summary of drug information (MedlinePlusDrug)
- Summary of consumer health information (MedlinePlusTopics)
- Summary of the effect on breastfeeding (LactMed)
- Summary of Drug-Induced Liver Injury (LiverTox)
- Manufacturers drug label (DailyMed)
- Clinical trials (ClinicalTrials.gov)
- Drug Identification and Image Display (Pillbox *beta*)

Detailed Summary

- Summary of reviewed biological and physical data (HSDB)
- References from scientific journals (Medline/PubMed)
- References from toxicological journals (TOXLINE)
- Biological activities and chemical structures (PubChem)
- Toxicological and chemical resources (ChemIDplus)

Additional Resources

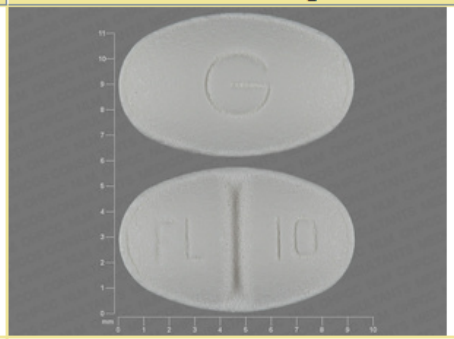
- Information from the US Food & Drug Administration (Drugs@FDA)
- Search engine for other government resources (USA.gov)

RxNav

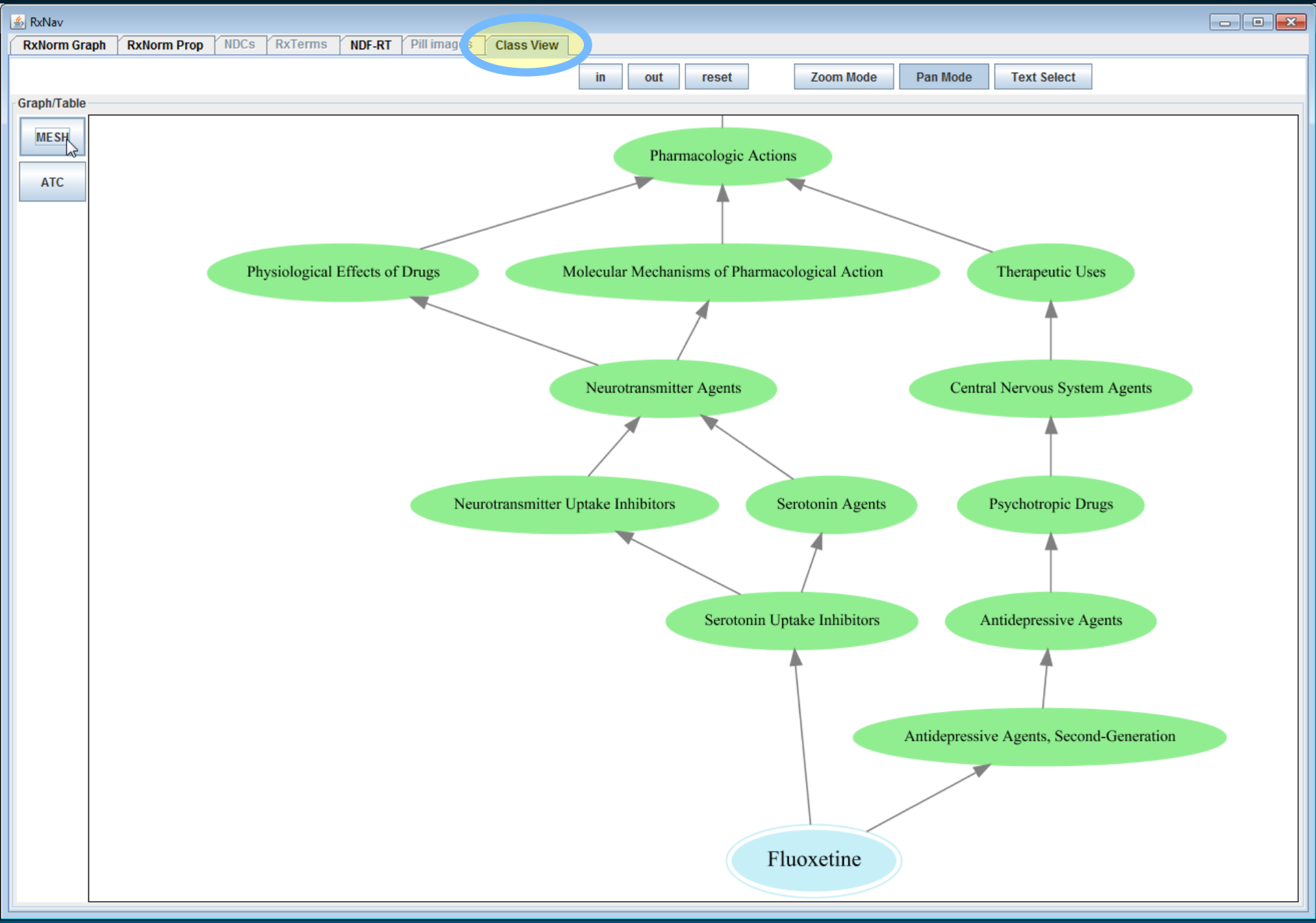
RxNorm Graph | RxNorm Prop | NDCs | RxTerms | NDF-T | Pill images | Class View

Results

Fluoxetine 10 MG Oral Tablet
RxCUI = 313990
Images and Properties

Property	Image 1	Image 2
Image		
Acq Date	02-09-2011	01-10-2013
Manufacturer	Par Pharmaceutical Inc.	Teva Pharmaceuticals USA Inc
SplSetId	Link to DailyMed	Link to DailyMed
NDC	49884-0734-11	00093-7188-56
Shape	OVAL	OVAL
Size	9	12
Color	WHITE	BLUE
Imprint	FL;10;G	7188;9;3
ImprintType	DEBOSSED	DEBOSSED
Part	N/A	N/A

For more information about Pill images, please visit Pill Image Website and **DISCLAIMER**


RxNav
RxNorm Graph
RxNorm Prop
NDCs
RxTerms
NDF-RT
Pill imag
Class View
in
out
reset
Zoom Mode
Pan Mode
Text Select
Graph/Table
MESH
ATC
Pharmacologic Actions
Physiological Effects of Drugs
Molecular Mechanisms of Pharmacological Action
Therapeutic Uses
Neurotransmitter Agents
Central Nervous System Agents
Neurotransmitter Uptake Inhibitors
Serotonin Agents
Psychotropic Drugs
Serotonin Uptake Inhibitors
Antidepressive Agents
Antidepressive Agents, Second-Generation
Fluoxetine

RxNav

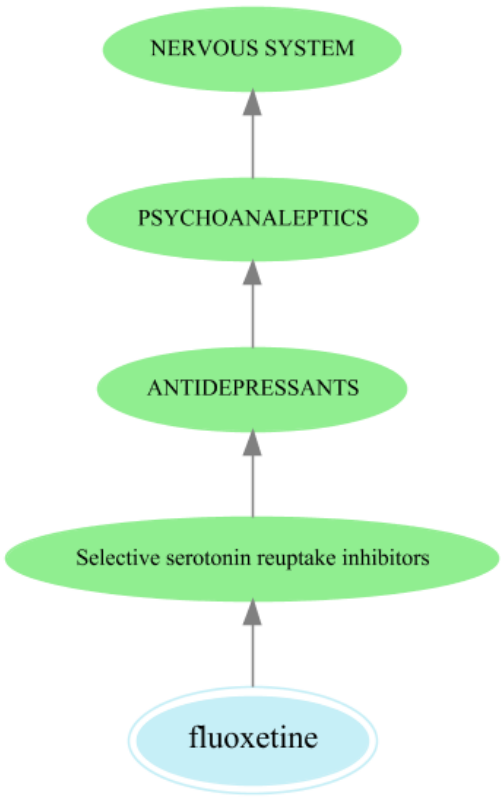
RxNorm Graph | RxNorm Prop | NDCs | RxTerms | NDF-RT | Pill images | Class View

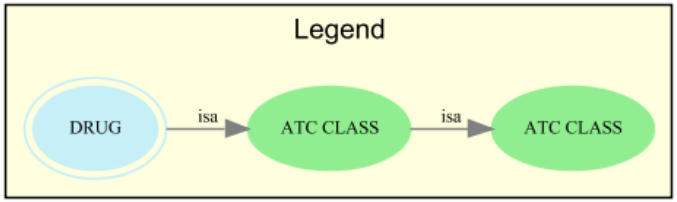
in | out | reset | Zoom Mode | Pan Mode | Text Select

Graph/Table

MESH

ATC





Processing drug information

RxNorm Application Programming Interface (API)

RxNorm API

- Made available in March 2008
- Based on Web Services
  - SOAP, REST (XML, JSON)
  - Independent of any programming language
- Used by *RxNav* and other applications
- Enable access to all information displayed in RxNav
- Documentation
  - http://rxnav.nlm.nih.gov/RxNormAPIs.html#

Main API functions

- Map drug codes and names to RxNorm
  - Including proprietary names and codes
  - Spelling correction
  - Various types of matching tailored to drugs
    - Exact, normalized, approximate
- Get RxNorm information
  - Properties (synonyms, NDCs, attributes, sources)
    - Proprietary names and codes require UMLS credentials
  - Relations (pairwise relations between entity types)
- Others
  - Concept status
    - Point to the current version of obsolete codes
  - List of all drug terms

SOAP Function	REST resource	Description
approxMatch	/approx?term=*value*	Search by name to find the closest RxNorm concepts
findRemapped	/remap/{*rxcui*}	Return the re-mapped concept identifiers from an obsolete concept
findRxcuiById	/rxcui?idtype=*value*&id=*value*&allsrc=*value*	Search by identifier to find RxNorm concepts
findRxcuiByString	/rxcui?name=*value*&srclist=*value*&allsrc=*value*&search=*value*	Search by name to find RxNorm concepts
getAllConceptsByTTY	/allconcepts?tty=*values*	Return the RxNorm concepts for the specified term types
getAllProperties	/rxcui/{*rxcui*}/allProperties?prop=*values*	Return all properties for a concept
getAllRelatedInfo	/rxcui/{*rxcui*}/allrelated	Return all related concept information
getApproximateMatch	/approximateTerm?term=*value*&maxEntries=*value*&option=*value*	NEW Approximate match search to find closest strings
getDisplayTerms	/displaynames	Return the auto suggestion names
getDrugs	/drugs?name=*value*	Return the related drugs
getIdTypes	/idtypes	Return the available identifier types
getMultiIngredBrand	/brands?ingredientids=*value*	Return the brands containing the specified ingredients
getNDCs	/rxcui/{*rxcui*}/ndcs	Return all National Drug Codes (NDC) for a concept
getPropCategories	/propCategories	Return the property categories.
getPropNames	/propnames	Return the property names.
getProprietaryInformation	/rxcui/{*rxcui*}/proprietary?srclist=*values*&ticket=*value*&rxaui=*value*	Return the proprietary information for a concept
getQuantity	/rxcui/{*rxcui*}/quantity	Return the quantity attribute for a concept
getRelatedByRelationship	/rxcui/{*rxcui*}/related?rela=*values*	Return the related concepts of specified relationship types
getRelatedByType	/rxcui/{*rxcui*}/related?tty=*values*	Return the related concepts of specified term types
getRelaTypes	/relatypes	Return the available relationship types
getRxConceptProperties	/rxcui/{*rxcui*}/properties	Return the concepts properties
getRxcuiStatus	/rxcui/{*rxcui*}/status	Return the status of the concept
getRxNormVersion	/version	Return the RxNorm data set version
getSourceTypes	/sourcetypes	Return the available vocabulary abbreviated source types
getSpellingSuggestions	/spellingsuggestions?name=*value*	Return spelling suggestions for a name
getSplSetId	/rxcui/{*rxcui*}/splsetid	Return the structured product label set identifiers for a concept
getStrength	/rxcui/{*rxcui*}/strength	Return the strength attribute for a concept
getTermTypes	/termtypes	Return the available term types
getUNII	/rxcui/{*rxcui*}/unii	Return the UNII Code for a concept

RESTful API Example

http://rxnav.nlm.nih.gov/REST/rxcui?name=bactrim

XML output

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<rxnormdata>
  <idGroup>
    <name>bactrim</name>
    <rxcui>151399</rxcui>
  </idGroup>
</rxnormdata>
```

JSON output

```
{
   "idGroup" : {
      "rxcui" : "151399",
      "name" : "bactrim"
   }
}
```

Differences from the database

- Does not require local installation / updates
- Focus on the logical representation of drug information
  - Not its storage
- Functions not available in SQL queries
  - Normalization and approximate matching
  - Remapping of obsolete concepts
- Optimized graph traversal / instantiation
  - All pairwise relations between entity types pre-computed

Reference implementations

Building Applications to Use the RxNorm (SOAP) API

This page describes how to build applications to use the RxNorm SOAP API. The same steps can be used for the Prescribable, RxTerms and NDF-RT APIs by substituting the appropriate service names contained in the WSDL files for those APIs.
We provide documentation for coding **Java** and **.Net** applications. Documentation for building applications in other programming languages (e.g. Perl) may be added at a later time.

- Building a Java Application to use the RxNorm API
- Building a .Net Application to use the RxNorm API

Building a Java Application to use the RxNorm API

The RxNorm API provides developers with functions for retrieving RxNorm data from the most current RxNorm data set. Building applications to use the RxNorm API require initial setup of the development environment and developing code. Each of these is described in detail in this chapter.

Java Development Environment Setup

Setup of a Java developer's environment involves the following steps. All steps must be completed before application code can be compiled and built to execute requests with the RxNorm API.

1. Obtain a Simple Object Access Protocol (SOAP) 1.2 compatible engine for web service message routing.
2. Download the WSDL for the RxNorm API web service.
3. Generate the client side stubs using Axis's WSDL2Java utility for the WSDL (for applications written in Java).

1. Obtaining a SOAP 1.2 Engine

Developers will require a Simple Object Access Protocol (SOAP) 1.2 compatible engine to route the web service messages to/from the RxNorm API. The client programs shown in this guide have been tested with Apache Axis Version 1.4 Follow the link to their website and download and install the version onto your development machine. The location of this download will be referred to as <AXIS_DIR> in this guide.

2. Downloading the RxNorm WSDL

The RxNorm WSDL may be downloaded from the RxNav web site. Right-click on the RxNorm Service WSDL and save the WSDL file to your development machine. The path to this file will be hereafter referred to as <RXNORM_WSDL_LOCATION>.

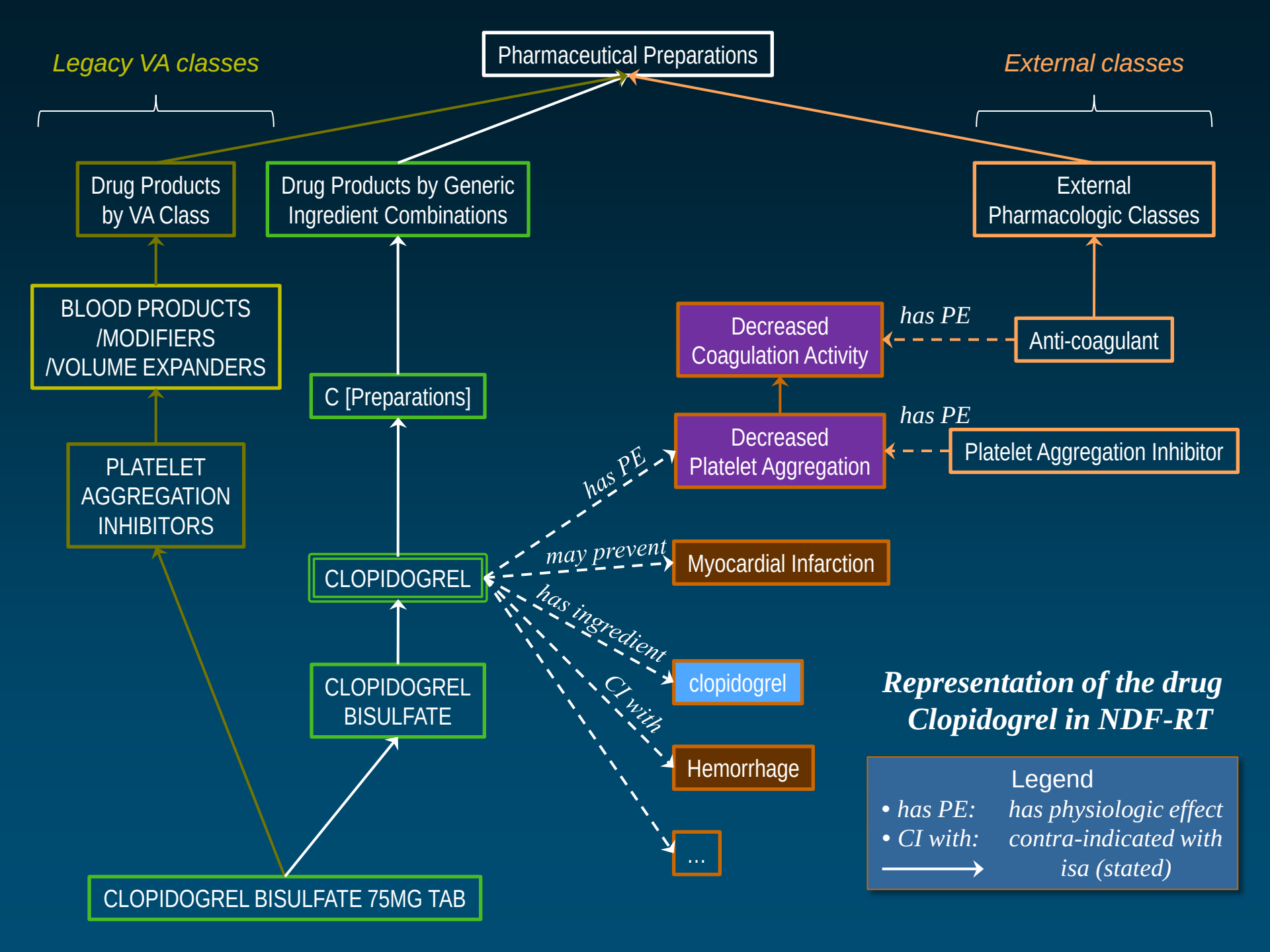
3. Generating Client Stubs for Java

Integrating drug information sources

“Sister APIs”

NDF-RT

- Developed by the Veterans Health Administration
- Integrated in RxNorm since June 2010
- Provides the clinical information “missing” from RxNorm
  - Therapeutic intent, contra-indications
  - Mechanism of action, physiologic effect
  - Pharmacologic classes
  - Drug-drug interactions


Legacy VA classes
Pharmaceutical Preparations
External classes
Drug Products by VA Class
Drug Products by Generic Ingredient Combinations
External Pharmacologic Classes
BLOOD PRODUCTS /MODIFIERS /VOLUME EXPANDERS
C [Preparations]
Decreased Coagulation Activity
has PE
Anti-coagulant
Decreased Platelet Aggregation
has PE
Platelet Aggregation Inhibitor
PLATELET AGGREGATION INHIBITORS
has PE
may prevent
Myocardial Infarction
CLOPIDOGREL
has ingredient
clopidogrel
CI with
Hemorrhage
...
CLOPIDOGREL BISULFATE
CLOPIDOGREL BISULFATE 75MG TAB
Representation of the drug Clopidogrel in NDF-RT
Legend
• has PE: has physiologic effect
• CI with: contra-indicated with
isa (stated)

NDF-RT API

- Made available in 2011
- SOAP and REST flavors
- Relies on the OWL version of NDF-RT
- Support for limited inference
  - All indications of a drug
    - Stated or inferred
  - All drugs that treat some disease
    - Drugs that treat the disease or any of its descendants
- Used to display NDF-RT information in RxNav

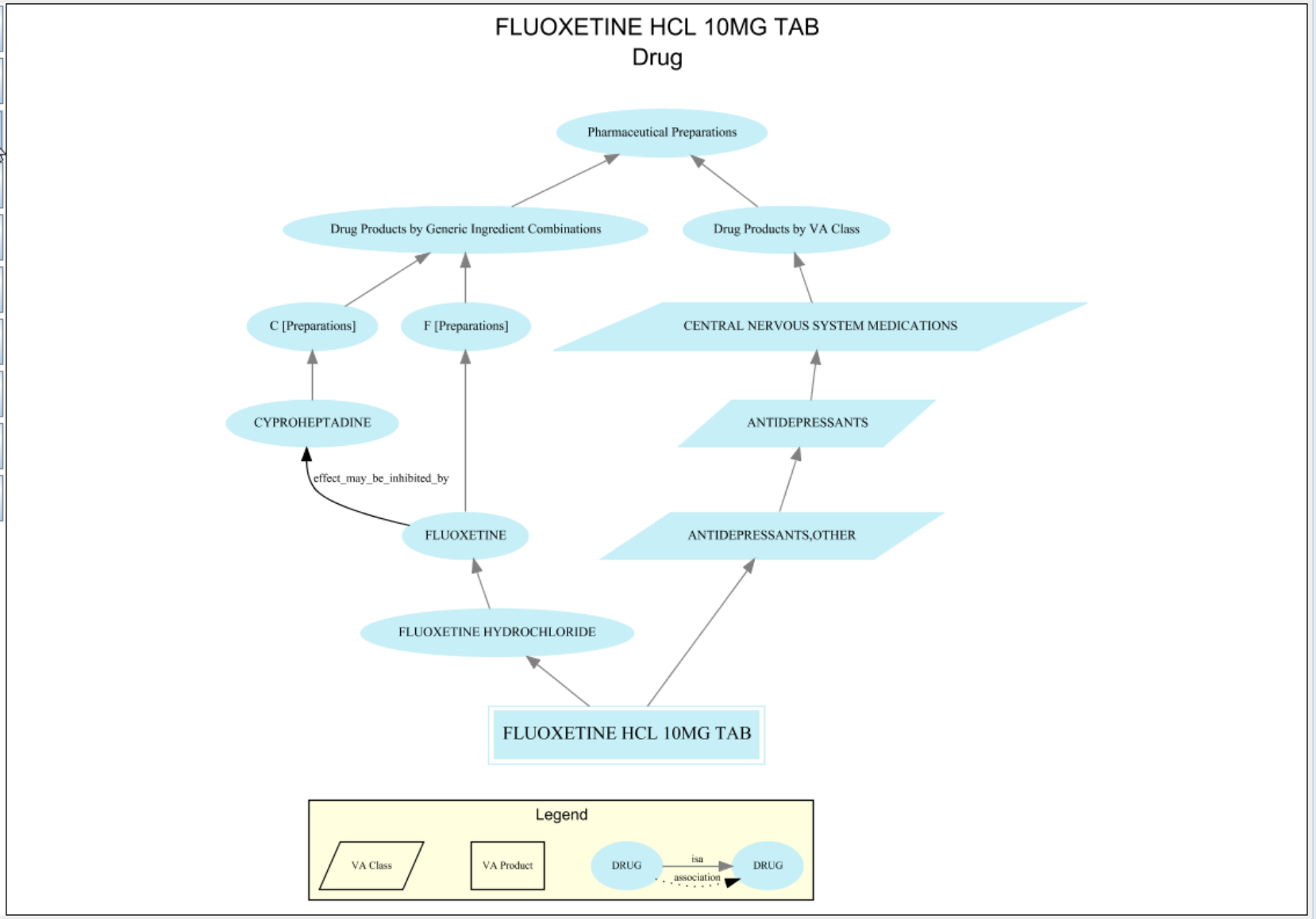
RxNav

RxNorm Graph | RxNorm Prop | NDCs | RxTerms | NDF-RT | Pill images | Class View

RxCUI : 313990 NUI : N0000161849 | in | out | reset | Zoom Mode | Pan Mode | Text Select | Version : 2013.09.03

Graph/Table

- Properties Table
- Relations Table
- Drug
- Disease
- Dose Form
- Ingredient
- Mechanism of Action
- Pharmacokinetics
- Physiologic Effect
- Drug Interactions



RxNav

RxNorm Graph | RxNorm Prop | NDCs | RxTerms | NDF-RT | Pill images | Class View

RxCUI : 313990 NUI : N0000161849 in out reset Zoom Mode Pan Mode Text Select Version : 2013.09.03

Graph/Table

- Properties Table
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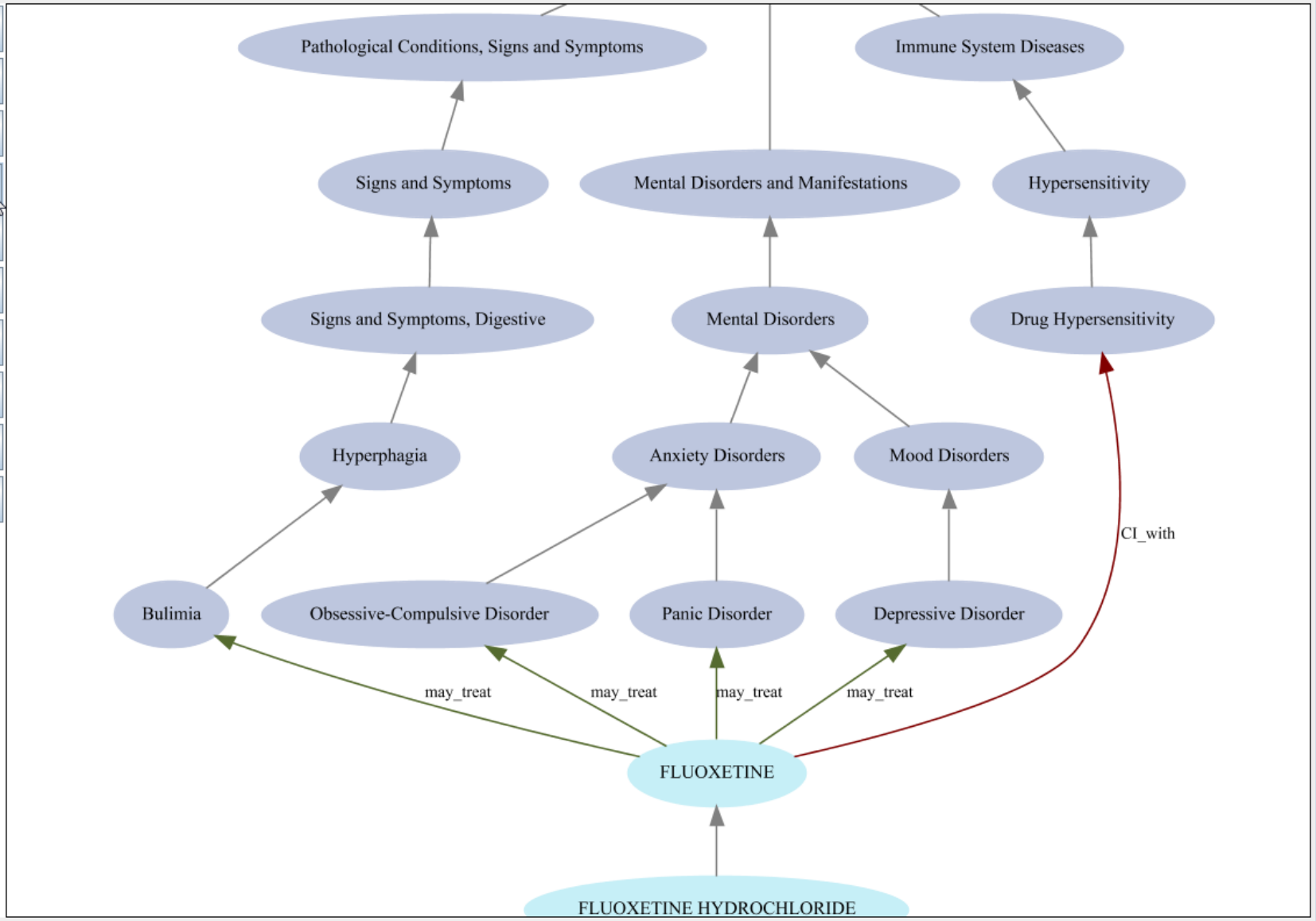
- Dose Form
- Ingredient
- Mechanism of Action
- Pharmacokinetics
- Physiologic Effect
- Drug Interactions



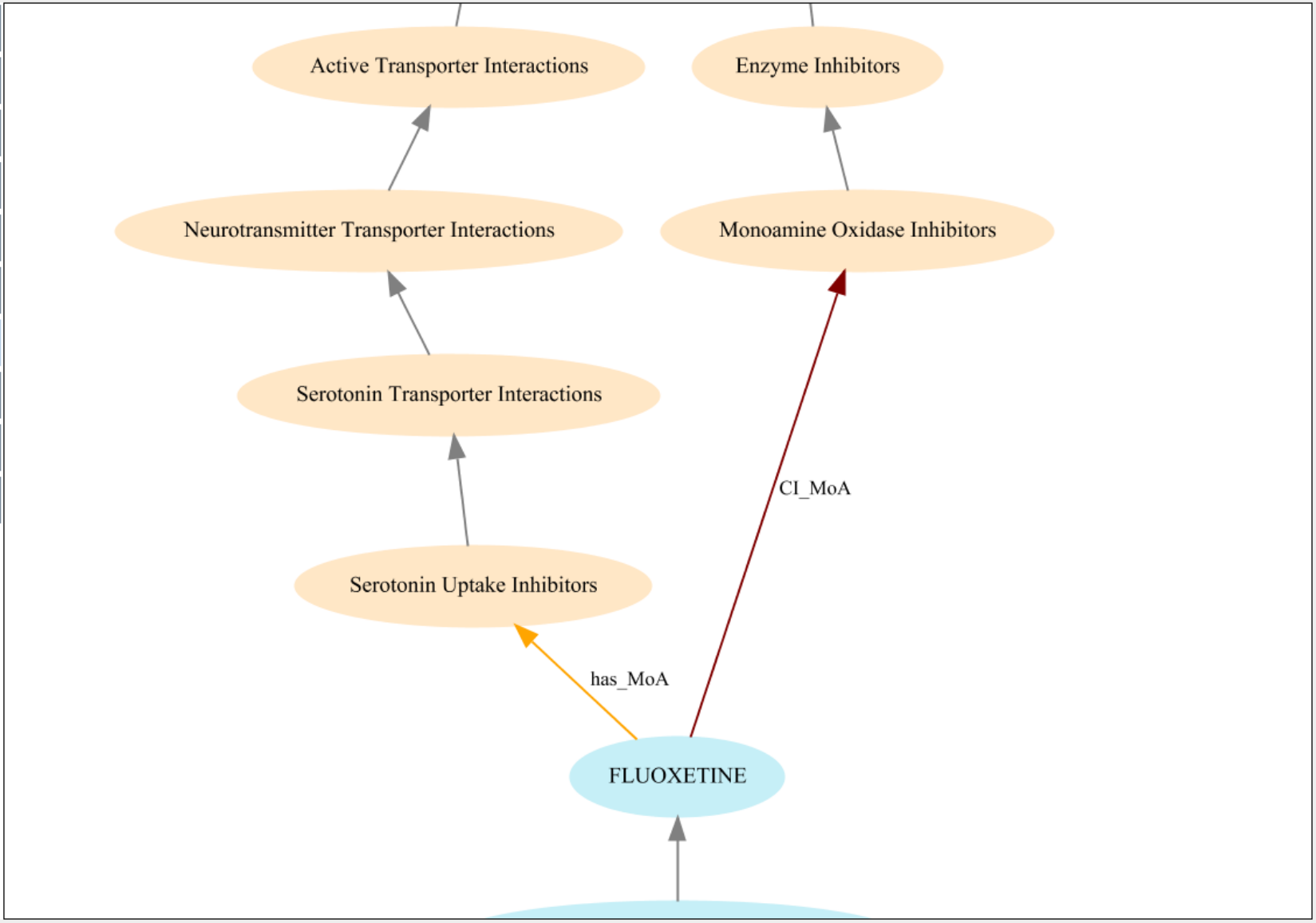
RxNav

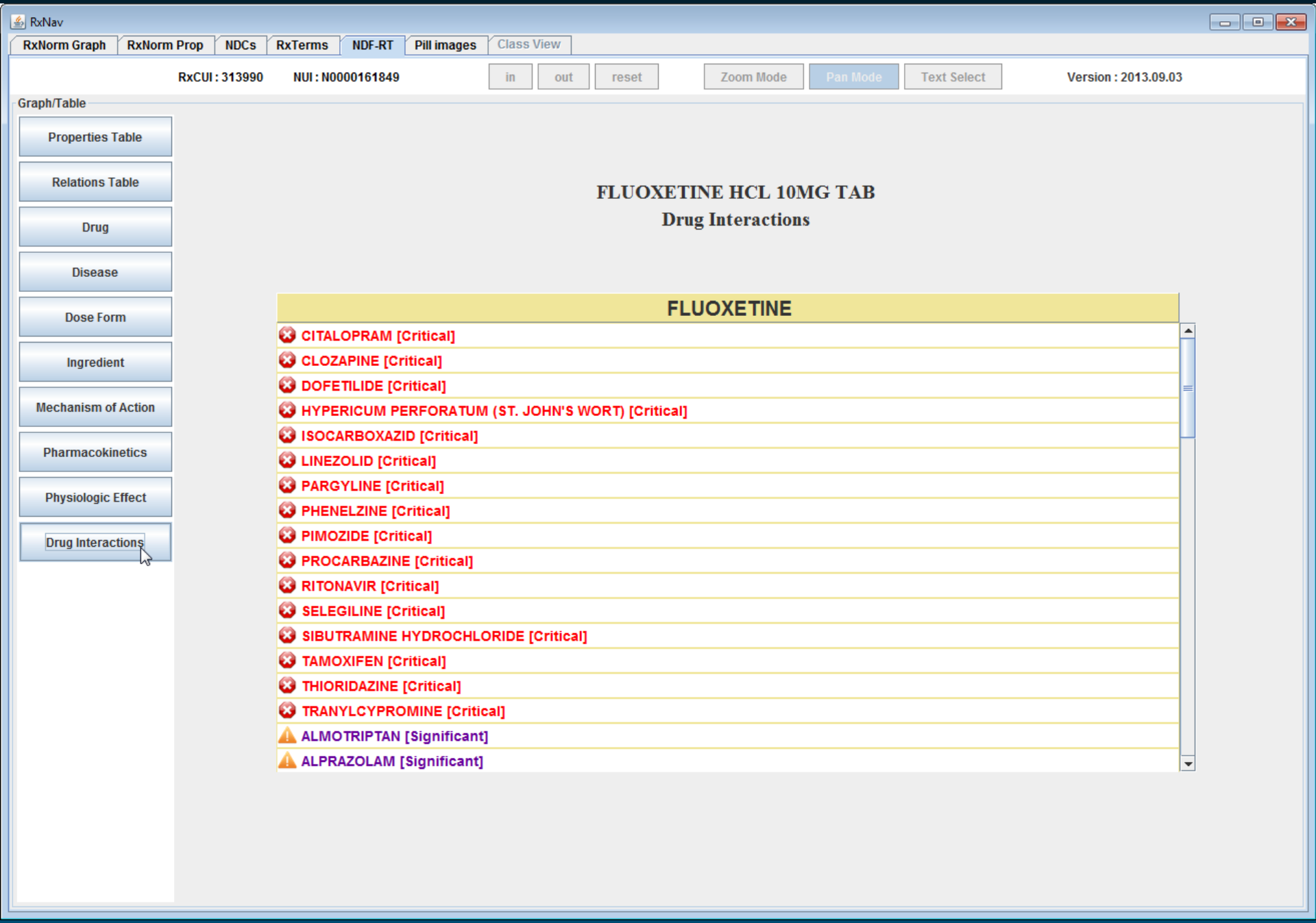
RxNorm Graph | RxNorm Prop | NDCs | RxTerms | NDF-RT | Pill images | Class View

RxCUI : 313990 NUI : N0000161849 | in | out | reset | Zoom Mode | Pan Mode | Text Select | Version : 2013.09.03

Graph/Table

- Properties Table
- Relations Table
- Drug
- Disease
- Dose Form
- Ingredient
- Mechanism of Action
- Pharmacokinetics
- Physiologic Effect
- Drug Interactions




RxNav
RxNorm Graph
RxNorm Prop
NDCs
RxTerms
NDF-RT
Pill images
Class View
RxCUI : 313990
NUI : N0000161849
in
out
reset
Zoom Mode
Pan Mode
Text Select
Version : 2013.09.03
Graph/Table
Properties Table
Relations Table
Drug
Disease
Dose Form
Ingredient
Mechanism of Action
Pharmacokinetics
Physiologic Effect
Drug Interactions
FLUOXETINE HCL 10MG TAB
Drug Interactions
FLUOXETINE
CITALOPRAM [Critical]
CLOZAPINE [Critical]
DOFETILIDE [Critical]
HYPERICUM PERFORATUM (ST. JOHN'S WORT) [Critical]
ISOCARBOXAZID [Critical]
LINEZOLID [Critical]
PARGYLINE [Critical]
PHENELZINE [Critical]
PIMOZIDE [Critical]
PROCARBAZINE [Critical]
RITONAVIR [Critical]
SELEGILINE [Critical]
SIBUTRAMINE HYDROCHLORIDE [Critical]
TAMOXIFEN [Critical]
THIORIDAZINE [Critical]
TRANYLCYPROMINE [Critical]
ALMOTRIPTAN [Significant]
ALPRAZOLAM [Significant]

RxTerms

- Drug interface terminology derived from RxNorm for prescription writing or medication history recording
  - Commonly used synonyms and abbreviations (e.g. HCTZ for hydrochlorothiazide)
  - "tall man" lettering recommended by FDA to avoid medication errors (e.g. ChlorproMAZINE and ChlorproPAMIDE)
- http://wwwcf.nlm.nih.gov/umlslicense/rxtermApp/rxTerm.cfm
- Developed at NLM
- Many RxTerms features have been integrated in RxNav

Enabling complex queries to drug information sources

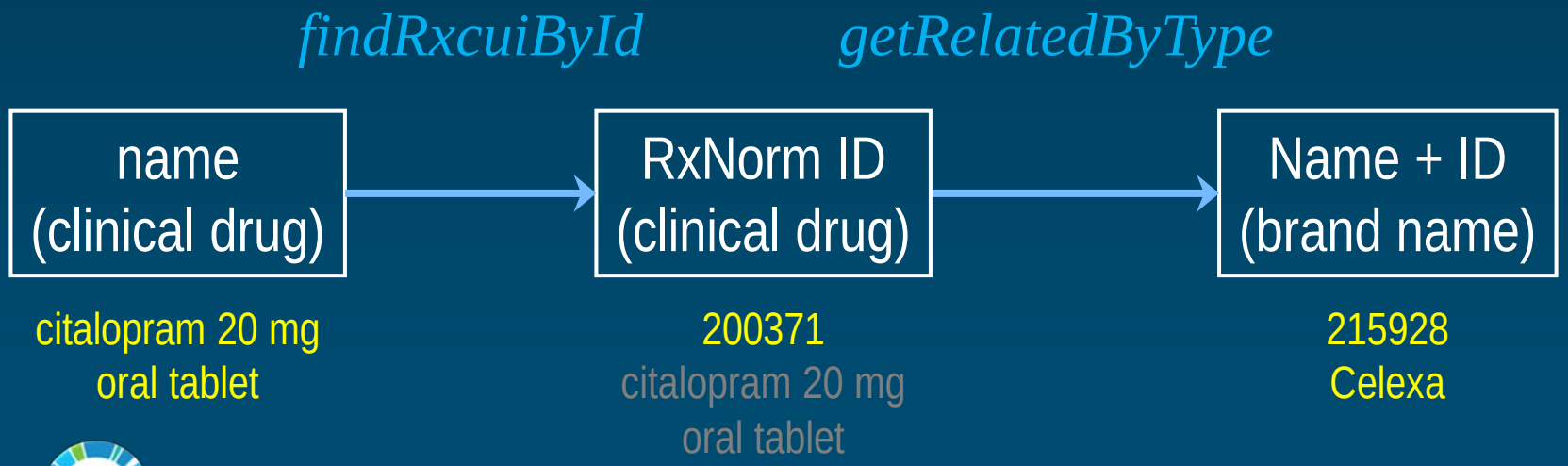
RxMix

Motivation

- Drug information sources can be used programmatically through Application Programming Interfaces (APIs)
  - RxNorm, NDF-RT, RxTerms, RxImageAccess
- Difficult to compose complex queries within and across multiple APIs
  - Interoperability of functions
    - → Model for interoperability
  - Programming is required
    - → Graphical interface

Example use case

- Find all the brand name products available for a given clinical drug string
  - Input: citalopram 20 mg oral tablet
  - Output: Celexa
- Workflow

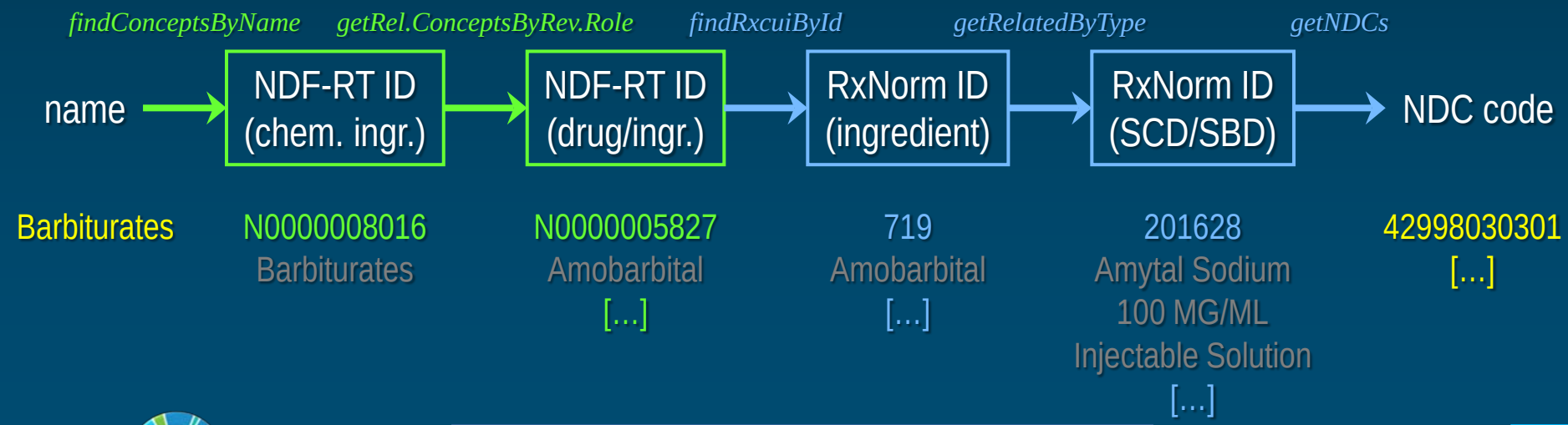


Interoperability among API functions

- Interoperability rule
  - If the input of function *B* matches the output of function *A*, then function *A* is potentially interoperable with function *B*
- Implementation
  - Supported by an ontology describing the input or output of functions
    - Also used to drive the RxMix application
- Example
  - A: *rxnorm:findRxcuiById has_output RxCUI*
  - B: *rxnorm:getRelatedByType has_input RxCUI*
  - input of *B* matches the output of *A* *=> rxnorm:getRelatedByType interoperable_with rxnorm:findRxcuiById*

“Real-life” use case

- Find all the NDC codes for a given allergy class (e.g., barbiturates)
  - Input: [NDF-RT] Barbiturates (N0000008016)
  - Output: [RxNorm] list of NDC codes
- Complex workflow



http://mor.nlm.nih.gov/RxMix/

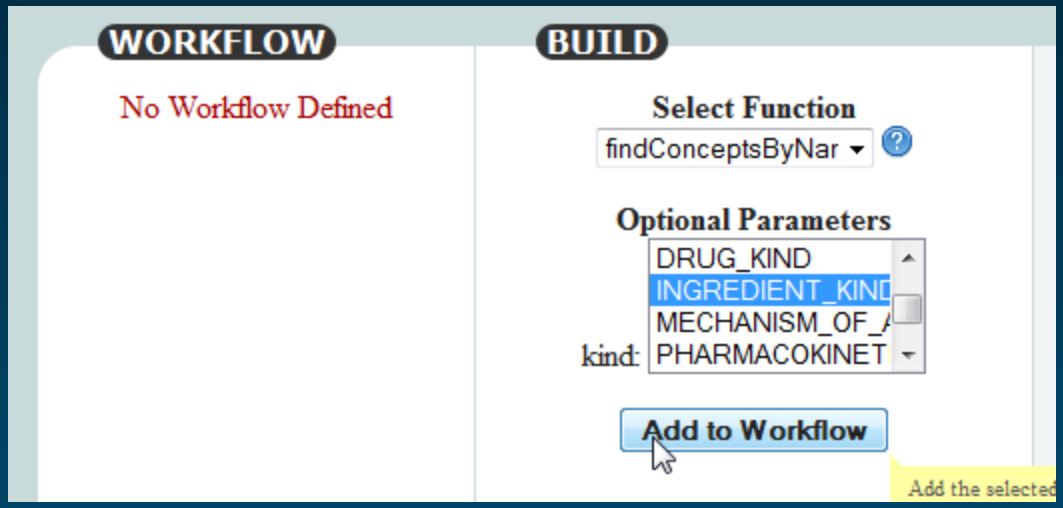
RxMix

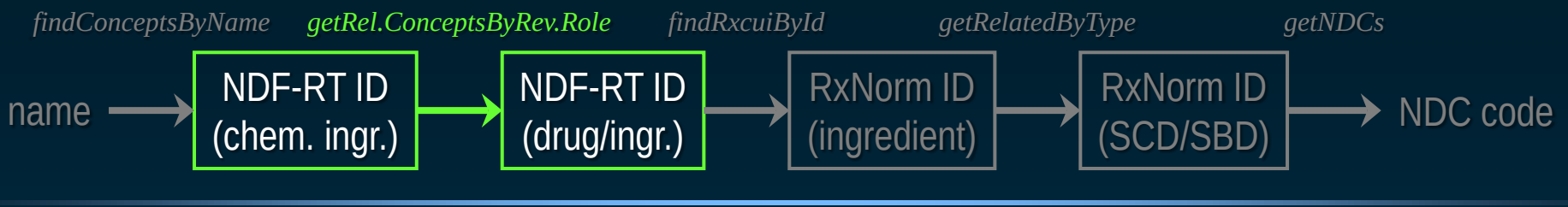
Create applications from RxNorm, RxTerms, NDF-RT, and RxImageAccess APIs

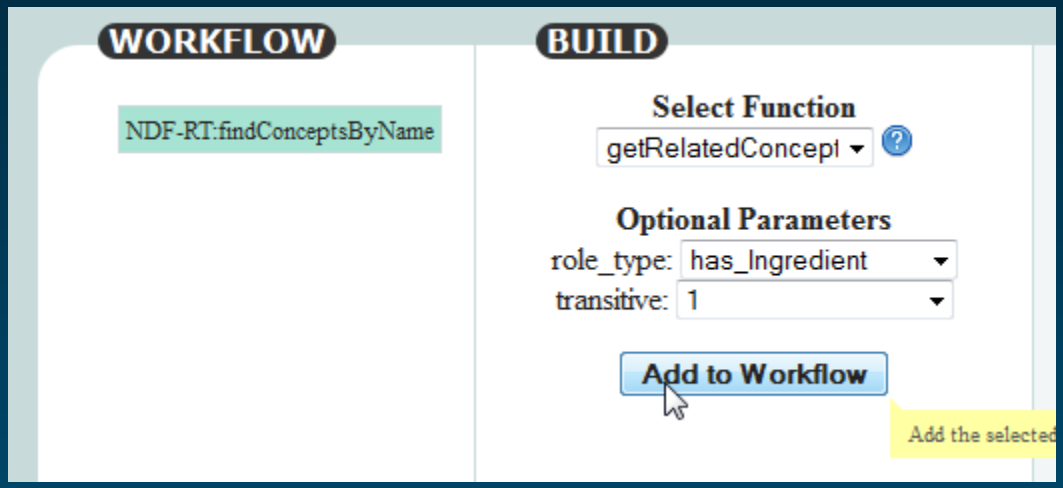
http://mor.nlm.nih.gov/RxMix/

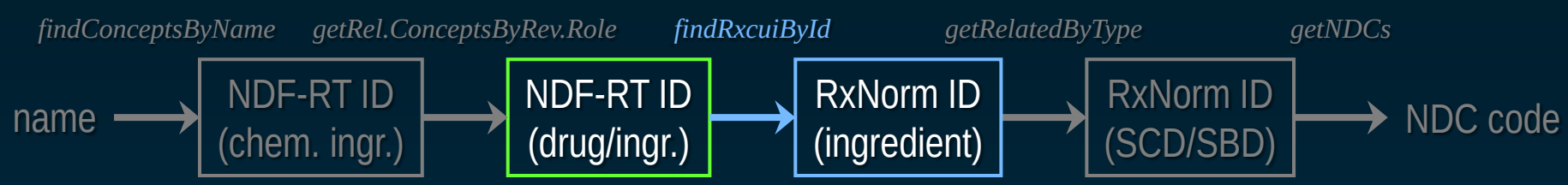
findConceptsByName *getRel.ConceptsByRev.Role* *findRxcuiById* *getRelatedByType* *getNDCs*

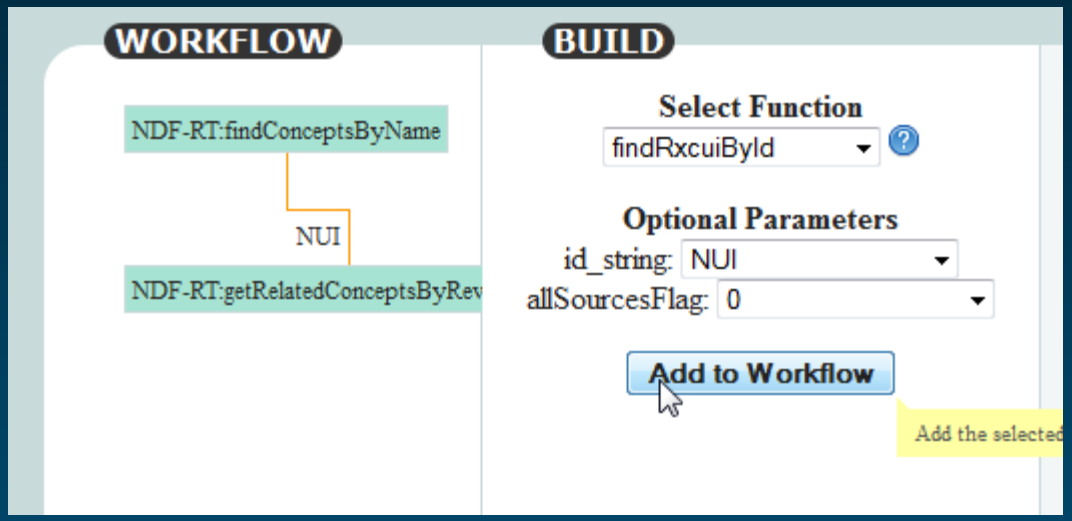
name → NDF-RT ID (chem. ingr.) → NDF-RT ID (drug/ingr.) → RxNorm ID (ingredient) → RxNorm ID (SCD/SBD) → NDC code

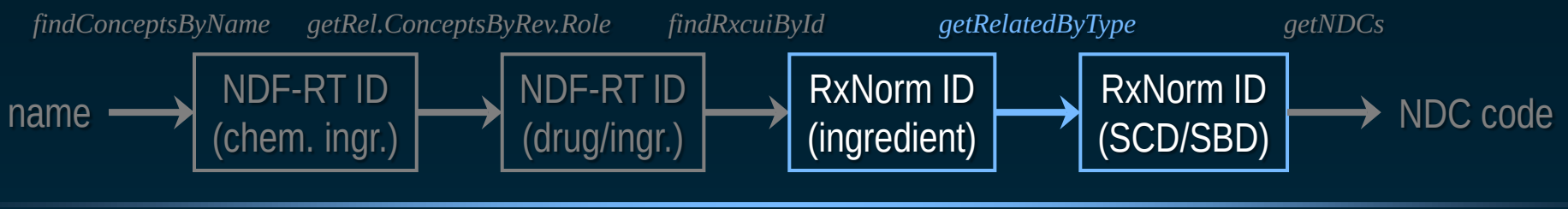


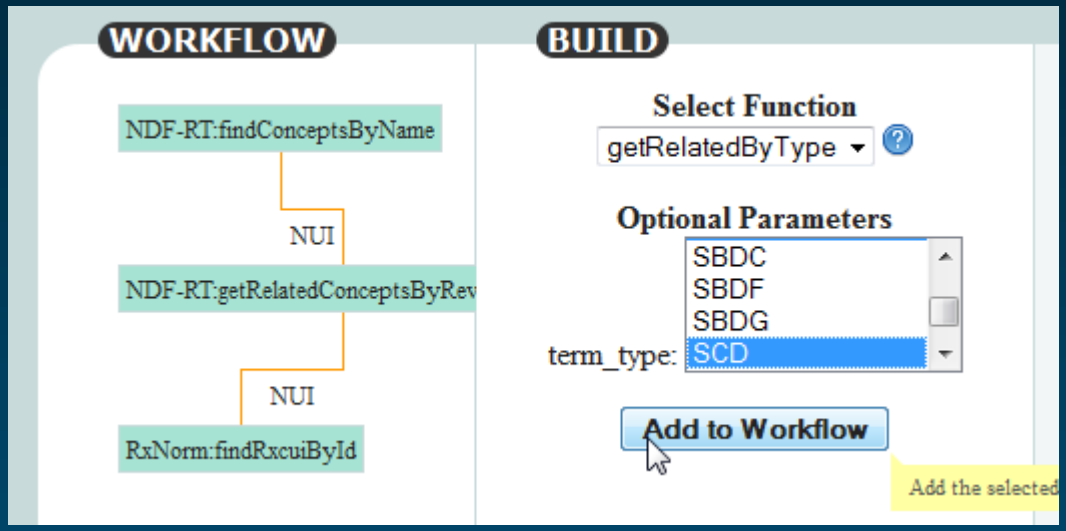

findConceptsByName
getRel.ConceptsByRev.Role
findRxcuiById
getRelatedByType
getNDCs
name
NDF-RT ID (chem. ingr.)
NDF-RT ID (drug/ingr.)
RxNorm ID (ingredient)
RxNorm ID (SCD/SBD)
NDC code

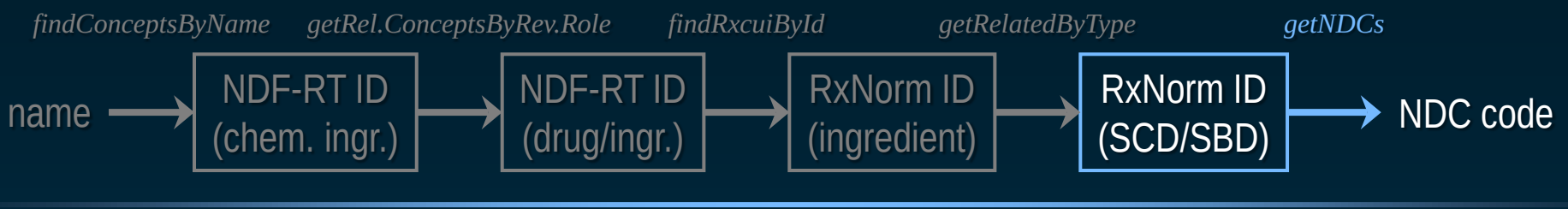

WORKFLOW
BUILD
NDF-RT:findConceptsByName
Select Function
getRelatedConcept
Optional Parameters
role_type: has_Ingredient
transitive: 1
Add to Workflow
Add the selected

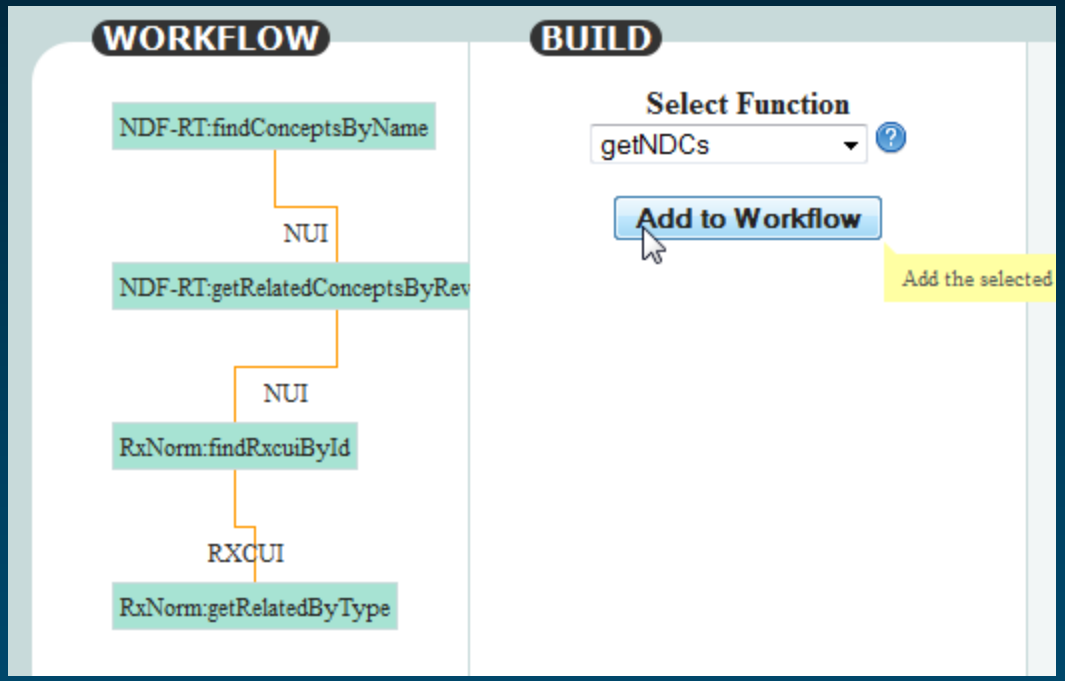

findConceptsByName
getRel.ConceptsByRev.Role
findRxcuiById
getRelatedByType
getNDCs
name
NDF-RT ID (chem. ingr.)
NDF-RT ID (drug/ingr.)
RxNorm ID (ingredient)
RxNorm ID (SCD/SBD)
NDC code

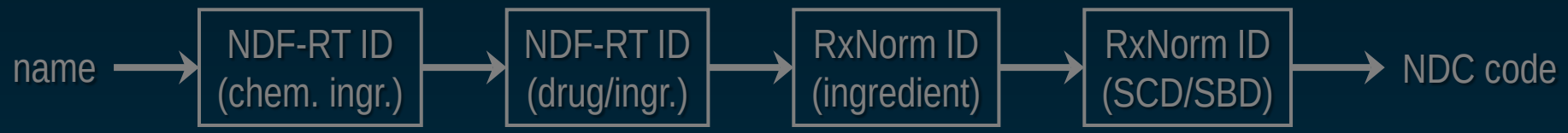

WORKFLOW
BUILD
NDF-RT:findConceptsByName
NUI
NDF-RT:getRelatedConceptsByRev
Select Function
findRxcuiById
Optional Parameters
id_string: NUI
allSourcesFlag: 0
Add to Workflow
Add the selected

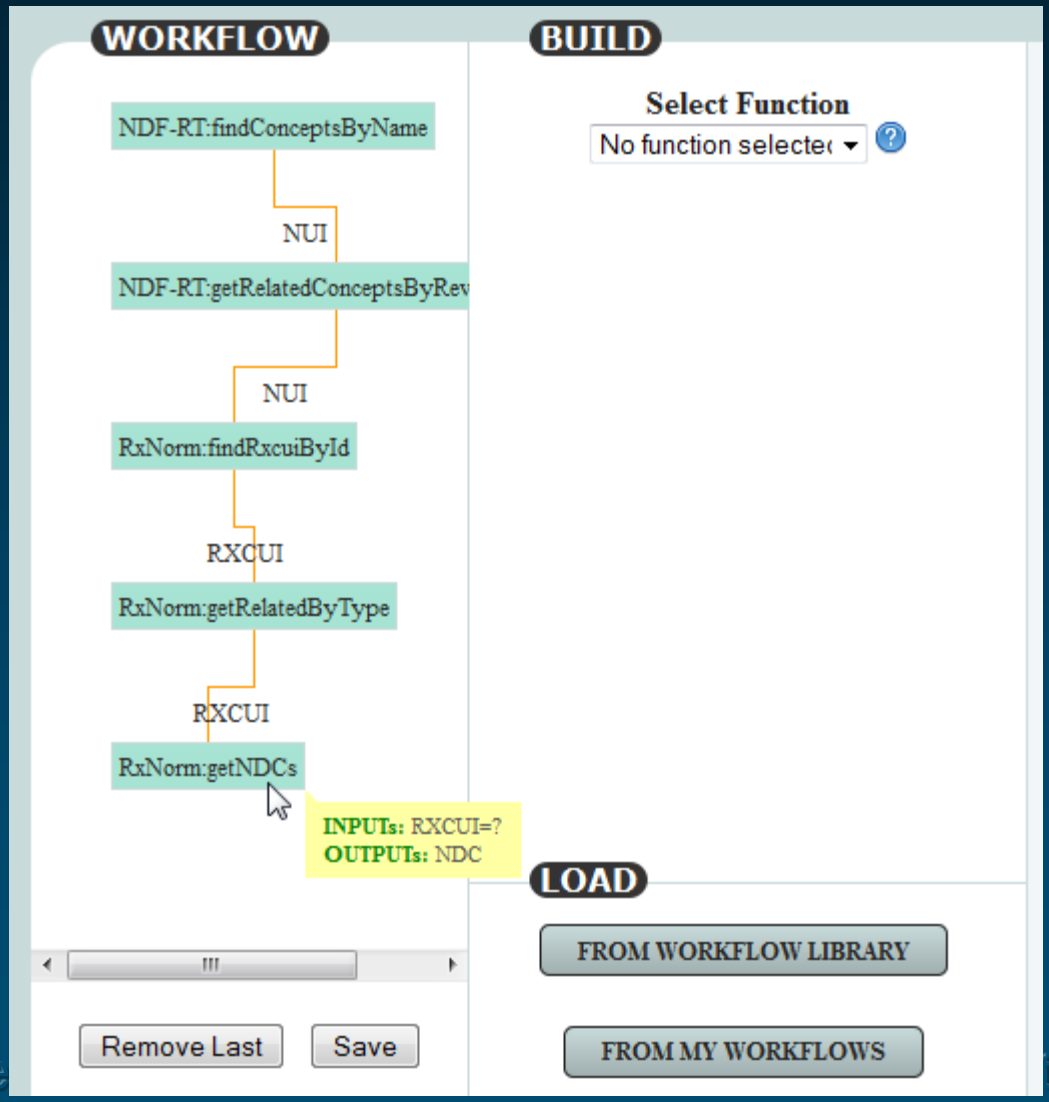

findConceptsByName
getRel.ConceptsByRev.Role
findRxcuiById
getRelatedByType
getNDCs
name
NDF-RT ID (chem. ingr.)
NDF-RT ID (drug/ingr.)
RxNorm ID (ingredient)
RxNorm ID (SCD/SBD)
NDC code


WORKFLOW
BUILD
NDF-RT:findConceptsByName
NUI
NDF-RT:getRelatedConceptsByRev
NUI
RxNorm:findRxcuiById
Select Function
getRelatedByType
Optional Parameters
SBDC
SBDF
SBDG
term_type:
SCD
Add to Workflow
Add the selected

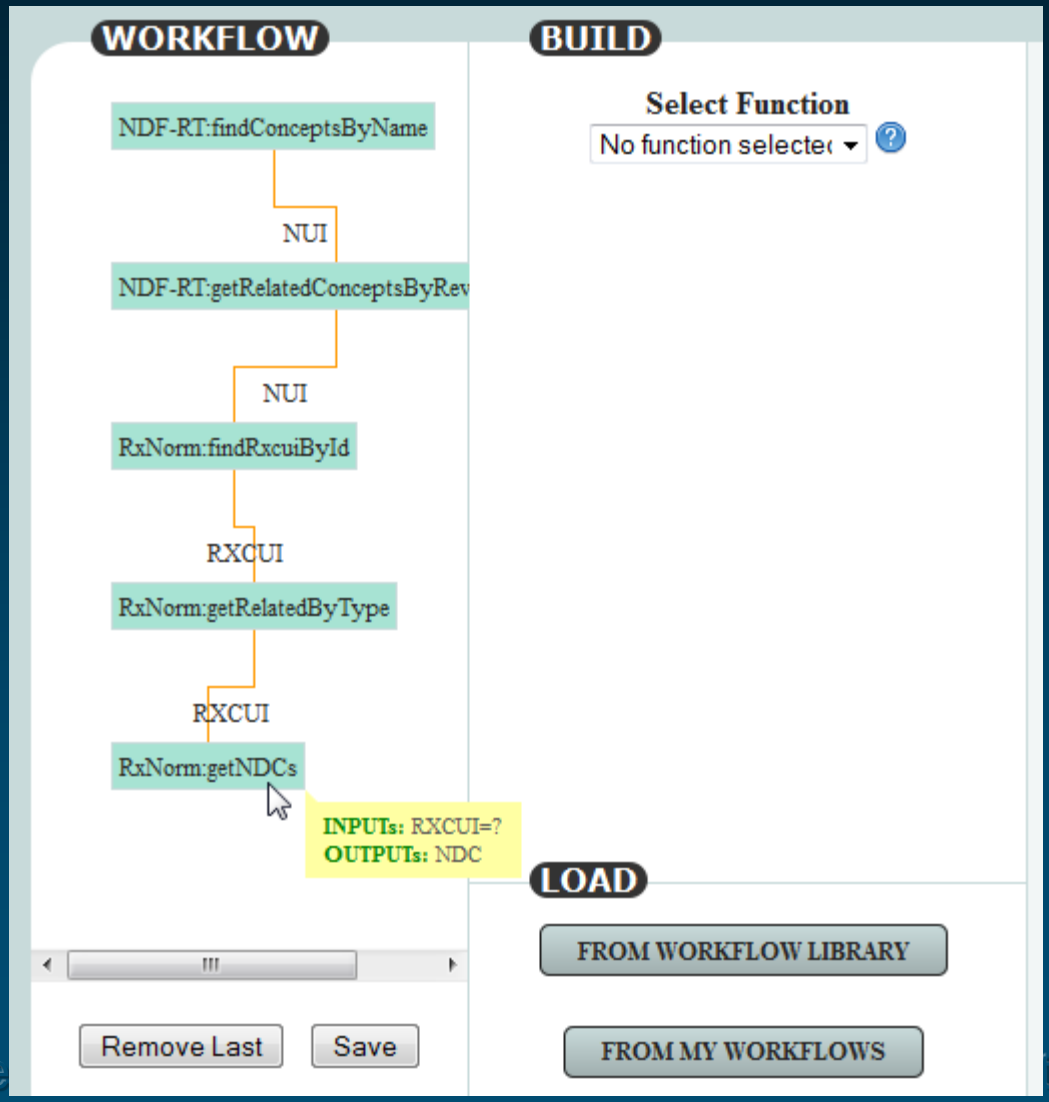

findConceptsByName
getRel.ConceptsByRev.Role
findRxcuiById
getRelatedByType
getNDCs
name
NDF-RT ID (chem. ingr.)
NDF-RT ID (drug/ingr.)
RxNorm ID (ingredient)
RxNorm ID (SCD/SBD)
NDC code


WORKFLOW
BUILD
NDF-RT:findConceptsByName
NUI
NDF-RT:getRelatedConceptsByRev
NUI
RxNorm:findRxcuiById
RXCUI
RxNorm:getRelatedByType
Select Function
getNDCs
Add to Workflow
Add the selected

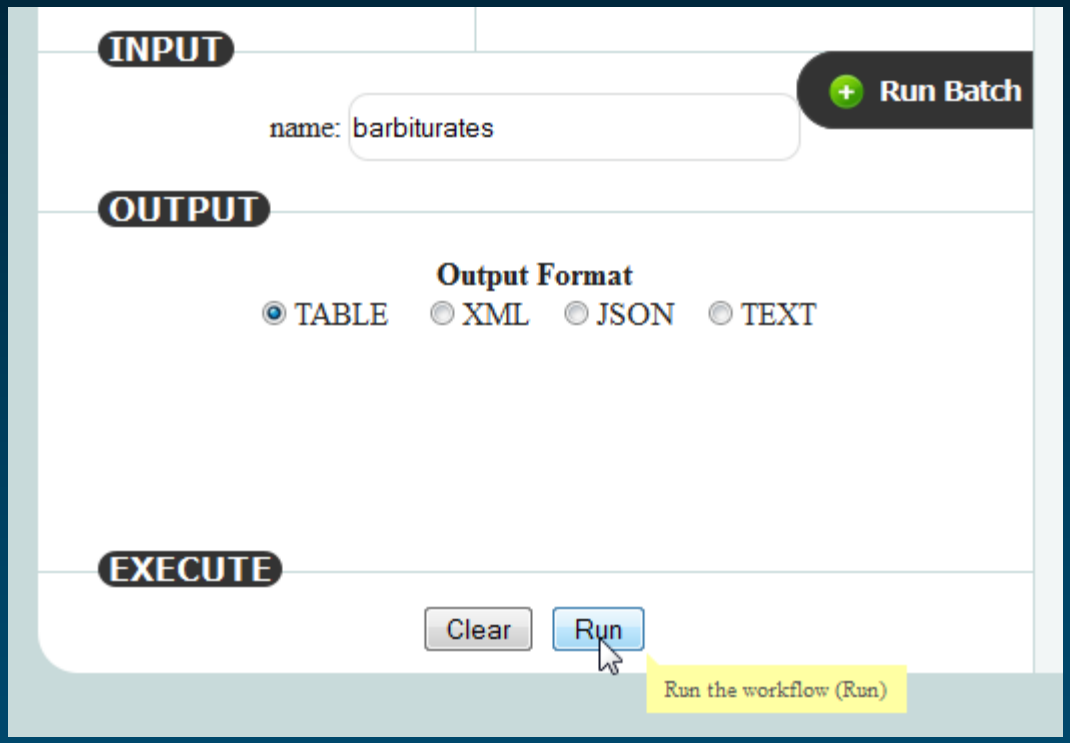

findConceptsByName
getRel.ConceptsByRev.Role
findRxcuiById
getRelatedByType
getNDCs
name
NDF-RT ID (chem. ingr.)
NDF-RT ID (drug/ingr.)
RxNorm ID (ingredient)
RxNorm ID (SCD/SBD)
NDC code


WORKFLOW
BUILD
NDF-RT:findConceptsByName
NUI
NDF-RT:getRelatedConceptsByRev
NUI
RxNorm:findRxcuiById
RXCUI
RxNorm:getRelatedByType
RXCUI
RxNorm:getNDCs
INPUTs: RXCUI=?
OUTPUTs: NDC
Select Function
No function selecte
LOAD
FROM WORKFLOW LIBRARY
FROM MY WORKFLOWS
Remove Last
Save

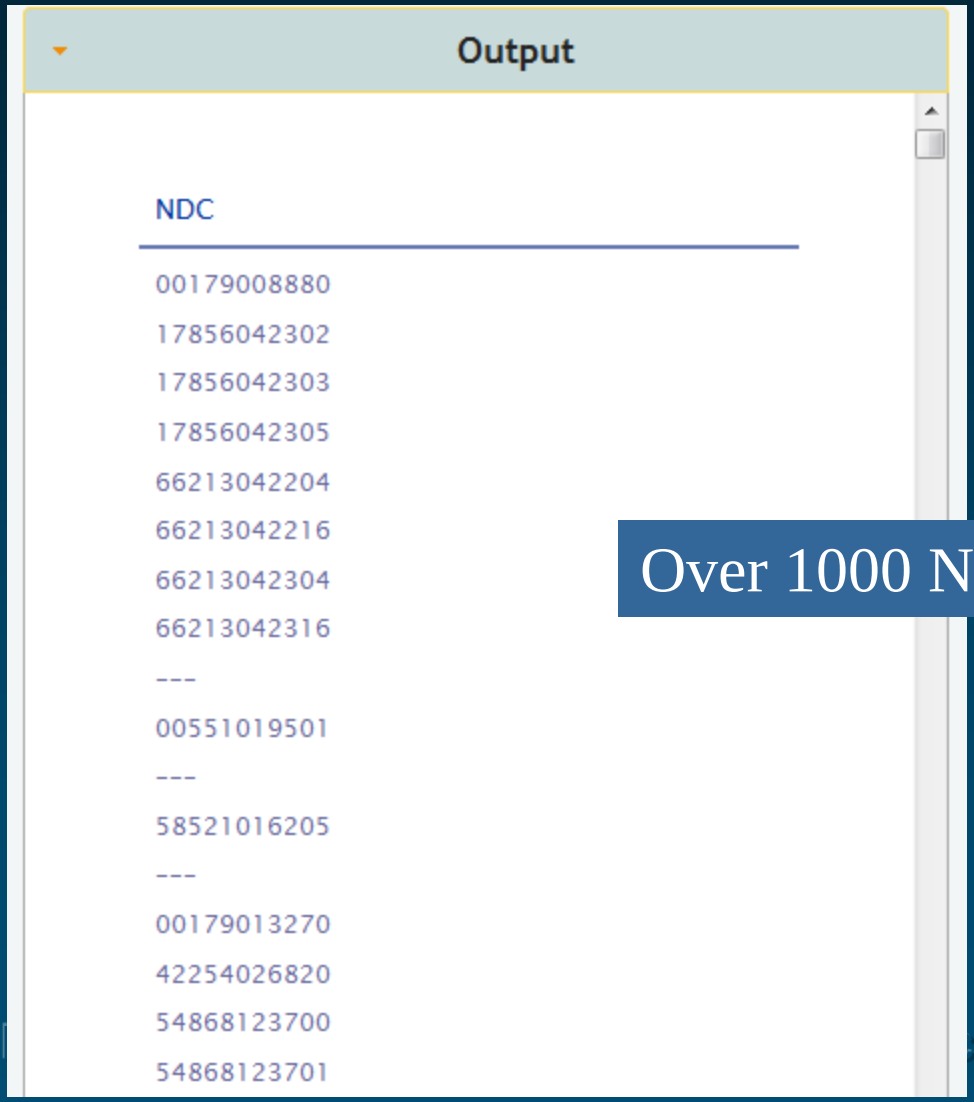
Complete workflow



Add input and run



Output



Over 1000 NDCs retrieved

Examples of use cases

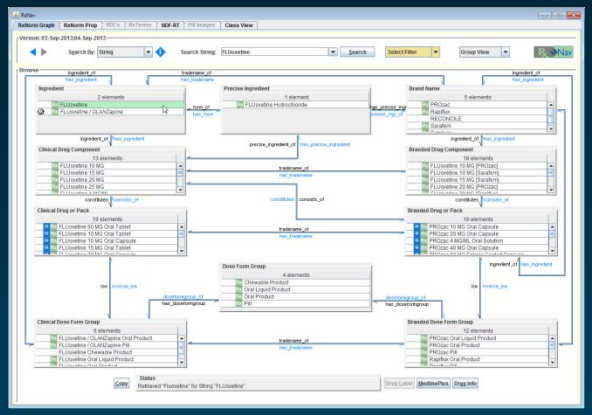
- Finding clinical drugs which may cause allergic reactions
- Finding interactions to RxNorm clinical drugs
- Finding NDF-RT ingredients from RxNorm clinical drugs
- Finding VA classes for RxNorm clinical dose forms
- Finding brand names from clinical drug strings

Library of common use cases integrated in RxMix

Applications & Usage

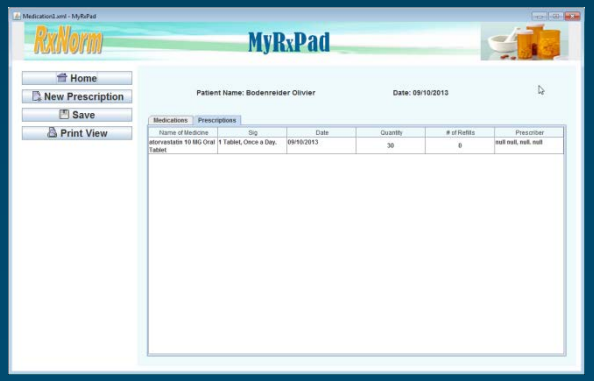
NLM applications

- RxNav



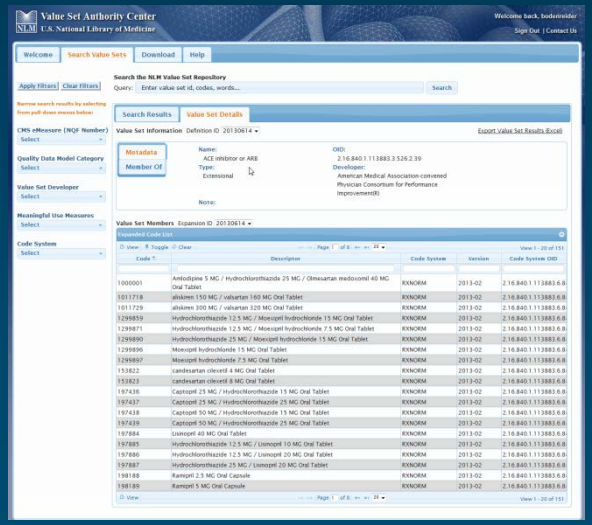
- MyMedicationList iOS app

- MyRxPad



NLM applications

- MedlinePlusConnect
  - Map NDCs to RxCUIs
  - Remap obsolete RxCUIs
  - Navigate through RxNorm
- Value Set Authority Center
  - Validate RxNorm codes
  - Check entity type
  - Remap obsolete codes



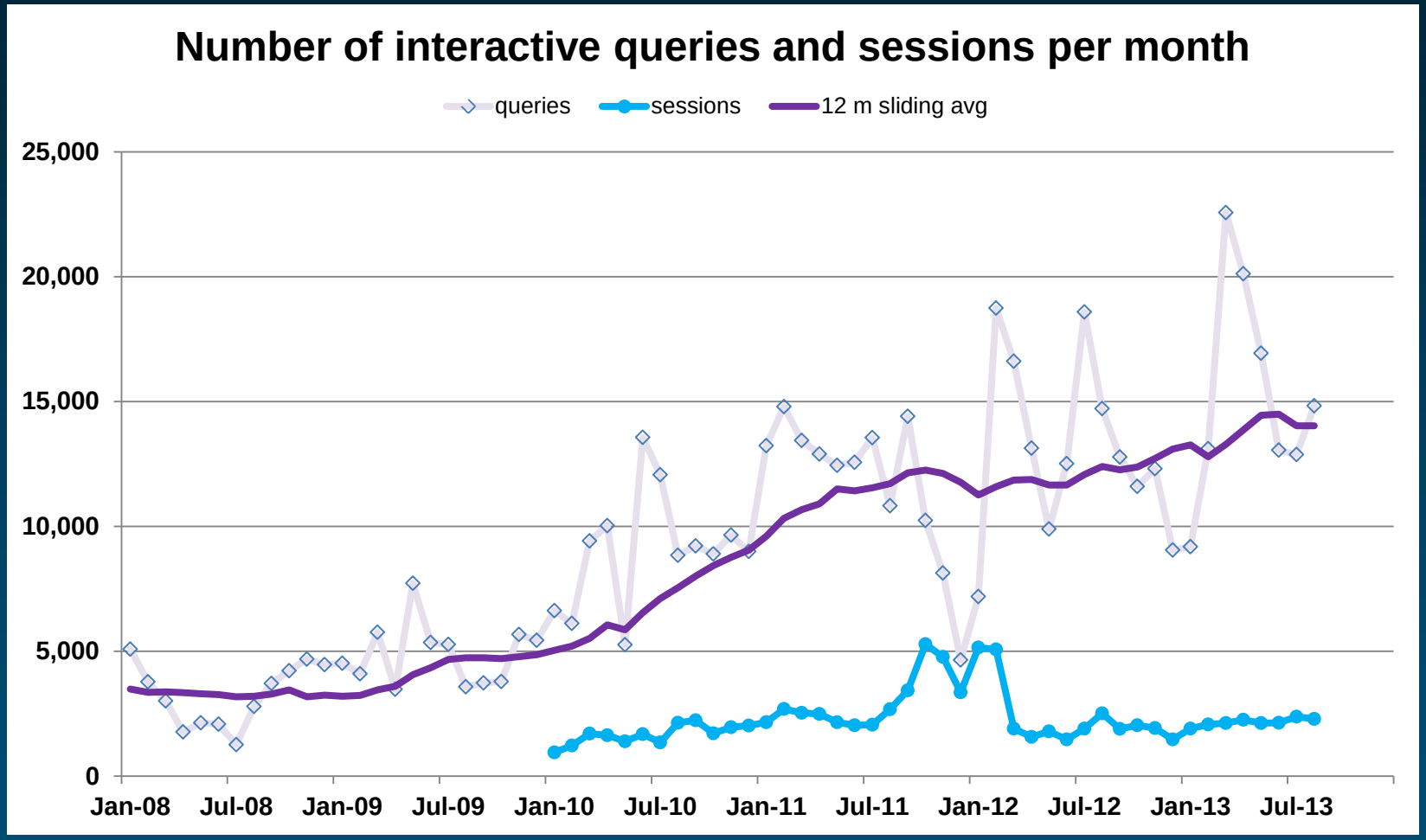
Applications outside NLM Research

- In research projects
  - RxSafe (OHSU)
    - "improve medication safety for patients"
    - http://www.ohsu.edu/RxSafe/
  - My-Medi-Health (Vanderbilt)
    - "Child-Centered Medication Management"
    - http://www.projecthealthdesign.org/projects/overview-2006_2008/405594/406293
  - Health Ontology Mapper (CTSA-i2b2/SHRINE)
    - "automated formulary data instance mapping"
    - https://community.i2b2.org/wiki/display/HOM/HOM+Home

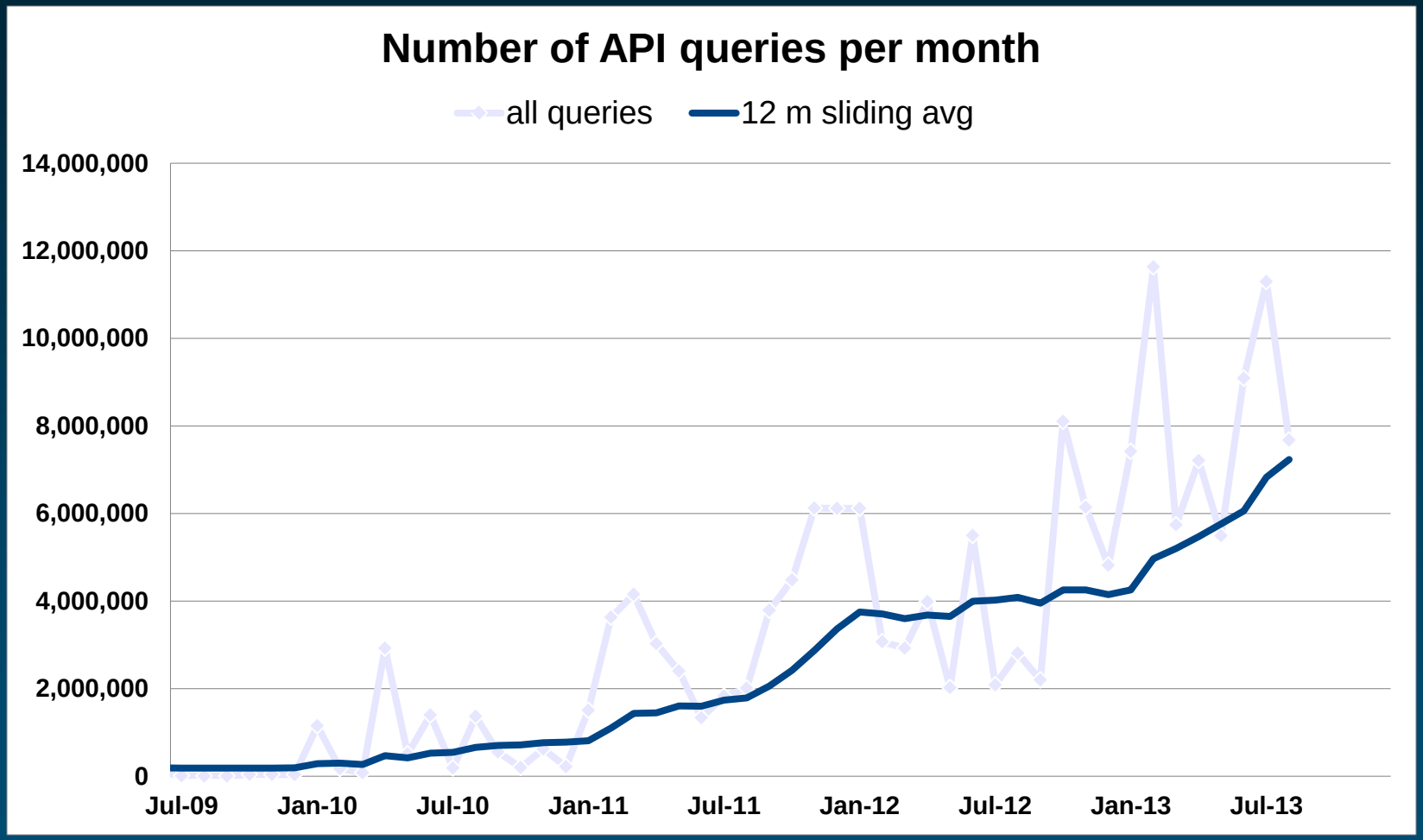
Applications outside NLM Apps

- EHR/PHR
  - iBlueButton
- Medication lists / histories
  - Drug Diary
  - RefillWizard
  - PillRack

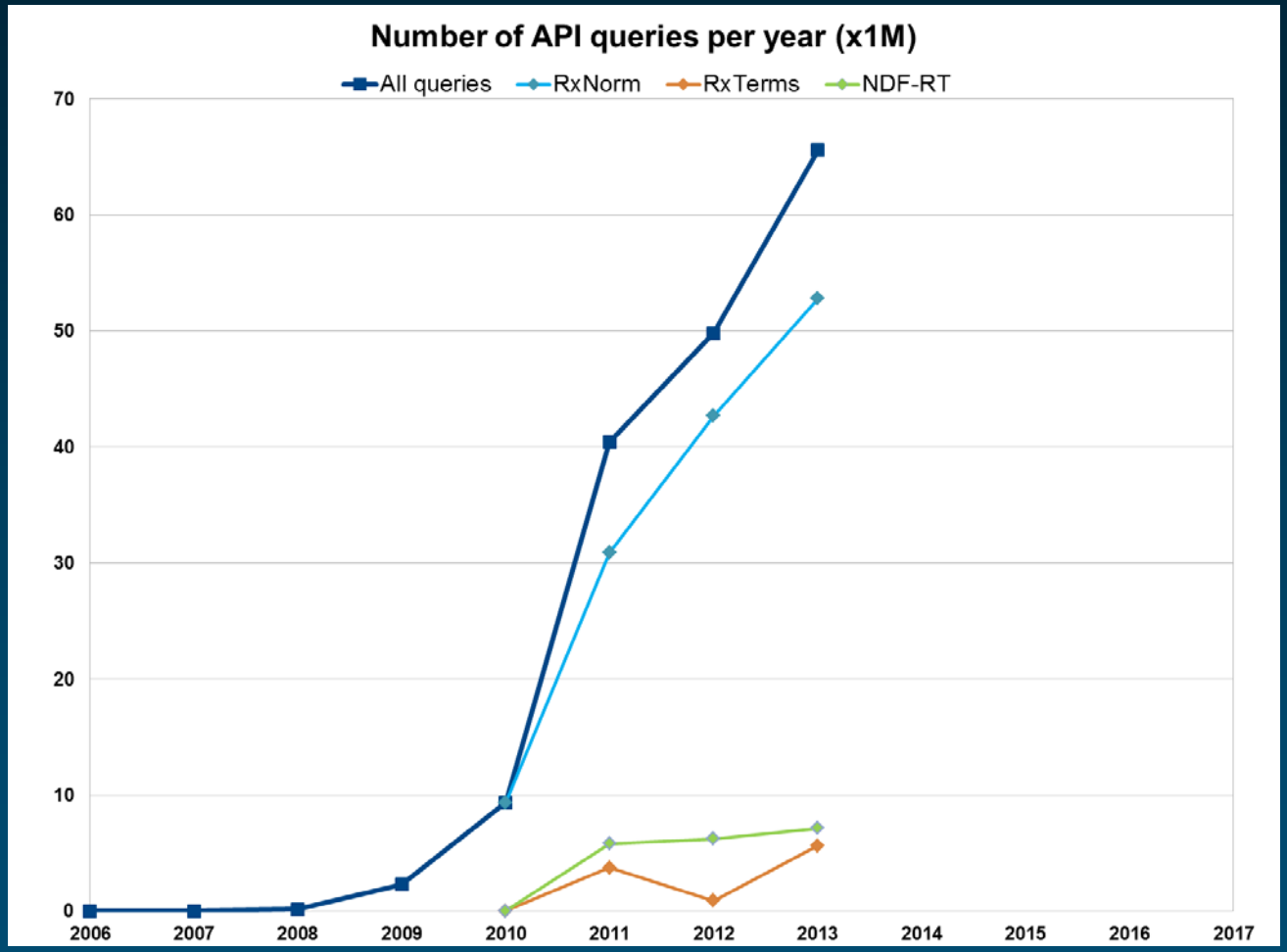
Usage statistics RxNav sessions



Usage statistics API queries



Usage statistics API queries

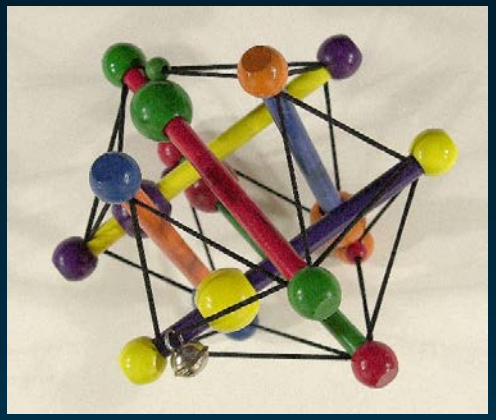


Who are our users?

- NLM
  - MedlinePlusConnect (~10%)
- Health application developers
- Academic projects
- Pharmacists (insurance, benefit managers)
- ???
  - 42,000 unique IP addresses (Jan.-Aug. 2013)
  - Top 20 IP addresses account for ~ 80% of the traffic
  - Who is "ec2-50-xx-211-251.us-west-1.compute.amazonaws.com"? (200,000 queries in Aug. 2013)

Spreading the word

- 8 posters (AMIA, Medinfo, MIE)
- 6 demos / webinars
- 5 conference papers (AMIA, Medinfo)
- 2 journal articles



Medical Ontology Research

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