

# cBioPortal Tutorial #7: Pathways

Explore genomics data in the context of pathways

# Tutorial Objectives

- Motivate viewing cancer genomics data in context of pathways
- Locate cBioPortal Pathways tabs in **Results** or **Patient** views
- Introduce pathway view components
- Detail pathway view toolbar operations
  - Save as static images
  - Perform layout
  - Expand query genes [Results view only]
  - Edit pathway with PathwayMapper editor [Results view only]
  - Get help on notation
- Walk through different pathway ranking options [Results view only]
- List technology behind the component

# Motivation for Pathways View

- Genomic alterations in cancer often affect a relatively small number of signaling pathways involved in cell proliferation, cell growth, apoptosis and DNA repair, among others [1]
- The Cancer Genome Atlas (TCGA), an effort to comprehensively characterize genomic alterations in more than 20 tumor types, produced a number of publications with hand-drawn pathways summarizing such alterations [2]
- Pathways tabs in cBioPortal overlay alteration data from your **study** or **patient of interest** on TCGA pathways while highlighting your genes of interest.
- The Pathways tab is available in *Results view* and *Patient view*

[1] Bahceci et al. "[PathwayMapper: a collaborative visual web editor for cancer pathways and genomic data](#)", Bioinformatics, 2017

[2] [The Cancer Genome Atlas Program](#)

# Pathways Tab in Results View

- One may be interested in viewing genetic alterations in a particular *study* in the context of pathways
- Start with Results view in *TP53* and *MDM2/4* alterations in “Glioblastoma (TCGA, Nature 2008)” as an example

Not sure how to run a query to get to Results View? Review [Tutorial #2: Single Study Query](#)

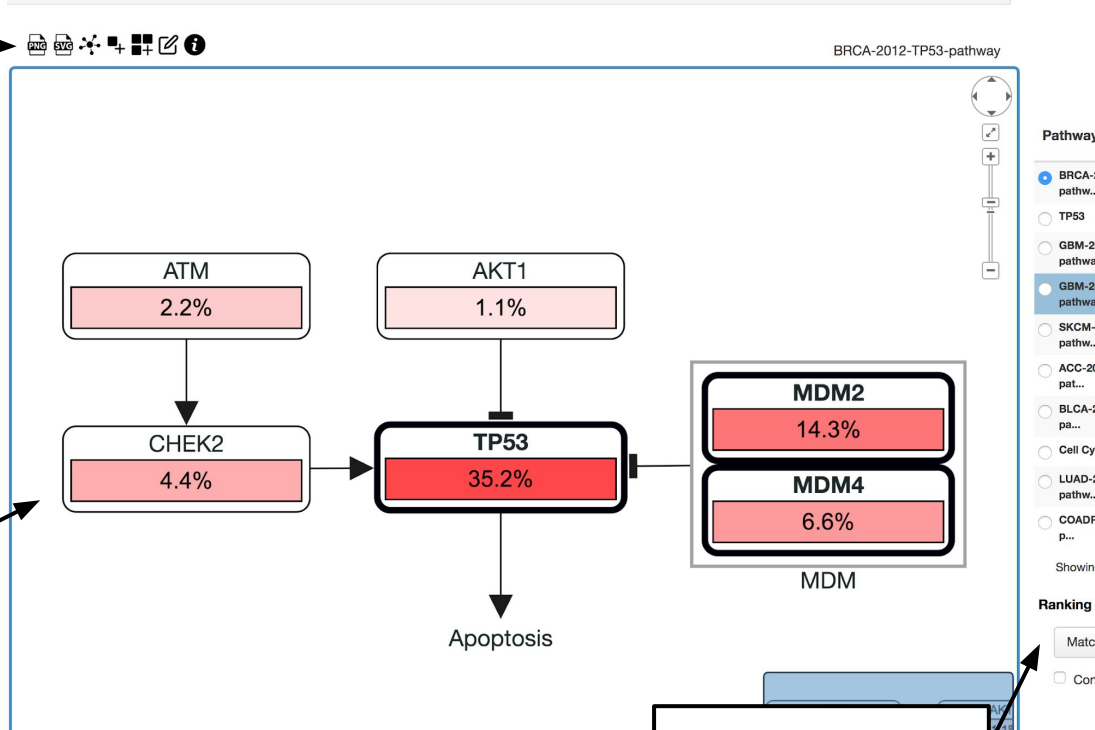
# Pathways Tab in Results View

Toolbar for pathway operations

Pathways tab

TCGA pathways table, sorted by score using current ranking scheme

OncoPrint Cancer Types Summary Mutual Exclusivity Plots Mutations Co-expression Comparison Survival CN Segments Pathways



Pathway with alteration frequencies of selected genetic profiles of the chosen study overlaid

Ranking options

Pathway name	Score	Genes matched
<input checked="" type="radio"/> BRCA-2012-TP53-pathw...	3.00	TP53 MDM2 MDM4
<input type="radio"/> TP53	3.00	TP53 MDM2 MDM4
<input type="radio"/> GBM-2008-TP53-pathwa...	3.00	TP53 MDM2 MDM4
<input checked="" type="radio"/> GBM-2013-TP53-pathwa...	3.00	TP53 MDM2 MDM4
<input type="radio"/> SKCM-2015-TP53-pathw...	2.00	TP53 MDM2
<input type="radio"/> ACC-2016-TP53-RB-pa...	2.00	TP53 MDM2
<input type="radio"/> BLCA-2014-TP53-RB-pa...	2.00	TP53 MDM2
<input type="radio"/> Cell Cycle	2.00	TP53 MDM2
<input type="radio"/> LUAD-2014-TP53-pathw...	2.00	TP53 MDM2
<input type="radio"/> COADREAD-2012-TP53-p...	1.00	TP53

Showing 1-10 of 55 [Show more](#)

Ranking options

[?](#)

☐ Consider alteration frequency [?](#)

# Results Pathways View

Toolbar for pathway operations



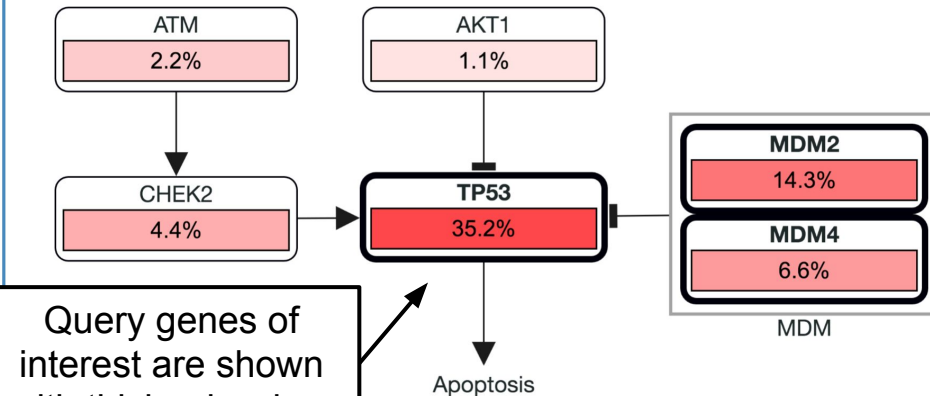
Resulting pathway tab from example query "TP53 and MDM2/4 alterations in GBM"

TCGA pathway ranking highest with default ranking scheme is shown

Name of TCGA pathway currently shown

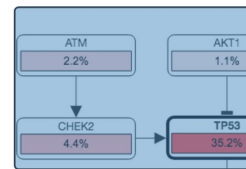
BRCA-2012-TP53-pathway

Pan-zoom controls



More information about **notation** used can be found [here](#)

Overview window (useful for navigating large pathways)



Powered by PathwayMapper

# Results Pathways View Toolbar

Buttons on the toolbar  
provide useful operations



Save current pathway as PNG



Save current pathway as SVG



Perform incremental layout, respecting current positions



Add selected genes to query



Add all valid genes in this pathway to query



Edit pathway with [PathwayMapper](#) editor



Quick help with a link to [detailed documentation](#)

# Results Pathways Table & Ranking Options

BRCA-2012-TP53-pathway

TCGA pathway currently selected / shown

Score of each TCGA pathway using current ranking scheme

Search pathway by name

Pathway name	Score	Genes matched
<input checked="" type="radio"/> BRCA-2012-TP53-pathw...	3.00	TP53 MDM2 MDM4
<input type="radio"/> TP53	3.00	TP53 MDM2 MDM4
<input type="radio"/> GBM-2008-TP53-pathwa...	3.00	TP53 MDM2 MDM4
<input type="radio"/> GBM-2013-TP53-pathwa...	3.00	TP53 MDM2 MDM4
<input type="radio"/> SKCM-2015-TP53-pathw...	2.00	TP53 MDM2
<input type="radio"/> ACC-2016-TP53-RB-pat...	2.00	TP53 MDM2
<input type="radio"/> BLCA-2014-TP53-RB-pa...	2.00	TP53 MDM2
<input type="radio"/> Cell Cycle	2.00	TP53 MDM2
<input type="radio"/> LUAD-2014-TP53-pathw...	2.00	TP53 MDM2
<input type="radio"/> COADREAD-2012-TP53-p...	1.00	TP53

Genes in current pathway matching those in query genes

Match count vs percentage: whether we should score pathways by the number of genes matched or by the percentage of genes matched

Showing 1-10 of 55 [Show more](#)

Ranking options

Match count ☐ Consider alteration frequency ☐

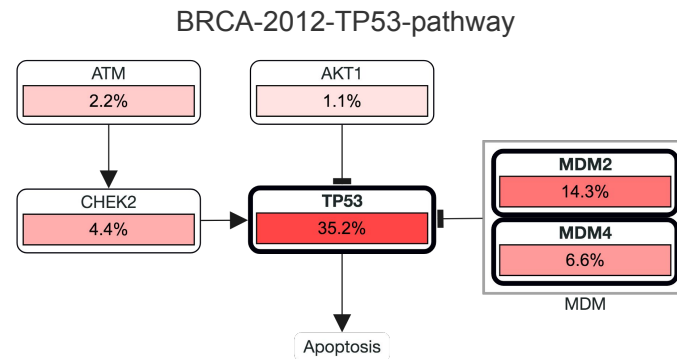
Consider **alteration frequency**: whether we should take each matching gene with a count of 1 or with a weight of its alteration frequency in scoring

Alteration frequency visualization: M2, 3%



# Results Pathways View Ranking Options

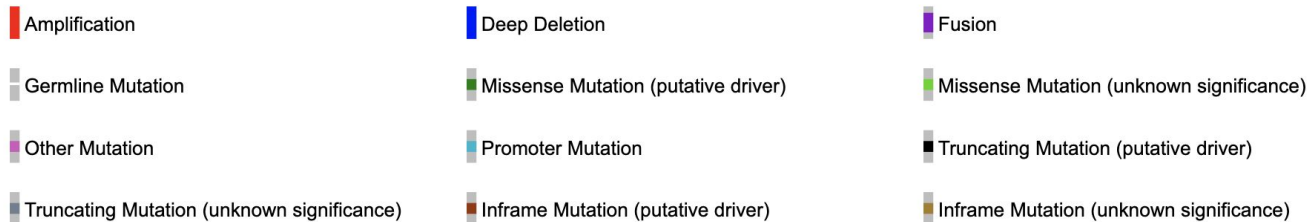
- When a query gene is in a particular pathway, we consider it “matching”.
- Example:
  - Query genes: TP53, MDM2, MDM4
  - Pathway: BRCA-2012-TP53-pathway (see on the right)



- Match count vs percentage:
  - Count the query genes matching and rank pathways based on this count. The score in our example is **3** as all three genes are in the pathway.
  - Take the ratio of query genes matching to total number of genes in the pathway. The score in our example is  $3 / 6 = 50\%$ .
- Consider alteration frequency:
  - When checked, each matching gene will not contribute to the score as 1 unit but with its alteration frequency of that gene. The score in our example is  $35.2 + 14.3 + 6.6 = 56.1$ .

# Pathways Tab in Patient View

- One may be interested in viewing following types of genetic alterations of a *patient* in the context of pathways



Putative driver and unknown significance annotations are based on data from OncoKB and CancerHotspots.org.

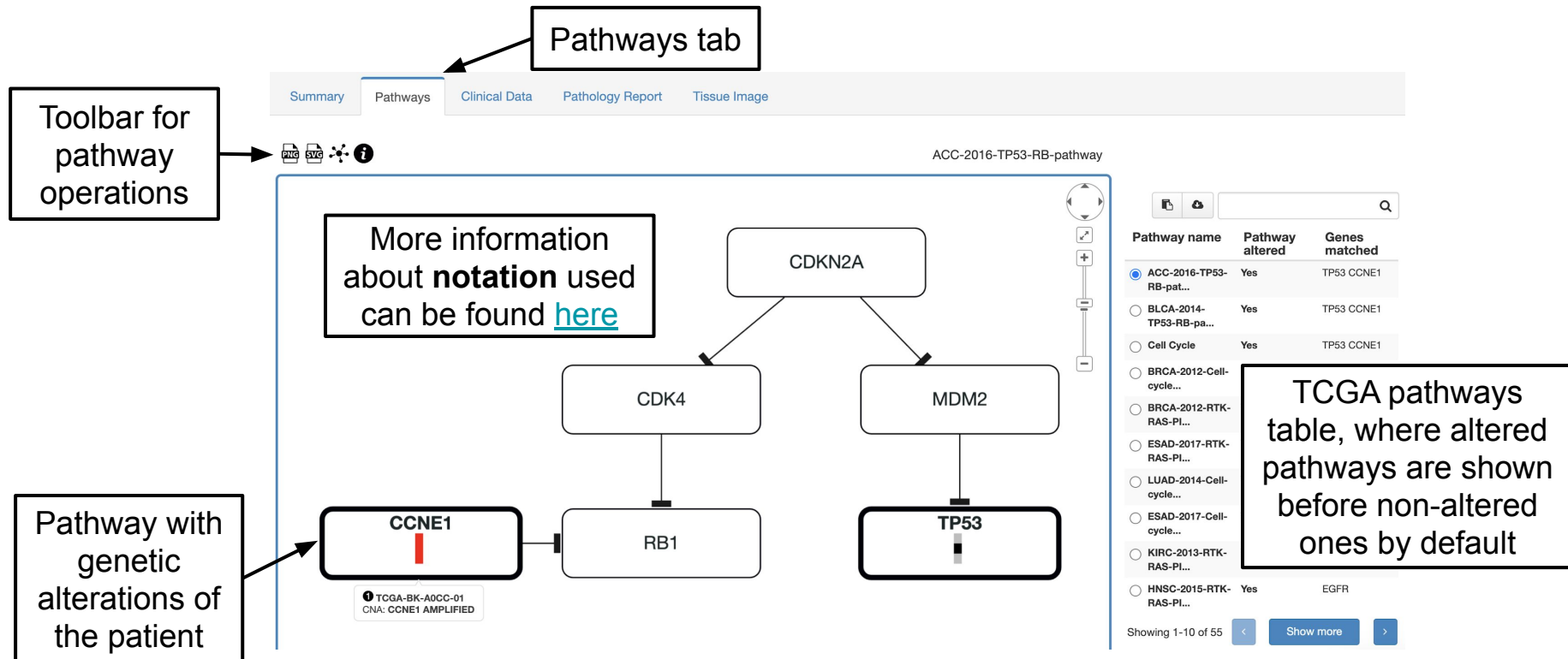
- Start with “Patient view of an endometrial cancer case (TCGA, Nature 2013)” as an example

Patient: [TCGA-BK-A0CC](#), Female, 69 years old, Endometrial Cancer (Uterine Serous Carcinoma/Uterine Papillary Serous Carcinoma),  
[LIVING](#) (10 months), [DiseaseFree](#) (10 months)  
Samples: ① [TCGA-BK-A0CC-01](#), Primary, Stage III

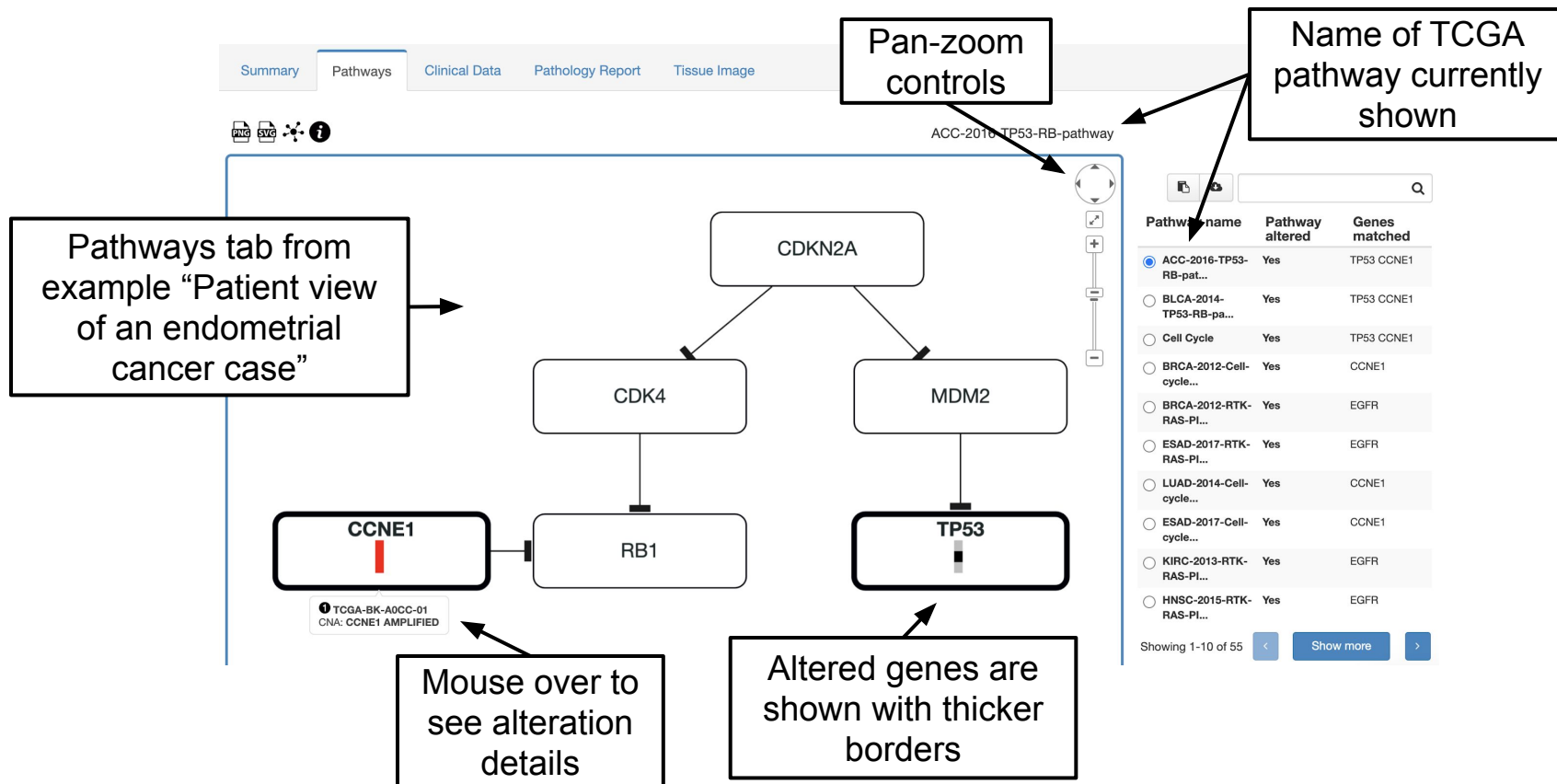
[Uterine Corpus Endometrial Carcinoma \(TCGA, Nature 2013\)](#)

Not sure how to get to patient view? Review [Tutorial #3: Patient View](#)

# Patient Pathways View

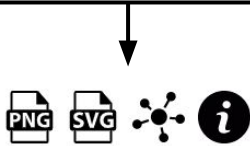


# Patient Pathways View



# Patient Pathways View

Buttons on the toolbar  
provide useful operations



Save current pathway as PNG



Save current pathway as SVG



Perform incremental layout, respecting current positions



Quick help with a link to [detailed documentation](#)

Pathways tabs in cBioPortal were built using a *viewer only edition* of [PathwayMapper](#), which in turn was based on [Cytoscape.js](#), a fully featured graph library in pure JavaScript.

Questions?

Check out our other tutorials  
or email us at:

[cbioportal@googlegroups.com](mailto:cbioportal@googlegroups.com)