

Douglas Connect

Working communities

eNanoMapper

Nano Safety Cluster Meeting
Antalya, Turkey

Barry.Hardy@douglasconnect.com

23 April 2014

Main objectives of eNanoMapper

- Modular infrastructure for **data storage, sharing and searching**, based on **open standards** and semantic web technologies, minimum information standards and established **security** solutions;
- Development of **ontologies** for the categorisation and characterisation of eNMs in collaboration with other projects
- Creation of new computational models in nanomaterials safety through the implementation of interfaces for **toxicity modelling and prediction** algorithms which may process all data made available through eNanoMapper (e.g. using algorithms available from the OpenTox FP7 project or statistical/data mining software)
- **Meta analysis of nano-bio interactions** supporting “safe-by-design” ENMs development by pursuing a Linked Data approach which integrates data and metadata originating from diverse sources within nanoscience, chemistry, biology and toxicology
- Creation of **tools** for the exchange, quality assurance and reporting of research protocols and data for regulatory purposes
- Creation of a **community** framework for interdisciplinary collaboration

More on Project Work summary at www.enanomapper.net/wp





More on Project Partners at www.enanomapper.net/partners



Interactions

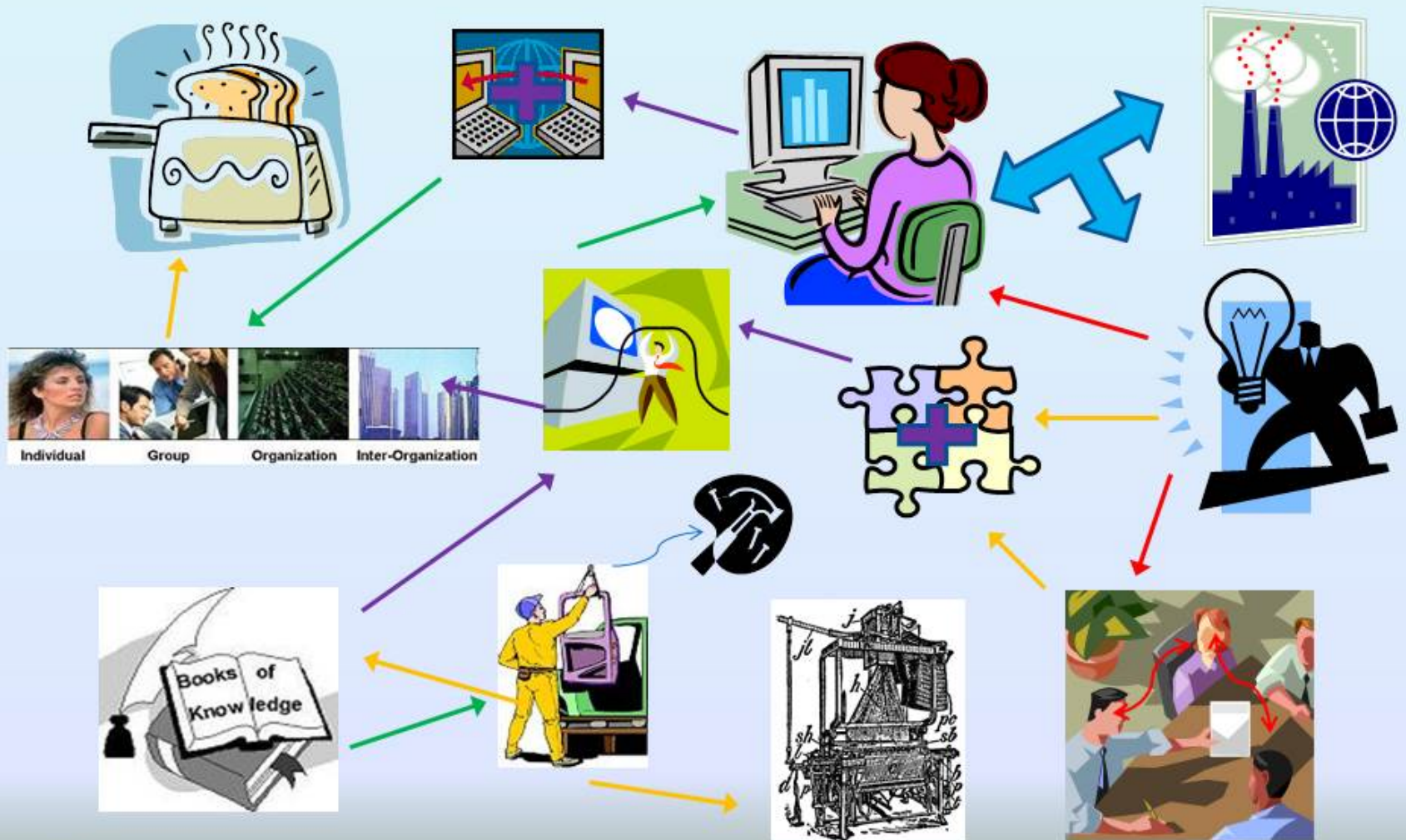
- We are here to meet you!
 - We are here to learn about your projects, needs and initiatives!
 - Support of a community framework for interdisciplinary collaboration
 - Participation in Working Groups (WG Leaders: Egon Willighagen, Bengt Fadeel)
 - Interaction with modelling Group Projects (Harmonisation, Data Standards and Infrastructure, Supporting Analysis, QSAR, Mechanistic Modelling of Pathway Perturbations)
 - Interaction with Future Nano Needs on Common Nomenclature
 - Interaction with Marina on Templates
 - Interaction with Nanosolutions on safety classification
 - Interaction with NANOREG – regulatory needs, creation of tools for the exchange, quality assurance and reporting of research protocols and data for risk assessment purposes
 - Contributions to workshop and training activity (e.g., Milan, Syracuse)
- and more to define with you through our discussions.

Islands



Source: Baily Ed, U.S. Fish and Wildlife Service

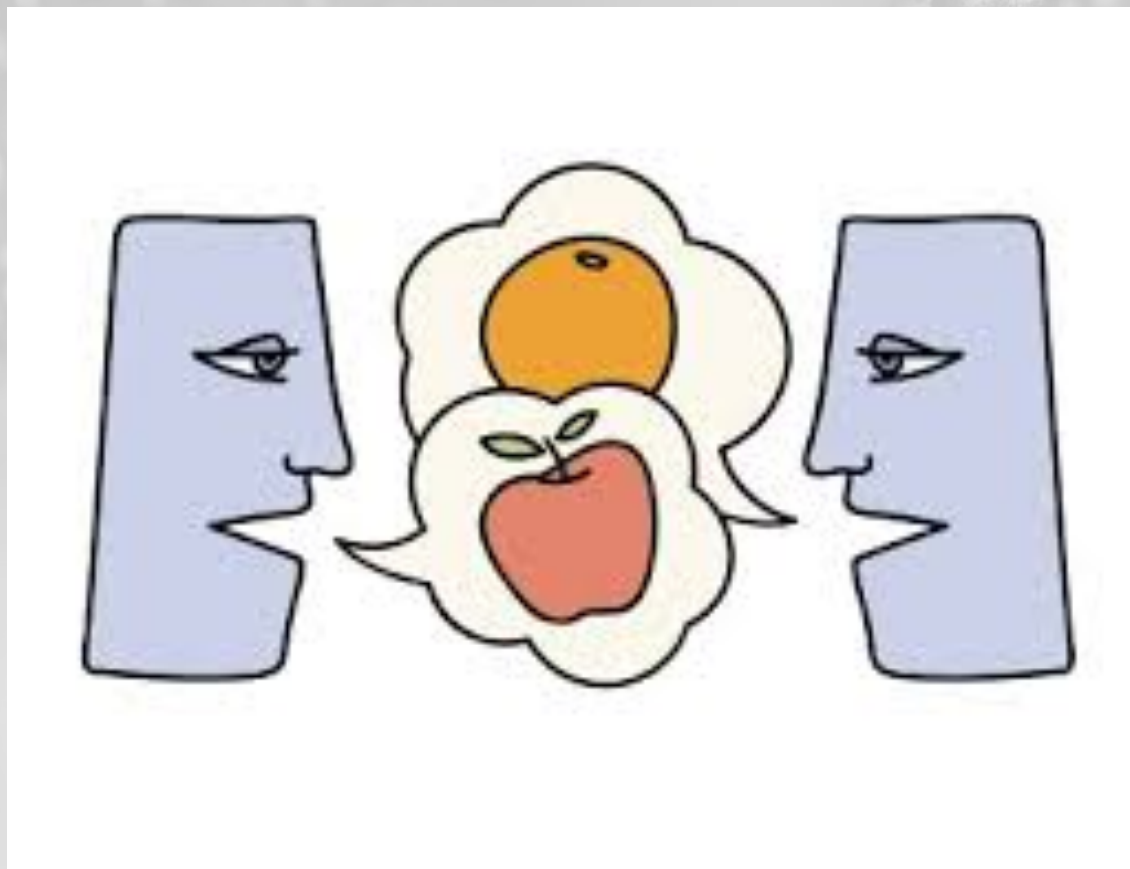
Knowledge Flow



Interaction

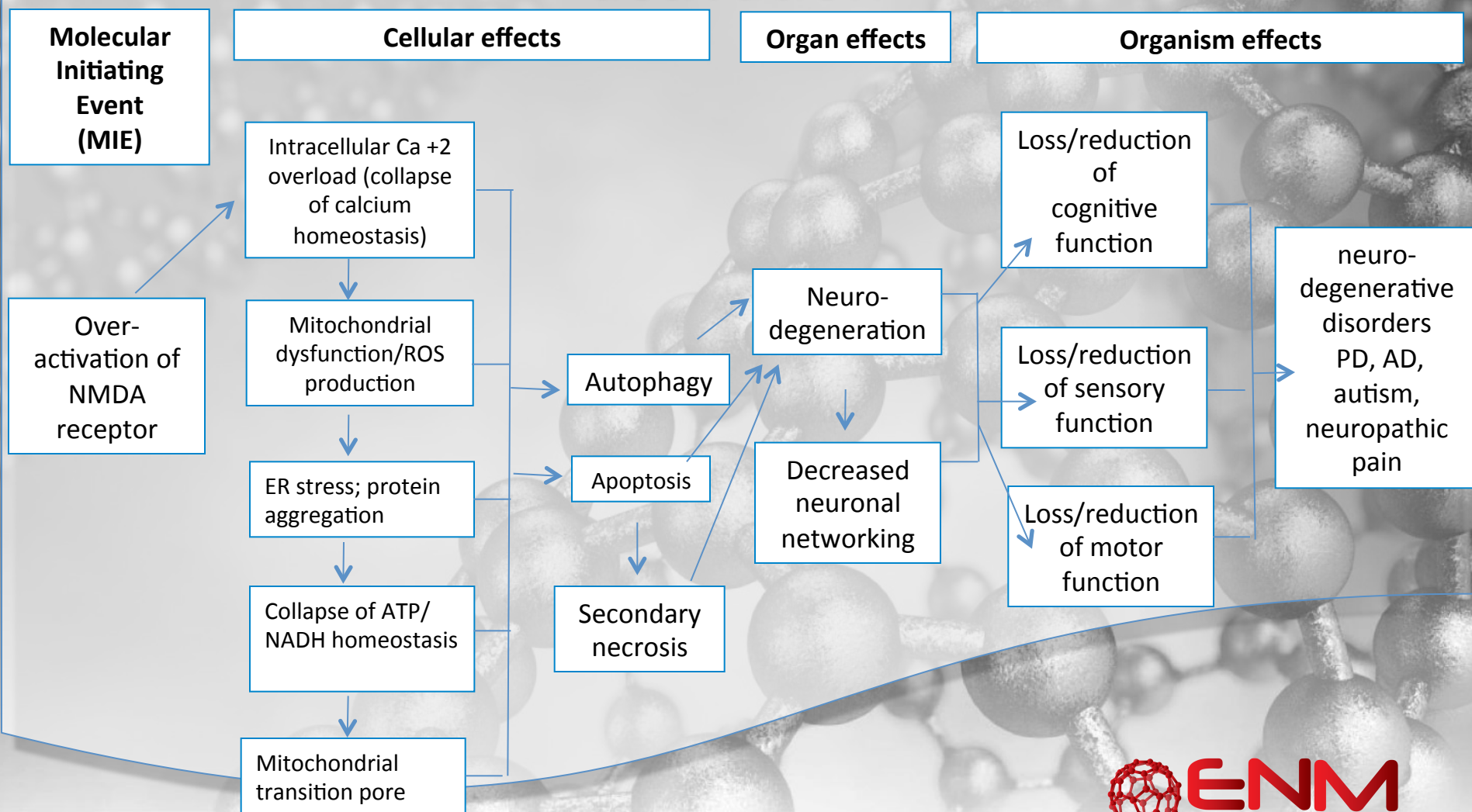


Common Language



Source: <http://sheezaredhead.wordpress.com/2011/01/12/use-common-language-please/>

Adverse Outcome Pathway (AOP): Neurotoxicity induced by NMDA receptor over activation



Linked Data is a term used to describe the exposing, sharing, and connecting of data on the Semantic Web using:

URIs a generic means to identify entities in the world

HTTP a simple yet universal mechanism for retrieving resources

RDF a generic graph-based data model with which to structure and link data

Linked Data needs:

1. Provision of a **URI** that describes a Data Resource
2. Use of **HTTP** to retrieve useful data from the **URI**
3. A Data Format described with standardised semantics (so relationships are enabled) e.g. **RDF**
4. Data should provide links to other Data (through **URIs**)



Linked Data approach can also be applied to other resource types e.g., for algorithms or models as done in OpenTox... Linked Resource approach enables Knowledge Creation, Combination and Analysis

DBpedia = Linked Data approach applied to Wikipedia

Open Standards and Open Source Components

<-New API addition from ToxBank

Investigation (Study, Assay)

GET
POST
PUT
DELETE

Authorisation & Authentication

GET
POST
PUT
DELETE

AppDomain

GET
POST
PUT
DELETE

Report

GET
POST
PUT
DELETE

Dataset

GET
POST
PUT
DELETE

Validation

GET
POST
PUT
DELETE

Feature

GET
POST
PUT
DELETE

Compound

GET
POST
PUT
DELETE

Model

GET
POST
PUT
DELETE

Algorithm

GET
POST
PUT
DELETE

Ontology

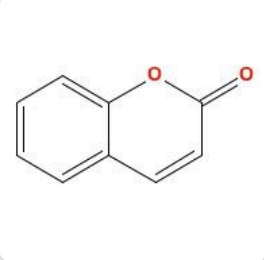
GET
POST
PUT
DELETE

Bioclipse – OpenTox Interactive Analysis

Bioclipse Decision Support
Chemical Liability Assessment

Report date: 2010/08/26

Query structure:



Properties

Mol.	146.143
H donors:	1
H	1
alogP:	1.031

Number of Consensus: 4
Endpoints: 2 negative, 1 inconclusive

Compound: coumarin
SMILES: O=C1OC2=CC=CC=C2C=C1
Formula: C₉H₆O₂
InChI: InChI=1S/C9H6O2/c10-9-6-5-7-3-1-2-4-8(7)/11-9/h1-6H

Endpoint: AHR **NEGATIVE**

Model: AHR exact matches
Consensus: INCONCLUSIVE

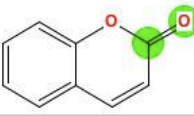
Model: AHR nearest neighbour
Consensus: **NEGATIVE**

Model: AHR Signature Alerts
Consensus: **NEGATIVE**

Model: AHR Signature Significance
Consensus: **NEGATIVE**

Compound: [O](=[C])
Classification: **NEGATIVE**

Details:



Consensus: **NEGATIVE**

Decision Support

- AHR
 - AHR Signature Alerts
 - AHR Signature Significance [1 neg]
 - [O](=[C])
 - AHR exact matches
 - AHR nearest neighbour
- Carcinogenicity
 - CPDB Signature Alerts
 - CPDB Signature Significance [1 pos]
 - Result: 1.002
 - CPDB exact matches [1 pos]
 - Index 199
 - CPDB nearest neighbour
- Mutagenicity
 - Ames Signature Significance [1 neg]
 - [C]([C](O)=O))
 - Ames Structural Alerts
 - Ames exact matches [1 pos]
 - 91-64-5
 - Ames nearest neighbour [3 neg]
 - 90-33-5 [tanimoto=0.78]
 - 2107-76-8 [tanimoto=0.76]
 - 26093-31-2 [tanimoto=0.75]

O. Spjuth, L. Carlsson, M. Eklund, E. Ahlberg Helgee, and Scott Boyer. *Integrated decision support for assessing chemical liabilities*. J Chem Inf Model. 2011 Aug 22;51(8):1840-7.

Requirements Analysis

Contextual Design methodology....

1. Interview
2. Interpretation
3. Consolidation
4. System design
5. Paper prototyping

....provides several opportunities to collaborate in specifying solutions for the Nano Safety cluster









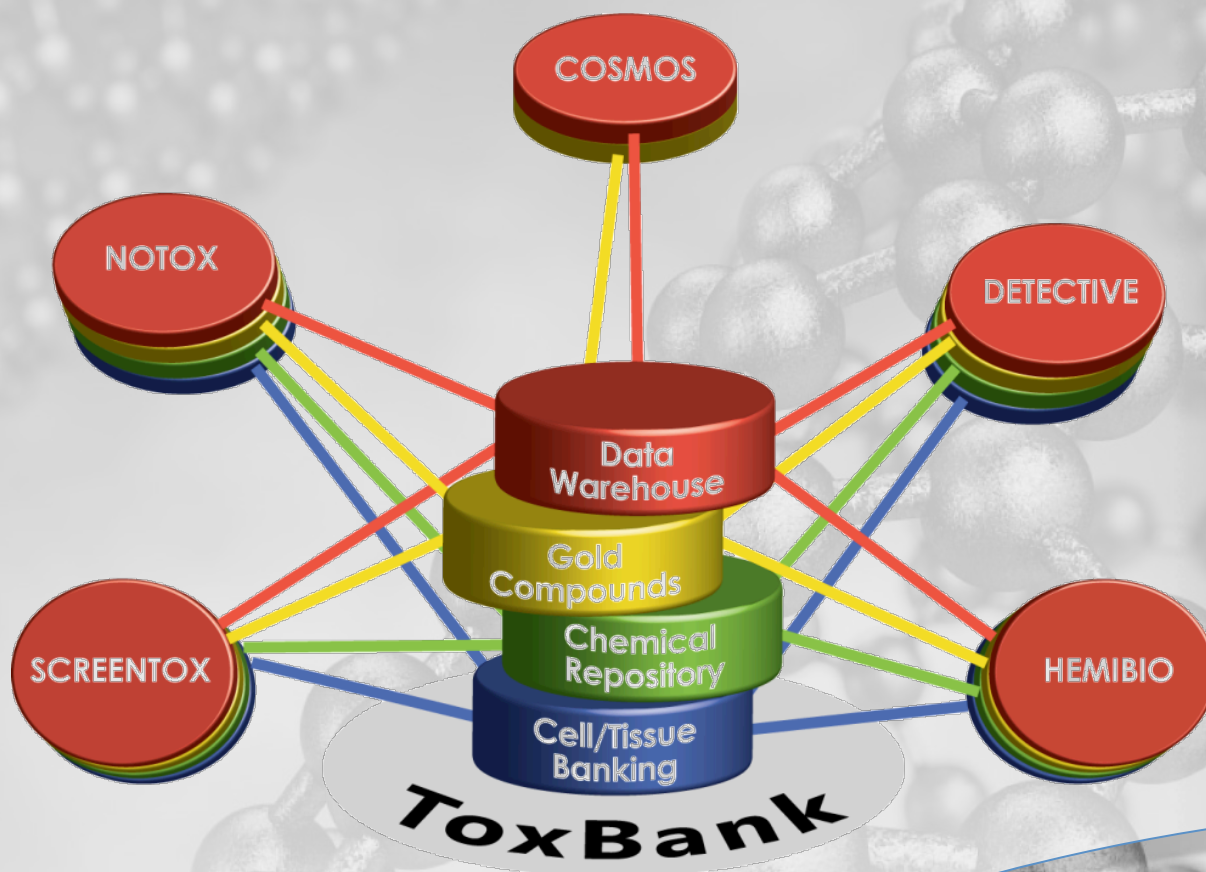
Storyboarding



Paper Prototyping

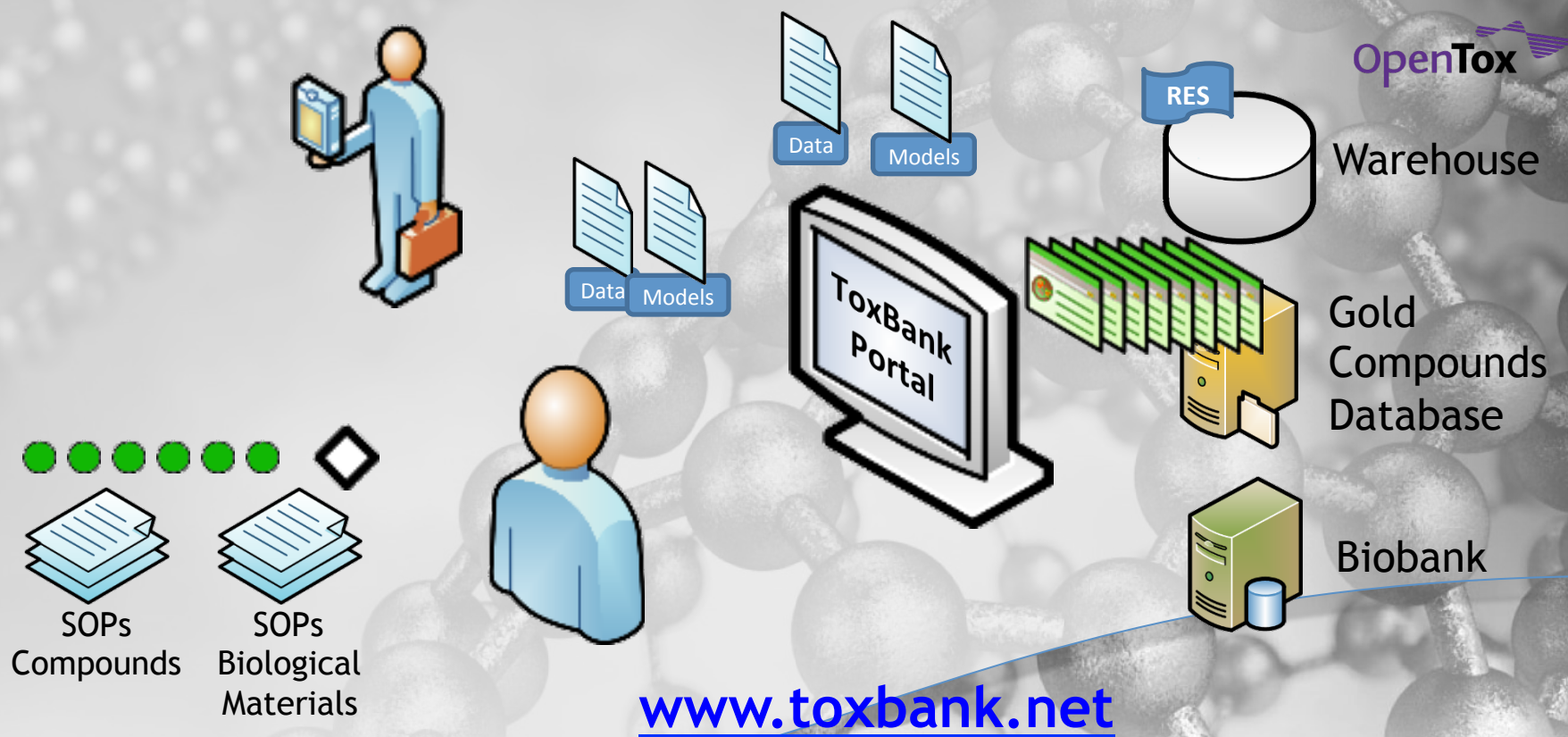


Collaboration



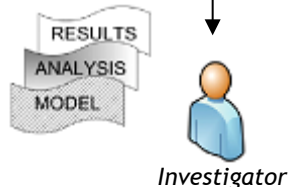
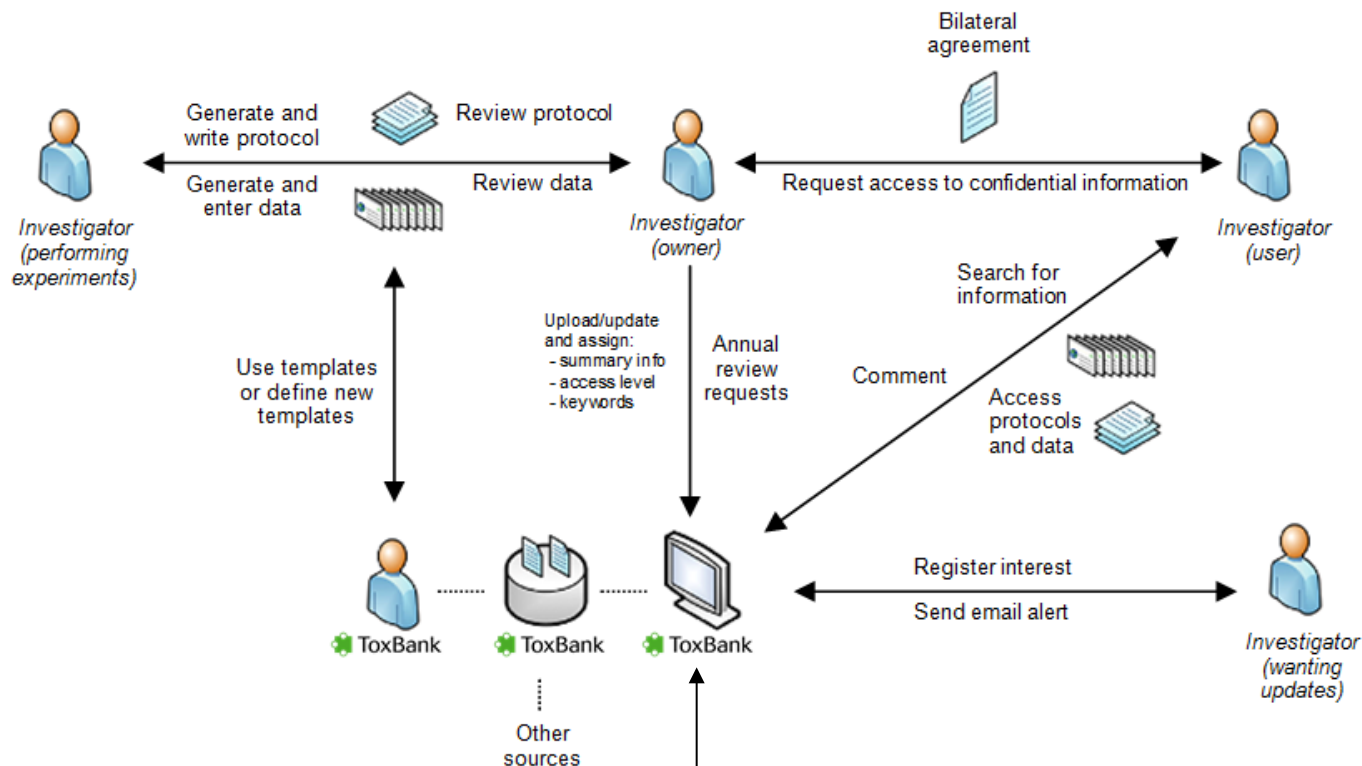
ToxBank Infrastructure System Vision

Users access compounds, biological materials, data and models for experimental planning and integrated analysis of experimental results



Outline of the ToxBank Data Warehouse

Phase 1: Unified data access



Use of SEURAT-configured ISAcreeator to prepare datasets

isatab overview

- ✓ Growth control of the eukaryote cell
 - ✓ BII-S-1
 - ✓ s_BII-S-1.txt
 - a_proteome.txt
 - a_metabolome.txt
 - a_transcriptome.txt

investigationdefinition

Investigation description

Investigation Identifier: BII-I-1

Investigation Title: Growth control of the eukaryote cell: a systems biology study

Investigation Description: Background Cell growth underlies many key cellular and developmental processes, yet a limited number of studies have been carried out on cell-growth regulation. Comprehensive studies at the

Investigation Submission Date: 30/04/2007

Investigation Public Release Date: 10/3/2009

Owning Organisation URI [c]: TBO:G176

Consortium URI [c]: TBC:G2

Principal Investigator URI [c]: TBU:U115

Investigation keywords [c]: TBK:CellViabilityAssay;TBK:CellMigrationAssays;;TBK:Epic

Last opened with configuration [c]:

INVESTIGATION PUBLICATIONS

+ add a new publication column search for publication

Field Name	publication
Investigation PubMed ID	17439666
Investigation Publication DOI	doi:10.1186/jb...
Investigation Publication Author List	Castrillo JI, Ze...
Investigation Publication Title	Growth control...
Investigation Publication Status	indexed in Pub...

INVESTIGATION CONTACTS

information

investigation

an **investigation** is the top level component of an ISATAB file. Its purpose is to group related studies together.

Investigation information

SEURAT-1 information

Publications

Templates are used to describe different experiments in a standardised way

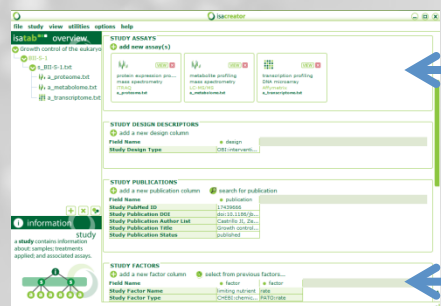
Use of SEURAT-configured ISAcreeator to prepare datasets



Investigation information

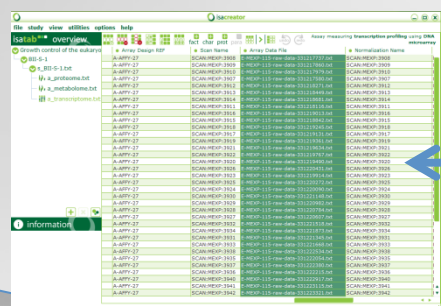
SEURAT-1 information

Publications

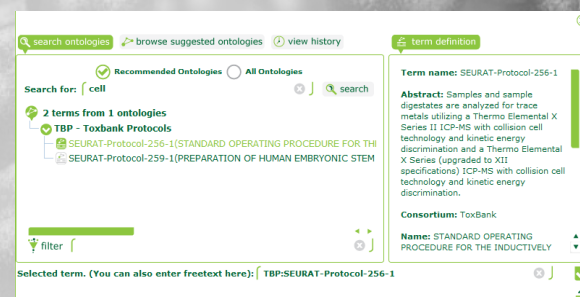


Templates for different assays

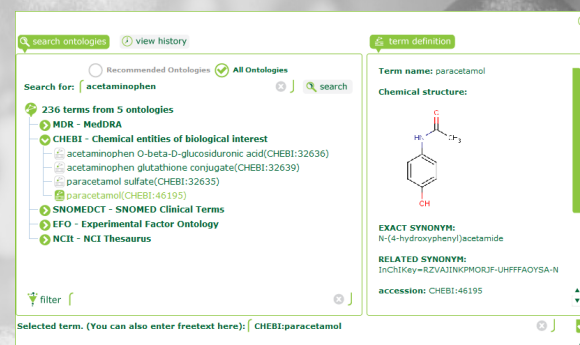
Specify experimental factors



Materials and results,
with links to files
containing the raw or
processed data



Each step linked to a
SEURAT-1 protocol



Terms mapped to
ontologies

Use of SEURAT-configured ISAcreeator to prepare datasets

The screenshot displays the ISAcreeator web interface. At the top, there are buttons for 'search ontologies' and 'view history'. Below these, a search bar contains 'acetaminophen' and a 'search' button. The results are categorized under '236 terms from 5 ontologies'. The 'All Ontologies' radio button is selected. The list of results includes:

- MDR - MedDRA
- CHEBI - Chemical entities of biological interest
 - acetaminophen O-beta-D-glucosiduronic acid(CHEBI:32636)
 - acetaminophen glutathione conjugate(CHEBI:32639)
 - paracetamol sulfate(CHEBI:32635)
 - paracetamol(CHEBI:46195)
- SNOMEDCT - SNOMED Clinical Terms
- EFO - Experimental Factor Ontology
- NCIt - NCI Thesaurus

At the bottom left, there is a 'filter' button. At the bottom, a 'Selected term. (You can also enter freetext here):' field contains 'CHEBI:paracetamol'. On the right side of the interface, a 'term definition' panel shows:

- Term name:** paracetamol
- Chemical structure:**
- EXACT SYNONYM:** N-(4-hydroxyphenyl)acetamide
- RELATED SYNONYM:** InChIKey=RZVAJINKPMORJF-UHFFFAOYSA-N
- accession:** CHEBI:46195

Mapped to terms in
ontologies

Define Ontology source

isacreator configurator

File Mappings Validation Help

Currently editing **toxbank-config**
measuring **size measurement** using **dynamic light scattering**

tables & forms

- envgen_survey_seq
- genome_seq
- HCI_staining
- hematology
- heterozygosity_micro
- histology
- histonemodification_seq
- investigation
- metaboliteprofiling_ms
- metaboliteprofiling_nmr
- metagenome_seq
- ppi_detection_micro
- proteinident_ms
- protein_dna_binding_ident_micro
- protein_dna_binding_ident_seq
- protein_expression_ge
- protein_expression_micro
- protein_expression_ms
- qHTS
- snpanalysis_micro
- studySample
- tfhsident_micro

34 tables...

fields

- ✓ Sample Name
- ✓ Protocol REF
- ✓ Assay Name
- ✓ Image File
- ✓ Raw Data File
- ✓ Derived Data
- ✓ Comment[con

field definition

Field Name: Protocol REF

Description:

Datatype: Ontology term

☒ Use recommended ontology source?

click on the **configure ontologies** button to open the ontology configurator to edit the list of ontologies and search areas within an ontology

ontologies

- ☐ ontology
- ☐ search under

NanoParticle Ontology

[configure ontologies](#)

selected ontologies

available ontologies

- Nano
- NanoParticle Ontology
- OLS NanoParticle Ontology

viewing 108 ontologies
[+ add ontology](#)

browse ontology

Click on 'show ontologies' to get a list of the available ontologies being served from the **BioPortal** and **OLS** ontology services.

When you select an ontology, you will be able to browse it in this pane.

Select a branch to restrict ontology searches for the end user...

functions

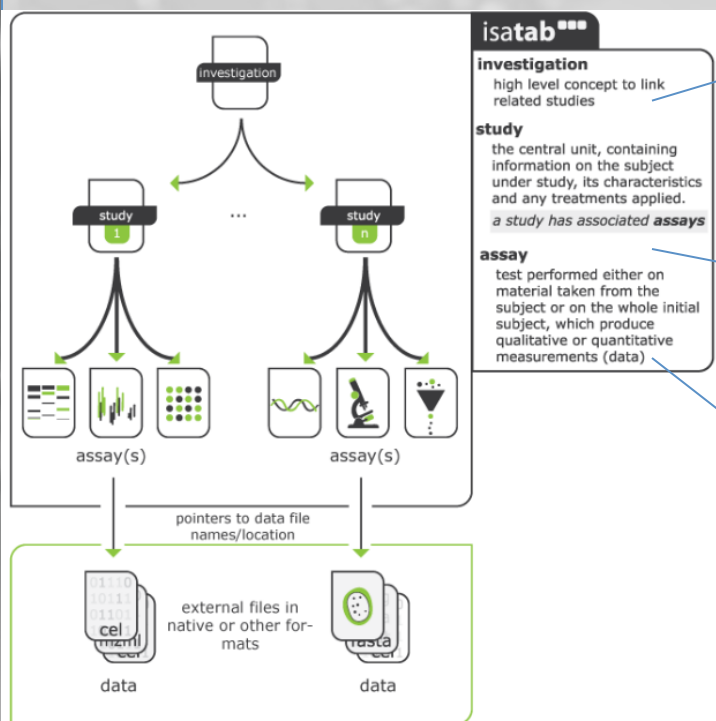
search for a term in this ontology and then locate which branch in the tree it is located...

click on a term to retrieve its definition

[confirm selections](#)

multiple instances

ISATab archives are created for each investigation



isatab
investigation
high level concept to link related studies
study
the central unit, containing information on the subject under study, its characteristics and any treatments applied.
a study has associated assays
assay
test performed either on material taken from the subject or on the whole initial subject, which produces qualitative or quantitative measurements (data)

A screenshot of an ISATab investigation file (i... files) showing a list of studies and their associated assays. The table has columns for study ID, study name, assay ID, assay name, and assay type. The data is organized into a hierarchical structure where each study is linked to its respective assays.

Overall investigation design and information (i... files)

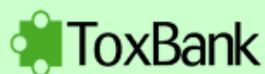
A screenshot of an ISATab study file (s... files) showing a detailed list of assays and their associated data files. The table includes columns for assay ID, assay name, data file name, and data type. The data is organized into a hierarchical structure where each assay is linked to its respective data files.

Study description (s... files)

A screenshot of an ISATab assay file (a... files) showing a detailed list of test results. The table includes columns for assay ID, assay name, test result, and test type. The data is organized into a hierarchical structure where each assay is linked to its respective test results.

Test results (a... files) with links to data table or native file (e.g. CEL files)

New data may be combined with reviewed community data on reference compounds



Supporting integrated data access and analysis across SEURAT-1

Search

Upload

G.Myatt's Settings

Sign Out

Published Protocol

Protocol Document:

Protocol ID:

Version:

Protocol Title:

Abstract:

Email the owner to request access: [U.Summer school](#)

SEURAT-Protocol-38-1

1

In vitro test for py

Parenteral pharm

pyrogenic (fever-

general be define

pyrogens that alm

pharmaceuticals

LPS) from Gram-

1979b). There are

contamination: th

amoebocyte lysat

detects LPS and

body temperature

a sterile solution

LAL test detects

the bacterial endo

that LPS causes

(haemolymph) of

8, Proc. 1984), A

Related links

[Gold compound Wiki \(Acetaminophen\)](#)

[Search PubMed for related terms](#)

[Subscribe for updates to this protocol](#)

Glennmyatt My talk My preferences My watchlist New messages My contributions

Page Discussion Read Edit View history Search

Acetaminophen

Acetaminophen

Executive Summary Information

Compound	Acetaminophen (Paracetamol)
Toxicities	Cytotoxicity
Mechanisms	Metabolic oxidation to the quinone imine NAPQI metabolite, which traps cellular thiols, both protein and GSH, by formation of covalent adducts. Studies of quinone imine analogues suggest additional depletion of thiols by redox cycling.
Comments	Acetaminophen is selected based on its chemical mechanism, which is representative of quinones with a high reduction potential.
Feedback Contact	Gold Compound Working Group (GCWG)

In Vivo Data LIINTOP Data PK-ADME Data 'Omics and IC₅₀ Data Physical Properties

Recommended Product and Source

In Vivo Data ?	Compound Assessment
Adverse Events ?	High doses can cause acute hepatic necrosis due to production of toxic quinone imine metabolite (NAPQI). From 1998 to 2003, acetaminophen was the leading cause of acute liver failure in the United States, with 48% of acetaminophen-related cases (131 of 275) associated with accidental

Acetaminophen

ToxBank Wiki Reference Information Resource



- Main page
- Recent changes
- Hepatotoxins
- Cardiotoxins
- Renal Toxins
- Special Substances
- Undifferentiated Stem Cells
- Reagents (Growth Factors)
- Reagents (Antibodies)
- Reagents (Others)
- Suppliers (Cells)
 - ALSPAC
 - Asterand
 - Biopredic
 - Cellartis
 - Cellular Dynamics
 - DSMZ
 - HPACC
 - ICLC
 - Lonza BioResearch
 - Riken Bioresource

Page [Discussion](#)

[Read](#) [Edit](#) [View history](#)

Search

Main Page

Main Page

ToxBank Wiki

[\[edit\]](#)

The following wiki pages provide information on compounds and biological materials developed as part of the [SEURAT-1](#) cluster through the ToxBank project. The research leading to these results has received funding from [Cosmetics Europe](#) and the [European Community's Seventh Framework Programme](#) (FP7/2007-2013) under grant agreement n° [267042]. This wiki site reflects only the authors' views. The European Community and Cosmetics Europe are not liable for any use that may be made of the information contained herein.

Gold compounds wiki pages

[\[edit\]](#)

Information on this wiki is based on the research and compound selection tasks performed by the Gold Compound Working Group (GCWG) using a selection criteria outlined by members of the GCWG. Further background information may be available from this working group or under review; selected reviewed materials are made available here.

- [Hepatotoxic Compounds](#)
- [Cardiotoxic Compounds](#)
- [Selection Criteria](#)

Questions, inquiries, comments and feedback regarding the scientific content on these pages may be directed to the [Gold Compound Working Group \(GCWG\)](#). The email will automatically be sent to all members on the GCWG group.

Assistance with wiki access or issues with the website in general may be directed to [Micha Rautenberg](#) or [David Bower](#) of the ToxBank project.

Biological materials wiki pages

[\[edit\]](#)

This wiki contains information on cells and reagents relevant to the SEURAT-1 cluster. The following document provides guidance for the banking and supply of human embryonic stem cells:

- [Consensus guidance for banking and supply of human embryonic stem cell lines for research purposes.](#)

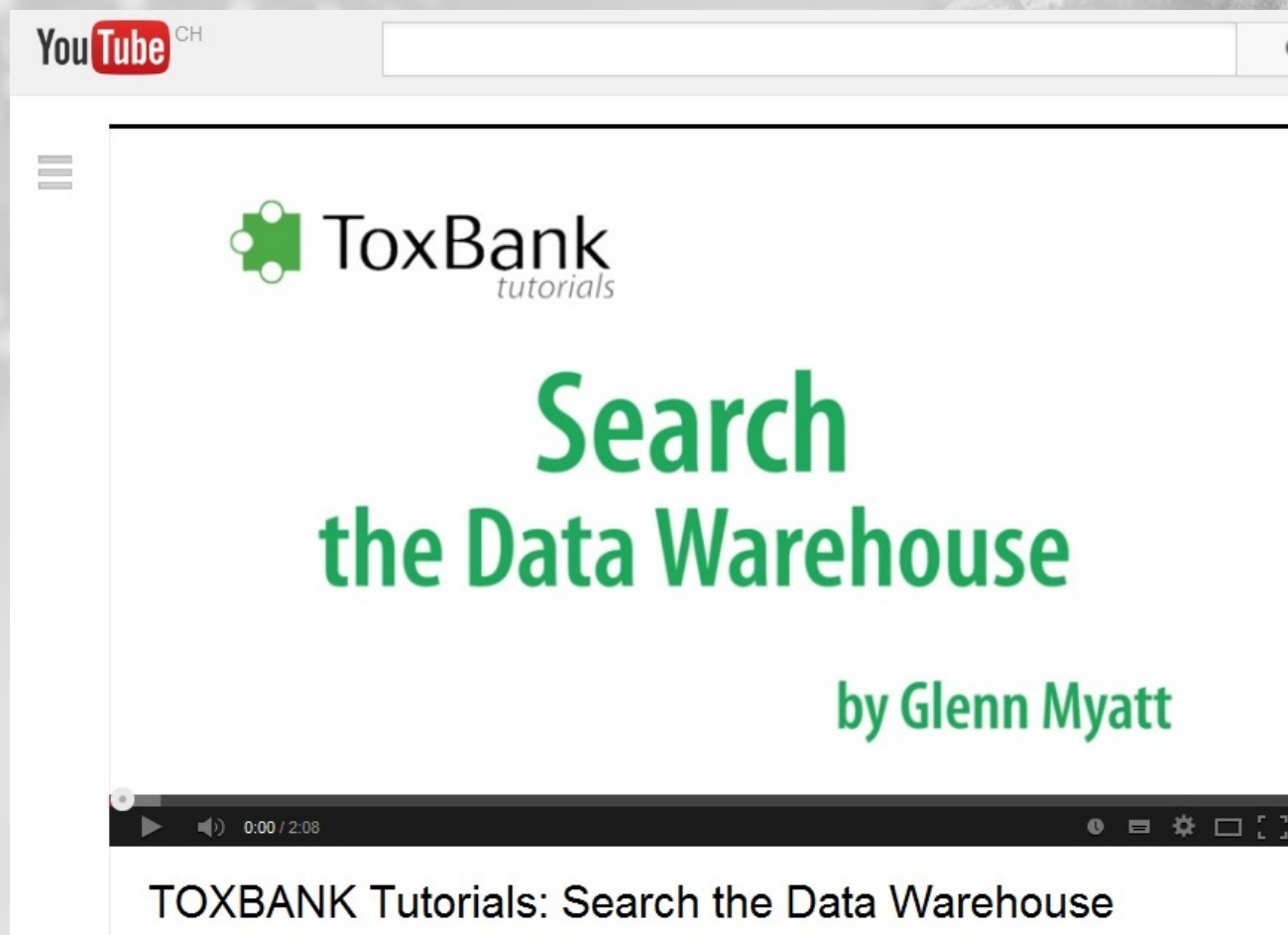
Questions, inquiries, comments and feedback regarding the scientific content on these pages may be directed to the [Luam Kidane](#) at the UK Stem Cell Bank.

Recent News

[\[edit\]](#)

A report detailing the compound selection strategy was produced as a result of the numerous insightful meetings held at the [Seurat-1 2nd Annual Meeting](#) and may be downloaded [here](#).

Data Warehouse Search Demo and Tutorial



Play Tutorial at www.youtube.com/watch?v=mE54EnY8uB4

ToxBank integrates systems biology concepts into toxicological assessment

Pekka Kohonen,^[a] Emilio Benfenati,^[b] David Bower,^[c] Rebecca Ceder,^[a] Michael Crump,^[c] Kevin Cross,^[c] Roland C. Grafström,^[a] Lyn Healy,^[d] Christoph Helma,^[e] Nina Jeliaskova,^[f] Vedrin Jeliaskov,^[f] Silvia Maggioni,^[b] Scott Miller,^[c] Glenn Myatt,^[c] Michael Rautenberg,^[e] Glyn Stacey,^[d] Egon Willighagen,^[a] Jeff Wiseman,^[g] and Barry Hardy^[h]; ^[a]Karolinska Institutet, Institute for Environmental Medicine, Molecular Toxicology, Stockholm, Sweden; ^[b] Istituto di Ricerche Farmacologiche Mario Negri, Milan, Italy; ^[c] Leadscope, Columbus, USA; ^[d] National Institute for Biological Standards and Control, Potters Bar, UK; ^[e] In silico toxicology, Basel, Switzerland; ^[f] Ideaconsult, Sofia, Bulgaria; ^[g] Pharmatrop, Wayne, USA; ^[h] Douglas Connect, Zeiningen, Switzerland.

Conclusions - great potential to contribute to

- ❖ toxicity evaluation based on **Mode-of-Action**
- ❖ decreased need for animal experiments

Systems toxicology - principles

Understanding the **toxicological interactions** in *biological systems under compound challenges*

Based on developments in high-throughput biology

- ❖ 'Omics profiling: gene expression, proteins, metabolites and others
- ❖ cell-based screening: High-Throughput and High-Content analyses

Risk assessment carried out primarily using

- ❖ *in vitro*
- ❖ *In silico* methods

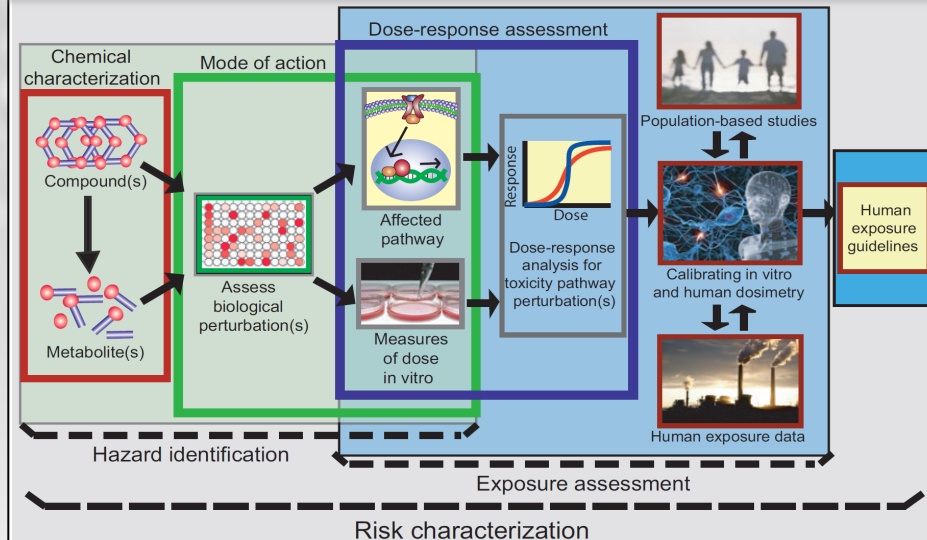
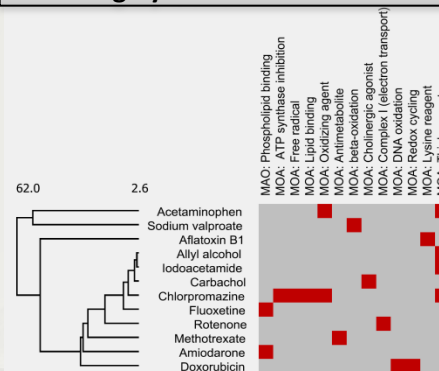


Figure 1. Multiple tools will be, **step by step**, implemented into an **innovative toxicity testing** strategy based on **mode-of-action**.

Clustering by Gene



Clustering by Gene Ontology

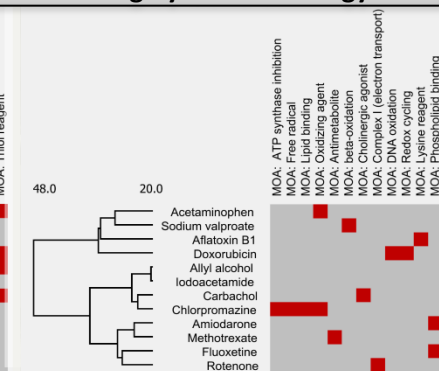


Figure 2. Clustering of ToxBank Gold Compounds by **biological similarity** using chemical-genome links from Comparative Toxicogenomics Database (CTD). Compounds with similar Mode-of-Action cluster together.

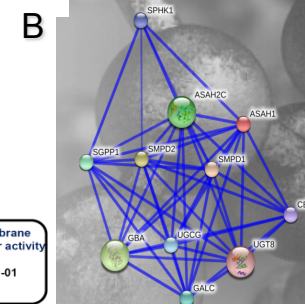
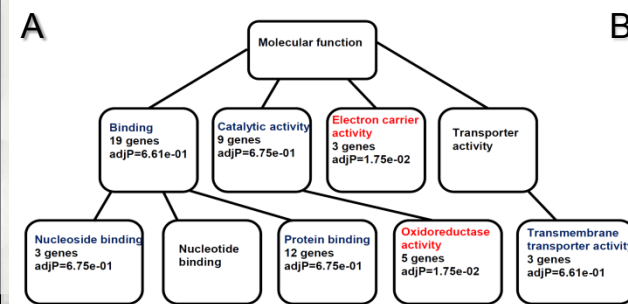
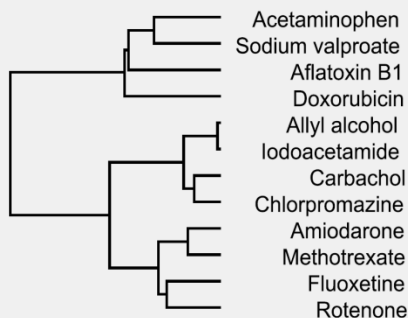


Figure 3. A) Enriched gene ontology (GO) categories of genes associated with the oxidizing agent mode-of-action (MOA) B) Protein-protein association network around the Asah1 protein. Associated with phospholipid binding MOA.

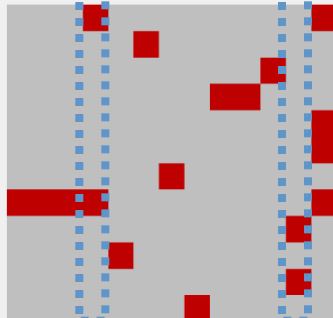
ToxBank builds databases and data management solutions to aid in systems toxicology-based risk assessment

Clustering by *Gene Ontology* associations from *CTD**

48.0 20.0

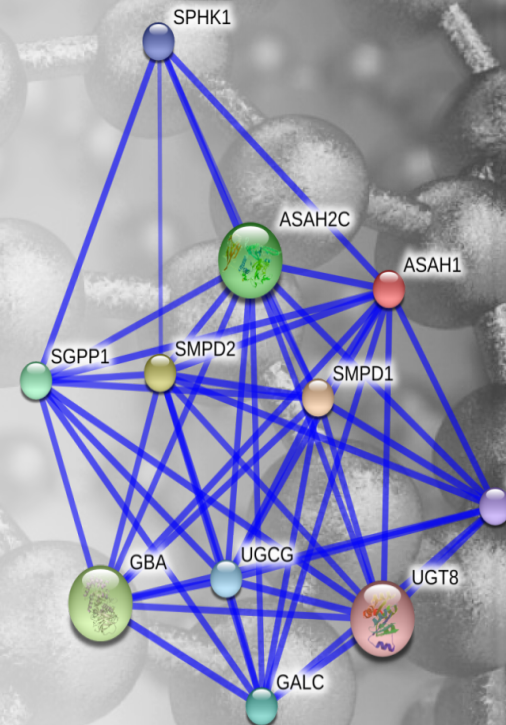


MOA: ATP synthase inhibition
MOA: Free radical
MOA: Lipid binding
MOA: Oxidizing agent
MOA: Antimetabolite
MOA: beta-oxidation
MOA: Cholinergic agonist
MOA: Complex I (electron transport)
MOA: DNA oxidation
MOA: Redox cycling
MOA: Lysine reagent
MOA: Phospholipid binding
MOA: Thiol reagent



Public Data Analysis

Phospholipid Binding



Oxidative Agent

Molecular function

Binding

19 genes
adjP=6.61e-01

Catalytic activity

9 genes
adjP=6.75e-01

**Electron carrier
activity**
3 genes
adjP=1.75e-02

Transporter
activity

Nucleoside binding
3 genes
adjP=6.75e-01

Nucleotide
binding

Protein binding
12 genes
adjP=6.75e-01

**Oxidoreductase
activity**
5 genes
adjP=1.75e-02

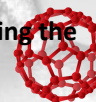
Transmembrane
transporter activity
3 genes
adjP=6.61e-01

*CTD = Comparative
Toxicogenomics
Database
(www.ctd.org)



Karolinska
Institutet

Kohonen P. et al. The ToxBank Data Warehouse: Supporting the Replacement of In Vivo Repeated Dose Systemic Toxicity Testing. Mol. Inf.17 JAN 2013.



eNEM
eNanoMapper

http://onlinelibrary.wiley.com/doi/10.1002/minf.201200114/full

File Edit View Favorites Tools Help

Home > Computational Chemistry & Molecular Modelling > Computational Chemistry & Molecular Modelling > Molecular Informa

JOURNAL TOOLS

- Get New Content Alerts
- Get RSS feed
- Save to My Profile
- Get Sample Copy
- Recommend to Your Librarian

JOURNAL MENU

- Journal Home

FIND ISSUES

- Current Issue
- All Issues

FIND ARTICLES

- Early View
- Most Accessed
- Most Cited

GET ACCESS

- Subscribe / Renew

FOR CONTRIBUTORS

- Author Guidelines
- OnlineOpen
- Submit an Article

ABOUT THIS JOURNAL

molecular informatics

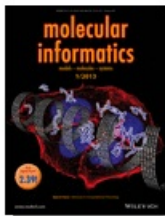
models – molecules – systems

Full Paper

The ToxBank Data Warehouse: Supporting the Replacement of In Vivo Repeated Dose Systemic Toxicity Testing

Pekka Kohonen¹, Emilio Benfenati², David Bower³, Rebecca Ceder¹, Michael Crump³, Kevin Cross³, Roland C. Grafström¹, Lyn Healy⁴, Christoph Helma⁵, Nina Jeliaskova⁶, Vedrin Jeliaskov⁶, Silvia Maggioni², Scott Miller³, Glenn Myatt³, Michael Rautenberg⁵, Glyn Stacey⁴, Egon Willighagen¹, Jeff Wiseman⁷, Barry Hardy^{8,*}

Issue



Molecular Informatics
Special Issue: Advances in Computational Toxicology
Volume 32, Issue 1, pages 47–63, January 2013

Article first published online: 17 JAN 2013
DOI: 10.1002/minf.201200114

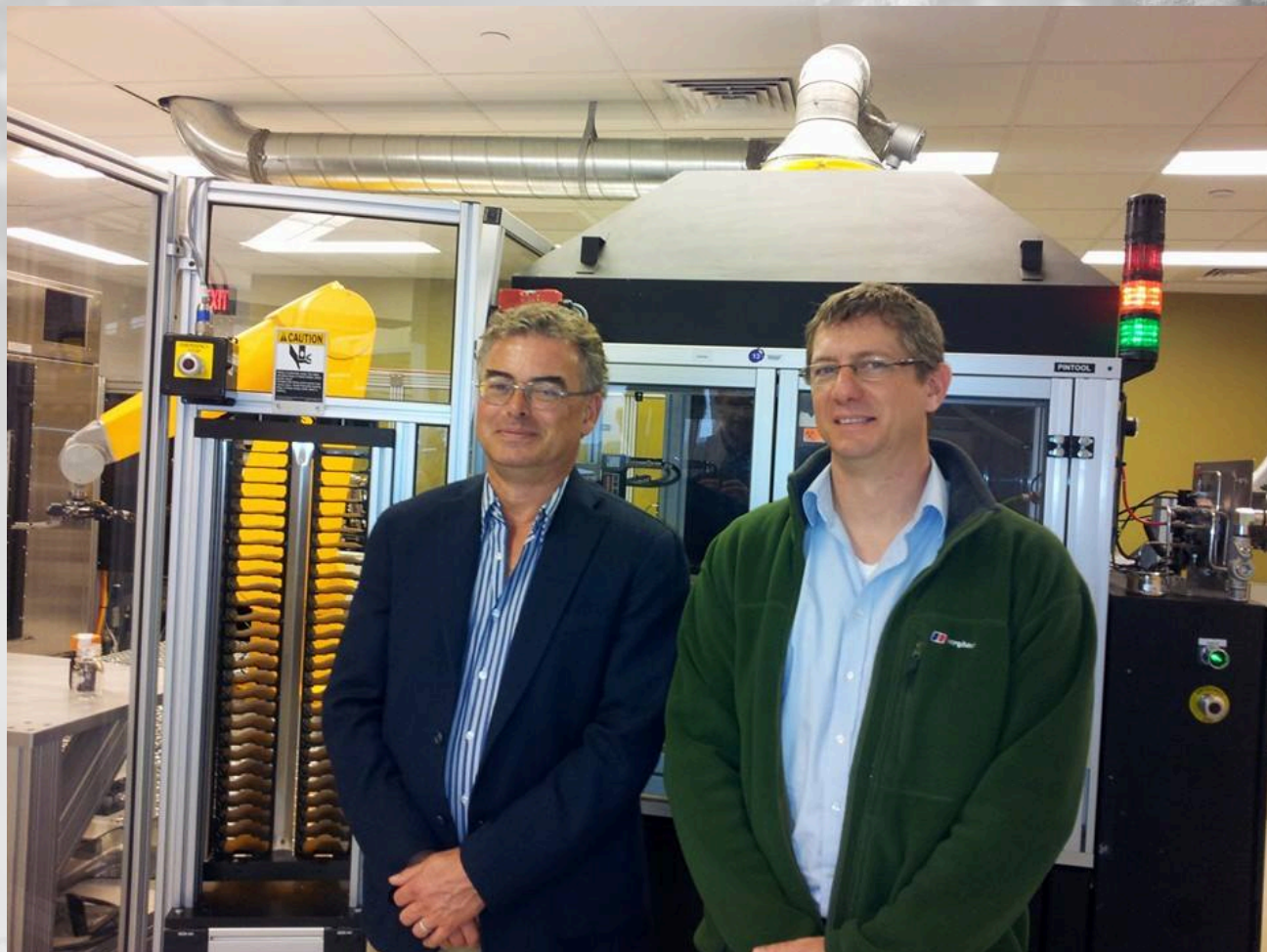
Copyright © 2013 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

Additional Information (Show All)

How to Cite | Author Information | Publication History | Funding Information

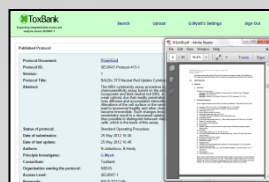
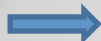
Abstract | **Article** | References | Supporting Information | Cited By

SEURAT-1 - Tox21 Collaboration



ToxBank – Integrated Data Analysis

Integrate experimental data across consortia

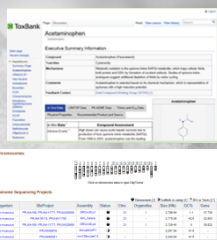


Protocols

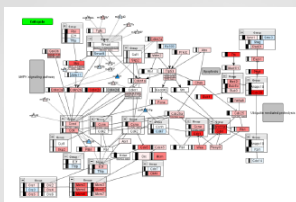


Investigation data

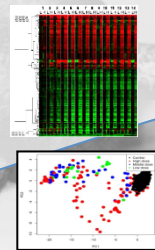
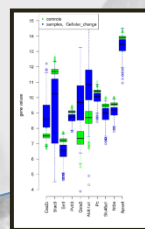
Integrate with public data (clinical, Tox21, ...)



DASHBOARD
Integrate/organize



Pathway integration across projects, omics platforms, and experiments



Analysis and visualization

Links to other resources

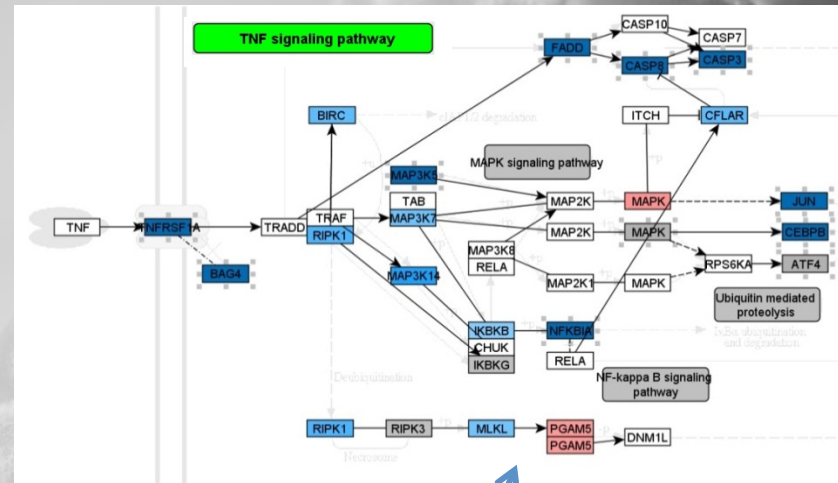


Differential Expression

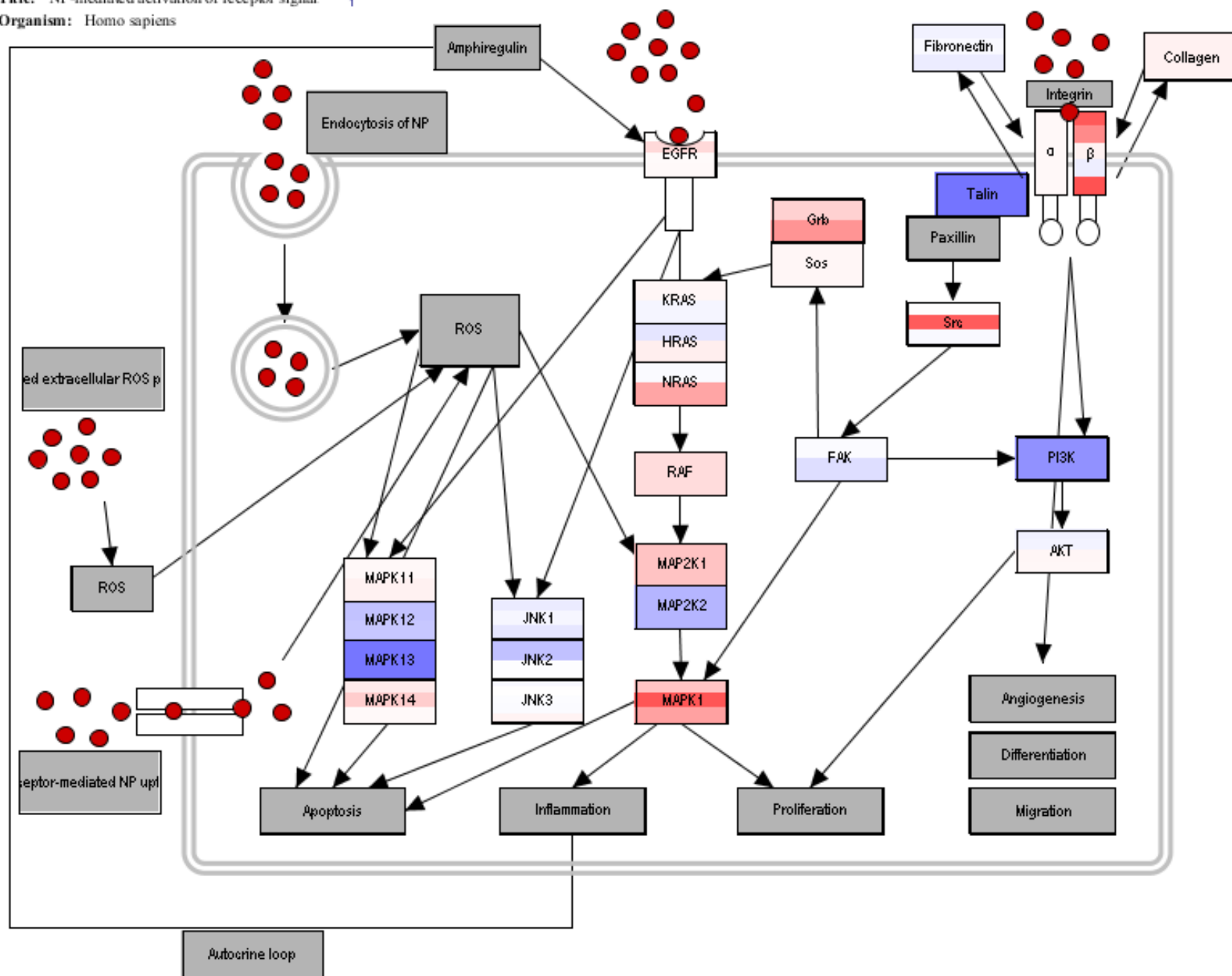
Ensembl	Entrez	Symbol	Log-average expression	FC'HC8hr'	FC'MC8hr'	FC'LC8hr'
ENSG000000000003	7105	TSPAN6	10.52	0.021	-0.112	0.005
ENSG000000000005	64102	TNMD	4.04	0.21	0.066	0.214
ENSG000000000419	8813	DPM1	12.31	0.168	0.316	0.184
ENSG000000000457	57147	SCYL3	7.19	-1.049	-0.206	0.101
ENSG000000000460	55732	C1orf112	5.26	-0.402	-0.497	-0.143
ENSG000000000938	2268	FGR	5.77	0.157	0.299	-0.026
ENSG000000000971	3075	CFH	10.1	0.571	0.232	0.035
ENSG000000001036	2519	FUCA2	10.46	0.036	-0.05	-0.041
ENSG000000001084	2729	GCLC	9.22	-0.377	-0.153	0.105
ENSG000000001167	4800	NFYA	6.88	-1.052	-0.966	-0.214
ENSG000000001460	90529	STPG1	6.42	0.046	0.025	0.005
ENSG000000001461	57185	NIPAL3	6.88	-0.048	0.223	0.056
ENSG000000001497	81887	LAS1L	8.9	0.303	0.129	-0.012
ENSG000000001561	22875	ENPP4	7.24	-0.059	-0.391	0.008
ENSG000000001517	6405	SEMA3F	6.55	0.130	0.307	0.111

*InCroMAP software (<http://www.ra.cs.uni-tuebingen.de/software/InCroMAP>)

Pathway enrichment*



Pathway class	Pathways	FC'LC8hr'	FC'MC8hr'	FC'HC8hr'	FC'ML8hr'	FC'HL8hr'	FC'HM8hr'	FC'LC24hr'	FC'MC24hr'	FC'HC24hr'	FC'ML24hr'	FC'HL24hr'	FC'HM24hr'	FC'LC8hr24hr'	FC'MC8hr24hr'	FC'HC8hr24hr'	FC'HL8hr24hr'	FC'ML8hr24hr'	FC'HM8hr24hr'	FC'LC8hr24hr'
Cellular Processes; Cell growth and death	Cell cycle	*						*	*	*				*	*					
Cellular Processes; Cell growth and death	p53 signaling pathway							*	*	*				*	*					
Cellular Processes; Cell growth and death	Oocyte meiosis							*	*	*				*	*					
Environmental Information Processing; Signal transduction	TNF signaling pathway									*										
Genetic Information Processing; Replication and repair	DNA replication							*	*	*				*	*					
Genetic Information Processing; Replication and repair	Mismatch repair							*	*	*				*	*					
Genetic Information Processing; Replication and repair	Fanconi anemia pathway							*	*	*				*	*					
Human Diseases; Cancers	Viral carcinogenesis							*	*	*				*	*					
Human Diseases; Immune diseases	Rheumatoid arthritis									*				*	*					*
Human Diseases; Infectious diseases	Influenza A									*		*	*	*	*					
Human Diseases; Infectious diseases	Chagas disease (American trypanosomiasis)									*		*	*	*	*					
Human Diseases; Infectious diseases	Hepatitis B									*		*	*	*	*					
Human Diseases; Infectious diseases	Herpes simplex infection									*		*	*	*	*					
Metabolism; Nucleotide metabolism	Pyrimidine metabolism							*	*	*				*	*					
Organismal Systems; Endocrine system	Progesterone-mediated oocyte maturation									*		*	*	*	*					
Organismal Systems; Immune system	Toll-like receptor signaling pathway									*		*	*	*	*					



Douglas Connect
Working communities

eNanoMapper

Nano Safety Cluster Meeting
Antalya, Turkey

Barry.Hardy@douglasconnect.com

23 April 2014