

Text Mining in Life Science Informatics

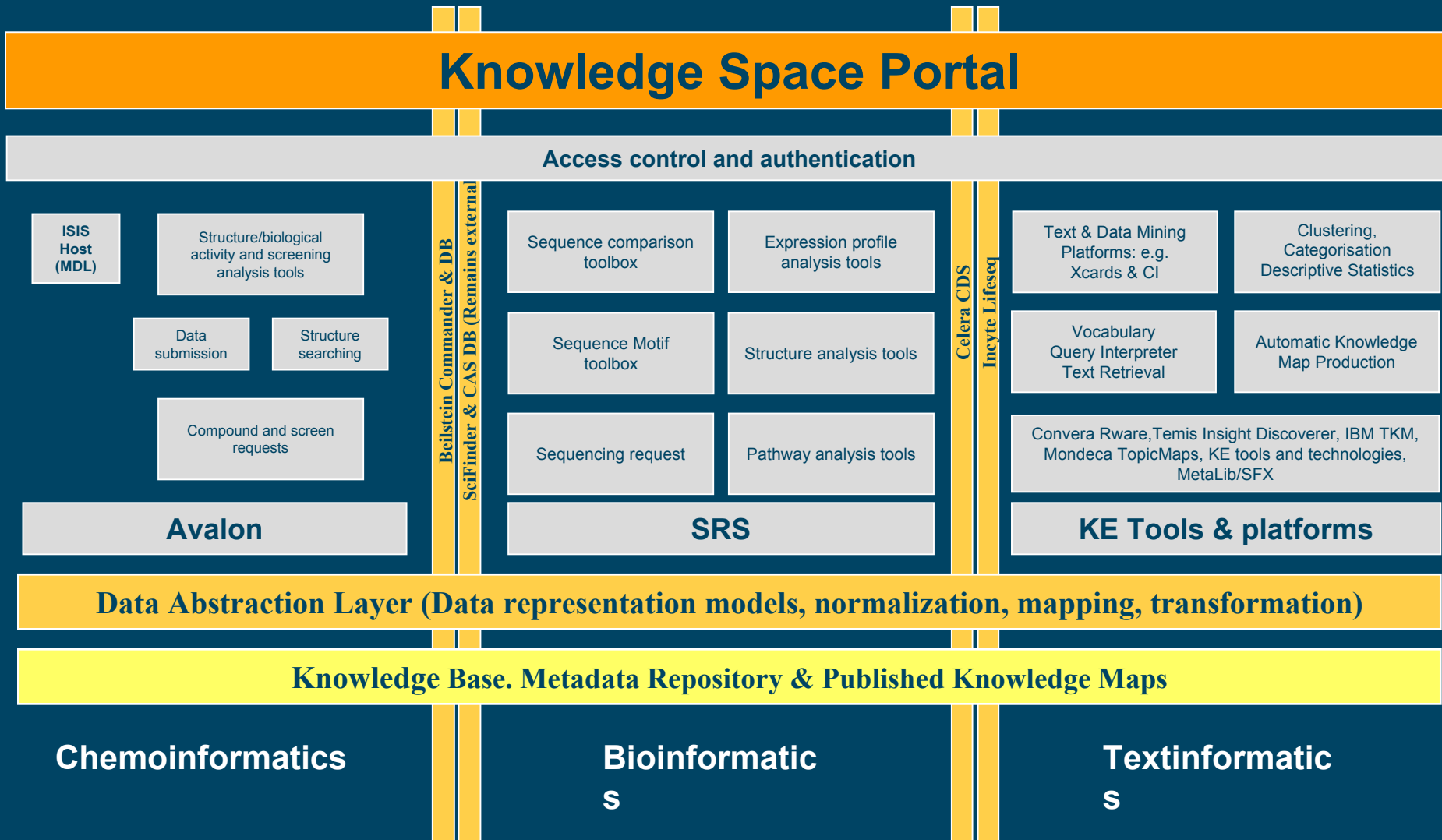
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IK@N, Informatics & Knowledge Management
Novartis Institutes for Biomedical Research**

Basel Computational Biology Conference 2003



IK@N Knowledge Space Architecture



The implementation of the KS requires

- **A knowledge representation model underlying the Knowledge Space**
- **A model for implementing the Novartis common terminology, for the validation and mapping of existing internal and external resources, and for the automatic production of consistent computational lexicons**
- **Advanced mining, information extraction and exploration techniques**
- **Advanced methods and tools for information searching and retrieval**
- **Advanced tools and components to be integrated on the Knowledge Space Portal**

Knowledge Space Portal - Vision

The "Knowledge Space Portal" will, via a single customizable interface

- **Federate heterogeneous data resources and provide precise organization of the content**
- **Provide quick and intuitive access to information**
- **Provide data extraction, analysis and exploration tools**
- **Allow data integration, data exchange and interoperability of applications**
- **Provide mechanisms for data capture and annotation**
- **Provide knowledge sharing and collaborative tools**

Purpose of Text Mining

Text is by far the most important source of information

It remains largely untapped

- Unstructured
- Metaphoric
- Ambiguous
- Redundant
- Requires *a priori* knowledge of content
- Allows different viewpoints and different readings

Purpose of text mining

- *Ad-hoc* extraction of relevant information from structured or unstructured text
 - Relevant concepts, ideas, relationships between concepts
- Normalization of data representations
- Filtering
- Categorization

Tools and Technologies

Tools and Technologies for Text Mining

Development and integration of advanced text mining, information extraction and exploration techniques

- Lexical extraction, tagging & hyperlinking
- Natural language processing, information extraction
- Descriptive statistics and clustering, categorization

Business benefits

- Identification and extraction of meaningful objects and relationships between objects from text
- Consistent, business-relevant terminology across data sources
- Knowledge inference mechanism
- Discovery of unexpected data relationships
- Automatic tagging and hyperlinking across sources and disciplines (compound codes, citations, authors, accession codes, etc.)
- Detection of novel patterns rather than predefined patterns in specific classes
- Improved navigation across data sources and document sets

Knowledge Representations

- Develop flexible data representation models and tools for handling vocabularies, taxonomies, ontologies, etc.
- Design a robust and stable scheme for metadata and a common terminology (thesauri, ontologies etc) for describing objects in the KS
- Design and implement a dynamic conceptual network linking objects in the KS (Knowledge Map)

Business benefit

- Common representation scheme for describing data resources and associations between data elements
- Bridges between databases belonging to different disciplines
- Data analysis, categorization, navigation and exploration across data sources
- Smooth data integration and data exchange among applications
- Comprehensive, easy, and rapid access to all relevant data in the Knowledge Space
- Intuitive and dynamic navigation

Structured controlled vocabularies

Provide structured controlled vocabularies and vocabulary stores, used for validation, indexing, retrieval, navigation, data analysis, interactive data reduction and exploration tools

Business benefit

- Consistent search, retrieval, and analysis across databases
- Validation of metadata entries
- Increased data consistency
- Data exchange and interoperability

Text mining and exploratory statistics

Analysis and exploration of large document sets

- Unified view of heterogeneous sources
- Analysis of trends and patterns
- Analysis of complex relationships between data elements
- Detection of deviant or emerging information
- Knowledge inference, serendipity

Data reduction and exploration methods

- Common representation scheme across heterogeneous data sources
- Lexical extraction, information extraction
- Unbiased analysis methods
- Intuitive data exploration and navigation tools
- Consistent graphical representations
- Link to underlying data

Data set construction

- Data acquisition
- Parsing
- Lexical extraction
- Information extraction
- Terminology mapping
- Normalization
- Variable typing
- Categorization

*→ Homogeneous formal representation
of heterogeneous data sources*

Descriptive Statistics

Methods

- univariate (statistical properties of a single variable)
- bivariate (link between two variables)
- trivariate (effect of a third variable on that link)
- n-variate (effects of a third variable on multiple sets of two variables)
- multivariate (relationships between all variables (or modalities) in a data set)
 - relational analysis
 - K-means clustering
 - single and double hierarchical clustering
 - correspondence analysis
 - multidimensional scaling

On several types of native (contingency) or derived tables

Interactive graphical exploration

- **Bar charts**
 - **Bubble charts**
 - **X-y plots**
 - **Factorial maps**
 - **Dendrograms**
 - **Heat maps**
 - **etc.**
-
- **Base lines**
 - **Filtering**
 - **Drill-down**
 - **Expansion**
 - **Localization**

Links to data resources underlying the graphs

Problems with textual data sources

- **Analysis cannot be conducted on tables derived directly from ‘documentary data’, either full text or secondary sources**
 - drastic degradation content
 - lack of reactivity to new concepts
 - discipline-orientation
 - obsolescence of indexing schemes
 - heterogeneous representations
 - distribution of words / long tails / loss of information
 - overlaps of meaning / non-homogeneous variables
 - tables are not mathematically valid for most methods (void tables / ‘no response’)
 - results are trivial, unstable, or meaningless

Lexical vs Information Extraction

Lexical extraction

Extraction of meaningful concepts from text (or other data sources). Mainly based on the use of dictionaries

Information extraction

Extraction of objects and relationships between concepts (associations), in a goal-oriented manner. Mainly based on syntactic analysis (global / local) supplemented by dictionaries

Lexical extraction

Identification of objects in text:

- Morphological rules, separators, etc.
- Identification of idioms (meaningful noun phrases)
- Multiple (*embedded or overlapping*) identification
- Dictionary selection

Followed optionally by:

- Normalization
- Assignment of classes
- Keyword indexing

Usual problems

- Contextual identification (disease : Indication vs SE)
- Ambiguous acronyms
 - EGFR [1] = epidermal growth factor receptor
 - EGFR [2] = estimated glomerular filtration rate
- Homographs, Polysemy
 - Vistagen = drug (levobunolol)
 - VistaGen = company
- Objects not identified by names (e.g. anaphoric reference by pronouns)
- Extraction of concepts / not of associations between concepts
 - different from information extraction

Exploratory analysis

Robust analysis can only be carried out on tables prepared from generic variables (classes, categories)

- **Mathematically valid tables**
- **Retention of specific detailed information**
- **Drill-down and iterative analysis**
- **Links to underlying documents**

Extracted Objects

- *Terms*: lexical item which triggers a concept
- *Concepts*: what is actually extracted, attached to a hierarchical structure and synonym groups (terms)
- *Types*: simple hierarchical structure attached to concepts

Filtering based on Types can be combined with document structure filtering.

Applications

-
- **Search & retrieval**
 - **Extraction**
 - **Categorization**
 - **Information analysis**
 - **Information exploration**
 - **Navigation**
 - **Data integration & data exchange**

Applications currently being developed

- **Ulix**
- **Knowledge Map**
- **Generic Text Analysis Platform**
 - **Applied to Competitive Intelligence**
 - **Applied to Genomics**
 - **Applied to NewsFlow**
 - ...
- **Knowledge Space Portal**

Ulix - Scope

- **Consistent retrieval and analysis over 80 internal and external databases**
- **Lexical extraction**
- **Typed variables**
- **Hierarchical vocabulary**
- **Simple statistics and iterative K-Means clustering**
- **Filtering**
- **Links to underlying documents**

ULIX Clustering

General graphical representation

Query: chronic pain
Libraries: Medline & EMBASE (1988-Present)(376)
Clustering fields: Topics



| Clusters | Stats | Chart | Documents |
|--|-------|-------|-----------|
| 1. opiate ; morphine ; hyperalgesia | stats | | 48 |
| 2. drug therapy ; antiinflammatory ; administration ; adverse drug reaction ; nonsteroid ; side effect ; magnesium ; | stats | | 44 |
| 3. fibromyalgia ; neck pain ; whiplash injury ; | stats | | 41 |
| 4. therapy ; clinical ; psychophysiology | stats | | 34 |
| 5. disability ; prevalence ; epidemiology ; patient ; distress syndrome ; world health organization | stats | | 32 |
| 6. anxiety ; complex regional pain syndrome ; spinal cord stimulation ; sympathetic dystrophy | stats | | 19 |
| 7. surgery ; abdominal pain ; knee ; laparoscopy ; ankle ; nuclear magnetic resonance imaging | stats | | 17 |
| 8. reliability ; questionnaire ; backache ; instrument | stats | | 16 |
| 9. chronic pancreatitis ; tendinitis ; pharmaceutical | stats | | 6 |
| 10. vasectomy ; contraception ; prostate cancer | stats | | 3 |

Clusters 1-8 include sub-clusters [indicated by blue flag]

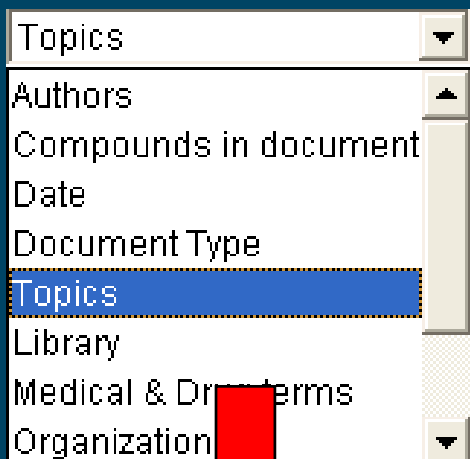
Graphical representation of sub-clusters

Access to a whole range of statistics

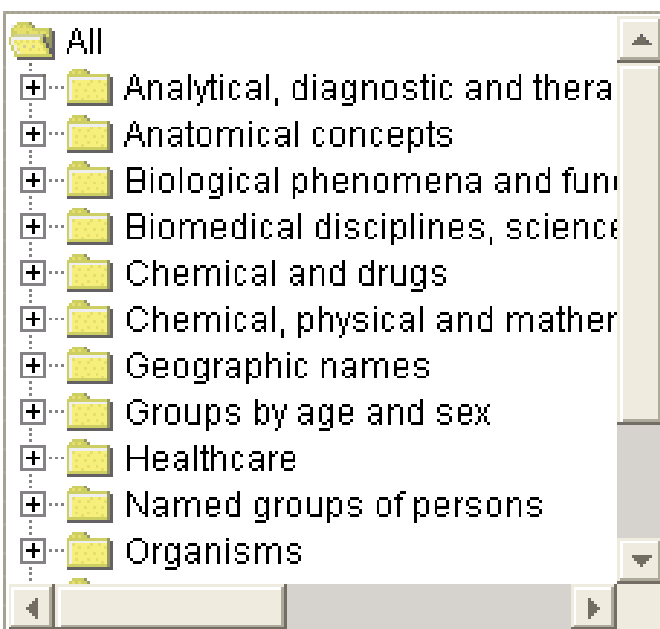
Access to documents



ULIX Clustering and Filtering

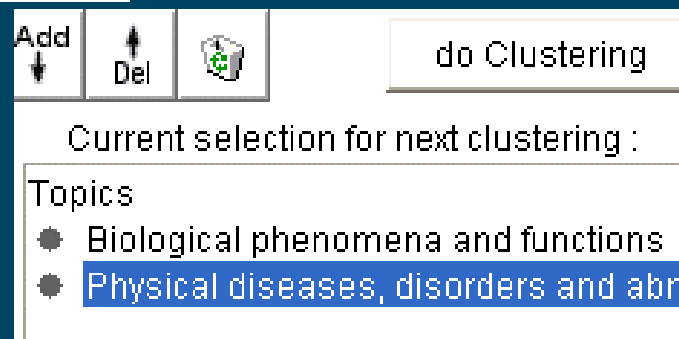
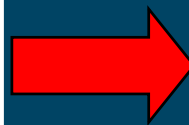


Select the main class for the clustering to be performed [here "topics"],...



.....one or several sub-classes belonging or not to 2 different classes [here „Biological phenomena and functions“, „Physical disorders and abnormalities“ and Psychological and psychiatric phenomena]

Add your selection(s) to the current selection box and perform the clustering



Ulix Clustering

Displaying cluster : /

Upper Cluster Animation : Off Print

Cluster: 6
 Name: disability ; prevalence ; epidemiology ; self report ; adjustment ; self concept ; work capacity ; backac
 Size: 26

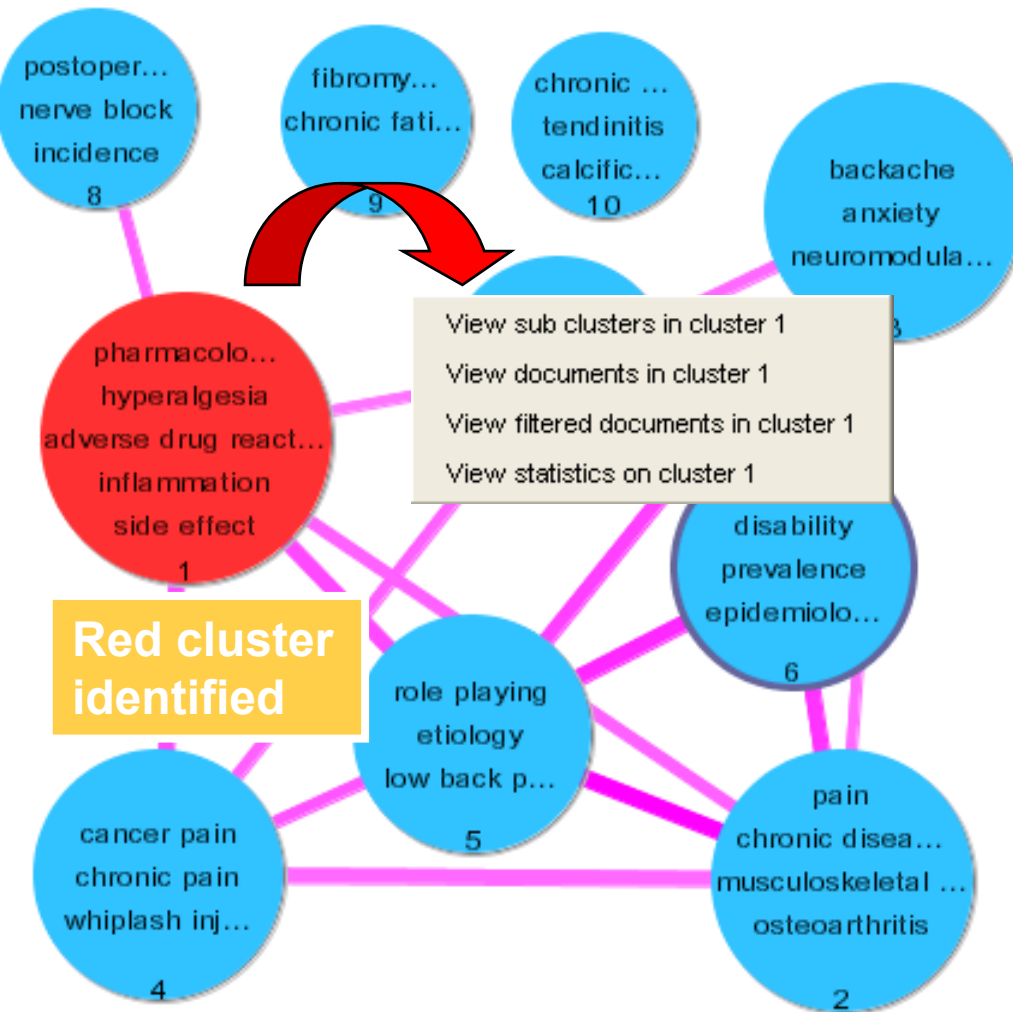
| Name | Support | Complete name |
|------------|---------|---|
| disability | 0.191 | Physical diseases, disorders and abnormalities/physical disease by body |

Drill-down mechanism: (right click)
access to sub-clusters
Statistics
Documents
Filtered documents by search criteria

Selection of a search criteria

Description of the highlighted cluster

Ulix Clustering and Filtering



The screenshot shows a search interface. At the top, a dropdown menu shows 'Search result'. Below it, a search result is displayed: 'Medical & Drug terms' with a sub-result 'vanilloid receptor endogenous comp...'. A red arrow points to this result. Below the search result, a search dialog box is open. The dialog box has a text input field containing 'vanilloid'. Below the input field, there is a checkbox labeled 'Search only on leaf' which is unchecked. A yellow box highlights the text input field with the label 'Search term box'. At the bottom of the dialog box are 'OK' and 'Cancel' buttons. The dialog box title is 'Java Applet Window'.

Knowledge Map - Scope

- **Tools for organizing retrieving, and navigating information resources**
- **Independent of the information resources themselves (knowledge layer)**
- **Node-link networks, where concept are nodes and associated relationships are links.**
- **Active, dynamic representations (hierarchies, networks, chains, etc.)**

Metadata / Knowledge Map model

Molecule-centric model

- **Organized and structured around the central concept of molecule and objects, attributes, parameters, properties, etc., attached directly or indirectly to those molecules**
- **Both types of objects are represented by topics, and the relationships between those objects by associations**
- **Together, they form the core Knowledge Base, further extended to two other classes of Topics**
 - **Vocabulary : terms from taxonomies, classifications, nomenclature, thesauri, etc.**
 - **Structures : real world individuals, structured objects and processes**

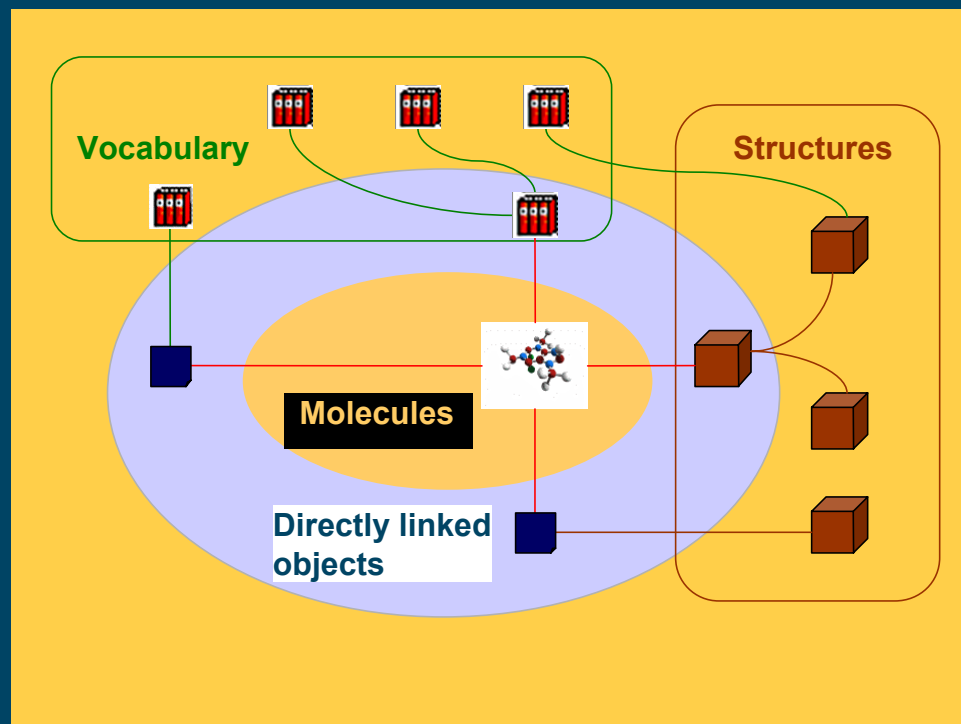
Metadata/Knowledge Maps Model

Topic Classes

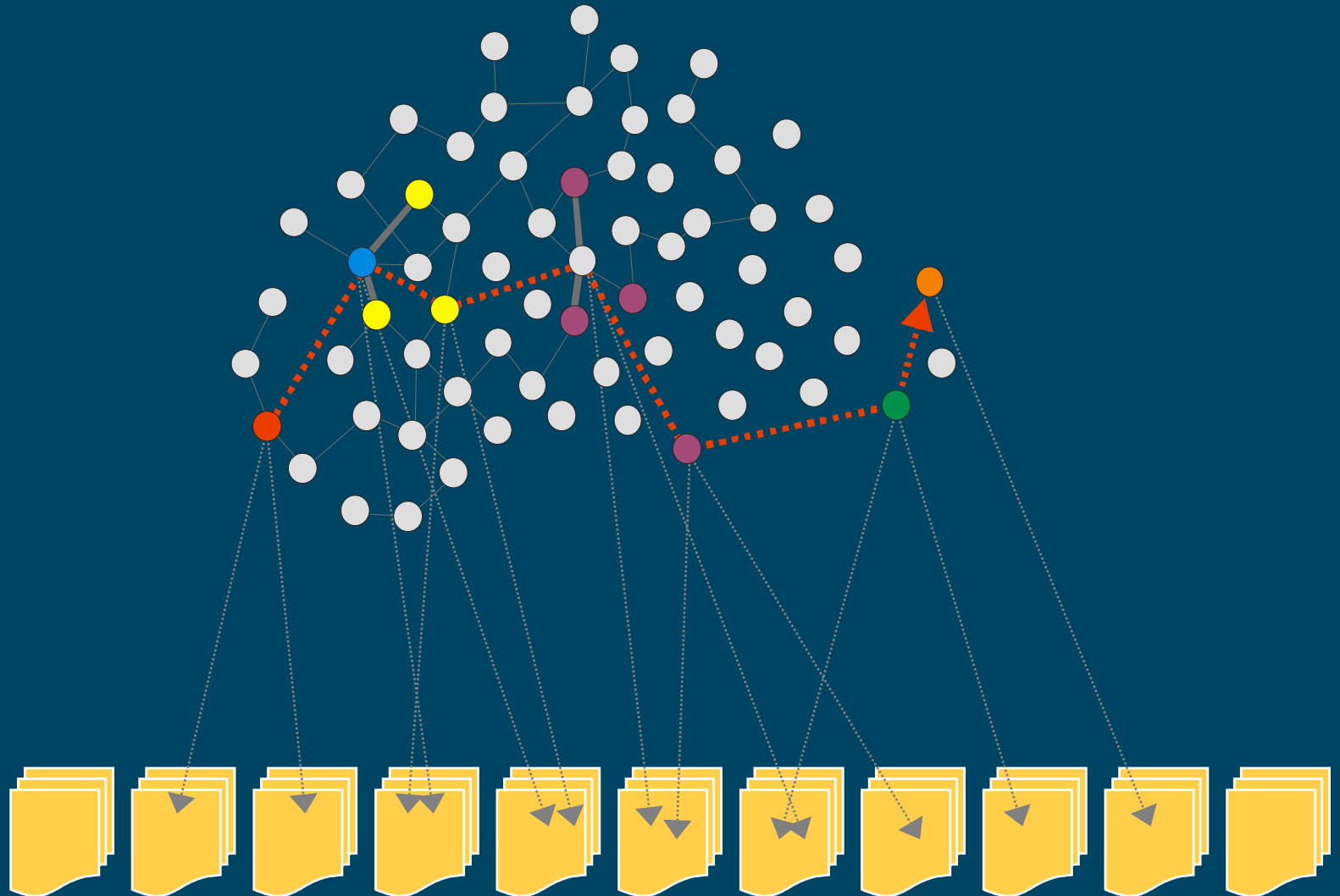
- Molecules
- Directly linked topics
- Structures
- Vocabulary

Association Types

- classified according to topics classes and subclassified as necessary by scopes
- Define the topic map "structural ontology".
- For each association type, the role types are defined



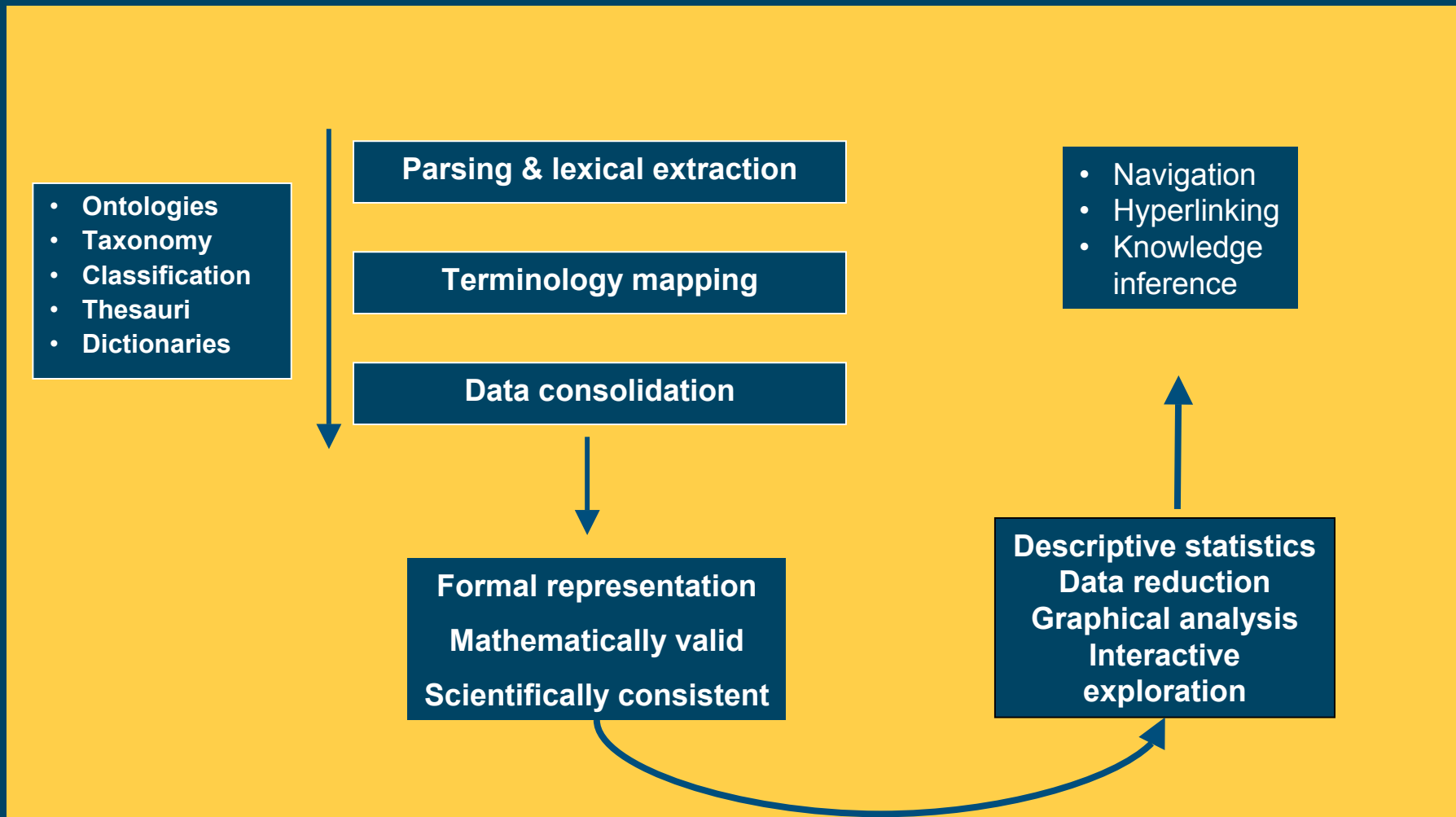
Navigation



Topic Types

- **Anatomy**
- **Assay**
- **Chemistry**
- **Date**
- **Development status**
- **External**
- **Galenics**
- **Diseases**
- **Molecular entities**
- **People**
- **Physiological Processes**
- **Organization**
- **Properties**
- **Targets**

Generic Text Analysis Platform - Scope



Interactive Exploration

Exploratory Statistics

Bivariate, trivariate and n-variate analysis

Multivariate analysis

- Hierarchical clustering, partitioning
- Multidimensional scaling
- Factorial analysis

Navigation

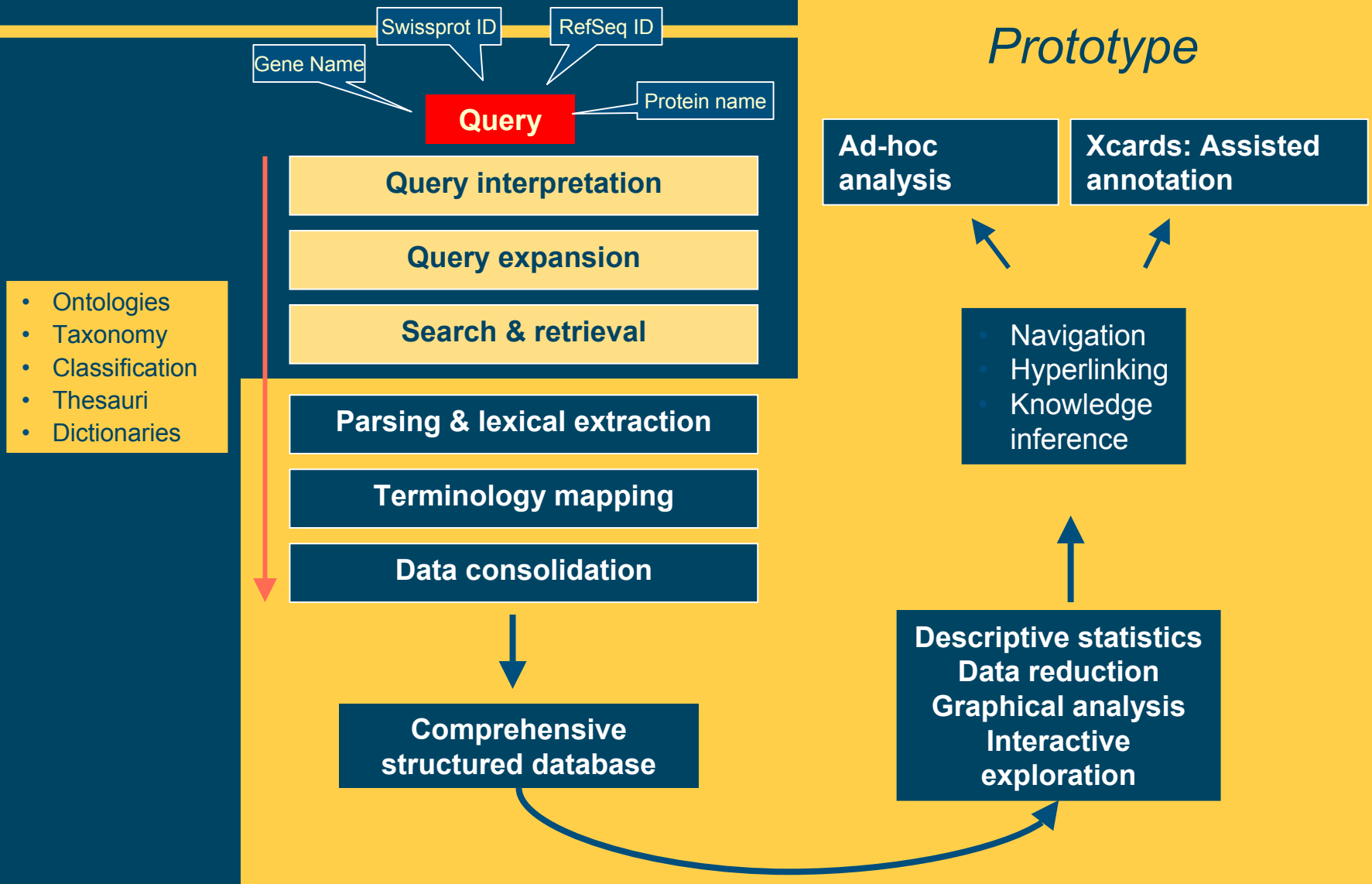
**Filtering, drill-down, expansion
via a combination of dynamic
graphs and lexical networks**

- bar charts, pie charts, radars, etc.
- x-y plots
- heat maps
- dendrograms
- clusters
- factorial maps

Information Linking

- Links to underlying data elements and supporting documents.
- Bridges to internal and external databases

Text Mining in Genomics - Prototype



Competitive Intelligence Analysis Platform

Consolidate all data essential for Competitive Intelligence (from multiple internal and external sources) into a single platform, together with interactive data analysis and exploration tools.

Consistent integration of data sources :

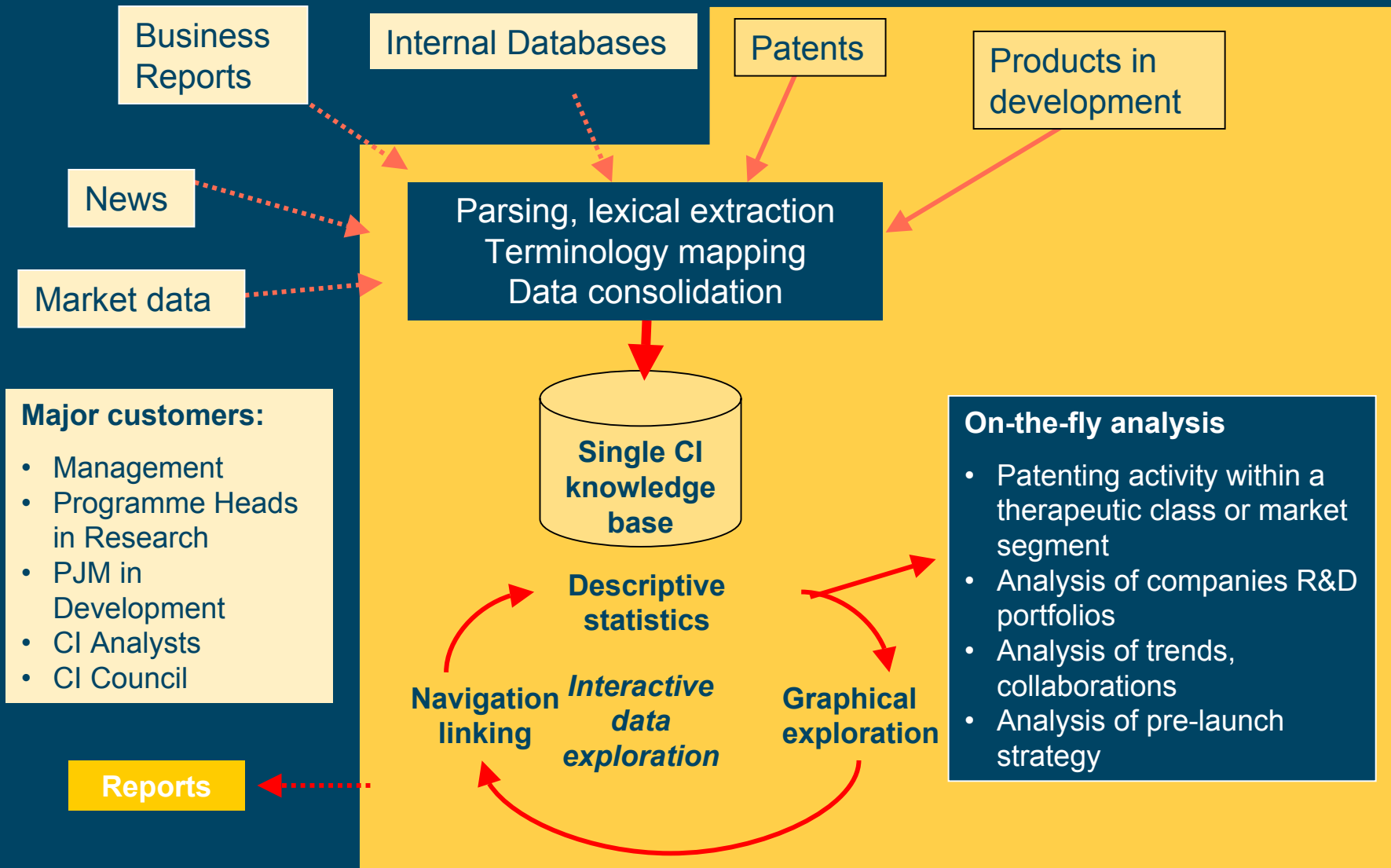
- Products in development
- Patents
- Internal CI sources
- Market data

(Mapped to a single representation scheme and taxonomy)

And

- Extensive data analysis, navigation, drill-down and reporting tools

Competitive Intelligence Analysis Platform



Competitive Intelligence Analysis Platform

- Comprehensive
 - Consolidating essential data from multiple internal and external sources into a single CI platform
- Consistent
 - Formats
 - Terminology
- Current
 - Daily updates
- Interactive analysis and data exploration tools

Examples of Analysis

- Patenting activity within a therapeutic class or market segment: type of protection, territorial coverage, build-up on original patents (process patents, formulations, *etc.*)
- Key inventors and teams
- Maturity / novelty of research projects
- Analysis of companies development portfolios: therapeutic classes, putative vs actual therapeutic indication, pharmacological classes, market segments, development phases, ranking, backups, speed of development, overlap of portfolios, pioneering research and me-too products
- Analysis of trends (over time and/or development phases)
- Collaborations (joint filings, product licenses, co-marketing)
- Analysis of pre-launch strategy

Data Sources

- Patent applications (primary and secondary sources)
- Products in development (commercial and internal sources)
- *Conference reports (internal and external)*
- *Published literature*
- *Market data*
- *Epidemiological data (prevalence, incidence)*
- *Business analysis reports*
- *Internal CI sources (internal analysis reports, annotations, validated 'human intelligence')*
- *Web crawling results, etc.*

Patents

- Research described in patents is approximately 2-yrs old
- Widely varying filing practices (broad vs specific applications, filing routes, territorial coverage, etc.)
- Lack of precision in some areas (e.g., potential therapeutic activities)
- Poor description of content

- The analysis of patent portfolios can give a reasonably accurate idea of the volume of activity in research, trends with time, *etc.*
- Not directly predictive of future clinical development activities.
- More sophisticated models must be applied to gain a clearer understanding of a company R&D strategy
- Also, a wealth of related information (collaborations, location of research, key inventors, *etc.*)

Patents remain the major source of information on R&D activity

News Flow Analysis Platform

Live news feed pulled every minute from News Edge

Lexical extraction to identify:

- Companies
- Products
- Diseases
- Company events (M&A, licences and agreements, product approvals)

Personalized categorization (e.g., top 10, BUs, disease area, etc.)

Live display of customized news flow (filtered)

Links to reference data (company profiles, product profiles, etc.)

Link to the portfolio analysis platform

Automatic processing and mining of a NewsFlow

News are pulled out of NewsEdge's server every minute

Entities which are recognised and processed automatically by the lexical extractors currently include :

- Full list of drugs, launched or in development, with synonyms and brand names, normalized to the INNs
- Subset of ~2000 major indications, with synonyms and narrower terms, consolidated and mapped to the dictionary of indications used by the CI analysis platform
- List of companies with their affiliates in different countries, automatically extracted from CI sources (products & patents) and constantly updated.

Information extraction prototype : Mergers and acquisitions, product approvals, licences are identified, marked and extracted

Annotation with lexical extraction and categorization

The screenshot shows a web browser window with a search results page. The address bar shows 'http://p'. The search results are for 'Novartis' and show 10 documents found. The first document is 'Successful Milestone for Speedel - Call-Back Option Exercised by (AP Alert - Business)' dated 15:28:18. The second document is 'Successful Milestone for Speedel - Call-Back Option Exercised by (PR Newswire Leased Line)' dated 15:01:56. The third document is 'Novartis Exercises Call-Back Option On Speedel Drug (Dow Jones Online News)' dated 10:33:17. The fourth document is 'Analysts Speculate on Drug-Company Mergers (Knight-Ridder / Tribune Business News)' dated Tuesday 04:31:20.

The detailed view of the article 'Successful Milestone for Speedel - Call-Back Option Exercised by' is shown below. The article is by Novartis for Aliskiren, the Oral Renin Inhibitor. The article text is as follows:

BASEL, Switzerland and BRIDGEWATER, N.J., Sept. 18 /PRNewswire/ -- **The Speedel Group**, a pharmaceutical company active in **cardiovascular** and metabolic drug development, based in Basel, Switzerland, announced today that **Novartis** has exercised its call-back option for **Aliskiren (SPP100)** with the goal to further develop this compound in order to gain regulatory approval and commercialization in **Hypertension**.

Aliskiren, an orally active renin inhibitor, targeted for **cardiovascular** indications, may be the first of a new class of compounds to enter the market. It inhibits the Renin Angiotensin System (RAS) at the very top of the cascade (unlike ACE inhibitors and Angiotensin II receptor antagonists), thus offering a totally new approach to block this clinically relevant system.

"Speedel is delighted about the positive call-back decision **Novartis** has taken; it optimizes the future exploitation of Aliskiren's development potential by a powerful company," comments Alice Huxley, CEO of Speedel. "**Aliskiren** is the first orally active renin inhibitor that has been developed through Phase II. Speedel believes that it has a significant potential since it targets **hypertension**, a USD 30+ billion market."

Major achievement in Speedel's history

The positive decision of **Novartis** to license back **Aliskiren** represents a major

The right sidebar shows 'Categories in this news' with the following categories and sub-categories:

- Novartis
- TFR-BU
 - CVM
- Companies
 - Speedel_Group
- Indication
 - cardiovascular disease
 - congestive heart failure
 - essential hypertension
 - hypertension
 - kidney failure
- Drug
 - Aliskiren
 - SPP_301

NewsFlow personalization

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home

Address <http://p> Go Links

Novartis

TFR-BU

CVM

CNS

ABGHI

RESPDERM

Top Ten Companies

Theme

Date

Refresh every minute(s)

Max. docs

Connector

Refresh

10 documents found.

| | News | Date |
|--|---|------------------|
| | Successful Milestone for Speedel - Call-Back Option Exercised by (AP Alert - Business) | 15:28:18 |
| | Successful Milestone for Speedel - Call-Back Option Exercised by (PR Newswire Leased Line) | 15:01:56 |
| | Novartis Exercises Call-Back Option On Speedel Drug (Dow Jones Online News) | 10:33:17 |
| | Analysts Speculate on Drug-Company Mergers (Knight-Ridder / Tribune Business News) | Tuesday 04:31:20 |

Successful Milestone for Speedel - Call-Back Option Exercised by

Novartis for **Aliskiren**, the Oral Renin Inhibitor

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Aliskiren, an orally active renin inhibitor, targeted for **cardiovascular** indications, may be the first of a new class of compounds to enter the market. It inhibits the Renin Angiotensin System (RAS) at the very top of the cascade (unlike ACE inhibitors and Angiotensin II receptor antagonists), thus offering a totally new approach to block this clinically relevant system.

"Speedel is delighted about the positive call-back decision **Novartis** has taken; it optimizes the future exploitation of Aliskiren's development potential by a powerful company," comments Alice Huxley, CEO of Speedel. "**Aliskiren** is the first orally active renin inhibitor that has been developed through Phase II. Speedel believes that it has a significant potential since it targets **hypertension**, a USD 30+ billion market."

Major achievement in Speedel's history

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Categories in this news

- [Novartis](#)
- TFR-BU
 - [CVM](#)
- Companies
 - [Speedel Group](#)
- Indication
 - [cardiovascular disease](#)
 - [congestive heart failure](#)
 - [essential hypertension](#)
 - [hypertension](#)
 - [kidney failure](#)
- Drug
 - [Aliskiren](#)
 - [SPP 301](#)

javascript:highlight('CVM','hypertension','essential_hypertension','Aliskiren','congestive_heart_failure')

Local intranet zone

Ultralinks to pertinent and correctly accessed applications

The screenshot shows a web browser window with a search results page. The browser's address bar shows 'http://p'. The search results are for '10 documents found.' The first result is 'Successful Milestone for Speedel - Call-Back Option Exercised by' with a date of 15:28:18. The second result is 'Successful Milestone for Speedel - Call-Back Option Exercised by' with a date of 15:01:56. The third result is 'Novartis Exercises Call-Back Option On Speedel Drug' with a date of 10:33:17. The fourth result is 'Analysts Speculate on Drug-Company Mergers' with a date of Tuesday 04:31:20.

The left sidebar contains a search filter with the following options:

- Novartis
- TFR-BU
 - CVM
 - CNS
 - ABGHI
 - RESPDERM
- Top Ten Companies
- Theme

Additional search settings include: Date (dropdown), Refresh every 5 minute(s), Max. docs 10, Connector AND, and a Refresh button.

The main content area displays the title 'Successful Milestone for Speedel - Call-Back Option Exercised by' and a snippet of text: 'Novartis for Aliskiren, the Oral Renin Inhibitor'. A dropdown menu is open over the word 'Novartis', showing links to 'Novartis portfolio analysis', 'Novartis company profile', 'Guessed company site', 'Google search', 'Yahoo business news', and 'Yahoo Novartis'.

The right sidebar shows 'Categories in this news' with a tree structure:

- Novartis
- TFR-BU
 - CVM
- Companies
 - Speedel Group
- Indication
 - cardiovascular disease
 - congestive heart failure
 - essential hypertension
 - hypertension
 - kidney failure
- Drug
 - Aliskiren
 - SPP 301

The main content area continues with text: 'BASEL, WATER, N.J., Sept. 18 /PRNewswire/ -- The Speedel Group announced today that Novartis has exercised its call-back option with the goal to further develop this compound in order to gain re...'. It then discusses 'Aliskiren' as a renin inhibitor targeted for cardiovascular indications, and mentions 'Speedel is delighted about the positive call-back decision Novartis has taken; it optimizes the future exploitation of Aliskiren's development potential by a powerful company,' comments Alice Huxley, CEO of Speedel. 'Aliskiren is the first orally active renin inhibitor that has been developed through Phase II. Speedel believes that it has a significant potential since it targets hypertension, a USD 30+ billion market.'

Below the text, it states 'Major achievement in Speedel's history' and 'The positive decision of Novartis to license back Aliskiren represents a major'.

Knowledge Space Portal - Scope

Provide key elements for efficiently accessing Novartis-internal and external information relevant to daily decision in the drug discovery and development process:

- **Data integration across heterogeneous data sources and applications (internal and external)**
- **Consistent user interface for data retrieval, exploration and analysis across all data types**
- **Contextual (ultralink), tree-based (static or dynamic taxonomies) and semantic (knowledge map) navigation**
- **Data exploration and analysis methods**
- **Personalized views**
- **Collaborative, annotation and information sharing tools**
- **Alerting**

Knowledge Space Portal Home Page

NOVARTIS INSTITUTES FOR BIOMEDICAL RESEARCH

Novartis Research Applications Search References

March 5, 2003

Text Search Results

- Biology of the PPAR family of receptors
- Relationship between different stages of the corpus luteum and the expression of the peroxisome proliferator-activated receptor gamma protein in bovine large lutein cells
- Potential therapeutic agents that raise high-density lipoprotein cholesterol levels
- Peroxisome proliferator-activated receptors in endothelial cell biology
- Minireview: A novel pathway of prostacyclin signaling - Hanging out with nuclear receptors
- Diverse peroxisome proliferator-activated receptors bind to the peroxisome proliferator-responsive elements of the rat hydratase/aldohydrogenase and fatty acyl-CoA oxidase genes but differentially induce expression
- Nonapoptotic cell death associated with S-phase arrest of prostate cancer cells via the peroxisome proliferator-activated receptor gamma ligand, 15-Deoxy-Delta12,14-prostaglandin J2
- Transforming growth factor-beta1 (TGF-beta1) and TGF-beta2 decrease expression of CD38, the type B scavenger receptor, through mitogen-activated protein kinase phosphorylation of peroxisome proliferator-activated receptor-gamma
- Peroxisome proliferator-activated receptors in macrophage biology. Friend or foe?
- Cloning of the human cholesterol ester hydrolase promoter. Identification of functional peroxisomal proliferator-activated receptor responsive elements
- Relationship between different stages of the corpus luteum and the expression of the peroxisome proliferator-activated receptor gamma protein in bovine large lutein cells
- Potential therapeutic agents that raise high-density lipoprotein cholesterol levels
- Peroxisome proliferator-activated receptors in endothelial cell biology
- Minireview: A novel pathway of prostacyclin signaling - Hanging out with nuclear receptors
- Diverse peroxisome proliferator-activated receptors bind to the peroxisome proliferator-responsive elements of the rat hydratase/aldohydrogenase and fatty acyl-CoA oxidase genes but differentially induce expression
- Nonapoptotic cell death associated with S-phase arrest of prostate cancer cells via the peroxisome proliferator-activated receptor gamma ligand, 15-Deoxy-Delta12,14-prostaglandin J2

Search

Text Sequence Structure

literature

for ppar

Go Clear

Resultset Highlighting

- MOA
 - Peroxisome proliferator-activated receptor agonist
 - Plasminogen activator inhibitor
 - Anticancer
 - Antioxidant
- Companies
- Diseases
- Products
- Targets

Resultset Tools

- Graph navigator
- Clustering
- Statistics
- Data analysis

Search Statistics

Search returned

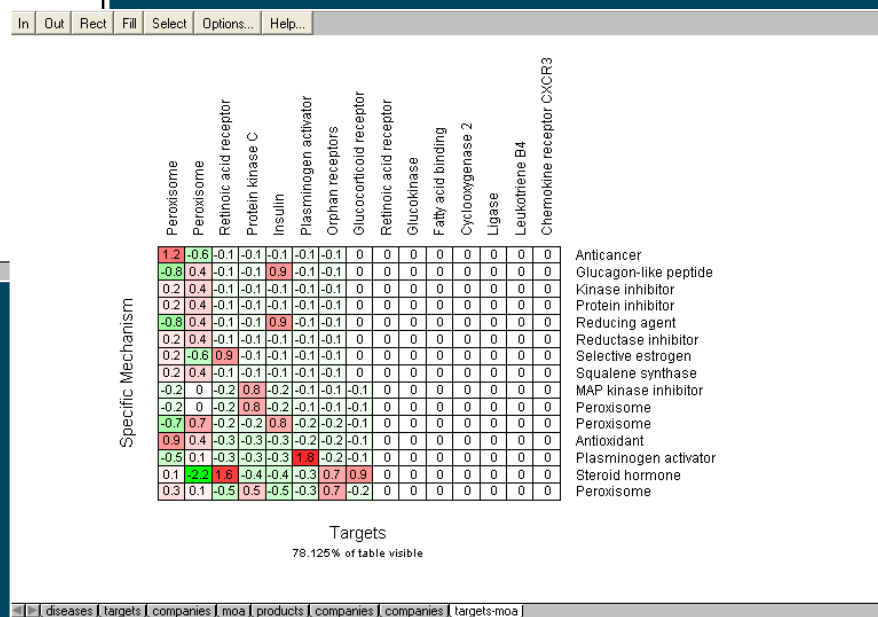
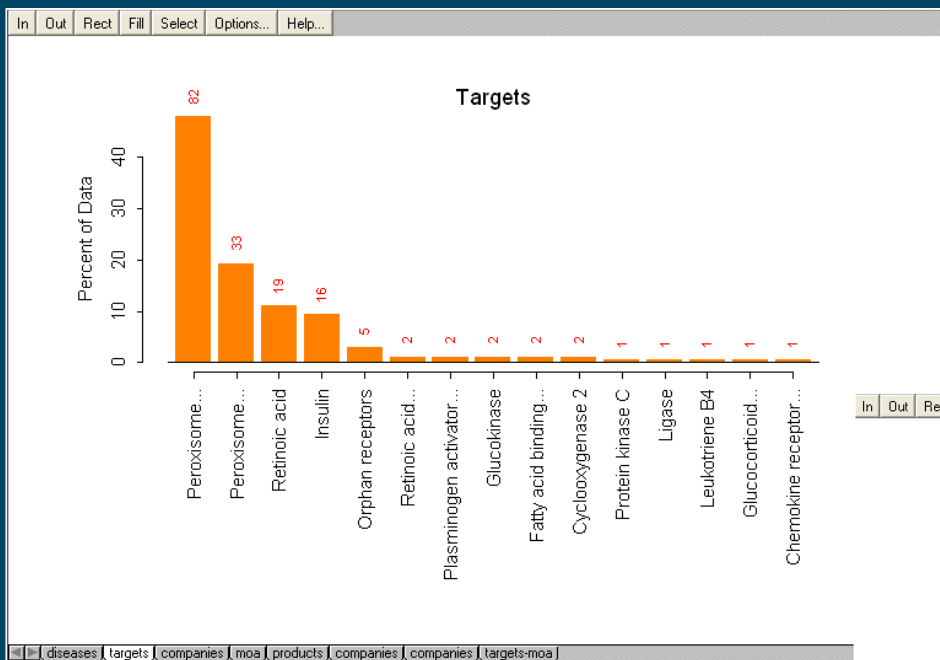
154 documents for "ppar"

Found Attributes:

| | |
|-----------|-----|
| Companies | 93 |
| Products | 118 |
| MOA | 39 |

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Data Analysis technologies integrated on the Knowledge Space Portal



Future Steps

Data integration into a problem-solving environment

Data types

Applications

Services

