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PathVisio 3

New Features for Pathway Analysis and Visualization

Martina Kutmon

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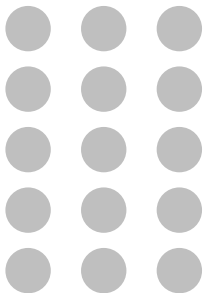Department of Bioinformatics, Maastricht University
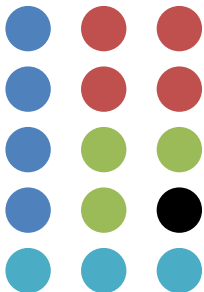
OpenTox Euro 2013

September 30, 2013

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Outline

Pathway Analysis

Quantify
Isolated Data Points

Pathway Analysis

Comparative statistics

Isolated lists

Clustering

Isolated groups

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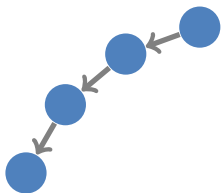
Pathway Analysis

Functional organization
Pathway lists
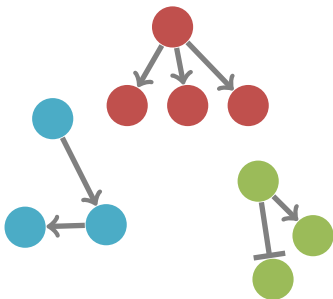
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Pathway Analysis

- **A picture is worth a thousand words**
  - Intuitive
  - Puts data into biological context

Pathway Analysis

- **A picture is worth a thousand words**
  - Intuitive
  - Puts data into biological context

- **Involvement in pathways**
  - Group genes, proteins and other biological molecules
  - Reducing complexity
  - Several hundreds pathways instead of thousands of genes
  - Analysis on functional level

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Pathway Analysis

- **A picture is worth a thousand words**
    - Intuitive
    - Puts data into biological context

- **Involvement in pathways**
    - Group genes, proteins and other biological molecules
    - Reducing complexity
    - Several hundreds pathways instead of thousands of genes
    - Analysis on functional level

- **Identification of active pathways**
    - Pathways that are turned on/off in specific experiments

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PathVisio 3

Publication: **Presenting and exploring biological pathways with PathVisio**
Martijn P. van Iersel *et al.*, BMC Bioinformatics (2008)
DOI: 10.1186/1471-2105-9-399
Website: http://www.pathvisio.org

PathVisio 3

What's new?

1. New modular framework that can be extended with plugins

2. Plugin repository: central plugin collection

3. Plugin manager: one-click installation of plugins

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What's new?

1. New modular framework that can be extended with plugins

2. Plugin repository: central plugin collection

3. Plugin manager: one-click installation of plugins

4. Annotations of interactions and reactions

5. Visualization of data on lines

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PathVisio 3

What's new?

1. New modular framework that can be extended with plugins
2. Plugin repository: central plugin collection
3. Plugin manager: one-click installation of plugins

4. Annotations of interactions and reactions
5. Visualization of data on lines

6. Interoperability with other standards
   - Draw pathways in SBGN or MIM
   - Import SBML models
   - Export in BioPAX

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PathVisio Plugins

Current and soon to be released plugins

Check out the plugin repository on http://www.pathvisio.org/plugins/plugins-repo/

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PathVisio functionality

1. **Draw pathways**

Create new pathway

Share/Upload

WikiPathways

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PathVisio functionality

1 *Draw pathways*

Create new pathway

Share/Upload

WikiPathways

2 *Visualize data*

Load dataset
*Transcriptomics, Proteomics,
Metabolomics, Fluxomics*

Create data visualization
Gradient / rule based

Visualize data on
pathway

Export pathway image
with data

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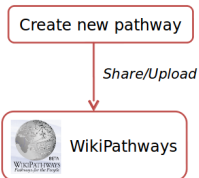
PathVisio functionality

1 **Draw pathways**

2 **Visualize data**
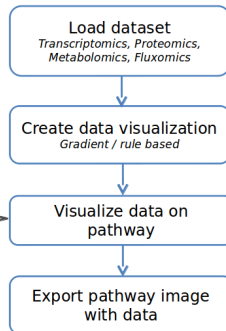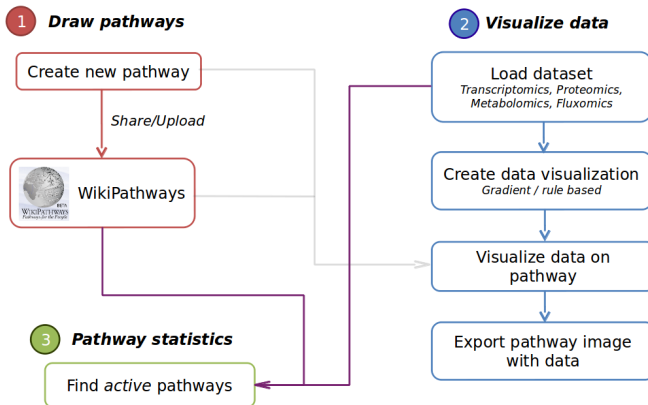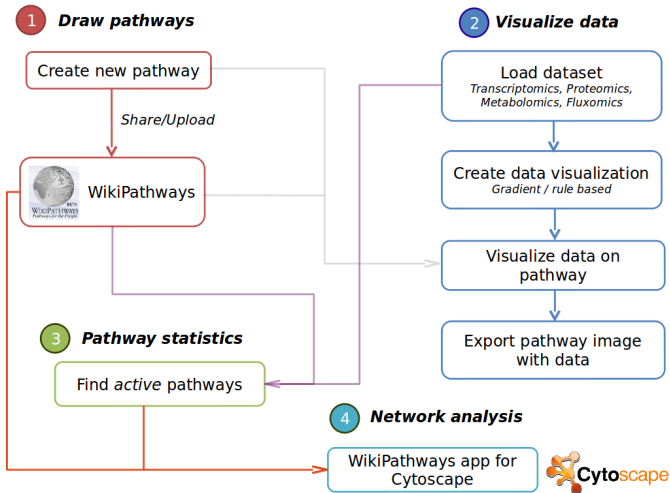
Create new pathway

Load dataset
Transcriptomics, Proteomics, Metabolomics, Fluxomics

Share/Upload

WikiPathways

Create data visualization
Gradient / rule based

Visualize data on pathway

3 **Pathway statistics**

Find *active* pathways

Export pathway image with data

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PathVisio functionality

1 *Draw pathways*

Create new pathway

Share/Upload

WikiPathways

2 *Visualize data*

Load dataset
*Transcriptomics, Proteomics,
Metabolomics, Fluxomics*

Create data visualization
Gradient / rule based

Visualize data on
pathway

Export pathway image
with data

3 *Pathway statistics*

Find *active* pathways

4 *Network analysis*

WikiPathways app for
Cytoscape

Cytoscape

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PathVisio plugins

WikiPathways client plugin

- WikiPathways is a pathway database using the wiki system
    - everybody can create, edit, curate, discuss, download and use pathways (CreativeCommons 3.0 License)
    - community curation
    - new findings can be added immediately

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PathVisio plugins

WikiPathways client plugin

- WikiPathways is a pathway database using the wiki system
    - everybody can create, edit, curate, discuss, download and use pathways (CreativeCommons 3.0 License)
    - community curation
    - new findings can be added immediately
- Plugin allows searching and browsing the database
- Users can create and upload pathways from PathVisio to WikiPathways
- Users can update pathways from WikiPathways in PathVisio

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PathVisio plugins

GeneSet Enrichment Analysis (GSEA) plugin

- Perform gene set enrichment analysis in PathVisio
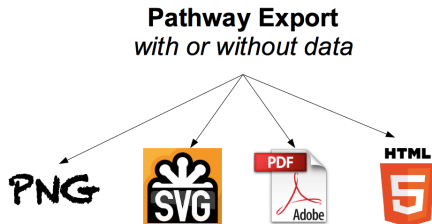- Use pathways as gene sets

PathwayLoom

- Find known interactions for a selected gene or protein
- Interactions from online databases and text mining results
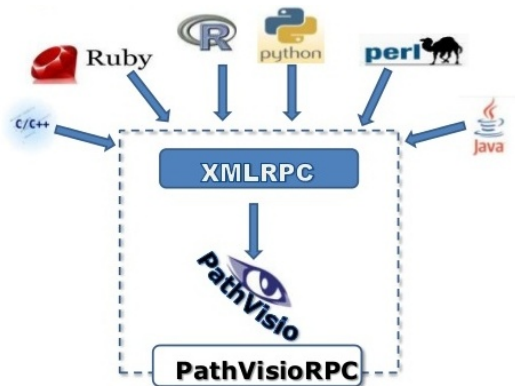
PathVisio plugins

Export options

High-quality figures for presentations and publications

Pathway Export
with or without data

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PathVisio plugins

Integration into workflows

Use PathVisio functionality from different programming languages

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PathVisio in Toxicology

Study 1

Title: **Biotransformation pathway maps in**
           WikiPathways enable direct visualization
           of drug metabolism related expression changes
Authors: D.G.J. Jennen *et al.*
Journal: Drug Discovery Today

- Biotransformation pathway
  map suitable for multi-omics
  analysis and data
  visualization
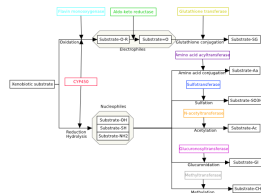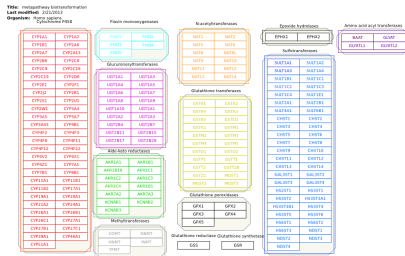
PathVisio in Toxicology

Study 1

Title:	**Biotransformation pathway maps in WikiPathways enable direct visualization of drug metabolism related expression changes**
Authors:	D.G.J. Jennen *et al.*
Journal:	Drug Discovery Today

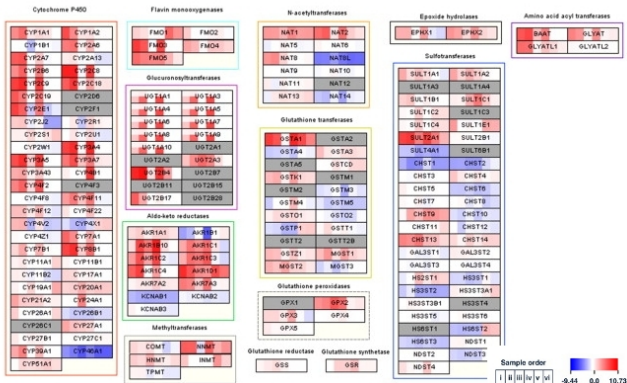- Biotransformation pathway map suitable for multi-omics analysis and data visualization

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PathVisio in Toxicology

Study 1

Compare expression profile in different cell types.

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PathVisio in Toxicology

Study 2

|	
Title:	**RNA-Seq Provides New Insights in the Transcriptome Responses Induced by the Carcinogen Benzo[a]pyrene**
Authors:	van Delft J. *et al.*
Journal:	Toxicological Sciences

Transcriptomic responses in HepG2 cells upon exposure to benzo[a]pyrene, pathway analysis with WikiPathways collection.

12h pathway name	Z-score	24h pathway name	Z-score
BaP metabolism	6.33[#]	BaP metabolism	7.38[#]
Oxidative stress	5.09[#]	Cholesterol biosynthesis	6.08
Keap1-Nrf2	4.63[#]	Codeine and morphine metabolism	4.16
GPCRs, class A rhodopsin-like	3.67	Keap1-Nrf2	3.85[#]
Metapathway biotransformation	3.47[#]	Urea cycle and metabolism of amino groups	3.66
Myometrial relaxation and contraction	3.12[#]	Metapathway biotransformation	3.65[#]
Nucleotide GPCRs	3.06	Oxidative stress	3.34[#]
Hypertrophy model	2.96	Statin pathway	3.26
Estrogen metabolism	2.94[#]	Estrogen metabolism	3.13[#]
Focal adhesion	2.88	Tryptophan metabolism	2.74[#]
DNA damage response	2.82	Adipogenesis	2.31
Blood clotting cascade	2.77	Inflammatory response pathway	2.30
Biogenic amine synthesis	2.70	Myometrial relaxation and contraction	2.18[#]

PathVisio in Toxicology

Study 2
Visualization of the effects in the *DNA damage response* pathway demonstrates that especially the network of genes around TP53 is upregulated.

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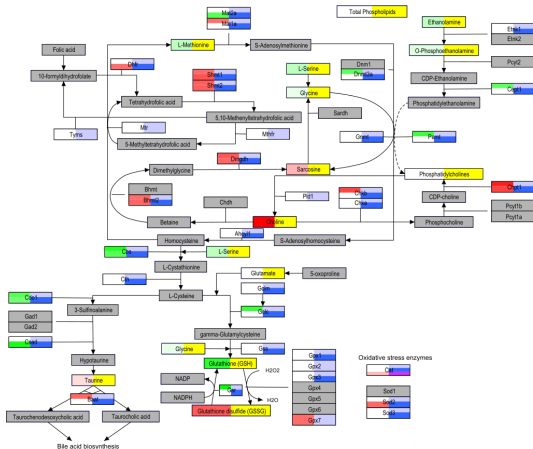00000000

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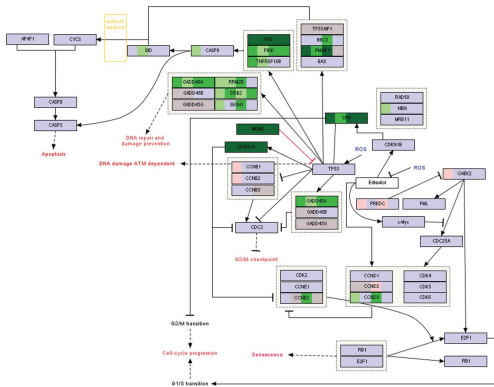
Other Examples

Rubio-Aliaga et al. "Alterations in hepatic one-carbon metabolism and related pathways following a high-fat dietary intervention". Physiological Genomics (2013).

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Other Examples

Tisoncik et al. "Into the eye of the cytokine storm". Microbiology and Molecular Biology Reviews (2012).

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Summary

1. PathVisio is a free, open source pathway editing, visualization and analysis tool
   - http://www.pathvisio.org

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Summary

1. PathVisio is a free, open source pathway editing, visualization and analysis tool
   - http://www.pathvisio.org
2. Extended functionality through plugins

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Summary

1. PathVisio is a free, open source pathway editing, visualization and analysis tool
   - http://www.pathvisio.org
2. Extended functionality through plugins
3. PathVisio is the pathway editor integrated in WikiPathways, new JavaScript version under development

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Summary

1. PathVisio is a free, open source pathway editing, visualization and analysis tool
   - http://www.pathvisio.org
2. Extended functionality through plugins
3. PathVisio is the pathway editor integrated in WikiPathways, new JavaScript version under development
4. Pathways drawn in PathVisio can be uploaded and shared on WikiPathways
   - http://www.wikipathways.org

Acknowledgements

Maastricht University

- Anwesha Dutta
- Nuno Nunes
- Chris Evelo

Gladstone Institutes, San Francisco

- Alex Pico
- Kristina Hanspers

Former developers

- Martijn van Iersel
- Thomas Kelder

Plugin Developers

- Collaborators around the world
- Google Summer of Code students
    - Sravanthi Sinha

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Thank you for your attention.

Questions?