Metabolomic Data Analysis with MetaboAnalyst 3.0

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1 Background

MESA or Metabolite Set Enrichment Analysis is a way to identify biologically meaningful patterns that are significantly enriched in quantitative metabolomic data. In conventional approaches, metabolites are evaluated individually for their significance under conditions of study. Those compounds that have passed certain sigificance level are then combined to see if any meaningful patterns can be discerned. In contrast, MSEA directly investigates if a set of functionally related metabolites without the need to preselect compounds based on some arbituary cut-off threshold. It has the potentail to identify subtle but consistent changes among a group of related compounds, which may go undetected with the conventional approaches.

Essentially, MSEA is a metabolomic version of the popular GSEA (Gene Set Enrichment Analysis) software with its own collection of metabolite set libraries as well as an implementation of user-friendly web-interfaces. GSEA is widely used in genomics data analysis and has proven to be a powerful alternative to conventional approaches. For more information, please refer to the original paper by Subramanian A, and a nice review paper by Nam D, Kim SY.

2 MSEA Overview

Metabolite set enrichment analysis consists of four steps - data input, data processing, data analysis, and results download. Different analysis procedures are performed based on different input types. In addition, users can also browse and search the metabolite set libraries as well as upload their self-defined metabolite sets for enrichment analysis. Users can also perform metabolite name mapping between a variety of compound names, synonyms, and major database identifiers.

3 Data Input

There are three enrichment analysis algorithms offered by MSEA. Accordingly, three different types of data inputs are required by these three approaches:

- A list of important compound names - entered as a one column data (*Over Representation Analysis (ORA)*);
- A single measured biofluid (urine, blood, CSF) sample- entered as tab separated two-column data with the first column for compound name, and the second for concentration values (*Single Sample Profiling (SSP)*);
- A compound concentration table - entered as a comma separated (.csv) file with the each sample per row and each metabolite concentration per column. The first column is sample names and the second column for sample phenotype labels (*Quantitative Enrichment Analysis (QEA)*)

You selected Quantitative Enrichment Analysis (QEA) which requires a concentration table. This is the most common data format generated from quantitative metabolomcs studies. The phenotype label can be can be discrete (binary or multi-class) or continuous.

4 Data Process

The first step is to standardize the compound labels. It is an essential step since the compound labels will be subsequently compared with compounds contained in the metabolite set library. MSEA has a built-in tool to convert between compound common names, synonyms, identifiers used in HMDB ID, PubChem, ChEBI, BiGG, METLIN, KEGG, or Reactome. **Table 1** shows the conversion results. Note: *1* indicates exact match, *2* indicates approximate match, and *0* indicates no match. A text file contain the result can be found the downloaded file *name_map.csv*

Table 1: Result from Compound Name Mapping

	Query	Match
1	1,2-dilinoleoyl-GPC	NA
2	1,2-dioleoyl-GPC	NA
3	1,2-dioleoyl-GPE	NA
4	1,2-dipalmitoyl-GPC	NA
5	1,2-distearoyl-GPC	NA
6	1,5-anhydroglucitol	1,5-Anhydrosorbitol
7	1-(1-enyl-oleoyl)-GPE	NA
8	1-(1-enyl-palmitoyl)-2-arachidonoyl-GPC	NA
9	1-(1-enyl-palmitoyl)-2-arachidonoyl-GPE	NA
10	1-(1-enyl-palmitoyl)-2-linoleoyl-GPC	NA
11	1-(1-enyl-palmitoyl)-2-linoleoyl-GPE	NA
12	1-(1-enyl-palmitoyl)-2-oleoyl-GPC	NA
13	1-(1-enyl-palmitoyl)-2-oleoyl-GPE	NA
14	1-(1-enyl-palmitoyl)-2-palmitoleoyl-GPC	NA
15	1-(1-enyl-palmitoyl)-2-palmitoyl-GPC	NA
16	1-(1-enyl-palmitoyl)-GPC	NA
17	1-(1-enyl-palmitoyl)-GPE	NA
18	1-(1-enyl-stearoyl)-2-arachidonoyl-GPE	NA
19	1-(1-enyl-stearoyl)-2-linoleoyl-GPE	NA
20	1-(1-enyl-stearoyl)-2-oleoyl-GPE	NA
21	1-(1-enyl-stearoyl)-GPE	NA
22	1-(3-aminopropyl)-2-pyrrolidone	NA
23	1-arachidonoyl-GPC	NA
24	1-arachidonoyl-GPE	NA
25	1-arachidonoyl-GPI	NA
26	1-lignoceroyl-GPC	NA
27	1-linolenoyl-GPC	NA
28	1-linoleoyl-2-arachidonoyl-GPC	NA
29	1-linoleoyl-GPC	NA
30	1-linoleoyl-GPE	NA
31	1-linoleoyl-GPI	NA
32	1-linoleoylglycerol	NA
33	1-methylguanidine	Methylguanidine
34	1-methylhistidine	1-Methylhistidine
35	1-methylimidazoleacetate	NA
36	1-methylnicotinamide	1-Methylnicotinamide
37	1-oleoyl-2-linoleoyl-glycerol	NA
38	1-oleoyl-2-linoleoyl-GPC	NA
39	1-oleoyl-2-linoleoyl-GPE	NA
40	1-oleoyl-3-linoleoyl-glycerol	NA
41	1-oleoyl-GPC	NA
42	1-oleoyl-GPE	NA
43	1-oleoyl-GPI	NA
44	1-oleoyl-GPS	NA
45	1-oleoylglycerol	NA
46	1-palmitoleoyl-2-linoleoyl-GPC	NA
47	1-palmitoleoyl-2-oleoyl-glycerol	NA
48	1-palmitoleoyl-3-oleoyl-glycerol	NA
49	1-palmitoleoyl-GPC	NA
50	1-palmitoleoylglycerol	NA
51	1-palmitoyl-2-arachidonoyl-GPC	NA
52	1-palmitoyl-2-arachidonoyl-GPE	NA
53	1-palmitoyl-2-linoleoyl-glycerol	NA
54	1-palmitoyl-2-linoleoyl-GPC	NA
55	1-palmitoyl-2-linoleoyl-GPE	NA
56	1-palmitoyl-2-oleoyl-GPC	NA
57	1-palmitoyl-2-oleoyl-GPE	NA
58	1-palmitoyl-2-oleoyl-GPG	NA
59	1-palmitoyl-2-palmitoleoyl-GPC	NA
60	1-palmitoyl-2-stearoyl-GPC	NA
61	1-palmitoyl-3-linoleoyl-glycerol	NA
62	1-palmitoyl-GPC	NA

63	1-palmitoyl-GPE	NA
64	1-palmitoyl-GPG	NA
65	1-palmitoyl-GPI	NA
66	1-stearoyl-2-arachidonoyl-GPC	NA
67	1-stearoyl-2-arachidonoyl-GPE	NA
68	1-stearoyl-2-arachidonoyl-GPI	NA
69	1-stearoyl-2-arachidonoyl-GPS	NA
70	1-stearoyl-2-linoleoyl-GPC	NA
71	1-stearoyl-2-linoleoyl-GPE	NA
72	1-stearoyl-2-oleoyl-GPC	NA
73	1-stearoyl-2-oleoyl-GPE	NA
74	1-stearoyl-2-oleoyl-GPS	NA
75	1-stearoyl-GPC	NA
76	1-stearoyl-GPE	NA
77	1-stearoyl-GPI	NA
78	1-stearoyl-GPS	NA
79	10-heptadecenoate	NA
80	10-nonadecenoate	NA
81	12,13-DiHOME	12,13-DHOME
82	12-HETE	12-HETE
83	15-HETE	15(S)-HETE
84	15-methylpalmitate	NA
85	16-hydroxypalmitate	NA
86	17-methylstearate	NA
87	2'-deoxycytidine	Deoxycytidine
88	2'-deoxyguanosine	Deoxyguanosine
89	2'-deoxyinosine	Deoxyinosine
90	2'-deoxyuridine	Deoxyuridine
91	2-aminoadipate	Aminoadipic acid
92	2-aminoheptanoate	NA
93	2-aminooctanoate	DL-2-Aminooctanoic acid
94	2-hydroxy-3-methylvalerate	2-Hydroxy-3-methylpentanoic acid
95	2-hydroxyadipate	2-Hydroxyadipic acid
96	2-hydroxybutyrate/2-hydroxyisobutyrate	NA
97	2-hydroxyglutarate	2-Hydroxyglutarate
98	2-hydroxystearate	NA
99	2-linoleoylglycerol	NA
100	2-methylbutyrylcarnitine	NA
101	2-methylbutyrylglycine	2-Methylbutyrylglycine
102	2-methylcitrate/homocitrate	NA
103	2-methylmalonyl carnitine	NA
104	2-oleoylglycerol	NA
105	2-palmitoleoyl-GPC	NA
106	2-palmitoyl-GPC	NA
107	2-stearoyl-GPE	NA
108	3-(4-hydroxyphenyl)lactate	3-(4-Hydroxyphenyl)lactate
109	3-aminoisobutyrate	3-Aminoisobutanoic acid
110	3-hydroxy-3-methylglutarate	3-Hydroxymethylglutaric acid
111	3-hydroxybutyrate	3-Hydroxybutyric acid
112	3-hydroxybutyrylcarnitine	NA
113	3-hydroxyisobutyrate	(S)-3-Hydroxyisobutyric acid
114	3-indoxyl	NA
115	3-methylcytidine	NA
116	3-methylhistidine	3-Methylhistidine
117	3-phosphoglycerate	3-Phosphoglyceric acid
118	3-ureidopropionate	Ureidopropionic acid
119	4-cholesten-3-one	Cholestenone
120	4-ethylphenylsulfate	NA
121	4-guanidinobutanoate	4-Guanidinobutanoic acid
122	4-hydroxy-nonenal-glutathione	NA
123	4-hydroxybutyrate	4-Hydroxybutyric acid
124	4-imidazoleacetate	Imidazoleacetic acid
125	4-vinylphenol sulfate	NA
126	5-aminovalerate	5-Aminopentanoic acid
127	5-dodecenoate	5-Dodecenoic acid
128	5-hydroxylysine	5-Hydroxylysine
129	5-methylthioadenosine	5'-Methylthioadenosine
130	5-oxoproline	Pyroglutamic acid
131	6-oxopiperidine-2-carboxylic acid	NA
132	6-phosphogluconate	6-Phosphogluconic acid
133	7-hydroxycholesterol	7b-Hydroxycholesterol
134	7-methylguanine	7-Methylguanine
135	9,10-DiHOME	9,10-DHOME
136	acetylcarnitine	L-Acetylcarnitine
137	acetylphosphate	Acetylphosphate
138	aconitate	NA
139	adenine	Adenine
140	adenosine	Adenosine
141	adenosine 2'-monophosphate	NA
142	adenosine 3',5'-diphosphate	Adenosine 3',5'-diphosphate
143	adenosine 3'-monophosphate	NA
144	adenosine 5'-diphosphoribose	Adenosine diphosphate ribose
145	adenosine 5'-monophosphate	Adenosine monophosphate
146	adrenate	Adrenic acid
147	alanine	Alanine
148	allantoin	Allantoin
149	alpha-hydroxyisocaproate	Leucinic acid

150	alpha-hydroxyisovalerate	2-Hydroxy-3-methylbutyric acid
151	alpha-ketoglutarate	NA
152	alpha-tocopherol	Alpha-Tocopherol
153	anserine	Anserine
154	arabitol/xylitol	NA
155	arabonate/xylonate	NA
156	arachidate	Arachidic acid
157	arachidonate	NA
158	arachidonoyl ethanolamide	NA
159	arginine	L-Arginine
160	argininosuccinate	Argininosuccinic acid
161	ascorbate	Ascorbic acid
162	asparagine	L-Asparagine
163	aspartate	L-Aspartic acid
164	azelate	Azelaic acid
165	behenoyl sphingomyelin	NA
166	beta-alanine	Beta-Alanine
167	beta-guanidinopropanoate	NA
168	beta-hydroxyisovaleroylcarnitine	NA
169	beta-muricholate	NA
170	betaine	Betaine
171	betaine aldehyde	Betaine aldehyde
172	butyrylcarnitine	Butyrylcarnitine
173	C-glycosyltryptophan	NA
174	campesterol	Campesterol
175	carboxyethyl-GABA	N-Carboxyethyl-g-aminobutyric acid
176	carnitine	Carnitine
177	carnosine	Carnosine
178	catechol sulfate	NA
179	cholesterol	Cholesterol
180	choline	Choline
181	choline phosphate	Phosphorylcholine
182	citrate	Citric acid
183	citrulline	Citrulline
184	corticosterone	Corticosterone
185	creatine	Creatine
186	creatine phosphate	Phosphocreatine
187	creatinine	Creatinine
188	cystathionine	L-Cystathionine
189	cysteine	Cysteine
190	cysteine s-sulfate	NA
191	cysteine sulfinic acid	3-Sulfinoalanine
192	cystine	L-Cystine
193	cytidine	Cytidine
194	cytidine 3'-monophosphate	NA
195	cytidine 5'-diphosphocholine	Citicoline
196	cytidine 5'-monophosphate	Cytidine monophosphate
197	cytidine 5'-monophospho-N-acetylneuraminic acid	NA
198	cytidine-5'-diphosphoethanolamine	NA
199	cytosine	Cytosine
200	decanoylcarnitine	Decanoylcarnitine
201	dehydroascorbate	Dehydroascorbate
202	deoxycarnitine	4-Trimethylammoniobutanoic acid
203	dihomo-linoleate	NA
204	dihomo-linolenate	NA
205	dihydoxyphenylalanine	NA
206	dihydroxyacetone	Dihydroxyacetone
207	dimethyl	NA
208	dimethylarginine	NA
209	dimethylglycine	Dimethylglycine
210	docosadienoate	NA
211	docosahexaenoate	Docosahexaenoic acid
212	docosapentaenoate	Docosapentaenoic acid
213	dopamine sulfate	NA
214	eicosapentaenoate	Eicosapentaenoic acid
215	eicosenoate	Eicosenoic acid
216	equol sulfate	NA
217	ergothioneine	Ergothioneine
218	erucate	NA
219	erythronate*	NA
220	ethylmalonate	Ethylmalonic acid
221	flavin adenine dinucleotide	FAD
222	fructose	D-Fructose
223	fumarate	Fumaric acid
224	galactitol	Galactitol
225	galactonate	Galactonic acid
226	gamma-aminobutyrate	Gamma-Aminobutyric acid
227	gamma-carboxyglutamate	NA
228	gamma-glutamyl-epsilon-lysine	NA
229	gamma-glutamylalanine	5-L-Glutamyl-L-alanine
230	gamma-glutamylglutamate	Gamma Glutamylglutamic acid
231	gamma-glutamylglutamine	Gamma-Glutamyl Glutamine
232	gamma-glutamylglycine	NA
233	gamma-glutamylhistidine	NA
234	gamma-glutamylisoleucine*	NA
235	gamma-glutamylleucine	L-gamma-glutamyl-L-leucine
236	gamma-glutamylphenylalanine	Glutamylphenylalanine

237	gamma-glutamylvaline	L-gamma-glutamyl-L-valine
238	gamma-tocopherol/beta-tocopherol	NA
239	gluconate	Gluconic acid
240	glucose	D-Glucose
241	glucuronate	D-Glucuronic acid
242	glutamate	D-Glutamic acid
243	glutamate, gamma-methyl ester	NA
244	glutamine	L-Glutamine
245	glutarate	Glutaric acid
246	glutarylcarnitine	Glutarylcarnitine
247	glutathione, oxidized (GSSG)	NA
248	glutathione, reduced (GSH)	NA
249	glycerate	Glyceric acid
250	glycerol	Glycerol
251	glycerol 3-phosphate	Glycerol 3-phosphate
252	glycerophosphoethanolamine	Glycerylphosphorylethanolamine
253	glycerophosphoglycerol	NA
254	glycerophosphoinositol*	NA
255	glycerophosphorylcholine	Glycerophosphocholine
256	glycine	Glycine
257	glycosyl-N-palmitoyl-sphingosine	NA
258	glycosyl-N-stearoyl-sphingosine	NA
259	glycylleucine	Glycyl-L-leucine
260	glycylvaline	NA
261	guanidinoacetate	Guanidoacetic acid
262	guanidinosuccinate	Guanidinosuccinic acid
263	guanine	Guanine
264	guanosine	Guanosine
265	guanosine 5'- monophosphate	NA
266	gulonic acid*	NA
267	heme	Heme
268	hexadecanedioate	Hexadecanedioic acid
269	hexanoylcarnitine	Hexanoylcarnitine
270	hexanoylglycine	Hexanoylglycine
271	hippurate	Hippuric acid
272	histamine	Histamine
273	histidine	L-Histidine
274	homoarginine	Homo-L-arginine
275	homocitrulline	Homocitrulline
276	homostachydrine*	NA
277	hypotaurine	Hypotaurine
278	hypoxanthine	Hypoxanthine
279	imidazole lactate	Imidazole lactate
280	imidazole propionate	NA
281	indolelactate	Indolelactic acid
282	inosine	Inosine
283	inosine 5'-monophosphate (IMP)	NA
284	Isobar: fructose 1,6-diphosphate, glucose 1,6-diphosphate, myo-inositol 1,4 or 1,3-diphosphate	NA
285	isobutyrylcarnitine	NA
286	isocitrate	Isocitric acid
287	isoleucine	(+/-)-erythro-Isoleucine
288	isoleucylglycine	NA
289	isovalerylcarnitine	Isovalerylcarnitine
290	isovalerylglycine	Isovalerylglycine
291	kynurenate	Kynurenic acid
292	kynurenine	L-Kynurenine
293	lactate	L-Lactic acid
294	laurylcarnitine	NA
295	leucine	L-Leucine
296	leucylglycine	NA
297	linoleate	Linoleic acid
298	linolenate	Alpha-Linolenic acid
299	linoleoylcarnitine*	NA
300	lysine	L-Lysine
301	malate	NA
302	malonylcarnitine	Malonylcarnitine
303	maltose	D-Maltose
304	maltotriose	Maltotriose
305	mannitol/sorbitol	NA
306	mannose	D-Mannose
307	margarate	Heptadecanoic acid
308	mead acid	5,8,11-Eicosatrienoic acid
309	methionine	NA
310	methionine sulfoxide	Methionine sulfoxide
311	methyl glucopyranoside	NA
312	methylmalonate	Methylmalonic acid
313	methylphosphate	NA
314	methylsuccinate	Methylsuccinic acid
315	myo-inositol	Myoinositol
316	myristate	Myristic acid
317	myristoleate	Myristoleic acid
318	myristoylcarnitine	Tetradecanoylcarnitine
319	N-acetyl-aspartyl-glutamate	NA
320	N-acetyl-beta-alanine	N-Acetyl-beta-alanine
321	N-acetyl-glucosamine 1-phosphate	N-Acetyl-glucosamine 1-phosphate
322	N-acetylalanine	N-Acetyl-L-alanine
323	N-acetylarginine	NA

324	N-acetylasparagine	N-Acetylasparagine
325	N-acetylaspartate	N-Acetyl-L-aspartic acid
326	N-acetylglucosamine 6-phosphate	N-Acetylglucosamine 6-phosphate
327	N-acetylglutamate	N-Acetylglutamic acid
328	N-acetylglutamine	N-Acetylglutamine
329	N-acetylglycine	Acetylglycine
330	N-acetylhistidine	N-Acetylhistidine
331	N-acetylleucine	N-Acetylleucine
332	N-acetylmethionine	N-Acetyl-L-methionine
333	N-acetylneuraminate	NA
334	N-acetylphenylalanine	N-Acetyl-L-phenylalanine
335	N-acetylputrescine	N-Acetylputrescine
336	N-acetylserine	N-Acetylserine
337	N-acetyltaurine	NA
338	N-acetylthreonine	NA
339	N-alpha-acetylornithine	NA
340	N-carbamoylaspartate	Ureidosuccinic acid
341	N-delta-acetylornithine	NA
342	N-formylmethionine	NA
343	N-formylphenylalanine	NA
344	N-glycolylneuraminate	N-Glycolylneuraminic acid
345	N-methyl-4-aminobutyric acid	NA
346	N-monomethylarginine	NA
347	N-palmitoyl-sphinganine	NA
348	N-palmitoyl-sphingosine	NA
349	N-palmitoyltaurine	NA
350	N-stearoyltaurine	NA
351	N1-Methyl-2-pyridone-5-carboxamide	N1-Methyl-2-pyridone-5-carboxamide
352	N1-methyladenosine	1-Methyladenosine
353	N2-acetyllysine/N6-acetyllysine	NA
354	N6,N6,N6-trimethyllysine	NA
355	N6-carboxymethyllysine	NA
356	N6-succinyladenosine	NA
357	nicotinamide	Niacinamide
358	nicotinamide adenine dinucleotide	NAD
359	nicotinamide riboside	Nicotinamide riboside
360	nonadecanoate	Nonadecanoic acid
361	O-sulfo-L-tyrosine	NA
362	octanoylcarnitine	L-Octanoylcarnitine
363	oleamide	Oleamide
364	oleate/vaccenate	NA
365	oleoyl ethanolamide	NA
366	oleoylcarnitine	Oleoylcarnitine
367	ornithine	Ornithine
368	orotate	Orotic acid
369	orotidine	Orotidine
370	oxalate	Oxalic acid
371	p-cresol sulfate	p-Cresol sulfate
372	p-cresol-glucuronide*	NA
373	palmitate	Palmitic acid
374	palmitoleate	Palmitoleic acid
375	palmitoyl dihydrosphingomyelin	NA
376	palmitoyl ethanolamide	Palmitoylethanolamide
377	palmitoyl sphingomyelin	NA
378	palmitoylcarnitine	NA
379	pantothenate	Pantothenic acid
380	phenol sulfate	NA
381	phenylacetylglycine	Phenylacetylglycine
382	phenylalanine	L-Phenylalanine
383	phenylalanylglycine	NA
384	phenyllactate	Phenyllactic acid
385	phosphate	Phosphate
386	phosphoenolpyruvate	Phosphoenolpyruvic acid
387	phosphoethanolamine	O-Phosphoethanolamine
388	phosphopantetheine	Pantetheine 4'-phosphate
389	pipecolate	Pipecolic acid
390	pro-hydroxy-pro	NA
391	proline	L-Proline
392	prolylglycine	L-prolyl-L-glycine
393	propionylcarnitine	Propionylcarnitine
394	pseudouridine	Pseudouridine
395	putrescine	Putrescine
396	pyridoxal	Pyridoxal
397	pyridoxamine	Pyridoxamine
398	pyridoxamine phosphate	NA
399	pyridoxate	NA
400	pyroglutamine*	NA
401	quinolinate	Quinolinic acid
402	retinol	Vitamin A
403	ribitol	Ribitol
404	riboflavin	Riboflavin
405	ribonate	Ribonic acid
406	ribose	D-Ribose
407	ribulose	L-Ribulose
408	S-adenosylhomocysteine	S-Adenosylhomocysteine
409	S-adenosylmethionine	S-Adenosylmethionine
410	saccharopine	Saccharopine

411	salicylate	Salicylic acid
412	sarcosine	Sarcosine
413	sebacate	Sebacic acid
414	sedoheptulose-7-phosphate	D-Sedoheptulose 7-phosphate
415	serine	L-Serine
416	spermidine	Spermidine
417	sphinganine	Sphinganine
418	sphingomyelin	SM(d18:1/18:0)
419	sphingosine	Sphingosine
420	stachydrine	Proline betaine
421	stearate	Stearic acid
422	stearidonate	NA
423	stearoyl ethanolamide	Stearoylethanolamide
424	stearoyl sphingomyelin	NA
425	stearoylcarnitine	Stearoylcarnitine
426	succinate	Succinic acid
427	succinylcarnitine	NA
428	sucrose	Sucrose
429	sulfate*	NA
430	tartronate	NA
431	taurine	Taurine
432	tauro-beta-muricholate	Tauro-b-muricholic acid
433	taurochenodeoxycholate	Taurochenodesoxycholic acid
434	taurocholate	Taurocholic acid
435	taurocyamine	Taurocyamine
436	taurodeoxycholate	NA
437	tauroursodeoxycholate	Tauroursodeoxycholic acid
438	tetradecanedioate	Tetradecanedioic acid
439	thiamin	Thiamine
440	thiamin monophosphate	Thiamine monophosphate
441	threonate	Threonic acid
442	threonine	L-Threonine
443	thymidine	Thymidine
444	tiglylcarnitine	Tiglylcarnitine
445	trans-4-hydroxyproline	4-Hydroxyproline
446	trans-urocanate	NA
447	tricosanoyl	NA
448	trigonelline	Trigonelline
449	trimethylamine N-oxide	Trimethylamine N-oxide
450	tryptophan	D-Tryptophan
451	tyrosine	L-Tyrosine
452	tyrosylglycine	NA
453	UDP-galactose	Uridine diphosphategalactose
454	UDP-glucose	Uridine diphosphate glucose
455	UDP-glucuronate	Uridine diphosphate glucuronic acid
456	UDP-N-acetylgalactosamine	Uridine diphosphate-N-acetylgalactosamine
457	UDP-N-acetylglucosamine	Uridine diphosphate-N-acetylglucosamine
458	uracil	Uracil
459	urate	Uric acid
460	urea	Urea
461	uridine	Uridine
462	uridine 5'-diphosphate	Uridine 5'-diphosphate
463	uridine 5'-monophosphate	Uridine 5'-monophosphate
464	valine	L-Valine
465	valylglycine	NA
466	xanthine	Xanthine
467	xanthosine	Xanthosine

The second step is to check concentration values. For SSP analysis, the concentration must be measured in *umol* for blood and CSF samples. The urinary concentrations must be first converted to *umol/mmol_creatinine* in order to compare with reported concentrations in literature. No missing or negative values are allowed in SSP analysis. The concentration data for QEA analysis is more flexible. Users can upload either the original concentration data or normalized data. Missing or negative values are allowed (coded as *NA*) for QEA. Please note, MSEA does not perform data normalization. If normalization is important, you should first normalize your data before upload. You can use our companion website **MetaboAnalyst** *www.metaboanalyst.ca* for a variety of data processing and normalization methods.

5 Selection of Metabolite Set Library

Before proceeding to enrichment analysis, a metabolite set library has to be chosen. There are seven built-in libraries offered by MSEA:

- Metabolic pathway associated metabolite sets (*currently contains 88 entries*);
- Disease associated metabolite sets (reported in blood) (*currently contains 416 entries*);
- Disease associated metabolite sets (reported in urine) (*currently contains 346 entries*)
- Disease associated metabolite sets (reported in CSF) (*currently contains 124 entries*)
- Metabolite sets associated with SNPs (*currently contains 4500 entries*)
- Predicted metabolite sets based on computational enzyme knockout model (*currently contains 912 entries*)
- Metabolite sets based on locations (*currently contains 57 entries*)

In addition, MSEA also allows user-defined metabolite sets to be uploaded to perform enrichment analysis on arbitrary groups of compounds which researchers want to test. The metabolite set library is simply a two-column comma separated text file with the first column for metabolite set names and the second column for its comound names (**must use HMDB compound name**) separated by "; ". Please note, the built-in libraries are mainly from human studies. The functional grouping of metabolites may not be valid. Therefore, for data from subjects other than human being, users are suggested to upload their self-defined metabolite set libraries for enrichment analysis.

6 Enrichment Analysis

Quantitative enrichment analysis (QEA) will be performed when the user uploads a concentration table. The enrichment analysis is performed using package **globaltest** [1]. It uses a generalized linear model to estimate a *Q-statistic* for each metabolite set, which describes the correlation between compound concentration profiles, X, and clinical outcomes, Y. The *Q statistic* for a metabolite set is the average of the Q statistics for each metabolite in the set. **Figure 2** below summarizes the result.

[1] Jelle J. Goeman, Sara A. van de Geer, Floor de Kort and Hans C. van Houwelingen. *A global test for groups of genes: testing association with a clinical outcome*, Bioinformatics Vol. 20 no. 1 2004, pages 93-99

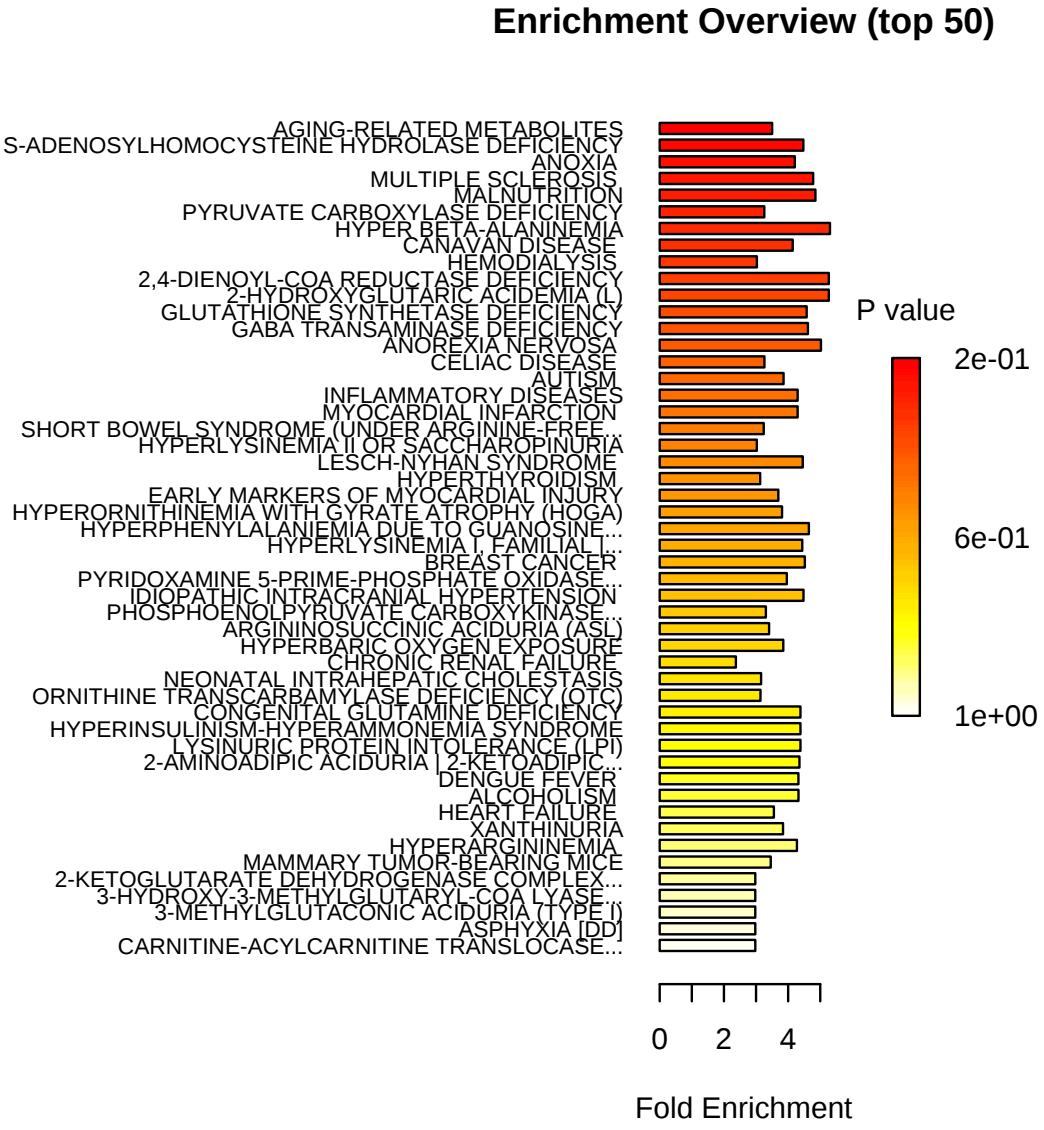

Figure 1: Summary Plot for Quantitative Enrichment Analysis (QEA)

Table 2: Result from Quantitative Enrichment Analysis

	Total Cmpd	Hits	Statistic Q	Expected Q	Raw p	Holm p	FDR
AGING-RELATED METABOLITES	6	2	50.03	14.29	8.54E-04	1.84E-01	7.68E-02
S-ADENOSYLHOMOCYSTEINE HYDROLASE DEFICIENCY	5	2	63.91	14.29	1.72E-03	3.70E-01	7.68E-02
ANOXIA	8	3	60.12	14.29	1.89E-03	4.04E-01	7.68E-02
MULTIPLE SCLEROSIS	39	3	68.28	14.29	2.08E-03	4.42E-01	7.68E-02
MALNUTRITION	8	3	69.28	14.29	2.11E-03	4.47E-01	7.68E-02
PYRUVATE CARBOXYLASE DEFICIENCY	10	6	46.53	14.29	4.38E-03	9.24E-01	7.68E-02
HYPER BETA-ALANINEMIA	1	1	75.75	14.29	4.93E-03	1.00E+00	7.68E-02
CANAVAN DISEASE	2	2	59.18	14.29	5.11E-03	1.00E+00	7.68E-02
HEMODIALYSIS	14	7	43.24	14.29	5.13E-03	1.00E+00	7.68E-02
2,4-DIENOYL-COA REDUCTASE DEFICIENCY	3	1	75.25	14.29	5.26E-03	1.00E+00	7.68E-02
2-HYDROXYGLUTARIC ACIDEMIA (L)	2	1	75.25	14.29	5.26E-03	1.00E+00	7.68E-02
GLUTATHIONE SYNTHETASE DEFICIENCY	8	2	65.39	14.29	5.37E-03	1.00E+00	7.68E-02
GABA TRANSAMINASE DEFICIENCY	2	2	65.94	14.29	7.36E-03	1.00E+00	7.68E-02
ANOREXIA NERVOSA	7	1	71.73	14.29	7.96E-03	1.00E+00	7.68E-02
CELIAC DISEASE	12	6	46.60	14.29	9.51E-03	1.00E+00	7.68E-02
AUTISM	8	2	55.11	14.29	1.01E-02	1.00E+00	7.68E-02
INFLAMMATORY DISEASES	2	2	61.37	14.29	1.14E-02	1.00E+00	7.68E-02
MYOCARDIAL INFARCTION	4	2	61.37	14.29	1.14E-02	1.00E+00	7.68E-02
SHORT BOWEL SYNDROME (UNDER ARGININE-FREE DIET)	4	3	46.29	14.29	1.16E-02	1.00E+00	7.68E-02
HYPERLYSINEMIA II OR SACCHAROPINURIA	3	2	43.21	14.29	1.21E-02	1.00E+00	7.68E-02
LESCH-NYHAN SYNDROME	5	4	63.65	14.29	1.22E-02	1.00E+00	7.68E-02
HYPERTHYROIDISM	5	2	44.71	14.29	1.24E-02	1.00E+00	7.68E-02
EARLY MARKERS OF MYOCARDIAL INJURY	14	9	52.78	14.29	1.29E-02	1.00E+00	7.68E-02
HYPERORNITHINEMIA WITH GYRATE ATROPHY (HOGA)	4	3	54.43	14.29	1.33E-02	1.00E+00	7.68E-02
HYPERPHENYLALANIEMIA DUE TO GUANOSINE TRIPHOSPHATE CYCLOHYDROLASE DEFICIENCY | HYPERPHENYLALANINEMIA DUE TO 6-PYRUVOYLTETRAHYDROPTERIN SYNTHASE DEFICIENCY (PTPS) | HYPERPHENYLALANINEMIA DUE TO DHPR-DEFICIENCY | HYPERPHENYLALANINEMIA DUE TO PTERIN-4A-CARBINOLAMINE DEHYDRATASE | PHENYLKETONURIA, MOTHER (MPKU)	1	1	66.37	14.29	1.38E-02	1.00E+00	7.68E-02
HYPERLYSINEMIA I, FAMILIAL | HYPERPIPECOLATEMIA	2	2	63.43	14.29	1.55E-02	1.00E+00	7.68E-02
BREAST CANCER	5	1	64.57	14.29	1.63E-02	1.00E+00	7.68E-02
PYRIDOXAMINE 5-PRIME-PHOSPHATE OXIDASE DEFICIENCY	3	3	56.56	14.29	1.67E-02	1.00E+00	7.68E-02
IDIOPATHIC INTRACRANIAL HYPERTENSION	1	1	63.98	14.29	1.71E-02	1.00E+00	7.68E-02
PHOSPHOENOLPYRUVATE CARBOXYKINASE DEFICIENCY 2 (PEPCK2)	5	3	47.24	14.29	1.72E-02	1.00E+00	7.68E-02
ARGININOSUCCINIC ACIDURIA (ASL)	6	5	48.67	14.29	1.73E-02	1.00E+00	7.68E-02
HYPERBARIC OXYGEN EXPOSURE	9	5	54.98	14.29	1.78E-02	1.00E+00	7.68E-02
CHRONIC RENAL FAILURE	13	6	33.90	14.29	1.85E-02	1.00E+00	7.68E-02
NEONATAL INTRAHEPATIC CHOLESTASIS	12	6	45.11	14.29	1.87E-02	1.00E+00	7.68E-02
ORNITHINE TRANSCARBAMYLASE DEFICIENCY (OTC)	10	8	44.84	14.29	1.92E-02	1.00E+00	7.68E-02
CONGENITAL GLUTAMINE DEFICIENCY	1	1	62.62	14.29	1.93E-02	1.00E+00	7.68E-02
HYPERINSULINISM-HYPERAMMONEMIA SYNDROME	2	1	62.62	14.29	1.93E-02	1.00E+00	7.68E-02
LYSINURIC PROTEIN INTOLERANCE (LPI)	4	1	62.62	14.29	1.93E-02	1.00E+00	7.68E-02

2-AMINOADIPIC ACIDURIA | 2-KETOADIPIC ACIDEMIA | ALPHA-AMINOADIPIC ACIDURIA	1	1	62.18	14.29	2.01E-02	1.00E+00	7.68E-02
DENGUE FEVER	3	2	61.72	14.29	2.04E-02	1.00E+00	7.68E-02
ALCOHOLISM	6	1	61.75	14.29	2.08E-02	1.00E+00	7.68E-02
HEART FAILURE	10	5	50.80	14.29	2.09E-02	1.00E+00	7.68E-02
XANTHINURIA	2	2	54.87	14.29	2.20E-02	1.00E+00	7.68E-02
HYPERARGININEMIA	4	1	61.05	14.29	2.20E-02	1.00E+00	7.68E-02
MAMMARY TUMOR-BEARING MICE	3	3	49.40	14.29	2.21E-02	1.00E+00	7.68E-02
2-KETOGLUTARATE DEHYDROGENASE COMPLEX DEFICIENCY	2	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
3-HYDROXY-3-METHYLGLUTARYL-COA LYASE DEFICIENCY	4	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
3-METHYLGLUTACONIC ACIDURIA (TYPE I)	3	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
ASPHYXIA [DD]	7	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
CARNITINE-ACYLCARNITINE TRANSLOCASE DEFICIENCY	4	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
CHRONIC PROGRESSIVE EXTERNAL OPHTHALMOPLEGIA AND KEARNS-SAYRE SYNDROM	3	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
GLYCOGEN SYNTHETASE DEFICIENCY	3	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
RESPIRATORY CHAIN DEFICIENCIES	4	2	42.53	14.29	2.27E-02	1.00E+00	7.68E-02
VERY-LONG-CHAIN ACYL COA DEHYDROGENASE DEFICIENCY (VLCAD)	21	8	34.66	14.29	2.41E-02	1.00E+00	7.68E-02
FUMARIC ACIDURIA	3	2	46.20	14.29	2.51E-02	1.00E+00	7.68E-02
REFRACTORY LOCALIZATION-RELATED EPILEPSY	10	9	49.45	14.29	2.53E-02	1.00E+00	7.68E-02
STROKE	5	1	59.22	14.29	2.56E-02	1.00E+00	7.68E-02
DIFFERENT SEIZURE DISORDERS	24	11	49.34	14.29	2.56E-02	1.00E+00	7.68E-02
3-METHYLGLUTACONIC ACIDURIA (TYPE II), X-LINKED	4	2	53.71	14.29	2.60E-02	1.00E+00	7.68E-02
LONG-CHAIN-3-HYDROXYACYL-COA DEHYDROGENASE DEFICIENCY (LCHAD)	10	4	37.09	14.29	2.60E-02	1.00E+00	7.68E-02
27-HYDROXYLASE DEFICIENCY	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
ACUTE MYELOGENOUS LEUKEMIA	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
APOLIPOPROTEIN C-II DEFICIENCY | CHOLESTERYL ESTER STORAGE DISEASE | GLYCOGENOSIS, TYPE IXB	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
CONGENITAL DISORDER OF GLYCOSYLATION CDG-IA	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
CONGENITAL DISORDER OF GLYCOSYLATION CDG-IB	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
CYSTINOSIS	4	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
FISH-EYE DISEASE	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
HYPERCHOLESTEROLEMIA	4	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
HYPERLIPIDAEMIA	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
LECITHIN:CHOLESTEROL ACYLTRANSFERASE DEFICIENCY	1	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
MEVALONIC ACIDURIA	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
OCULOCEREBRORENAL SYNDROME OF LOWE	2	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
SMITH-LEMLI-OPITZ SYNDROME	6	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
TANGIER DISEASE	3	1	58.48	14.29	2.71E-02	1.00E+00	7.68E-02
ABETALIPOPROTEINEMIA, BASSEN-KORNZWEIG-SYNDROME, ACANTHOCYTOSIS (ABL)	5	3	54.38	14.29	2.75E-02	1.00E+00	7.68E-02
PROGRESSIVE FAMILIAL INTRAHEPATIC CHOLESTASIS	6	3	54.38	14.29	2.75E-02	1.00E+00	7.68E-02
CONTINUOUS AMBULATORY PERITONEAL DIALYSIS (CAPD)	15	14	47.47	14.29	2.84E-02	1.00E+00	7.68E-02
METABOLITES AFFECTED BY EXERCISE	5	4	48.87	14.29	2.86E-02	1.00E+00	7.68E-02
DIABETIC KETOACIDOSIS	2	1	57.69	14.29	2.88E-02	1.00E+00	7.68E-02
OBESITY	2	1	57.69	14.29	2.88E-02	1.00E+00	7.68E-02

SUCCINYL COA: 3-KETOACID COA TRANSFERASE DEFICIENCY	3	1	57.69	14.29	2.88E-02	1.00E+00	7.68E-02
SHORT CHAIN ACYL-COA DEHYDROGENASE DEFICIENCY (SCAD)	4	3	40.25	14.29	3.07E-02	1.00E+00	7.87E-02
PROPIONIC ACIDEMIA	8	4	50.62	14.29	3.14E-02	1.00E+00	7.87E-02
SCHIZOPHRENIA	26	12	47.13	14.29	3.18E-02	1.00E+00	7.87E-02
ACUTE SEIZURES	14	9	48.47	14.29	3.18E-02	1.00E+00	7.87E-02
GLUTARIC ACIDURIA I	3	2	48.39	14.29	3.19E-02	1.00E+00	7.87E-02
HEPATIC ENCEPHALOPATHY	4	1	56.27	14.29	3.21E-02	1.00E+00	7.87E-02
PREMENSTRUAL DYSPHORIC DISORDER	3	1	56.27	14.29	3.21E-02	1.00E+00	7.87E-02
VALPROATE THERAPY: ANTICONVULASANT HYPERSENSITIVITY SYNDROME VALPROATE ASSOCIATED HEPATOTOXICITY	5	2	50.67	14.29	3.39E-02	1.00E+00	7.95E-02
GLYCOGENOSIS, TYPE III. CORI DISEASE, DEBRANCHER GLYCOGENOSIS	3	2	45.08	14.29	3.43E-02	1.00E+00	7.95E-02
BETA-THALASSEMIA	6	2	52.77	14.29	3.53E-02	1.00E+00	7.95E-02
GLYCOGENOSIS (TYPE IA, IB, IC) | GLYCOGENOSIS, TYPE VI. HERS DISEASE	5	4	42.97	14.29	3.71E-02	1.00E+00	7.95E-02
CRITICAL ILLNESS (MAJOR TRAUMA, SEVERE SEPTIC SHOCK, OR CARDIOGENIC SHOCK)	6	6	43.34	14.29	3.74E-02	1.00E+00	7.95E-02
MAPLE SYRUP URINE DISEASE	9	5	46.00	14.29	3.75E-02	1.00E+00	7.95E-02
ADRENOLEUKODYSTROPHY, X-LINKED	6	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
D-BIFUNCTIONAL PROTEIN DEFICIENCY	3	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
INFANTILE REFSUM'S DISEASE	4	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
PEROXISOMAL BIFUNCTIONAL ENZYME DEFICIENCY	2	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
PEROXISOMAL DISORDERS, NEW TYPE, LIVER	7	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
PSEUDO ZELLWEGER -> D-BIFUNCTIONAL PROTEIN DEFICIENCY	2	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
PYRIDOXINE DEPENDENCY WITH SEIZURES	2	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
REFSUM DISEASE	4	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
ZELLWEGER SYNDROME	8	1	53.96	14.29	3.79E-02	1.00E+00	7.95E-02
PHENYLKETONURIA	7	4	48.39	14.29	3.92E-02	1.00E+00	8.11E-02
HYPERPROLINEMIA, TYPE I	1	1	53.26	14.29	3.99E-02	1.00E+00	8.11E-02
HAWKINSINURIA	3	1	53.14	14.29	4.02E-02	1.00E+00	8.11E-02
TYROSINEMIA II | TYROSINEMIA III | TYROSINEMIA, TRANSIENT, OF THE NEWBORN	1	1	53.14	14.29	4.02E-02	1.00E+00	8.11E-02
CYSTIC FIBROSIS (CF)	4	3	46.84	14.29	4.12E-02	1.00E+00	8.18E-02
HISTIDINEMIA	2	2	36.58	14.29	4.16E-02	1.00E+00	8.18E-02
PELLAGRA	3	2	38.19	14.29	4.17E-02	1.00E+00	8.18E-02
HYPERORNITHINEMIA-HYPERAMMONEMIA-HOMOCITRULLINURIA [HHH-SYNDROME]	3	2	39.37	14.29	4.27E-02	1.00E+00	8.20E-02
MYOCARDIAL ISCHEMIA	6	4	37.54	14.29	4.54E-02	1.00E+00	8.20E-02
DICARBOXYLIC AMINOACIDURIA. GLUTAMATE-ASPARTATE TRANSPORT DEFECT	2	2	42.59	14.29	4.61E-02	1.00E+00	8.20E-02
D-GLYCERIC ACIDURA | HYPERGLYCINEMIA, NONKETOTIC	1	1	50.90	14.29	4.69E-02	1.00E+00	8.20E-02
SUCCINIC SEMIALDEHYDE DEHYDROGENASE DEFICIENCY	3	1	50.90	14.29	4.69E-02	1.00E+00	8.20E-02

2-METHYL-3-HYDROXYBUTYRYL-COA DEHYDROGENASE DEFICIENCY | 3-METHYLGLUTACONIC ACIDURIA, NOVEL SUBTYPE | BENIGN INFANTILE MITOCHONDRIAL MYOPATHY | CYTOCHROME-C-OXIDASE DEFICIENCY | FEEDING: THIAMINE DEFICIENY [DD] | LETHAL INFANTILE MITOCHONDRIAL DISEASE (LIMD) | MITOCHONDRIAL COMPLEX II DEFICIENCY | MITOCHONDRIAL DNA DEPLETION SYNDROME	1	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
3-HYDROXYISOBUTYRIC ACIDURIA	3	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
ACYL COA DEHYDROGENASE 9 DEFICIENCY | PYRUVATE DEHYDROGENASE DEFICIENCY (E2)	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
BIOTINIDASE DEFICIENCY	5	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
CONGENITAL LACTIC ACIDOSIS	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
ETHYLMALONIC ENCEPHALOPATHY (EPEMA)	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
LEIGH'S SYNDROME, SUBACUTE NECROTIZING ENCEPHALOPATHY, SNE	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
LIVER DISEASE, LIVER FAILURE, UNSPECIFIC	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
METHANOL POISONING	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
MITOCHONDRIAL-ENCEPHALOPATHY-LACTIC ACIDOSIS-STROKE (MELAS)	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
MYOCLONIC EPILEPSY AND RAGGED RED FIBER DISEASE (MERRF) | PYRUVATE DEHYDROGENASE DEFICIENCY (E1)	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
PYRUVATE DEHYDROGENASE E3-BINDING PROTEIN DEFICIENCY	3	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
SEPSIS, NEONATAL [DD]	2	1	50.30	14.29	4.88E-02	1.00E+00	8.20E-02
MEDIUM CHAIN ACYL-COA DEHYDROGENASE DEFICIENCY (MCAD)	10	3	40.24	14.29	4.93E-02	1.00E+00	8.20E-02
METHYLMALONIC ACIDURIA, CBLA TYPE	4	3	38.03	14.29	4.94E-02	1.00E+00	8.20E-02
SOTOS SYNDROME	2	2	48.45	14.29	4.98E-02	1.00E+00	8.20E-02
BETA-KETOTHIOLASE DEFICIENCY	8	2	44.83	14.29	5.17E-02	1.00E+00	8.36E-02
FRUCTOSE-1,6-DIPHOSPHATASE DEFICIENCY	5	3	38.78	14.29	5.19E-02	1.00E+00	8.36E-02
LONG CHAIN ACYL-COA DEHYDROGENASE DEFICIENCY (LCAD)	5	3	38.78	14.29	5.19E-02	1.00E+00	8.36E-02
DIABETES MELLITUS (MODY), NON-INSULIN-DEPENDENT	19	12	34.53	14.29	5.31E-02	1.00E+00	8.36E-02
DIHYDROPYRIMIDINE DEHYDROGENASE DEFICIENCY	4	3	32.47	14.29	5.39E-02	1.00E+00	8.36E-02
GROWTH HORMONE DEFICIENCY	4	2	45.58	14.29	5.49E-02	1.00E+00	8.36E-02
PERSISTANT HYPERINSULINEMIC HYPOGLYCEMIA OF INFANCY, PHHI	3	2	45.58	14.29	5.49E-02	1.00E+00	8.36E-02
3-PHOSPHOGLYCERATE DEHYDROGENASE DEFICIENCY	2	2	45.79	14.29	5.50E-02	1.00E+00	8.36E-02
JUVENILE MYOCLONIC EPILEPSY	3	2	45.79	14.29	5.50E-02	1.00E+00	8.36E-02
PHOSPHOSERINE AMINOTRANSFERASE DEFICIENCY - NEW DISORDER?	2	2	45.79	14.29	5.50E-02	1.00E+00	8.36E-02
POST TRANSURETHRAL PROSTATIC RESECTION	5	2	45.79	14.29	5.50E-02	1.00E+00	8.36E-02
PURINE NUCLEOSIDE PHOSPHORYLASE DEFICIENCY	5	3	42.00	14.29	5.61E-02	1.00E+00	8.41E-02
ARGININEMIA. HYPERARGININEMIA, ARGINASE DEFICIENCY	5	3	33.69	14.29	5.61E-02	1.00E+00	8.41E-02

PYRUVATE DEHYDROGENASE DEFICIENCY (E3)	7	4	39.35	14.29	5.79E-02	1.00E+00	8.63E-02
HYPERTENSION	12	4	40.30	14.29	6.01E-02	1.00E+00	8.88E-02
CARBAMOYL PHOSPHATE SYNTHETASE DEFICIENCY (CPS)	3	2	33.84	14.29	6.04E-02	1.00E+00	8.88E-02
DELTA-PYRROLIDINE-5-CARBOXYLATE SYNTHASE DEFICIENCY	5	4	28.71	14.29	6.17E-02	1.00E+00	9.01E-02
GLYCOGENOSIS, TYPE IXA	3	2	43.42	14.29	6.38E-02	1.00E+00	9.26E-02
GLYCEROL KINASE DEFICIENCY	2	2	42.50	14.29	6.59E-02	1.00E+00	9.43E-02
TYROSINEMIA I	5	2	42.77	14.29	6.59E-02	1.00E+00	9.43E-02
HYPERVALINEMIA	1	1	45.43	14.29	6.68E-02	1.00E+00	9.49E-02
METABOLITES AFFECTED BY GENDER	9	5	33.50	14.29	7.87E-02	1.00E+00	1.11E-01
FRUCTOSE INTOLERANCE, HEREDITARY	5	3	28.45	14.29	8.10E-02	1.00E+00	1.14E-01
OROTIC ACIDURIA, HEREDITARY	1	1	40.99	14.29	8.73E-02	1.00E+00	1.22E-01
CITRULLINEMIA TYPE I	3	2	32.10	14.29	9.08E-02	1.00E+00	1.26E-01
TRANSALDOLASE DEFICIENCY	6	1	39.48	14.29	9.53E-02	1.00E+00	1.31E-01
SMOKER	7	1	38.54	14.29	1.00E-01	1.00E+00	1.37E-01
GLUTARIC ACIDURIA II	8	2	34.57	14.29	1.06E-01	1.00E+00	1.44E-01
N-ACETYLGLUTAMATE SYNTHETASE DEFICIENCY. NAGS DEFICIENCY	5	3	25.81	14.29	1.07E-01	1.00E+00	1.44E-01
RHABDOMYOLYSIS	4	3	29.53	14.29	1.08E-01	1.00E+00	1.44E-01
CIRRHOSIS	23	6	27.84	14.29	1.11E-01	1.00E+00	1.47E-01
GLYCEROL INTOLERANCE SYNDROM	3	2	31.81	14.29	1.11E-01	1.00E+00	1.47E-01
ISOBUTYRYL-COA DEHYDROGENASE DEFICIENCY	2	1	36.59	14.29	1.12E-01	1.00E+00	1.48E-01
DIMETHYLGLYCINURIA	1	1	36.12	14.29	1.15E-01	1.00E+00	1.51E-01
METHYLMALONIC ACIDURIA (MMA)	8	4	27.45	14.29	1.16E-01	1.00E+00	1.51E-01
SHORT-BOWEL SYNDROME (PERMANENT INTESTINAL FAILURE)	2	2	28.71	14.29	1.18E-01	1.00E+00	1.53E-01
HYPERPROLINEMIA, TYPE II	2	2	28.70	14.29	1.19E-01	1.00E+00	1.53E-01
MALONYL-COA DECARBOXYLASE DEFICIENCY	3	2	30.97	14.29	1.38E-01	1.00E+00	1.67E-01
ADENYLOSUCCINASE DEFICIENCY	3	1	32.02	14.29	1.44E-01	1.00E+00	1.67E-01
FAMILIAL LIPOPROTEIN LIPASE DEFICIENCY	2	1	32.02	14.29	1.44E-01	1.00E+00	1.67E-01
GLYCOGENOSIS, TYPE VII. TARUI DISEASE	2	1	32.02	14.29	1.44E-01	1.00E+00	1.67E-01
GOUT | PHOSPHORIBOSYLPYROPHOSPHATE SYNTHETASE SUPERACTIVITY	1	1	32.02	14.29	1.44E-01	1.00E+00	1.67E-01
IMPAIRED GLUCOSE TOLERANCE	2	1	32.02	14.29	1.44E-01	1.00E+00	1.67E-01
MOLYBDENIUM CO-FACTOR DEFICIENCY	2	1	32.02	14.29	1.44E-01	1.00E+00	1.67E-01
21-HYDROXYLASE DEFICIENCY (CYP21)	11	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
3-BETA-HYDROXYSTEROID DEHYDROGENASE DEFICIENCY	9	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
3-METHYL-CROTONYL-GLYCINURIA	4	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
ACTH DEFICIENCY, ISOLATED | ADRENAL HYPOPLASIA. ADDISON DISEASE, X-LINKED	4	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
BECKWITH-WIEDEMANN SYNDROME. EXOMPHALOS-MAKROGLOSSIA-GIGANTISM SYNDROME | EXERCISE-INDUCED-HYPERINSULINSM [EIHI] | HYPOGLYCEMIA, FAMILIAL NEONATAL	2	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
CARNITINE DEFICIENCY, MYOPATHIC	3	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
CARNITINE PALMITOYL TRANSFERASE DEFICIENCY (I)	5	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
DIABETES MELLITUS, INSULIN-DEPENDENT	5	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01

DIABETES, FETAL EFFECTS FROM MATERNAL | GLUCAGON DEFICIENCY | GLUT-1 DEFICIENCY SYNDROME | GLYCOGENOSIS, TYPE IV. AMYLOPECTINOSIS, ANDERSON DISEASE | SHORT-CHAIN 3-HYDROXYACYL-COA DEHYDROGENASE DEFICIENCY (SCHAD) | TRIFUNCTIONAL PROTEIN DEFICIENCY | WOLFRAM SYNDROME, DIDMOAD	1	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
FAMILIAL HYPERINSULINEMIA AND HYPERPROINSULINEAMIA WITH MILD DIABETES	3	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
GALACTOSEMIA I	6	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
GLUCOCORTICOID DEFICIENCY, FAMILIAL ISOLATED. MIGEON SYNDROME | HYPOADRENOCORTICISM, FAMILIAL	2	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
KETOTIC HYPOGLYCEMIA	2	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
NEONATAL HEMOCHROMATOSIS	2	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
REYE SYNDROME	2	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
REYE SYNDROME LIKE MANIFESTATIONS	2	1	31.52	14.29	1.48E-01	1.00E+00	1.67E-01
PEARSON SYNDROM	3	2	26.50	14.29	1.50E-01	1.00E+00	1.69E-01
CARNITINE TRANSPORTER DEFECT. PRIMARY SYSTEMIC CARNITINE DEFICIENCY	4	2	26.47	14.29	1.60E-01	1.00E+00	1.79E-01
DIHYDROPYRIMIDINASE DEFICIENCY	5	2	25.41	14.29	1.68E-01	1.00E+00	1.87E-01
17-ALPHA-HYDROXYLASE DEFICIENCY (CYP17)	11	1	26.92	14.29	1.88E-01	1.00E+00	2.07E-01
LIPOID ADRENAL HYPERPLASIA (STAR DEFICIENCY)	8	1	26.92	14.29	1.88E-01	1.00E+00	2.07E-01
L-ARGININE:GLYCINE AMIDINOTRANSFERASE DEFICIENCY	2	2	21.88	14.29	2.26E-01	1.00E+00	2.48E-01
RIBOSE-5-PHOSPHATE ISOMERASE DEFICIENCY	6	1	22.81	14.29	2.31E-01	1.00E+00	2.52E-01
COBALAMIN (AND FOLATE) DEFICIENCY	3	1	20.26	14.29	2.63E-01	1.00E+00	2.83E-01
METHYLMALONIC ACIDURIA, CBLB TYPE	2	1	20.26	14.29	2.63E-01	1.00E+00	2.83E-01
MITOCHONDRIAL ENCEPHALOMYOPATHTHY WITH ELEVANTED METHYLMALONIC ACID, SUCLA2	1	1	20.26	14.29	2.63E-01	1.00E+00	2.83E-01
SEPTIC SHOCK	2	1	19.91	14.29	2.68E-01	1.00E+00	2.86E-01
CREATINE DEFICIENCY, GUANIDINOACETATE METHYLTRANSFERASE DEFICIENCY	4	4	19.50	14.29	2.70E-01	1.00E+00	2.87E-01
BILIARY ATRESIA	5	1	19.69	14.29	2.71E-01	1.00E+00	2.87E-01
CARNITINE PALMITOYL TRANSFERASE DEFICIENCY (II)	8	4	18.35	14.29	2.98E-01	1.00E+00	3.14E-01
NEPHROTIC SYNDROME	3	1	11.20	14.29	4.18E-01	1.00E+00	4.38E-01
ISOVALERIC ACIDEMIA	9	4	12.63	14.29	5.09E-01	1.00E+00	5.31E-01
SARCOSINEMIA	1	1	4.69	14.29	6.07E-01	1.00E+00	6.30E-01
ALZHEIMER'S DIESEASE	2	1	3.38	14.29	6.63E-01	1.00E+00	6.82E-01
CARNOSINURIA, CARNOSINEMIA	1	1	3.38	14.29	6.63E-01	1.00E+00	6.82E-01
SHORT/BRANCHED-CHAIN ACYL-COA DEHYDROGENASE DEFICIENCY	3	1	2.85	14.29	6.89E-01	1.00E+00	7.06E-01
CITRULLINEMIA TYPE II, ADULT-ONSET	2	1	1.26	14.29	7.91E-01	1.00E+00	8.03E-01
NARP SYNDROME	1	1	1.26	14.29	7.91E-01	1.00E+00	8.03E-01
HOMOCYSTINURIA, CYSTATHIONINE BETA-SYNTHASE DEFICIENCY	5	1	0.57	14.29	8.60E-01	1.00E+00	8.68E-01
X-LINKED CREATINE-TRANSPORTER DEFECT	1	1	0.11	14.29	9.38E-01	1.00E+00	9.42E-01
GESTATIONAL DIABETES MELLITUS	3	2	0.11	14.29	9.94E-01	1.00E+00	9.94E-01

The report was generated on Fri Sep 25 03:56:37 2015 with R version 3.2.0 (2015-04-16). Thank you for using MetaboAnalyst! For suggestions and feedback please contact Jeff Xia (*jeff.xia@mcgill.ca*).