THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Knowledge that will change your world

Pathway analysis with Metaboanalyst and KEGG

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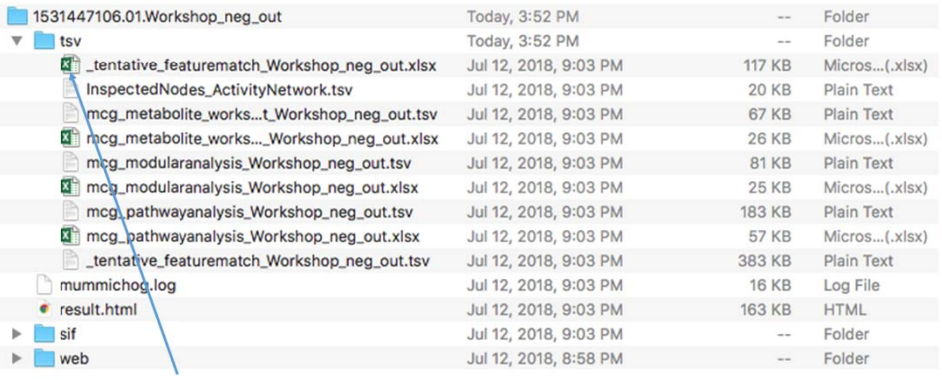
Targeted Metabolomics & Proteomics Laboratory

Files in mummichog results folder



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tsv	Today, 3:52 PM	--	Folder
_tentative_featurematch_Workshop_neg_out.xlsx	Jul 12, 2018, 9:03 PM	117 KB	Micros...(.xlsx)
InspectedNodes_ActivityNetwork.tsv	Jul 12, 2018, 9:03 PM	20 KB	Plain Text
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mummichog.log	Jul 12, 2018, 9:03 PM	16 KB	Log File
result.html	Jul 12, 2018, 9:03 PM	163 KB	HTML
sif	Jul 12, 2018, 9:03 PM	--	Folder
web	Jul 12, 2018, 8:58 PM	--	Folder

Open the file. It's on your thumb drive.

Identification of each observed ion

m/z	id	match_forr	mz_differe	name	pathway
73.0294	C00116	M-H2O-H[-	0	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
73.0294	C00163	M-H[-]	-0.0001	Propanoate	Bile acid biosynthesis$Propanoate metabolism
73.0294	C00207	M-H+O[-]	-0.0001	Acetone; D	Pyruvate Metabolism$Propanoate metabolism
73.0294	C00418	M-2H[2-]	-0.0001	(R)-Mevalo	Squalene and cholesterol biosynthesis
73.0294	C00424	M-H[-]	-0.0001	(S)-Lactalde	Pyruvate Metabolism
73.0294	C00479	M-H+O[-]	-0.0001		Tryptophan metabolism
73.0294	C00937	M-H[-]	-0.0001	(R)-Lactalde	Pyruvate Metabolism$Glycine, serine, alanine and threonine metabolism
73.0294	C05235	M-H[-]	-0.0001	Hydroxyace	Pyruvate Metabolism
73.0294	C05999	M-H[-]	-0.0001	Lactaldehyde; 2-Hydroxypropionaldehyde; 2-Hydroxypropanal	
75.0101	C00385	M-2H[2-]	0.0007	Xanthine	Purine metabolism
87.0456	C00246	M-H[-]	0.0005	Butanoic ac	Butanoate metabolism$Fatty acid activation
93.0353	C00116	M(S34)-H[-	-0.0005	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
93.0353	C00146	M-H[-]	0.0007	Phenol; Ber	Benzoate degradation via CoA ligation
93.0353	C04221	M-H2O-H[-	0.0008	trans-1,2-Dihydrobenzene-1,2-diol	
93.0353	C15584	M-H[-]	0.0007	Phenol	
93.0355	C00116	M(S34)-H[-	-0.0003	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
93.0355	C00146	M-H[-]	0.0009	Phenol; Ber	Benzoate degradation via CoA ligation
93.0355	C15584	M-H[-]	0.0009	Phenol	
93.0374	C00116	M(Cl37)-H[	0.0002	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
99.0079	C00042	M-H2O-H[-	-0.0008	Succinate; S	Valine, leucine and isoleucine degradation$Phytanic acid peroxisomal oxidation$Arginine and F
99.0079	C01036	M-2H[2-]	-0.0009	4-Maleylac	Tyrosine metabolism
99.0079	C01061	M-2H[2-]	-0.0009	4-Fumaryla	Tyrosine metabolism
99.0079	C02170	M-H2O-H[-	-0.0008	Methylmalo	Valine, leucine and isoleucine degradation
99.0079	C05985	M+HCOO[-	-0.0003	2-Propyn-1	Propanoate metabolism

Select and copy the KEGG IDs

m/z	id	match_forr	mz_differe	name	pathway
73.0294	C00116	M-H2O-H[-	0	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
73.0294	C00163	M-H[-]	-0.0001	Propanoate	Bile acid biosynthesis$Propanoate metabolism
73.0294	C00207	M-H+O[-]	-0.0001	Acetone; D	Pyruvate Metabolism$Propanoate metabolism
73.0294	C00418	M-2H[2-]	-0.0001	(R)-Mevalo	Squalene and cholesterol biosynthesis
73.0294	C00424	M-H[-]	-0.0001	(S)-Lactalde	Pyruvate Metabolism
73.0294	C00479	M-H+O[-]	-0.0001		Tryptophan metabolism
73.0294	C00937	M-H[-]	-0.0001	(R)-Lactalde	Pyruvate Metabolism$Glycine, serine, alanine and threonine metabolism
73.0294	C05235	M-H[-]	-0.0001	Hydroxyace	Pyruvate Metabolism
73.0294	C05999	M-H[-]	-0.0001	Lactaldehyde; 2-Hydroxypropionaldehyde; 2-Hydroxypropanal	
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93.0353	C00116	M(S34)-H[-	-0.0005	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
93.0353	C00146	M-H[-]	0.0007	Phenol; Ber	Benzoate degradation via CoA ligation
93.0353	C04221	M-H2O-H[-	0.0008	trans-1,2-Dihydrobenzene-1,2-diol	
93.0353	C15584	M-H[-]	0.0007	Phenol	
93.0355	C00116	M(S34)-H[-	-0.0003	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
93.0355	C00146	M-H[-]	0.0009	Phenol; Ber	Benzoate degradation via CoA ligation
93.0355	C15584	M-H[-]	0.0009	Phenol	
93.0374	C00116	M(Cl37)-H[	0.0002	Glycerol; G	Phosphatidylinositol phosphate metabolism$Galactose metabolism$Fatty Acid Metabolism$Si
99.0079	C00042	M-H2O-H[-	-0.0008	Succinate; S	Valine, leucine and isoleucine degradation$Phytanic acid peroxisomal oxidation$Arginine and
99.0079	C01036	M-2H[2-]	-0.0009	4-Maleylac	Tyrosine metabolism
99.0079	C01061	M-2H[2-]	-0.0009	4-Fumaryla	Tyrosine metabolism
99.0079	C02170	M-H2O-H[-	-0.0008	Methylmalo	Valine, leucine and isoleucine degradation
99.0079	C05985	M+HCOO[-	-0.0003	2-Propyn-1	Propanoate metabolism

Go to Metaboanalyst

MetaboAnalyst - statistical, functional and integrative analysis of metabolomics data

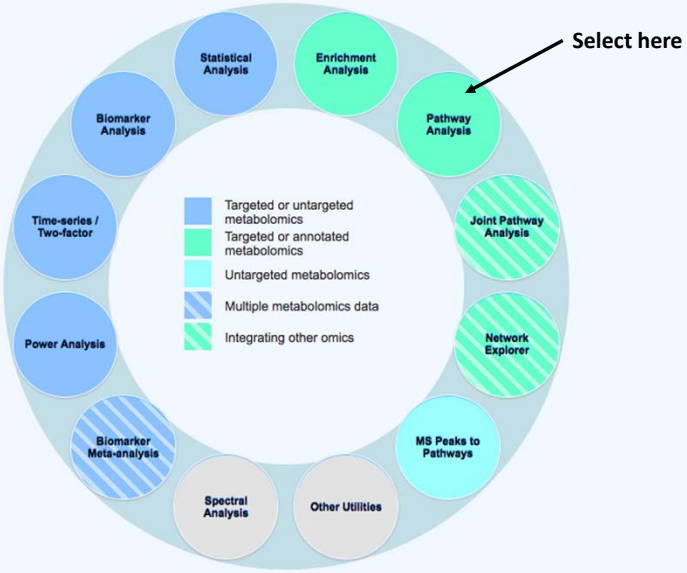
Welcome >> click here to start <<

News & Updates

- Check out our latest paper on MetaboAnalyst 4.0; NEW
- Check out our OmicsNet for **flexible creation & 3D visualization** of complex networks integrating metabolites, genes/proteins, miRNAs and transcription factors; NEW
- Fixed issue with name mapping in enrichment analysis (06/28/2018); NEW
- Fixed issue with pathway visualization (06/18/2018); NEW
- Enhanced pathway image generation to deal with concurrency issue (06/13/2018); NEW
- Fixed the issues for name mapping and node-click information in pathway visualization (06/12/2018); NEW
- Fixed the issue for data editor in biomarker analysis (05/28/2018); NEW
- Fixed the issue for sample hold-out analysis in biomarker analysis (04/23/2018); NEW
- Fixed the issue with time-series group ordering based on numeric values (04/19/2018); NEW
- Enhanced support for SVG export for KEGG global network (04/04/2018); NEW
- Check out our MicrobiomeAnalyst for comprehensive analysis of microbiome data;
- Release of MetaboAnalyst 4.0 together with a companion R package MetaboAnalystR. You can still access version 3.0 here (01/29/2018);

MetaboAnalyst - statistical, functional and integrative analysis of metabolomics data

Click a module to proceed, or **scroll down** for more details:



Please enter a one-column compound list:

iC00116
C00163
C00207
C00418
C00424
C00479
C00937
C05235
C05999
C00385
C00246
C00116
C00146
C04221
C15584
C00116

Input Type: KEGG ID

Use our example data

Submit

Transfer the KEGG IDs into the box, select the input type and submit

Listed metabolites

Compound Name/ID Standardization:

PLease note:

- Greek alphabets are not recognized, they should be replaced by English names (i.e. alpha, beta)
- Query names in normal white indicate exact match - marked by "1" in the download file;
- Query names highlighted indicate **no exact or unique match** - marked by "0" in the downloaded file;
- For **compound name**, you should click the **View** link to perform **approximate search** and manually select the correct match if found;
- For **KEGG ID**, it is possible to have multiple hits, you should click the **View** link to manually select the correct match if found;

Query	Hit	HMDB	PubChem	KEGG	Details
C00116	Glycerol	HMDB0000131	753	C00116	
C00163	Propionic acid	HMDB0000237	1032	C00163	
C00207	Acetone	HMDB0001659	180	C00207	
C00418	Mevalonic acid	HMDB0000227	449	C00418	
C00424	Lactaldehyde	HMDB0003052	439231	C00424	
C00479	Propanal	HMDB0003366	527	C00479	
C00937	D-Lactaldehyde	HMDB0006458	439350	C00937	
C05235	Hydroxyacetone	HMDB0006961	8299	C05235	
C05999		-	-	-	View
C00385	Xanthine	HMDB0000292	1188	C00385	
C00246	Butyric acid	HMDB0000039	264	C00246	
C00116	Glycerol	HMDB0000131	753	C00116	
C00146	Phenol	HMDB0000228	996	C00146	
C04221	trans-1,2-Dihydrobenzene-1,2-diol	HMDB0001164	149186	C04221	

No records?

Query name: CE0520

	Matched Name	HMDB	PubChem	KEGG
No records found.				

OK Cancel

Search unknown on KEGG to identify metabolite

Proceed to bottom of the table

C00016	FAD	HMDB0001248	643975	C00016
C00016	FAD	HMDB0001248	643975	C00016
C01352	FADH	HMDB0001197	446013	C01352

You can download the result here

Submit

Choose a species

Please select a pathway library:

Mammals	Homo sapiens (human) [80]
	Mus musculus (mouse) [82]
	Rattus norvegicus (rat) [81]
	Bos taurus (cow) [81]
Birds	Gallus gallus (chicken) [78]
Fish	Danio rerio (zebrafish) [81]
Insects	Drosophila melanogaster (fruit fly) [79]
Nematodes	Caenorhabditis elegans (nematode) [78]
Fungi	Saccharomyces cerevisiae (yeast) [65]
Plants	Oryza sativa japonica (Japanese rice) [83]
	Arabidopsis thaliana (thale cress) [87]
Parasites	Schistosoma mansoni [69]
	Plasmodium falciparum 3D7 (Malaria) [47]
	Trypanosoma brucei [54]
Prokaryotes	Escherichia coli K-12 MG1655 [87]
	Bacillus subtilis [80]
	Pseudomonas putida KT2440 [89]
	Staphylococcus aureus N315 (MRSA/VSSA) [73]
	Thermotoga maritima [57]
	Synechococcus elongatus PCC7942 [75]
	Mesorhizobium loti [86]

Statistical analysis selection

Please specify pathway analysis algorithms:

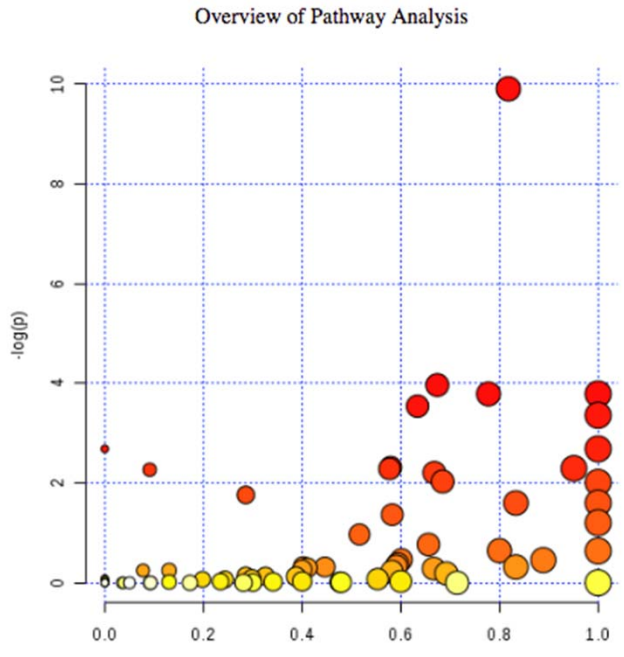
Over Representation Analysis	(•) Hypergeometric Test ( ) Fisher's Exact Test
Pathway Topology Analysis	(•) Relative-betweeness Centrality ( ) Out-degree Centrality

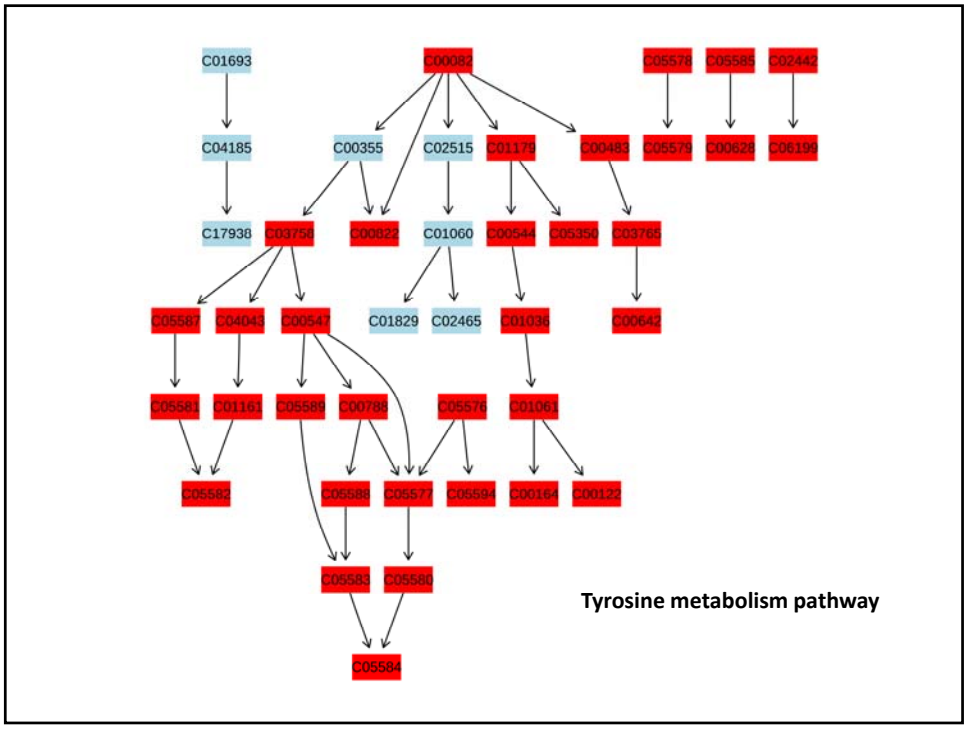
Please specify a reference metabolome:

(•) Use all compounds in the selected pathways

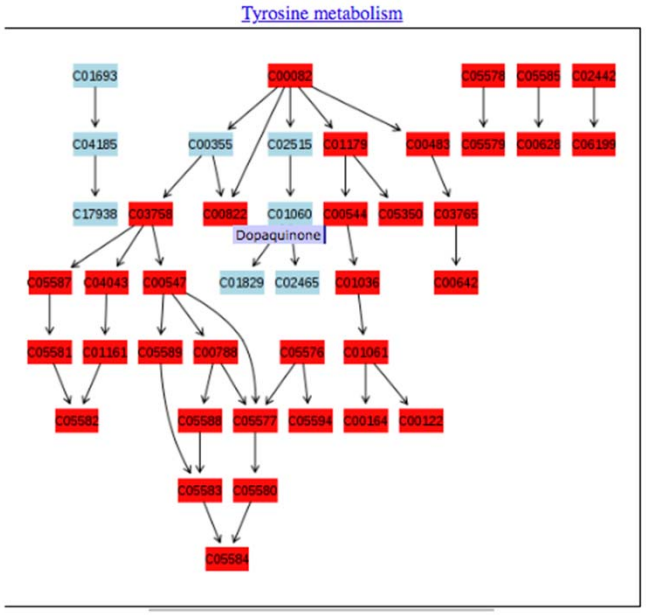
( ) Upload a reference metabolome based on your technical platform

Submit





Move the mouse over the red box to reveal the metabolite



Summary table

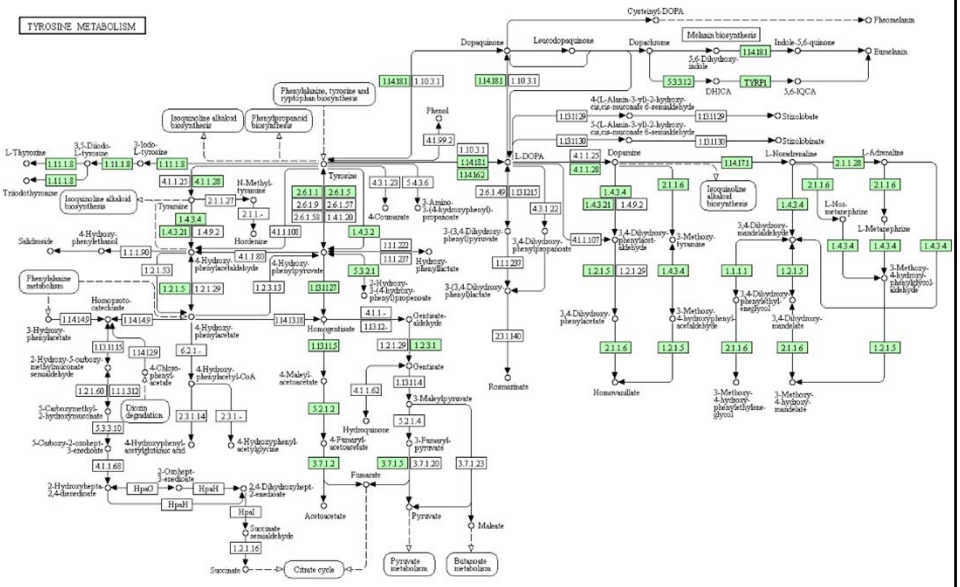
Pathway Name	Match Status	p	-log(p)	Holm p	FDR	Impact	Details
Tyrosine metabolism	34/42	4.9719E-5	9.9091	0.0040272	0.0040272	0.81825	KEGG
Arachidonic acid metabolism	25/36	0.018939	3.9665	1.0	0.45836	0.67402	KEGG
Phenylalanine metabolism	8/9	0.022635	3.7882	1.0	0.45836	0.77778	KEGG
One carbon pool by folate	8/9	0.022635	3.7882	1.0	0.45836	1.0	KEGG
Steroid hormone biosynthesis	44/70	0.028935	3.5427	1.0	0.46875	0.63389	KEGG
D-Glutamine and D-glutamate metabolism	5/5	0.034745	3.3597	1.0	0.46905	1.0	KEGG
D-Arginine and D-ornithine metabolism	4/4	0.068125	2.6864	1.0	0.6852	0.0	KEGG
Phenylalanine, tyrosine and tryptophan biosynthesis	4/4	0.068125	2.6864	1.0	0.6852	1.0	KEGG
Pentose phosphate pathway	13/19	0.098427	2.3184	1.0	0.6852	0.57963	KEGG
Vitamin B6 metabolism	7/9	0.10086	2.294	1.0	0.6852	0.95098	KEGG
Galactose metabolism	17/26	0.10173	2.2854	1.0	0.6852	0.57712	KEGG
Pentose and glucuronate interconversions	10/14	0.10339	2.2693	1.0	0.6852	0.09091	KEGG
Arginine and proline metabolism	27/44	0.10997	2.2075	1.0	0.6852	0.66803	KEGG
Tryptophan metabolism	25/41	0.13119	2.0311	1.0	0.72081	0.68487	KEGG
Ubiquinone and other terpenoid-quinone biosynthesis	3/3	0.13348	2.0138	1.0	0.72081	1.0	KEGG
Pantothenate and CoA biosynthesis	10/15	0.17143	1.7636	1.0	0.86788	0.28571	KEGG
Biotin metabolism	4/5	0.20165	1.6012	1.0	0.9074	0.83334	KEGG
Linoleic acid metabolism	4/5	0.20165	1.6012	1.0	0.9074	1.0	KEGG
Folate biosynthesis	10/16	0.25483	1.3671	1.0	1.0	0.58261	KEGG
Valine, leucine and isoleucine biosynthesis	7/11	0.29998	1.204	1.0	1.0	0.99999	KEGG

Click on matched metabolites in the table

Matched metabolites:

Pathway	Metabolites
Tyrosine metabolism	L-Dopachrome; **Normetanephrine**; **3-Methoxy-4-hydroxyphenylglycolaldehyde**; **Norepinephrine**; **Epinephrine**; **3,4-Dihydroxymandelate**; **3,4-Dihydroxymandelaldehyde**; **3,4-Dihydroxyphenylglycol**; **Metanephrine**; **Dopamine**; **3,4-Dihydroxyphenylacetaldehyde**; **3,4-Dihydroxybenzeneacetic acid**; **Homovanillin**; **3-Methoxytyramine**; L-Dopa; 3,5-Diiodo-L-tyrosine; Iodotyrosine; **L-Tyrosine**; **4-Fumarylacetoacetic acid**; **Maleylacetoacetic acid**; **Homogentisic acid**; **4-Hydroxyphenylpyruvic acid**; **4-Hydroxyphenylacetaldehyde**; **Tyramine**; **5,6-Dihydroxyindole**; **Gentisate aldehyde**; **N-Methyltyramine**; 5,6-Dihydroxyindole-2-carboxylic acid; **Vanillylmandelic acid**; **Vanylglycol**; **Homovanillic acid**; Liothyronine; **Fumaric acid**; **Acetoacetic acid**; **2-Hydroxy-3-(4-hydroxyphenyl)propenoic acid**; **p-Hydroxyphenylacetic acid**; **Indole-5,6-quinone**; **Dopaquinone**; Thyroxine; **Gentisic acid**; **Hordenine**; 5,6-Indolequinone-2-carboxylic acid

Click on KEGG (right side of table)

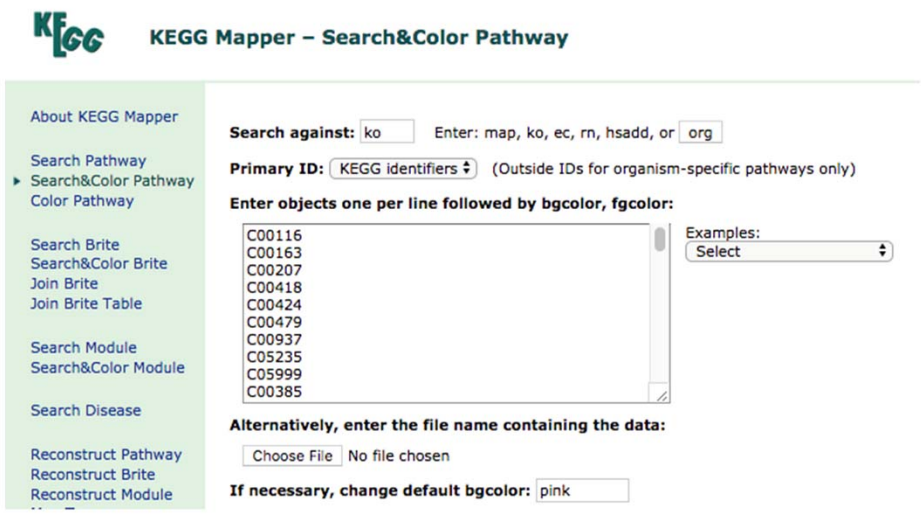


Pathway mapping with KEGG

- KEGG, Kyoto Encyclopedia of Genes and Genomes
- A comprehensive resource of genes, proteins and metabolites
- Has a Pathway tool

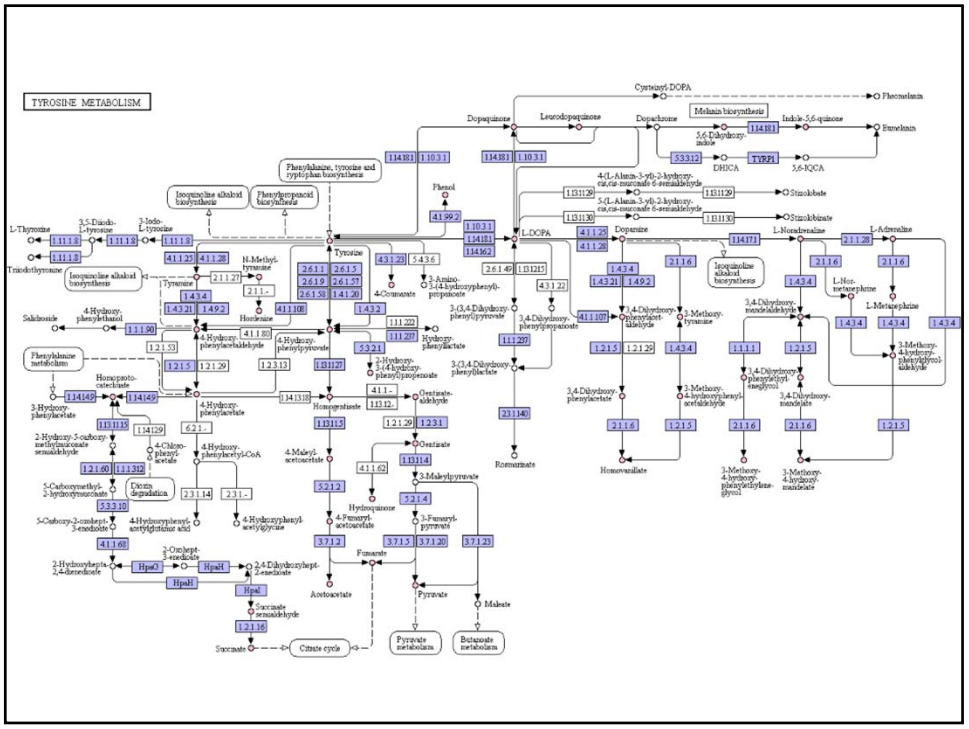
- https://www.genome.jp/kegg/tool/map_pathway2.html

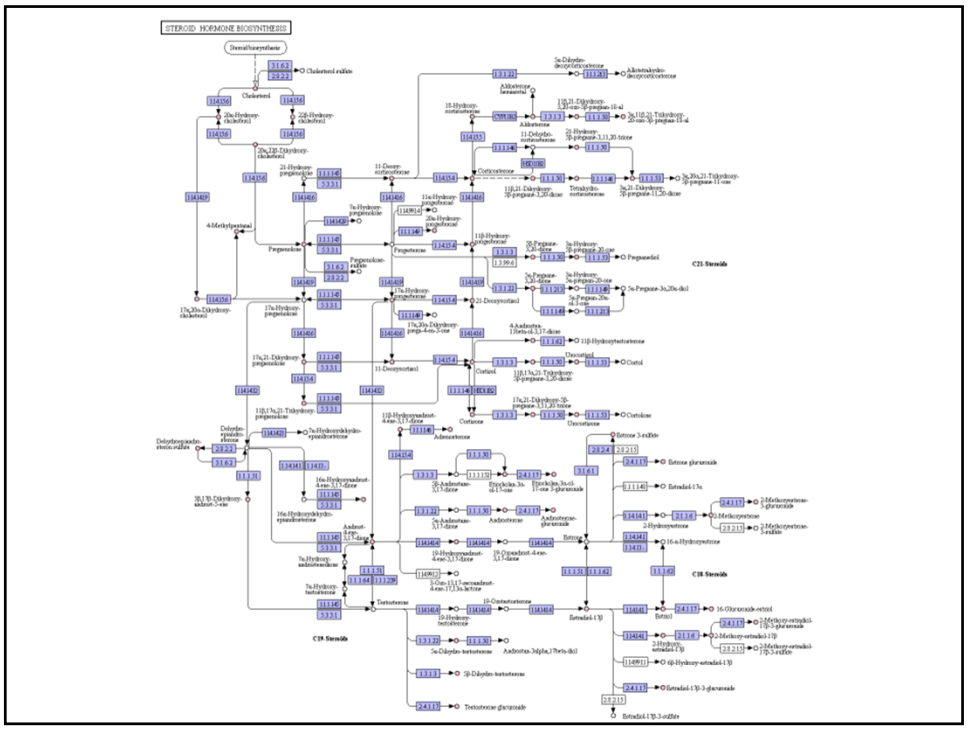
Enter the KEGG IDs into the box



Press the "Exec" button below the table

These are the IDs that weren't recognized


TYROSINE METABOLISM
Cysteinyl-DOPA
Pheomelanin
Dopaquinone
Leucodopaquinone
Dopachrome
Melanin biosynthesis
Indole-5,6-quinone
Eumelanin
5,6-Dihydroxy-indole
DHICA
TYRP1
5,6-IQCA
Phenylalanine, tyrosine and tryptophan biosynthesis
Isoquinoline alkaloid biosynthesis
Phenylpropanoid biosynthesis
Phenol
4-(L-Alanin-3-yl)-2-hydroxy-cis,cis-muconate 6-semialdehyde
5-(L-Alanin-3-yl)-2-hydroxy-cis,cis-muconate 6-semialdehyde
Stizolobate
Stizolobinate
L-Thyronine
3,5-Diiodo-L-tyrosine
3-Iodo-L-tyrosine
Triiodothyronine
Tyramine
N-Methyl-tyramine
Tyrosine
4-Coumarate
3-Amino-3-(4-hydroxyphenyl)-propanoate
L-DOPA
Dopamine
L-Noradrenaline
L-Adrenaline
Isoquinoline alkaloid biosynthesis
L-Normetanephrine
L-Metanephrine
Salidroside
4-Hydroxy-phenylethanol
Hordenine
4-Hydroxy-phenylacetaldehyde
4-Hydroxy-phenylpyruvate
Hydroxy-phenyllactate
3-(3,4-Dihydroxy-phenyl)pyruvate
3-(3,4-Dihydroxy-phenyl)lactate
3,4-Dihydroxy-phenylpropanoate
1,4-Dihydroxy-2-naphthoate-aldehyde
5-Methoxy-tyrosine
3,4-Dihydroxy-mandelaldehyde
3,4-Dihydroxy-mandelate
3-Methoxy-4-hydroxy-phenylethylene-glycol
3-Methoxy-4-hydroxy-mandelate
3-Methoxy-4-hydroxy-phenylglycol-aldehyde
Phenylalanine metabolism
Homogento-catechisate
3-Hydroxy-phenylacetate
4-Hydroxy-phenylacetate
Homogentisate
Oxepinate-aldehyde
Oxepinate
3,4-Dihydroxy-phenylacetate
3-Methoxy-4-hydroxy-phenylacetaldehyde
Homovanillate
2-Hydroxy-5-carboxy-methylmuconate semialdehyde
4-Chloro-phenyl-acetate
4-Hydroxy-phenylacetyl-CoA
4-Maleyl-acetoacetate
3-Maleylpyruvate
Hydroquinone
4-Fumaryl-acetoacetate
3-Fumaryl-pyruvate
Fumarate
Roxemurate
5-Carboxymethyl-2-hydroxymuconate
Dioxin degradation
4-Hydroxyphenyl-acetylglycine
5-Carboxy-2-oxohept-3-enedioate
4-Hydroxyphenyl acetylglutamic acid
2-Oxohept-3-enedioate
2-Hydroxyhepta-2,4-dienedioate
2,4-Dihydroxyhept-2-enedioate
Acetoacetate
Pyruvate
Malesate
Succinate semialdehyde
Succinate
Citrate cycle
Pyruvate metabolism
Butanoate metabolism


STEROID HORMONE BIOSYNTHESIS
Cholesterol
Pregnenolone
Progesterone
Androstenedione
Testosterone
Estrone
Estradiol
C21-Steroids
C19-Steroids
C18-Steroids

Questions?