Metabolomic Data Analysis with MetaboAnalyst 5.0

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1 Background

The Pathway Analysis module combines results from powerful pathway enrichment analysis with pathway topology analysis to help researchers identify the most relevant pathways involved in the conditions under study.

There are many commercial pathway analysis software tools such as Pathway Studio, MetaCore, or Ingenuity Pathway Analysis (IPA), etc. Compared to these commercial tools, the pathway analysis module was specifically developed for metabolomics studies. It uses high-quality KEGG metabolic pathways as the backend knowledgebase. This module integrates many well-established (i.e. univariate analysis, over-representation analysis) methods, as well as novel algorithms and concepts (i.e. Global Test, Global Ancova, network topology analysis) into pathway analysis. Another feature is a Google-Map style interactive visualization system to deliver the analysis results in an intuitive manner.

2 Data Input

The Pathway Analysis module accepts either a list of compound labels (common names, HMDB IDs or KEGG IDs) with one compound per row, or a compound concentration table with samples in rows and compounds in columns. The second column must be phenotype labels (binary, multi-group, or continuous). The table is uploaded as comma separated values (.csv).

3 Compound Name Matching

The first step is to standardize the compound labels used in user uploaded data. This is a necessary step since these compounds will be subsequently compared with compounds contained in the pathway library. There are three outcomes from the step - exact match, approximate match (for common names only), and no match. Users should click the textbfView button from the approximate matched results to manually select the correct one. Compounds without match will be excluded from the subsequently pathway analysis.

Table 1 shows the conversion results. Note: 1 indicates exact match, 2 indicates approximate match, and θ indicates no match. A text file contain the result can be found the downloaded file $name_map.csv$

	Query	Match	HMDB
1	HMDB0000123	Glycine	HMDB0000123
2	HMDB0014691	Acetohydroxamic Acid	HMDB0014691
3	HMDB0031239	Ethyl nitrite	HMDB0031239
4	HMDB0161401	NA	NA
5	HMDB0000925	Trimethylamine N-oxide	HMDB0000925
6	HMDB0142449	NA	NA
7	HMDB0140038	NA	NA
8	HMDB0012136	1-Amino-propan-2-ol	HMDB0012136
9	HMDB0062143	NA	NA

10	HMDB0031558	Methyloxirane	HMDB0031558
11	${\rm HMDB0031652}$	Allyl alcohol	${\rm HMDB0031652}$
12	HMDB0003366	Propanal	HMDB0003366
13	HMDB0001659	Acetone	HMDB0001659
14	HMDB0000246	Tetrahydrofuran	HMDB0000246
$\frac{15}{16}$	HMDB0171202 HMDB0000474	NA Butanone	NA HMDB0000474
17	HMDB0000474	Butanal	HMDB0003543
18	HMDB0033431	2.2-Dimethyloxirane	HMDB00334431
19	HMDB0031324	3-Buten-1-ol	HMDB0031324
20	HMDB0033858	2-Buten-1-ol	HMDB0033858
21	HMDB0031243	2-Methylpropanal	HMDB0031243
22	HMDB0171604	NA NA	NA
$\frac{23}{24}$	HMDB0171603	NA Dimethylethanolamine	NA HMDB0032231
25	HMDB0032231 HMDB0031404	Cyclohexylamine	HMDB0032231
26	HMDB0031404	2-Methylpiperidine	HMDB0031404
27	HMDB0031544	3-Methylcyclopentene	HMDB0031544
28	HMDB0062716	NA	NA
29	HMDB0033971	2-Diethylaminoethanol	HMDB0033971
30	HMDB0000630	Cytosine	HMDB0000630
$\frac{31}{32}$	HMDB0031335 HMDB0182885	2-Chloro-1-propanol NA	HMDB0031335 NA
33	HMDB0039786	NA NA	NA
34	HMDB0173815	NA	NA
35	HMDB0173816	NA	NA
36	HMDB0171081	NA	NA
37	HMDB0032576	2-Methoxy-1,4-benzoquinone	HMDB0032576
$\frac{38}{39}$	HMDB0033812	Sesamol NA	HMDB0033812 NA
40	HMDB0059965 HMDB0032920	alpha-Furyl methyl diketone	HMDB0032920
41	HMDB0032320	NA	NA
42	HMDB0062484	NA	NA
43	HMDB0004062	Gentisate aldehyde	HMDB0004062
44	HMDB0002466	3-Hydroxybenzoic acid	HMDB0002466
45	HMDB0000500	4-Hydroxybenzoic acid	HMDB0000500
46	HMDB0001895	Salicylic acid Mathyl 2 (mathylthic) acatata	HMDB0001895
$\frac{47}{48}$	HMDB0035646 HMDB0001527	Methyl 2-(methylthio)acetate 3-Methylthiopropionic acid	HMDB0035646 HMDB0001527
49	HMDB0001327	NA NA	NA
50	HMDB0126388	NA NA	NA
51	HMDB0166105	NA	NA
52	HMDB0125590	NA	NA
53	HMDB0168417	NA	NA
54	HMDB0168448	NA NA	NA
55 56	HMDB0041607 HMDB0004284	NA Tyrosol	NA HMDB0004284
57	HMDB0004284 HMDB0032137	2,6-Dimethyl-1,4-benzenediol	HMDB0004284
58	HMDB0040174	NA NA	NA
59	HMDB0040177	NA	NA
60	HMDB0032139	1,2-Dimethoxybenzene	HMDB0032139
61	HMDB0032036	4-Ethoxyphenol	HMDB0032036
62	HMDB0039802	NA NA	NA
63 64	HMDB0029671 HMDB0029672	1,4-Dimethoxybenzene	HMDB0029671 HMDB0029672
65	HMDB0029072	1,3-Dimethoxybenzene 1-(2-Furyl)butan-3-one	HMDB0029072
66	HMDB0168418	NA	NA
67	HMDB0032159	2-Acetyl-3,5-dimethylfuran	HMDB0032159
68	HMDB0029563	3-Acetyl-2,5-dimethylfuran	HMDB0029563
69	HMDB0032136	2-Methoxy-4-methylphenol	HMDB0032136
70	HMDB0034241	4-Methoxybenzyl alcohol	HMDB0034241
$\frac{71}{72}$	HMDB0029638 HMDB0006236	4-Methylbenzaldehyde Phenylacetaldehyde	HMDB0029638 HMDB0006236
73	HMDB0000230	2,3-Dihydrobenzofuran	HMDB0006236
73 74	HMDB0013813	2,5-Dinydrobenzoluran 3-Methylbenzaldehyde	HMDB0013813
75	HMDB0172088	NA NA	NA
76	HMDB0029636	2-Methylbenzaldehyde	HMDB0029636
77	HMDB0038997	NA	NA
78	HMDB0062765	Styrene Oxide	HMDB0062765
79	HMDB0004072	4-Hydroxystyrene	HMDB0004072
80	HMDB0124943	NA Agetophonono	NA HMDB0033910
81 82	HMDB0033910 HMDB0167775	Acetophenone NA	NA
83	HMDB0167776	NA	NA
84	HMDB0039781	NA NA	NA
85	HMDB0041476	NA	NA
86	HMDB0041562	NA	NA
87	HMDB0032373	3-Mercapto-2-methyl-1-butanol	HMDB0032373
88	HMDB0036149	NA Tamina	NA HMDD0000251
89 90	HMDB0000251	Taurine 3-Methylcytosine	HMDB0000251
90 91	HMDB0011601 HMDB0004339	2-O-Methylcytosine	HMDB0011601 HMDB0004339
92	HMDB0004339	5-Methylcytosine	HMDB0004339
93	HMDB0041922	NA NA	NA
94	${\rm HMDB0171225}$	NA	NA
95	HMDB0164607	NA	NA
96	HMDB0166218	NA	NA

```
HMDB0164608
 97
                      NA
                                                                                                                    NA
      HMDB0171213
                      NA
                                                                                                                    NA
 98
 99
      HMDB0166253
                      NA
                                                                                                                    NA
100
      {\rm HMDB0171212}
                      NA
                                                                                                                    NA
101
      {\rm HMDB0166254}
                      NA
                                                                                                                    NA
      HMDB0166217
102
                      NA
                                                                                                                    NA
      HMDB0172056
103
                      NA
                                                                                                                    NA
104
      HMDB0172059
                      NA
                                                                                                                    NA
      HMDB0172058
105
                      NA
                                                                                                                    NA
      HMDB0172057
                      NA
106
107
      {\rm HMDB0159225}
                      NA
                                                                                                                    NA
108
     HMDB0159223
HMDB0159222
                      NA
                                                                                                                    NA
109
                      NΑ
                                                                                                                    NA
      HMDB0005785
                      Indole-3-carbinol
                                                                                                                    HMDB0005785
110
111
      HMDB0030204
                      1-(2-Furanylmethyl)-1H-pyrrole
                                                                                                                    HMDB0030204
      HMDB0040009
112
                                                                                                                    NA
      HMDB0040011
                      NA
                                                                                                                    NA
113
114
      {\rm HMDB0159224}
                      NA
                                                                                                                    NA
                                                                                                                    HMDB0011664
      HMDB0011664
                      3-Methylene-indolenine
115
      HMDB0033731
                                                                                                                    HMDB0033731
116
                      Quinoline
      HMDB0034244
117
                      Isoquinoline
                                                                                                                    HMDB0034244
118
      HMDB0032980
                      3,4-Dimethylthiophene
                                                                                                                    {\rm HMDB0032980}
119
      {\rm HMDB0032979}
                      2,5-Dimethylthiophene
                                                                                                                    {\rm HMDB0032979}
120
      HMDB0032977
                      2,3-Dimethylthiophene
                                                                                                                    HMDB0032977
      HMDB0032978
121
                      2, 4\hbox{-} {\rm Dimethylthiophene}
                                                                                                                    HMDB0032978
      HMDB0035385
                      3-Ethylthiophene
                                                                                                                    HMDB0035385
122
      HMDB0035384
123
                      2-Ethylthiophene
                                                                                                                    {\rm HMDB0035384}
      HMDB0038973
124
                                                                                                                    NA
125
      HMDB0038433
                      NA
                                                                                                                    NA
126
      {\rm HMDB0032341}
                      Isoamyl isothiocyanate
                                                                                                                    HMDB0032341
127
      HMDB0179339
                      NA
                                                                                                                    NA
      HMDB0187593
                                                                                                                    NA
128
                      NΑ
      HMDB0179338
                      NA
                                                                                                                    NA
129
      HMDB0179340
                                                                                                                    NA
130
                      NA
      HMDB0179337
                      NA
                                                                                                                    NA
132
      HMDB0031543
                      3-Methyl-1,2-cyclopentanedione
                                                                                                                    HMDB0031543
133
      HMDB0032233
                      2,5-Dimethyl-3(2H)-furanone
                                                                                                                    HMDB0032233
      HMDB0034247
134
                      2-(Methoxymethyl)furan
                                                                                                                    HMDB0034247
      HMDB0039778
                      ΝÀ
135
                                                                                                                    NA
      HMDB0029581
                                                                                                                    HMDB0029581
136
                      (2E,4E)-2,4-Hexadienoic acid
      HMDB0031344
                       1,2-Cyclohexanedione
                                                                                                                    {\rm HMDB0031344}
138
      {\rm HMDB0031759}
                      (E)-4-Oxo-2-hexen-1-al
                                                                                                                    HMDB0031759
139
      HMDB0001164
                      trans-1,2-Dihydrobenzene-1,2-diol
                                                                                                                    HMDB0001164
      HMDB0040260
140
                      NA
                                                                                                                    HMDB0033569
      HMDB0033569
                      Svovualdehvde
141
142
      HMDB0029444
                      2-Pyrrolidineacetic acid
                                                                                                                    {\rm HMDB0029444}
      HMDB0094697
143
                                                                                                                    NA
144
      {\rm HMDB0059649}
                      NA
                                                                                                                    NA
                                                                                                                    {\rm HMDB0015212}
145
      {\rm HMDB0015212}
                      Vigabatrin
      HMDB0062225
                                                                                                                    NA
HMDB0000070
146
                      NA
      HMDB00002220
                      Pipecolic acid
147
      HMDB0062767
148
                      ΝÂ
                                                                                                                    NA
      HMDB0004226
                      N4-Acetylaminobutanal
                                                                                                                    HMDB0004226
      HMDB0005960
                      D-Pipecolic acid
                                                                                                                    HMDB0005960
150
151
      HMDB0000716
                      L-Pipecolic acid
                                                                                                                    HMDB0000716
      HMDB0029435
                      L-trans-4-Methyl-2-pyrrolidinecarboxylic acid
152
                                                                                                                    HMDB0029435
      HMDB0094696
                                                                                                                    HMDB0094696
                      N-Methyl-proline
153
      HMDB0033453
                                                                                                                    HMDB0033453
154
                      Fagomine
      HMDB0142963
155
                      ΝĂ
                                                                                                                    NA
156
      HMDB0168724
                      NA
                                                                                                                    NA
157
      HMDB0168723
                      NΑ
                                                                                                                    NA
158
      HMDB0061157
                                                                                                                    NA
      HMDB0029449
                      (2R,3R,4R)-2-Amino-4-hydroxy-3-methylpentanoic acid
                                                                                                                    HMDB0029449
159
      HMDB0031537
                                                                                                                    HMDB0031537
                      3-Methylcyclohexanethiol
160
      HMDB0040153
161
                                                                                                                    NA
      HMDB0128943
162
                      NA
                                                                                                                    NA
163
      HMDB0132477
                      NA
                                                                                                                    NA
164
      HMDB0129097
                      NA
                                                                                                                    NA
      HMDB0168839
165
                      NΑ
                                                                                                                    NA
      HMDB0128916
166
                      NA
                                                                                                                    NA
      {\rm HMDB0012233}
                                                                                                                    HMDB0012233
167
                      Glutarate semialdehyde
      HMDB0029172
                      3-keto-2-Methylbutyrate
                                                                                                                    HMDB0029172
168
      HMDB0001865
                      2-Oxovaleric acid
                                                                                                                    HMDB0001865
169
     HMDB0000310
HMDB0031643
170
                      Methylacetoacetic acid
                                                                                                                    HMDB0000310
171
                      Ethyl pyruvate
                                                                                                                    HMDB0031643
      HMDB0000019
                      Alpha-ketoisovaleric acid
                                                                                                                    HMDB0000019
172
      HMDB0003771
                      2-Methylacetoacetic acid
                                                                                                                    HMDB0003771
173
174
      HMDB0000720
                      Levulinic acid
                                                                                                                    HMDB0000720
      HMDB0034466
                                                                                                                    {\rm HMDB0034466}
175
                      Acetoxyacetone
176
      HMDB0128917
                      NΑ
                                                                                                                    NA
177
      HMDB0129096
                      NA
                                                                                                                    NA
      HMDB0129098
178
                      NA
                                                                                                                    NA
      HMDB0168838
                      NA
                                                                                                                    NA
179
      HMDB0177210
180
                      NA
                                                                                                                    NA
181
      HMDB0169666
                      NA
                                                                                                                    NA
182
      {\rm HMDB}0177209
                      NA
                                                                                                                    NA
183
      HMDB0171727
                      NA
                                                                                                                    NA
```

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HMDB0032356
      HMDB0032356
184
                       N-Lactoyl ethanolamine
185
      HMDB0039499
                      NA
                                                                                                                     NA
      HMDB0031658
                      L-2-Amino-5-hydroxypentanoic acid
                                                                                                                     HMDB0031658
186
      {\rm HMDB0002108}
                       Methylcysteine
                                                                                                                     {\rm HMDB0002108}
187
188
      {\rm HMDB0000742}
                      Homocysteine
                                                                                                                     {\rm HMDB0000742}
      HMDB0038949
                                                                                                                     \begin{array}{c} {\rm NA} \\ {\rm HMDB0030410} \end{array}
189
                      NA
      HMDB0030410
                      L-2-Amino-3-methylenehexanoic acid
190
                                                                                                                     HMDB0004827
191
      HMDB0004827
                      Proline betaine
      HMDB0034080
192
                      3-Methyl-1,2-cyclohexanedione
                                                                                                                     HMDB0034080
      HMDB0033629
                       xi-4-Hydroxy-4-methyl-2-cyclohexen-1-one
                                                                                                                     HMDB0033629
193
194
      {\rm HMDB0041474}
                      NA
                                                                                                                     NA
195
      HMDB0034835
HMDB0031223
                       3-(3-Ethyloxiranyl)-2-propenal
                                                                                                                     HMDB0034835
                       Enol-3-Ethyl-1,2-cyclopentanedione
                                                                                                                     HMDB0031223
196
197
      HMDB0040445
                      NA
                                                                                                                     NA
198
      HMDB0037026
                      NA
                                                                                                                     NA
      {\rm HMDB0031222}
                                                                                                                     HMDB0031222
199
                      3-Ethyl-1,2-cyclopentanedione
200
      HMDB0037027
                                                                                                                     HMDB0029582
                      Methyl sorbate
201
      HMDB0029582
                                                                                                                     HMDB0032067
202
      HMDB0032067
                       Allyl crotonate
      HMDB0032333
                                                                                                                     HMDB0032333
203
                       4-Hydroxy-4-methyl-5-hexenoic acid gamma lactone
204
      HMDB0145126
                      NA
                                                                                                                     NA
      HMDB0000062
                       L-Carnitine
                                                                                                                     HMDB0000062
206
      {\rm HMDB0062496}
                       Malonyl-Carnitin
                                                                                                                     HMDB0062496
207
      HMDB0062634
                                                                                                                     NA
      HMDB0155786
208
                      NA
                                                                                                                     NA
      HMDB0032380
                                                                                                                     HMDB0032380
209
                       (S1)-Methoxy-3-heptanethiol
      HMDB0172136
210
                      NA
                                                                                                                     NA
      HMDB0165770
211
                      NA
                                                                                                                     NA
212
      HMDB0165771
                       NA
                                                                                                                     NA
213
      {\rm HMDB0165773}
                      NA
                                                                                                                     NA
214
      HMDB0172134
                      NA
                                                                                                                     NA
      HMDB0172135
215
                      NΑ
                                                                                                                     NΑ
216
      {\rm HMDB0240308}
                      NA
                                                                                                                     NA
      HMDB0165772
217
                      NA
                                                                                                                     NA
                       1H-Indole-3-carboxaldehyde
      HMDB0029737
                                                                                                                     HMDB0029737
218
219
      HMDB0004186
                      3-Methyldioxyindole
                                                                                                                     {\rm HMDB0004186}
220
      HMDB0001424
                      4-(3-Pyridyl)-3-butenoic acid
                                                                                                                     HMDB0001424
      HMDB0062406
221
                      NA
                                                                                                                     NA
      HMDB0029300
                       p-Anisidine
                                                                                                                     HMDB0029300
222
      HMDB0167379
223
                                                                                                                     NA
      HMDB0032578
                       4-Hydroxybenzylamine
                                                                                                                     HMDB0032578
224
225
      {\rm HMDB0040360}
                      NA
                                                                                                                     NA
226
      HMDB0036058
                      NΑ
                                                                                                                     NA
      HMDB0167378
227
                      NA
                                                                                                                     NA
228
      HMDB0032492
                      2-Propionylpyrrole
                                                                                                                     HMDB0032492
229
      HMDB0166738
                      NA
                                                                                                                     NA
      {\rm HMDB0164724}
                      NA
                                                                                                                     NA
231
      HMDB0165094
                       NA
                                                                                                                     NA
232
      {\rm HMDB0165096}
                      NA
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      HMDB0165095
233
                      NA
                                                                                                                     NA
      HMDB0165097
234
                      NA
                                                                                                                     NA
      HMDB0166737
                      NA
235
                                                                                                                     NA
236
      HMDB0031484
                       2-Heptenoic acid
                                                                                                                     HMDB0031484
      HMDB0038962
237
                       NA
                                                                                                                     HMDB0031500
238
      HMDB0031500
                       Methyl 2E-hexenoate
      HMDB0166739
                                                                                                                    NA
HMDB0029314
239
                      NA
      HMDB0029314
240
                      Isopentenyl acetate
      HMDB0031477
                                                                                                                     HMDB0031477
                      3.4-Heptanedione
241
      HMDB0031476
                                                                                                                     HMDB0031476
242
                       2,3-Heptanedione
243
      HMDB0031504
                       Methyl (Z)-3-hexenoate
                                                                                                                     HMDB0031504
244
      HMDB0031603
                       Ethyl 4-pentenoate
                                                                                                                     HMDB0031603
245
      HMDB0040214
                      NA
                                                                                                                     NA
      HMDB0031342
                                                                                                                     HMDB0031342
                      Cyclohexanecarboxylic acid
246
      HMDB0038271
247
                                                                                                                     NA
      HMDB0031174
                                                                                                                     HMDB0031174
248
                       4-Methyl-5-hexanolide
      HMDB0031681
                                                                                                                     HMDB0031681
                      Dihydro-5-propyl-2(3H)-furanone
250
      {\rm HMDB0033793}
                       4-Heptenoic acid
                                                                                                                     HMDB0033793
251
      HMDB0031593
                      5-Methyl-2,3-hexanedione
                                                                                                                     HMDB0031593
      HMDB0039819
252
                      NΑ
                                                                                                                     NA
      HMDB0166736
                                                                                                                     NA
253
                      NA
      {\rm HMDB0173760}
254
                      NA
                                                                                                                     NA
      HMDB0173761
                       NA
                                                                                                                     NA
      {\rm HMDB0173762}
                       NA
                                                                                                                     NA
256
257
      {\rm HMDB}0173763
                      NA
                                                                                                                     NA
258
      HMDB0180322
                      NΑ
                                                                                                                     NΑ
      HMDB0180323
259
                      NA
                                                                                                                     NA
260
      HMDB0029165
                       1,3-Diacetylpropane
                                                                                                                     HMDB0029165
261
      HMDB0031351
                       Cyclohexyl formate
                                                                                                                     HMDB0031351
      HMDB0032460
                                                                                                                     {\rm HMDB0032460}
262
                       4-Pentenvl acetate
263
      {\rm HMDB0032391}
                      3-Methyl-3-butenyl acetate
                                                                                                                     HMDB0032391
264
      HMDB0030330
                      1	ext{-Methoxy-}3	ext{-methylene-}2	ext{-pentanone}
                                                                                                                     HMDB0030330
      HMDB0059876
265
                      NA
                                                                                                                     NA
266
      HMDB0040591
                      NA
                                                                                                                     NA
      HMDB0145113
267
                      NA
                                                                                                                     NA
268
      HMDB0145114
                      NA
                                                                                                                     NA
269
      HMDB0145115
                       NA
                                                                                                                     NA
270
      HMDB0145125
                      NA
                                                                                                                     NA
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	TT (DD 04.151.14		
$\frac{271}{272}$	HMDB0145116 HMDB0094649	NA	NA HMDB0094649
$\frac{272}{273}$	HMDB0094649 HMDB0001161	2-Amino-heptanoic acid 4-Trimethylammoniobutanoic acid	HMDB0094649 HMDB0001161
274	HMDB0006831	3-Dehydroxycarnitine	HMDB0006831
275	HMDB0000895	Acetylcholine	HMDB0000895
276	HMDB0013811	1-Nitroheptane	HMDB0013811
277	HMDB0240327	NA	NA
278	HMDB0159478	NA NA	NA
279	HMDB0159477	NA	NA
$\frac{280}{281}$	HMDB0158747 HMDB0158748	NA NA	NA NA
282	HMDB0158745	NA NA	NA
283	HMDB0158746	NA	NA
284	HMDB0159480	NA	NA
285	HMDB0159479	NA	NA
286	HMDB0161124	NA	NA
287	HMDB0161123	NA NA	NA
288	HMDB0161125	NA NA	NA NA
$\frac{289}{290}$	HMDB0155922 HMDB0061930	NA NA	NA NA
291	HMDB0033837	Dimethyl succinate	HMDB0033837
292	HMDB0006900	(S)-2-Aceto-2-hydroxybutanoic acid	HMDB0006900
293	HMDB0002173	Solerol	HMDB0002173
294	HMDB0002074	2,2-Dimethylsuccinic acid	${\rm HMDB0002074}$
295	HMDB0000858	Monomethyl glutaric acid	HMDB0000858
296	HMDB0000752	Methylglutaric acid	HMDB0000752
297	HMDB0000422	2-Methylglutaric acid	HMDB0000422
$\frac{298}{299}$	HMDB0000448 HMDB0062489	Adipic acid NA	HMDB0000448 NA
300	HMDB0002489	L-Rhamnulose	HMDB0010207
301	HMDB0033821	2-O-Methyl-D-xylose	HMDB0033821
302	HMDB0062477	NA	NA
303	${\rm HMDB0062498}$	NA	NA
304	HMDB0062499	NA	NA
305	HMDB0060267	L-Fuculose	HMDB0060267
$\frac{306}{307}$	HMDB0005876	3-Deoxyfructose	HMDB0005876
308	HMDB0012327 HMDB0002712	2-Deoxygalactopyranose 1,5-Anhydrosorbitol	HMDB0012327 HMDB0002712
309	HMDB0059625	NA	NA
310	HMDB0029196	D-Fucose	HMDB0029196
311	HMDB0003081	Beta-D-Fucose	HMDB0003081
312	HMDB0000174	L-Fucose	HMDB0000174
313	HMDB0059624	NA	NA
314	HMDB0000849	Rhamnose	HMDB0000849
$\frac{315}{316}$	HMDB0124735 HMDB0240304	NA NA	NA NA
317	HMDB0240304 HMDB0041477	NA NA	NA
318	HMDB0031660	Dibutyl sulfide	HMDB0031660
319	HMDB0168717	NA	NA
320	HMDB0168715	NA	NA
321	HMDB0168716	NA	NA
322	HMDB0168718	NA	NA
323	HMDB0062061	NA	NA
$\frac{324}{325}$	HMDB0030302 HMDB0029595	2,3,4-Trimethylhexane Nonane	HMDB0030302 HMDB0029595
326	HMDB0029393	2,2,3,4-Tetramethylpentane	HMDB0029393
327	HMDB0031556	Isononane	HMDB0031556
328	HMDB0031416	3,4-Dimethylheptane	HMDB0031416
329	HMDB0062017	ŇA	NA
330	HMDB0062013	NA	NA
331	HMDB0240251	NA NA	NA
332	HMDB0061880	NA cis 4 Hydroxy D proling	NA HMDB0060460
$\frac{333}{334}$	HMDB0060460 HMDB0000725	cis-4-Hydroxy-D-proline 4-Hydroxyproline	HMDB0060460 HMDB0000725
$\frac{334}{335}$	HMDB0036576	NA	NA
336	HMDB0030376	N-Acetyl-L-alanine	HMDB0000766
337	HMDB0000783	Propionylglycine	HMDB0000783
338	HMDB0002104	L-Glutamic gamma-semialdehyde	HMDB0002104
339	HMDB0002113	3-Hydroxy-L-proline	HMDB0002113
340	HMDB0006055	4-Hydroxy-L-proline	HMDB0006055
341	HMDB0059659	Trans-3-hydroxy-L-proline	HMDB0059659
$\frac{342}{343}$	HMDB0001149 HMDB0006272	5-Aminolevulinic acid 5-Amino-2-oxopentanoic acid	HMDB0001149 HMDB0006272
$\frac{343}{344}$	HMDB0006272 HMDB0177404	5-Amino-2-oxopentanoic acid NA	NA
$344 \\ 345$	HMDB0177404 HMDB0164041	NA NA	NA NA
346	HMDB0014389	Mesalazine	HMDB0014389
347	${\rm HMDB0001972}$	3-Aminosalicylic acid	${\rm HMDB0001972}$
348	HMDB0059749	NA .	NA
349	HMDB0001476	3-Hydroxyanthranilic acid	HMDB0001476
350	HMDB0059811	NA	NA
$\frac{351}{352}$	HMDB0014378 HMDB0001280	Aminosalicylic Acid 2-Aminomuconic acid semialdehyde	HMDB0014378 HMDB0001280
352 353	HMDB0001280	2-Ammonuconic acid semialdenyde 1-(Hydroxymethyl)-5,5-dimethyl-2,4-imidazolidinedione	HMDB0031670
354	HMDB0031070	Alanyl-Serine	HMDB0031070
355	HMDB0029032	Serylalanine	HMDB0029032
356	HMDB0145395	NA	NA
357	HMDB0029061	Threoninyl-Glycine	HMDB0029061

358	HMDB0028851	Glycyl-Threonine	HMDB0028851
359	HMDB0169117	NA NA	NA
360	HMDB0105117	NA NA	NA
361	HMDB0120100	NA NA	NA
362		2-Isopropylphenol	HMDB0032029
	HMDB0032029		HMDB0032029
363	HMDB0032149	1-Methoxy-2,4-dimethylbenzene	
364	HMDB0032625	4-Propylphenol	HMDB0032625
365	HMDB0029667	2,3,6-Trimethylphenol	HMDB0029667
366	HMDB0039782	NA	NA
367	HMDB0038986	NA	NA
368	HMDB0032624	2-Propylphenol	HMDB0032624
369	HMDB0038988	NA	NA
370	HMDB0032621	(2-Methoxyethyl)benzene	HMDB0032621
371	HMDB0038985	NA	NA
372	HMDB0031312	Benzyl ethyl ether	HMDB0031312
373	HMDB0033962	3-Phenyl-1-propanol	HMDB0033962
374	HMDB0031627	1-Phenyl-1-propanol	HMDB0031627
375	HMDB0034378	$(\hat{A}\hat{s})$ -1-(4-Methylphenyl)ethanol	HMDB0034378
376	HMDB0031628	2-Phenyl-1-propanol	HMDB0031628
377	HMDB0038984	NA	NA
378	HMDB0032544	2,4,6-Trimethylphenol	HMDB0032544
379	HMDB0031446	p-Isopropylphenol	HMDB0031446
380	HMDB0032441	Nona-2,4,6-trienal	HMDB0032441
381	HMDB0059896	NA	NA
382	HMDB0169118	NA	NA
383	HMDB0163404	NA	NA
384	HMDB0164725	NA NA	NA
385	HMDB0164726	NA NA	NA
$\frac{386}{387}$	HMDB0165787 HMDB0172015	NA NA	NA NA
388	HMDB0180325	NA NA	NA
389	HMDB0180324	NA	NA
390	HMDB0034230	Mesifurane	HMDB0034230
391	HMDB0164727	NA NA	NA
392	HMDB0041426	NA	NA
393	HMDB0041427	NA	NA
394	HMDB0033551	5-Ethyl-3-hydroxy-4-methyl-2(5H)-furanone	HMDB0033551
395	HMDB0033736	Homofureanol	HMDB0033736
396	HMDB0038593	NA	NA
397	HMDB0029412	Betonicine	HMDB0029412
398	HMDB0011757	N-Acetylvaline	HMDB0011757
399	HMDB0031345	Calystegine A6	HMDB0031345
400	HMDB0000339	2-Methylbutyrylglycine	HMDB0000339
401	HMDB0000678	Isovalerylglycine	HMDB0000678
402	HMDB0000927	Valerylglycine	HMDB0000927
403	HMDB0012154	3-Dehydrocarnitine	HMDB0012154
404	HMDB0012175	5-Acetamidovalerate	HMDB0012175
405	HMDB0036384	NA	NA
406	HMDB0029409	Turicine	HMDB0029409
407	HMDB0038625	NA	NA
408	HMDB0029230	4-Hydroxystachydrine	HMDB0029230
409	HMDB0061678	NA NA	NA
410	HMDB0035360	N-Methyl-1-deoxynojirimycin	HMDB0035360
411	HMDB0163316	NA	NA
412	HMDB0163318	NA	NA
413	HMDB0163317	NA NA	NA
414	HMDB0163315	NA	NA
415	HMDB0163319	NA NA	NA
		NA NA	NA NA
$\frac{416}{417}$	HMDB0062166 HMDB0032164	Allyl valerate	HMDB0032164
417	HMDB0037624	NA NA	NA
		A	
419	HMDB0029761	Ethyl (As)-2-methyl-4-pentenoate	HMDB0029761
420	HMDB0031403	Cyclohexaneacetic acid	HMDB0031403
421		4 To 4 1	
	HMDB0035422	4-Butyl-gamma-butyrolactone	${\rm HMDB}0035422$
422	HMDB0035422 HMDB0031352	Cyclohexyl acetate	HMDB0035422 HMDB0031352
$\frac{422}{423}$	HMDB0031352 HMDB0031343	Cyclohexyl acetate Methyl cyclohexanecarboxylate	HMDB0035422 HMDB0031352 HMDB0031343
422	HMDB0031352	Cyclohexyl acetate	HMDB0035422 HMDB0031352 HMDB0031343 NA
$\frac{422}{423}$	HMDB0031352 HMDB0031343	Cyclohexyl acetate Methyl cyclohexanecarboxylate	HMDB0035422 HMDB0031352 HMDB0031343
422 423 424	HMDB0031352 HMDB0031343 HMDB0036212	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA	HMDB0035422 HMDB0031352 HMDB0031343 NA
422 423 424 425	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533
422 423 424 425 426	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA
422 423 424 425 426 427	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266
422 423 424 425 426 427 428	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0036236	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA
422 423 424 425 426 427 428 429	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB0032268
422 423 424 425 426 427 428 429 430	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB0032268 HMDB000392	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB00032268 HMDB0000392
422 423 424 425 426 427 428 429 430 431	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB00001568 HMDB00038036	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB0032268 HMDB0000392 HMDB0001568
422 423 424 425 426 427 428 429 430 431 432 433	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038036 HMDB00389793	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB00032268 HMDB0000392 HMDB0001568 NA NA
422 423 424 425 426 427 428 429 430 431 432 433 434	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB00038036 HMDB0038793 HMDB0037630	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA NA NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB00032268 HMDB0000392 HMDB0001568 NA NA
422 423 424 425 426 427 428 429 430 431 432 433 434	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB0000392 HMDB0001568 HMDB0038036 HMDB0039793 HMDB0037630 HMDB0038310	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA NA NA NA NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB00032268 HMDB0000392 HMDB0001568 NA NA NA
422 423 424 425 426 427 428 430 431 432 433 434 435 436	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038036 HMDB0038793 HMDB0037630 HMDB0038310 HMDB0038872	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA NA NA NA NA NA NA NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB00032268 HMDB0000392 HMDB0001568 NA NA NA NA
422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038036 HMDB0039793 HMDB0037630 HMDB0038310 HMDB0038972 HMDB0038972	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB00032268 HMDB0000392 HMDB0001568 NA NA NA NA NA
422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032266 HMDB000392 HMDB0001568 HMDB0038036 HMDB00387630 HMDB0038310 HMDB003872 HMDB00387622 HMDB0037622	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB000392 HMDB0001568 NA NA NA NA NA NA NA NA NA NA NA
422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038036 HMDB0039793 HMDB0037630 HMDB0038310 HMDB0038721 HMDB0037622 HMDB0037622 HMDB0037622 HMDB0040215	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB000392 HMDB0001568 NA NA NA NA NA NA NA NA
422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0032266 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038036 HMDB0037630 HMDB0037630 HMDB0037630 HMDB0037622 HMDB0037622 HMDB0037622 HMDB0037622	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid trans-2-Octenoic acid NA Ethyl acetate NA Ethyl trans-2-methyl-2-pentenoate	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB000392 HMDB0001568 NA NA NA NA NA NA NA NA HMDB0040215 NA
422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038036 HMDB00387630 HMDB0037630 HMDB00387630 HMDB00387630 HMDB003872 HMDB0037622 HMDB0040215 HMDB0040215 HMDB0040212 HMDB0040212 HMDB0032278 HMDB0031293	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB000392 HMDB0001568 NA NA NA NA NA NA NA NA NA NA HMDB0040215 NA HMDB0032278 HMDB00031293
422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038793 HMDB0037630 HMDB0038310 HMDB0038310 HMDB003872 HMDB003872 HMDB0032278 HMDB0032278 HMDB0031293 HMDB0031293 HMDB0031293	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA NA NA NA NA NA NA S S S S S S S S S	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032566 NA HMDB0032266 HMDB000392 HMDB0001568 NA NA NA NA NA NA NA HMDB0032278 HMDB0032278 HMDB00013904
422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441	HMDB0031352 HMDB0031343 HMDB0036212 HMDB0032533 HMDB0240301 HMDB0032266 HMDB0032268 HMDB000392 HMDB0001568 HMDB0038036 HMDB00387630 HMDB0037630 HMDB00387630 HMDB00387630 HMDB003872 HMDB0037622 HMDB0040215 HMDB0040215 HMDB0040212 HMDB0040212 HMDB0032278 HMDB0031293	Cyclohexyl acetate Methyl cyclohexanecarboxylate NA trans-3-Hexenyl acetate NA Ethyl (E)-3-hexenoate NA Ethyl 2E-hexenoate 2-Octenoic acid trans-2-Octenoic acid NA	HMDB0035422 HMDB0031352 HMDB0031343 NA HMDB0032533 NA HMDB0032266 NA HMDB000392 HMDB0001568 NA NA NA NA NA NA NA NA NA NA HMDB0040215 NA HMDB0032278 HMDB00031293

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HMDB0013897
                      4-ene-Valproic acid
                                                                                                                   HMDB0013897
445
446
      HMDB0013903
                      (3Z)-2-Propylpent-3-enoic acid
                                                                                                                   HMDB0013903
      HMDB0061342
447
                                                                                                                   HMDB0032267
448
      {\rm HMDB0032267}
                      Ethyl 5-hexenoate
449
      {\rm HMDB0032207}
                      cis-5-Octenoic acid
                                                                                                                   HMDB0032207
      HMDB0062077
450
                      NΑ
                                                                                                                   NA
      HMDB0240571
451
                      NA
                                                                                                                   NA
      HMDB0000991
                      DL-2-Aminooctanoic acid
                                                                                                                   HMDB0000991
452
453
      HMDB0240732
                      NA
                                                                                                                   NA
                      Pregabalin
454
      HMDB0014375
                                                                                                                   HMDB0014375
455
      {\rm HMDB0013305}
                      Propionylcholine
                                                                                                                   {\rm HMDB0013305}
456
     HMDB0015654
HMDB0002285
                      Methacholine
                                                                                                                   HMDB0015654
                      2-Indolecarboxylic acid
                                                                                                                   HMDB0002285
457
458
      HMDB0240311
                      NA
                                                                                                                   NA
459
      HMDB0060289
                      Quinoline-4,8-diol
                                                                                                                   HMDB0060289
      {\rm HMDB0003320}
                                                                                                                   {\rm HMDB0003320}
460
                      Indole-3-carboxylic acid
461
      HMDB0031172
                      3-Formyl-6-hydroxyindole
                                                                                                                   {\rm HMDB0031172}
462
      HMDB0004077
                      4,6-Dihydroxyquinoline
                                                                                                                   HMDB0004077
      HMDB0032398
                                                                                                                   HMDB0032398
                      Methyl n-formylanthranilate
463
      HMDB0000992
                                                                                                                   HMDB0000992
464
                      3-Succinovlpyridine
      HMDB0000714
465
                      Hippuric acid
                                                                                                                   HMDB0000714
466
      HMDB0062583
                                                                                                                   HMDB0032595
467
      HMDB0032595
                      1-(4-Methoxyphenyl)-2-nitroethylene
468
      HMDB0184242
                      ΝÁ
                                                                                                                   NA
                                                                                                                   HMDB0012884
                      Adrenochrome
      HMDB0012884
469
      HMDB0038174
470
                      NA
                                                                                                                   NA
      HMDB0033388
471
                      NA
                                                                                                                   NA
      HMDB0185632
472
                      NA
                                                                                                                   NA
473
      HMDB0059856
                      NA
                                                                                                                   NA
474
      {\rm HMDB0012153}
                      3, 4\hbox{-}{\rm Dihydroxybenzylamine}
                                                                                                                   HMDB0012153
475
      HMDB0032332
                      Hydroxylated lecithin
                                                                                                                   HMDB0032332
      HMDB0145430
476
                      NΑ
                                                                                                                   NΑ
477
      {\rm HMDB0128078}
                      NA
                                                                                                                   NA
      HMDB0134039
478
                      NA
                                                                                                                   NA
      HMDB0135273
                      NA
                                                                                                                   NA
479
480
      HMDB0135648
                      NA
                                                                                                                   NA
481
      HMDB0135274
                      NΑ
                                                                                                                   NA
      HMDB0135275
482
                      NA
                                                                                                                   NA
      HMDB0035243
                      1-Phenyl-1,2-propanedione
                                                                                                                   HMDB0035243
483
      HMDB0000930
484
                      trans-Cinnamic acid
                                                                                                                   HMDB0000930
      HMDB0000567
                                                                                                                   {\rm HMDB0000567}
485
                      Cinnamic acid
486
      {\rm HMDB0036626}
                                                                                                                   NA
                                                                                                                   HMDB0040986
487
      HMDB0040986
                      (E)-3-(4-Hydroxyphenyl)-2-propenal
      HMDB0031725
488
                      (E)-3-(2-Hydroxyphenyl)-2-propenal
                                                                                                                   HMDB0031725
                                                                                                                   HMDB0032947
489
      HMDB0032947
                      Di-2-furanylmethane
490
      HMDB0062407
                                                                                                                   NA
                      NA
      HMDB0004992
                                                                                                                   HMDB0004992
491
                      Benzocaine
492
      {\rm HMDB0001007}
                      3-Pyridinebutanoic acid
                                                                                                                   {\rm HMDB0001007}
493
      {\rm HMDB0059934}
                      NΑ
                                                                                                                   NA
      HMDB0033589
                                                                                                                   HMDB0033589
494
                      Ethyl 2-aminobenzoate
      HMDB0033485
                                                                                                                   HMDB0033485
495
                      Gentiatibetine
                      Methyl N-methylanthranilate
496
      {\rm HMDB0034169}
                                                                                                                   HMDB0034169
497
      HMDB0006044
                      Norsalsolinol
                                                                                                                   HMDB0006044
      HMDB0000159
                      L-Phenylalanine
                                                                                                                   HMDB0000159
498
499
      HMDB0159744
                      NA
                                                                                                                   NA
      HMDB0062402
500
                      NΑ
                                                                                                                   NA
      HMDB0155168
501
                      NA
                                                                                                                   NA
      HMDB0029455
                                                                                                                   HMDB0029455
502
                      Ginkgotoxin
      HMDB0000068
503
                      Epinephrine
                                                                                                                   HMDB0000068
504
      HMDB0000819
                      Normetanephrine
                                                                                                                   HMDB0000819
505
      HMDB0002832
                      Methylnoradrenaline
                                                                                                                   HMDB0002832
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510
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                      2-Amino-3-carboxymuconic acid semialdehyde
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514
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                      Taurocyamine
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518
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520
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521
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542
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                      2', 3'- Dihydroxy ace to phenone\\
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566
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567
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                      p-Hydroxyphenylacetic acid
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569
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                      Norepinephrine
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572
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                      Pyridoxine
5-Hydroxydopamine
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579
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616
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617
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                      Betamipron
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$619 \\ 620$	HMDB0000073 HMDB0060277	Dopamine NA	HMDB0000073 NA
621	HMDB0000277	Vanillylamine	HMDB0012309
622	HMDB0004825	p-Octopamine	HMDB0004825
623	HMDB0156498	NA .	NA
624	HMDB0037786	NA	NA
625	HMDB0172919	NA.	NA
626	HMDB0177509	NA NA	NA NA
$\frac{627}{628}$	HMDB0141046 HMDB0133751	NA NA	NA NA
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630	HMDB0133749	NA	NA
631	HMDB0133752	NA	NA
632	HMDB0146627	NA	NA
633 634	HMDB0157134 HMDB0151225	NA NA	NA NA
635	HMDB0131223	NA NA	NA
636	HMDB0135643	NA	NA
637	${\rm HMDB0133755}$	NA	NA
638	HMDB0133594	NA	NA
639 640	HMDB0133595	NA NA	NA NA
641	HMDB0133504 HMDB0133598	NA NA	NA NA
642	HMDB0133599	NA	NA
643	HMDB0133596	NA	NA
644	HMDB0133747	NA	NA
645	HMDB0133748	NA NA	NA
$646 \\ 647$	HMDB0133597 HMDB0060335	NA 1,2-Dihydronaphthalene-1,2-diol	NA HMDB0060335
648	HMDB0000333	(Cassistearoptene	HMDB0000333
649	HMDB0040577	NA	NA
650	HMDB0029714	4,5-Dihydro-1-benzoxepin-3(2H)-one	HMDB0029714
651	HMDB0033591	Safrole	HMDB0033591
$652 \\ 653$	HMDB0033833	Methyl cinnamate 3-(4-Methoxyphenyl)-2-propenal	HMDB0033833
654	HMDB0032611 HMDB0040592	NA	HMDB0032611 NA
655	HMDB0038893	NA	NA
656	${\rm HMDB0039655}$	NA	NA
657	HMDB0033763	Ethyl N-methylanthranilate	HMDB0033763
658	HMDB0040021	NA Maltanarina	NA
$659 \\ 660$	HMDB0030372 HMDB0041931	Maltoxazine NA	HMDB0030372 NA
661	HMDB0001189	2(N)-Methyl-norsalsolinol	HMDB0001189
662	HMDB0005199	(R)-Salsolinol	HMDB0005199
663	HMDB0031811	3,5-Dimethylphenyl methylcarbamate	HMDB0031811
664	HMDB0042012	NA	NA
$665 \\ 666$	HMDB0029224 HMDB0029223	N-methylphenylalanine alpha-Methylphenylalanine	HMDB0029224 HMDB0029223
667	HMDB0029223	NA	NA
668	HMDB0094799	NA	NA
669	HMDB0094784	NA	NA
670	HMDB0094786	NA	NA
$671 \\ 672$	HMDB0094787 HMDB0094793	NA NA	NA NA
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676	HMDB0094783	NA NA	NA
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682	HMDB0094796	NA NA	NA NA
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686	HMDB0094792	NA	NA
687	${\rm HMDB0094795}$	NA	NA
688	HMDB0185183	NA	NA
689 690	HMDB0004063 HMDB0036074	Metanephrine NA	HMDB0004063 NA
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692	HMDB0154796	NA	NA
693	${\rm HMDB0062493}$	NA	NA
694	HMDB0094781	NA	NA
695	HMDB0033433	(S)-Homostachydrine	HMDB0033433
$696 \\ 697$	HMDB0014447 HMDB0000462	Tranexamic Acid Allantoin	HMDB0014447 HMDB0000462
698	HMDB0000402	NA NA	NA
699	HMDB0170209	NA	NA
700	HMDB0038896	NA	NA
701	HMDB0033556	2,5-Dimethyl-1,4-dithiane-2,5-diol	HMDB0033556
702 703	HMDB0013858 HMDB0060881	3-Dechloroethylifosfamide NA	HMDB0013858 NA
703	HMDB0000881	2-Dechloroethylifosfamide	HMDB0013859
705	HMDB0014480	Nitrofurazone	HMDB0014480

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722
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723
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724
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744
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747
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818
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      HMDB0033752
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820
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821
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822
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                       Ethyl vanillin
824
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825
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                                                                                                                      HMDB0029817
826
                       Ethyl salicylate
                       Homovanillin
      {\rm HMDB0005175}
                                                                                                                      HMDB0005175
828
      HMDB0032573
                       Ethylparaben
                                                                                                                      {\rm HMDB0032573}
829
      HMDB0032639
                       Methyl 4-methoxybenzoate
                                                                                                                      HMDB0032639
      HMDB0031132
830
                       3,4-Dihydroxyphenylacetone
                                                                                                                      HMDB0031132
      HMDB0062026
831
                       NA
                                                                                                                      NA
      HMDB0059969
                       NA
                                                                                                                      NA
832
      HMDB0062590
833
                       NA
                                                                                                                      NA
834
      {\rm HMDB0041683}
                       NA
                                                                                                                      NA
835
      HMDB0142137
                       NΑ
                                                                                                                      NA
                                                                                                                      HMDB0032138
                       3,4-Dimethoxybenzaldehyde
836
      HMDB0032138
837
      HMDB0002229
                       3-Phenoxypropionic acid
                                                                                                                      HMDB0002229
838
      HMDB0168657
                       NA
                                                                                                                      NA
      HMDB0000375
                                                                                                                      HMDB0000375
839
                       3-(3-Hydroxyphenyl)propanoic acid
840
      {\rm HMDB0000563}
                       D-Phenyllactic acid
                                                                                                                      {\rm HMDB0000563}
841
      {\rm HMDB0002199}
                       Desaminotyrosine
                                                                                                                      HMDB0002199
      HMDB0000779
842
                       Phenyllactic acid
                                                                                                                      HMDB0000779
      HMDB0002072
                      4-Methoxyphenylacetic acid
L-3-Phenyllactic acid
                                                                                                                      HMDB0002072
843
      HMDB0000748
                                                                                                                      {\rm HMDB0000748}
844
      HMDB0185611
                                                                                                                      NA
      HMDB0185616
                       NA
                                                                                                                      NA
846
847
      HMDB0185609
                       NA
                                                                                                                      NA
848
      HMDB0185610
                       NΑ
                                                                                                                      NA
      HMDB0185613
849
                       NA
                                                                                                                      NA
      HMDB0035291
                       Isoplumbagin
                                                                                                                      HMDB0035291
850
      HMDB0166096
851
                                                                                                                      NA
852
      HMDB0029472
                       Isoeugenitol
                                                                                                                      HMDB0029472
853
      {\rm HMDB0029466}
                       Eugenitol
                                                                                                                      HMDB0029466
854
      HMDB0032952
                       Citropten
                                                                                                                      HMDB0032952
      HMDB0036627
                                                                                                                      \begin{array}{c} {\rm NA} \\ {\rm HMDB0030818} \end{array}
855
                       NA
      HMDB0030818
856
                       Scoparone
      HMDB0136785
857
                       NA
                                                                                                                      NA
      HMDB0136786
                                                                                                                      NA
858
                       NA
859
      HMDB0181531
                       NA
                                                                                                                      NA
860
      {\rm HMDB0136784}
                       NA
                                                                                                                      NA
      HMDB0035303
                       {\it 3-} Methoxy-4, {\it 5-} methylenedioxycinnamal dehyde
                                                                                                                      HMDB0035303
861
      HMDB0029775
                                                                                                                      HMDB0029775
862
                       Vinyl caffeate
      {\rm HMDB0181534}
863
                       NA
                                                                                                                      NA
      HMDB0181532
                       NA
                                                                                                                      NA
864
865
      {\rm HMDB0181533}
                       NA
                                                                                                                      NA
866
      HMDB0129368
                       NA
                                                                                                                      NA
867
      HMDB0036187
                       NΑ
                                                                                                                      NA
      HMDB0032414
                                                                                                                      HMDB0032414
868
                       2-Methyl-3 or 5 or 6-(furfurylthio)pyrazine (mixture of isomers)
869
      HMDB0038791
                       NA
                                                                                                                      NA
870
      HMDB0033584
                       Diethyl tartrate
                                                                                                                      HMDB0033584
871
      HMDB0059767
872
      {\rm HMDB}0157322
                       NΑ
                                                                                                                      NA
873
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                      NA
                                                                                                                      NA
      HMDB0157320
874
                       NA
                                                                                                                      NA
      HMDB0157323
                       NA
                                                                                                                      NA
875
876
      HMDB0157324
                       NA
                                                                                                                      NA
877
      HMDB0029416
                       L-Targinine
                                                                                                                      HMDB0029416
878
      HMDB0000670
                       Homo-L-arginine
                                                                                                                      HMDB0000670
879
      HMDB0015454
                       Rasagiline
                                                                                                                      HMDB0015454
```

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HMDB0032926
                                                                                                                  HMDB0032926
880
                      Polycartine B
881
      HMDB0005973
                                                                                                                   HMDB0005973
                      Dimethyltryptamine
      HMDB0033961
                      2-(3-Methylbutyl)-1H-pyrrolo[2,3-b]pyridine
                                                                                                                  HMDB0033961
882
883
      {\rm HMDB0061284}
                                                                                                                  NA
                                                                                                                  HMDB0001892
884
      {\rm HMDB0001892}
                      Menadione
      HMDB0033765
                      Methyl (Z)-2-decene-4,6,8-triynoate
885
                                                                                                                  HMDB0033765
      HMDB0061682
886
                      NA
                                                                                                                  NA
887
      HMDB0060608
                      NA
                                                                                                                  NA
      HMDB0163574
888
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                                                                                                                  NA
889
      HMDB0163573
                      NA
                                                                                                                  NA
890
      {\rm HMDB0162439}
                      NA
                                                                                                                  NA
891
      HMDB0165489
HMDB0002042
                      NΑ
                                                                                                                  NA
                                                                                                                   HMDB0002042
                      3-Phenylpropionylglycine
892
893
      HMDB0000860
                      Phenylpropionylglycine
                                                                                                                  HMDB0000860
894
      HMDB0000512
                      N-Acetyl-L-phenylalanine
                                                                                                                  {\rm HMDB0000512}
      HMDB0165491
895
896
      HMDB0015165
                      Ethinamate
                                                                                                                  {\rm HMDB0015165}
897
      {\rm HMDB0167325}
                      NA
                                                                                                                  NA
                                                                                                                  HMDB0002182
      HMDB0002182
                      Phenylephrine
898
      HMDB0062266
899
                      NA
                                                                                                                  NA
      HMDB0014748
                                                                                                                  HMDB0014748
900
                      Metaraminol
901
      HMDB0060592
                                                                                                                  NA
902
      HMDB0060807
                      NA
                                                                                                                  NA
                                                                                                                  HMDB0032020
903
      HMDB0032020
                      4-(beta-Methylaminoethyl)catechol
      HMDB0041888
                                                                                                                  NA
NA
904
                      NA
      HMDB0062811
                      NA
905
      HMDB0039837
906
                      NA
                                                                                                                  NA
      HMDB0038869
907
                      NA
                                                                                                                  NA
908
      {\rm HMDB0000022}
                      3-Methoxytyramine
                                                                                                                  HMDB0000022
909
      {\rm HMDB0004826}
                      p-Synephrine
                                                                                                                  {\rm HMDB0004826}
910
      HMDB0012162
                      4-Methoxytyramine
                                                                                                                  HMDB0012162
      HMDB0094703
                                                                                                                  HMDB0094703
                      Propanoic acid, 2-(methoxyimino)-, trimethylsilyl ester
911
      HMDB0012286
                      S-Prenyl-L-cysteine
912
                                                                                                                  {\rm HMDB0012286}
      HMDB0169421
913
                                                                                                                  NA
      HMDB0163468
                      NA
                                                                                                                  NA
914
915
      HMDB0163469
                      NA
                                                                                                                  NA
916
      HMDB0179168
                      NA
                                                                                                                  NA
      HMDB0163465
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                      NA
                                                                                                                  NA
      HMDB0163466
                      NΑ
                                                                                                                  NΑ
918
      HMDB0094711
                      NA
919
                                                                                                                  NA
      HMDB0059936
920
                      NA
921
      {\rm HMDB0062081}
                      NA
                                                                                                                  NA
922
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                                                                                                                  NA
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923
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                                                                                                                  NA
      HMDB0036396
924
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                                                                                                                  NA
925
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                                                                                                                  NA
      HMDB0036188
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                                                                                                                   NA
927
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                                                                                                                   NA
928
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      HMDB0163470
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                                                                                                                  NA
931
932
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      HMDB0166861
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933
934
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                      NA
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      HMDB0157326
935
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                                                                                                                  NA
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                                                                                                                  HMDB0000325
936
                      3-Hydroxysuberic acid
      HMDB0040220
937
                      NA
                                                                                                                  NA
      HMDB0061681
938
                                                                                                                  NA
939
      HMDB0029968
                      Ethyl beta-D-glucopyranoside
                                                                                                                  {\rm HMDB0029968}
940
      HMDB0033942
                      Dambonitol
                                                                                                                  HMDB0033942
941
      HMDB0032329
                      2-Hexylthiophene
                                                                                                                  HMDB0032329
      HMDB0060323
                      NA
942
                                                                                                                  NA
      HMDB0003066
                                                                                                                  HMDB0003066
                      Chalcone
943
      HMDB0135598
944
                      NA
                                                                                                                  NA
      HMDB0031016
                      10-Undecen-1-ol
                                                                                                                  HMDB0031016
946
      {\rm HMDB0032371}
                      1-Menthyl methyl ether
                                                                                                                  {\rm HMDB0032371}
947
      HMDB0030943
                      6-Undecanone
                                                                                                                  HMDB0030943
      HMDB0032379
                      trans- and cis-1-Methoxy-1-decene
948
                                                                                                                  HMDB0032379
      HMDB0163244
949
                      NA
                                                                                                                  NA
      HMDB0030941
                                                                                                                  HMDB0030941
950
                      Undecanal
951
      HMDB0031065
                      (Âś)-(E)-3-Methyl-4-decen-1-ol
                                                                                                                  HMDB0031065
                      (Z)-3-Methyl-3-decen-1-ol
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                                                                                                                  HMDB0031064
952
      HMDB0033713
                                                                                                                  {\rm HMDB0033713}
953
                      2-Úndecanone
954
      HMDB0034856
                      2-Undecen-1-ol
                                                                                                                  {\rm HMDB0034856}
955
      HMDB0014631
                      Altretamine
                                                                                                                  HMDB0014631
      HMDB0041615
956
                      NA
                                                                                                                  NA
      HMDB0035753
                                                                                                                  HMDB0035753
957
                      (R)-(E)-4,7-Megastigmadien-9-one
      HMDB0034959
                                                                                                                  HMDB0034959
958
                      Edulan I
      HMDB0036818
959
                      NΑ
                                                                                                                  NA
      HMDB0036144
960
                      NA
                                                                                                                  NA
961
      {\rm HMDB0151804}
                      NA
                                                                                                                  NA
                      gamma-Ionone
                                                                                                                  HMDB0034979
962
      HMDB0034979
                      2,5-Diisopropyl-3-methylphenol
      HMDB0029822
                                                                                                                  HMDB0029822
963
      HMDB0029824
                      2,4-Diisopropyl-3-methylphenol
                                                                                                                  HMDB0029824
964
965
      HMDB0032541
                      4-(2,6,6-Trimethylcyclohex-1-enyl)but-2-en-4-one
                                                                                                                  {\rm HMDB0032541}
      HMDB0029821
                      2,5-Diisopropyl-4-methylphenol
                                                                                                                  HMDB0029821
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HMDB0036565
967
                        NA
                                                                                                                       NA
                        (2E,4Z,7Z)-2,4,7-Tridecatrienal
                                                                                                                       HMDB0033545
       HMDB0033545
968
       HMDB0035682
                                                                                                                       HMDB0035682
969
                        delta-Damascone
970
       {\rm HMDB0034671}
                        (E)-5,8-Megastigmadien-4-one
                                                                                                                       HMDB0034671
971
       {\rm HMDB0036027}
                        alpha-Damascone
                                                                                                                       HMDB0036027
       HMDB0037139
                                                                                                                       \begin{array}{c} {\rm NA} \\ {\rm HMDB0032498} \end{array}
972
                        NA
       HMDB0032498
973
                       Pseudoionone
                                                                                                                       HMDB0036022
974
       HMDB0036022
                       Isospirene
       HMDB0031733
                        4-(4-Methyl-3-pentenyl)-3-cyclohexene-1-carboxaldehyde
975
                                                                                                                       HMDB0031733
976
       HMDB0029823
                        2,4-Diisopropyl-5-methylphenol
                                                                                                                       HMDB0029823
977
       {\rm HMDB0036684}
                       ŃΑ
                                                                                                                       NA
978
       HMDB0029825
                       2, 3\hbox{-Diisopropyl-}5\hbox{-methylphenol}
                                                                                                                       HMDB0029825
       HMDB0059883
979
                       NΑ
                                                                                                                       NΑ
                                                                                                                       HMDB0029820
980
       HMDB0029820
                       2,6-Diisopropyl-3-methylphenol
981
       HMDB0014018
                       4-Hydroxypropofol
                                                                                                                       HMDB0014018
       {\rm HMDB0037389}
982
                                                                                                                       NA
983
       HMDB0038292
                        NA
                                                                                                                       NA
984
       HMDB0040439
                       NΑ
                                                                                                                       NA
       HMDB0039685
                       NA
                                                                                                                       NA
985
       HMDB0041497
986
                       NA
                                                                                                                       NA
       HMDB0031840
                                                                                                                       HMDB0031840
987
                        (S,Z)-Lyratol acetate
 988
       HMDB0035801
                        (2S,4R)-p-Mentha-1(7),5-dien-2-ol acetate
                                                                                                                       HMDB0035801
989
       HMDB0035375
                        Ethyl (2E,4E,7Z)-Decatrienoate
                                                                                                                       HMDB0035375
990
       HMDB0035376
                        Ethyl (2E,4Z,7Z)-Decatrienoate
                                                                                                                       HMDB0035376
       HMDB0132986
                                                                                                                       \begin{array}{c} {\rm NA} \\ {\rm HMDB0034450} \end{array}
991
                        NA
       HMDB0034450
                        Neocnidilide
992
993
       {\rm HMDB0032567}
                        Hexylresorcinol
                                                                                                                       {\rm HMDB0032567}
                                                                                                                       HMDB0035126
       HMDB0035126
994
                        (Âś)-Myrtenyl acetate
       HMDB0041610
995
                        ŇΑ
                                                                                                                       NA
       HMDB0038046
                       NA
                                                                                                                       NA
996
997
       HMDB0037018
                                                                                                                       NA
                       NA
998
       HMDB0037231
                        NA
                                                                                                                       NA
                                                                                                                       HMDB0035085
999
       HMDB0035085
                        Vulgarole
       HMDB0041572
1000
                        NA
       HMDB0029388
                                                                                                                       HMDB0029388
1001
                       Cucurbic acid
1002
       HMDB0037326
                       NΑ
                                                                                                                       NA
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                       Dihydrojasmonic acid
                                                                                                                       HMDB0033601
1003
1004
       {\rm HMDB0040195}
                        (1R,2S,3S,4R)-p-Menthane-2,3-diol
                                                                                                                       HMDB0035723
1005
       HMDB0035723
       HMDB0034457
                                                                                                                       HMDB0034457
1006
                        Propyl heptanoate
       HMDB0061987
1007
                       NA
                                                                                                                       NA
       HMDB0062146
1008
                       NA
                                                                                                                       NA
1009
       HMDB0038038
                       NA
                                                                                                                       NA
                                                                                                                       HMDB0036228
1010
       HMDB0036228
                        2-Methylpropyl hexanoate
1011
       HMDB0040167
                       NA
                                                                                                                       NA
       HMDB0036136
1012
                       NΑ
                                                                                                                       NΑ
       HMDB0187563
                       NΑ
                                                                                                                       NA
1013
       HMDB0037387
                       NA
1014
                                                                                                                       NA
1015
       HMDB0000511
                        Capric acid
                                                                                                                       HMDB0000511
1016
       HMDB0031264
                        Methyl nonanoate
                                                                                                                       {\rm HMDB0031264}
1017
       HMDB0094654
                        1-Methylethyl heptanoic acid
                                                                                                                       HMDB0094654
1018
       HMDB0171179
                       NΑ
                                                                                                                       NA
       HMDB0171178
1019
                       NA
                                                                                                                       NA
       HMDB0171177
1020
                       NA
                                                                                                                       NA
       HMDB0171176
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1022
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1024
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1025
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1026
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                                                                                                                       NA
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1035
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1036
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                        Heptanal propyleneglycol acetal
                                                                                                                       HMDB0032302
                                                                                                                       HMDB0032155
1037
       HMDB0032155
                        Acetaldehyde 1.3-octanediol acetal
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                                                                                                                       HMDB0032264
                        Ethyl 2-ethylhexanoate
1038
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1039
                        Hexanal butane-2,3-diol acetal
                                                                                                                       HMDB0032315
       HMDB0032045
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1040
                        Pentyl 3-methylbutanoate
1041
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                                                                                                                       HMDB0034849
1042
       HMDB0034849
                        4-Methylnonanoic acid
       HMDB0037849
1043
                       Hexyl 2-methylpropanoate
                                                                                                                       HMDB0037849
       HMDB0040157
1044
                       NΑ
                                                                                                                       NA
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                                                                                                                       HMDB0033620
                        Hexyl butyrate
1045
       HMDB0035595
1046
                       trans-p-Menthane-1,8-diol
                                                                                                                       {\rm HMDB0035595}
       HMDB0029760
                        1,1-Diethoxy-2-hexene
                                                                                                                       HMDB0029760
1047
1048
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                        Isooctyl acetate
                                                                                                                       {\rm HMDB0032070}
1049
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                        NA
                                                                                                                       NA
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1050
                       NΑ
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                       NA
1051
                                                                                                                       NA
1052
       HMDB0036145
                       NA
                                                                                                                       NA
       HMDB0039218
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HMDB0038602
1054
                                                                                                                    HMDB0038602
                       Octvl acetate
       HMDB0030029
                       Isopentyl isopentanoate
1055
                                                                                                                    HMDB0030029
1056
       HMDB0031739
                       7-Hydroxy-3,7-dimethyloctanal
                                                                                                                    HMDB0031739
1057
       {\rm HMDB0014362}
                       Bethanidine
                                                                                                                    {\rm HMDB0014362}
1058
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                       NA
                                                                                                                    NA
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       HMDB0060602
                       N-acetyl-5-aminosalicylic acid
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1060
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                       2-Hydroxy-6,7-dimethoxybenzoxazole
                                                                                                                    HMDB0004067
1061
       HMDB0004067
                       Leucodopachrome
       HMDB0002404
                       Alpha-Hydroxyhippuric acid
                                                                                                                    {\rm HMDB0002404}
1062
1063
       HMDB0002016
                       4-Carboxyphenylglycine
                                                                                                                    HMDB0002016
1064
       {\rm HMDB0001229}
                       Dopaquinone
                                                                                                                    {\rm HMDB0001229}
1065
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                       Salicyluric acid
                                                                                                                    HMDB0000840
       HMDB0183407
1066
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                                                                                                                    NA
1067
       HMDB0184100
                       NΑ
                                                                                                                    NΑ
1068
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                                                                                                                    HMDB0006116
       {\rm HMDB0166076}
1069
                                                                                                                    NA
1070
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                                                                                                                    NA
       HMDB0039119
1071
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                                                                                                                    NA
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                                                                                                                    HMDB0013678
1072
       HMDB0166113
1073
                       NA
                                                                                                                    NA
       HMDB0141198
1074
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                                                                                                                    NA
1075
       HMDB0136739
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                                                                                                                    HMDB0030819
1076
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1077
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                                                                                                                    NA
       HMDB0141199
1078
                       NA
                                                                                                                    NA
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                       4,7-Dihydroxy-2H-1-benzopyran-2-one
                                                                                                                    HMDB0032951
1079
       HMDB0032950
1080
                       5,7-Dihydroxy-4H-1-benzopyran-4-one
                                                                                                                    {\rm HMDB0032950}
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1081
                                                                                                                    NA
1082
       HMDB0141201
                       NA
                                                                                                                    NA
1083
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                       NA
                                                                                                                    NA
                                                                                                                    {\rm HMDB0015627}
1084
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1085
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                                                                                                                    NΑ
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1086
                       NA
                                                                                                                    NA
       HMDB0159159
1087
                                                                                                                    NA
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                                                                                                                    HMDB0006488
1088
1089
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1090
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                                                                                                                    NA
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1091
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                                                                                                                    NA
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1092
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       HMDB0009805
                         PI(18:0/16:0)
                                                                                                                                HMDB0009805
       HMDB0112518
4636
                         NA
                                                                                                                               NA
4637
       {\rm HMDB0112350}
                          NA
                                                                                                                                NA
4638
       HMDB0112517
                         NA
                                                                                                                               NA
       HMDB0112364
                         NΑ
                                                                                                                               NΑ
4639
       HMDB0112910
4640
                         NA
                                                                                                                               NA
       HMDB0112882
4641
                         NA
                                                                                                                               NA
4642
       HMDB0112739
                         NA
                                                                                                                                NA
4643
       {\rm HMDB0112711}
                         NA
                                                                                                                               NA
4644
       HMDB0112545
                         NA
                                                                                                                               NA
       HMDB0112375
4645
                         NA
                                                                                                                               NA
       HMDB0112392
                         NA
                                                                                                                               NA
4646
       HMDB0112411
4647
                         NA
                                                                                                                               NA
       HMDB0112319
4648
                         NA
                                                                                                                               NA
4649
       HMDB0112307
                          NA
                                                                                                                                NA
4650
       HMDB0010628
                         PG(18:1(11Z)/22:5(7Z,10Z,13Z,16Z,19Z))
                                                                                                                               HMDB0010628
                         \begin{array}{l} PG(18:1(11Z)/22:5(4Z,7Z,10Z,13Z,16Z)) \\ PG(18:1(9Z)/22:5(4Z,7Z,10Z,13Z,16Z)) \\ PG(18:1(9Z)/22:5(7Z,10Z,13Z,16Z,19Z)) \end{array}
4651
       HMDB0010627
                                                                                                                               HMDB0010627
       HMDB0010642
                                                                                                                               HMDB0010642
4652
       HMDB0010643
                                                                                                                               HMDB0010643
4653
       HMDB0010614
                          PG(18:0/22:6(4Z,7Z,10Z,13Z,16Z,19Z))
                                                                                                                               HMDB0010614
4654
       HMDB0010656
                          PG(18:2(9Z,12Z)/22:4(7Z,10Z,13Z,16Z))
                                                                                                                               HMDB0010656
4655
4656
       {\rm HMDB0116586}
                          NA
                                                                                                                               NA
4657
       HMDB0116593
                         NA
                                                                                                                               NA
       HMDB0116580
4658
                         NA
                                                                                                                               NA
       HMDB0116630
4659
                         NA
                                                                                                                               NΑ
       HMDB0116624
                         NA
                                                                                                                               NA
4660
       HMDB0116625
4661
                         NA
                                                                                                                                NA
4662
       {\rm HMDB0116617}
                         NA
                                                                                                                               NA
4663
       HMDB0116583
                         NΑ
                                                                                                                               NA
4664
       HMDB0116582
                         NA
                                                                                                                               NA
4665
       HMDB0116579
                         NA
                                                                                                                               NA
4666
       HMDB0116616
                         NA
                                                                                                                               NA
       HMDB0112745
4667
                         NA
                                                                                                                               NA
4668
       {\rm HMDB0112746}
                          NA
                                                                                                                                NA
4669
       {\rm HMDB0112769}
                         NA
                                                                                                                               NA
       HMDB0112793
4670
                         NA
                                                                                                                               NA
       HMDB0112580
4671
                         NA
                                                                                                                               NA
       HMDB0112606
4672
                         NA
                                                                                                                               NA
4673
       HMDB0112718
                         NA
                                                                                                                                NA
4674
       HMDB0112665
                          NA
                                                                                                                                NA
4675
       {\rm HMDB0112640}
                         NA
                                                                                                                               NA
       HMDB0112382
4676
                         NA
                                                                                                                               NA
       HMDB0112461
4677
                         NA
                                                                                                                               NA
       HMDB0112478
4678
                         NA
                                                                                                                               NΑ
       HMDB0112504
                         NA
4679
                                                                                                                               NA
4680
       HMDB0112529
                          NA
4681
       HMDB0112528
                         NA
                                                                                                                               NA
4682
       HMDB0112554
                         NA
                                                                                                                               NA
       HMDB0112555
4683
                         NA
                                                                                                                               NA
       HMDB0112626
                         NA
                                                                                                                               NA
4684
       HMDB0112437
4685
                         NA
                                                                                                                               NA
       HMDB0169205
4686
                                                                                                                               NA
4687
       {\rm HMDB0169206}
                                                                                                                               NA
                          PE(22:4(7Z,10Z,13Z,16Z)/22:6(4Z,7Z,10Z,13Z,16Z,19Z))
                                                                                                                               HMDB0009605
4688
       HMDB0009605
       HMDB0009702
                         PE(22:6(4Z,7Z,10Z,13Z,16Z,19Z)/22:4(7Z,10Z,13Z,16Z))
                                                                                                                               HMDB0009702
4689
4690
       HMDB0114593
                         NA
                                                                                                                               NA
       HMDB0009671
                         \begin{array}{l} \text{PE}(22:5(7\text{Z},10\text{Z},13\text{Z},16\text{Z},19\text{Z})/22:5(7\text{Z},10\text{Z},13\text{Z},16\text{Z},19\text{Z})) \\ \text{PE}(22:5(7\text{Z},10\text{Z},13\text{Z},16\text{Z},19\text{Z})/22:5(4\text{Z},7\text{Z},10\text{Z},13\text{Z},16\text{Z})) \end{array}
                                                                                                                               HMDB0009671
4691
4692
       HMDB0009670
                                                                                                                                HMDB0009670
4693
       HMDB0009638
                         PE(22:5(4Z,7Z,10Z,13Z,16Z)/22:5(7Z,10Z,13Z,16Z,19Z))
                                                                                                                               HMDB0009638
4694
       {\rm HMDB0116722}
                          NA
                                                                                                                               NA
4695
       HMDB0114567
                         NΑ
                                                                                                                               NΑ
       HMDB0114540
4696
                         NΑ
                                                                                                                               NΑ
4697
       HMDB0114406
                         NA
                                                                                                                               NA
4698
       HMDB0114405
                         NA
                                                                                                                               ΝA
4699
       HMDB0114378
                          NA
                                                                                                                               NA
4700
       HMDB0114349
                         NΑ
                                                                                                                               NA
                         PE(22:5(4Z,7Z,10Z,13Z,16Z)/22:5(4Z,7Z,10Z,13Z,16Z))
                                                                                                                               HMDB0009637
4701
       HMDB0009637
       HMDB0061425
4702
                         NA
                                                                                                                               NA
       HMDB0061422
                         NA
                                                                                                                               NA
4703
       HMDB0061438
4704
                         NA
                                                                                                                               NA
4705
       HMDB0061465
                         NA
                                                                                                                               NA
4706
       HMDB0113821
                         NA
                                                                                                                               NA
4707
       HMDB0113813
                         NA
                                                                                                                               NA
```

4708	HMDB0113789	NA	NA
4709	HMDB0113774	NA	NA
4710	HMDB0113764	NA	NA
4711	HMDB0113758	NA	NA
4712	HMDB0113827	NA	NA
4713	HMDB0113828	NA	NA
4714	HMDB0113835	NA	NA
4715	HMDB0114666	NA	NA
4716	HMDB0114680	NA	NA
4717	HMDB0114686	NA	NA
4718	HMDB0114714	NA	NA
4719	HMDB0114729	NA	NA
4720	HMDB0114733	NA	NA
4721	HMDB0114739	NA	NA
4722	HMDB0114721	NA	NA
4723	HMDB0113781	NA	NA
4724	HMDB0061511	NA	NA
4725	HMDB0061507	NA	NA
4726	HMDB0061499	NA	NA
4727	HMDB0061475	NA	NA
4728	HMDB0061483	NA	NA
4729	HMDB0061471	NA	NA
4730	HMDB0061522	NA	NA
4731	HMDB0061530	NA	NA
4732	HMDB0061533	NA	NA
4733	HMDB0061549	NA	NA
4734	HMDB0059616	all-trans-Decaprenyl diphosphate	HMDB0059616

4 Pathway Analysis

In this step, users are asked to select a pathway library, as well as specify the algorithms for pathway enrichment analysis and pathway topology analysis.

4.1 Pathway Library

There are 15 pathway libraries currently supported, with a total of 1173 pathways:

- Homo sapiens (human) [80]
- Mus musculus (mouse) [82]
- Rattus norvegicus (rat) [81]
- Bos taurus (cow) [81]
- Danio rerio (zebrafish) [81]
- Drosophila melanogaster (fruit fly) [79]
- Caenorhabditis elegans (nematode) [78]
- Saccharomyces cerevisiae (yeast) [65]
- Oryza sativa japonica (Japanese rice) [83]
- Arabidopsis thaliana (thale cress) [87]
- Escherichia coli K-12 MG1655 [87]
- Bacillus subtilis [80]
- Pseudomonas putida KT2440 [89]
- Staphylococcus aureus N315 (MRSA/VSSA)[73]
- Thermotoga maritima [57]

Your selected pathway library code is **hsa** (KEGG organisms abbreviation).

4.2 Over Representation Analysis

Over-representation analysis tests if a particular group of compounds is represented more than expected by chance within the user uploaded compound list. In the context of pathway analysis, we are testing if compounds involved in a particular pathway are enriched compared to random hits. MetPA offers two of the most commonly used methods for over-representation analysis:

- Fishers'Exact test
- Hypergeometric Test

Please note, MetPA uses one-tailed Fisher's exact test which will give essentially the same result as the result calculated by the hypergeometric test.

The selected over-representation analysis method is **Hypergeometric test**.

4.3 Pathway Topology Analysis

The structure of biological pathways represent our knowledge about the complex relationships among molecules within a cell or a living organism. However, most pathway analysis algorithms fail to take structural information into consideration when estimating which pathways are significantly changed under conditions of study. It is well-known that changes in more important positions of a network will trigger a more severe impact on the pathway than changes occurred in marginal or relatively isolated positions.

The pathway topology analysis uses two well-established node centrality measures to estimate node importance - degree centrality and betweenness centrality. Degree centrality is defined as the number of links occurred upon a node. For a directed graph there are two types of degree: in-degree for links come from other nodes, and out-degree for links initiated from the current node. Metabolic networks are directed graph. Here we only consider the out-degree for node importance measure. It is assumed that nodes upstream will have regulatory roles for the downstream nodes, not vice versa. The betweenness centrality measures the number of shortest paths going through the node. Since the metabolic network is directed, we use the relative betweenness centrality for a metabolite as the importance measure. The degree centrality measure focuses more on local connectivities, while the betweenness centrality measure focuses more on global network topology. For more detailed discussions on various graph-based methods for analyzing biological networks, please refer to the article by Tero Aittokallio, T. et al. ¹

Please note, for comparison among different pathways, the node importance values calculated from centrality measures are further normalized by the sum of the importance of the pathway. Therefore, the total/maximum importance of each pathway is 1; the importance measure of each metabolite node is actually the percentage w.r.t the total pathway importance, and the pathway impact value is the cumulative percentage from the matched metabolite nodes.

Your selected node importance measure for topological analysis is relative betweenness centrality.

5 Pathway Analysis Result

The results from pathway analysis are presented graphically as well as in a detailed table.

A Google-map style interactive visualization system was implemented to facilitate data exploration. The graphical output contains three levels of view: **metabolome view**, **pathway view**, and **compound view**. Only the metabolome view is shown below. Pathway views and compound views are generated dynamically based on your interactions with the visualization system. They are available in your downloaded files.

¹Tero Aittokallio and Benno Schwikowski. *Graph-based methods for analyzing networks in cell biology*, Briefings in Bioinformatics 2006 7(3):243-255

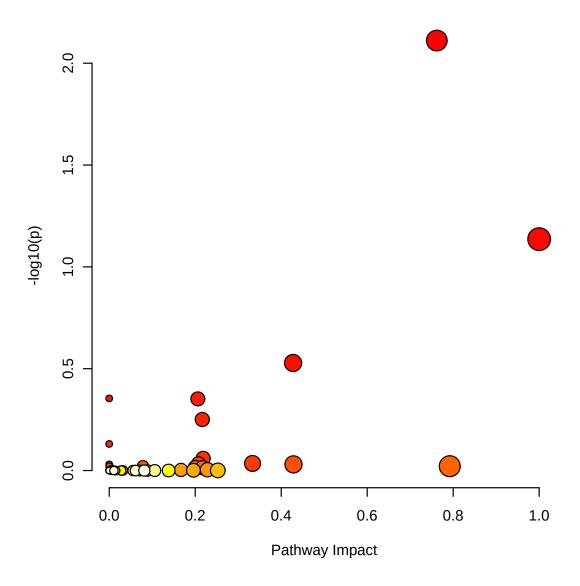


Figure 1: Summary of Pathway Analysis

The table below shows the detailed results from the pathway analysis. Since we are testing many pathways at the same time, the statistical ${\bf p}$ values from enrichment analysis are further adjusted for multiple testings. In particular, the **Total** is the total number of compounds in the pathway; the **Hits** is the actually matched number from the user uploaded data; the **Raw p** is the original ${\bf p}$ value calculated from the enrichment analysis; the **Holm p** is the ${\bf p}$ value adjusted by Holm-Bonferroni method; the **FDR p** is the ${\bf p}$ value adjusted using False Discovery Rate; the **Impact** is the pathway impact value calculated from pathway topology analysis.

Table 2: Result from Pathway Analysis

Table 2. Result from Lachway Analysis											
	Total	Expected	Hits	Raw p	-log10(p)	Holm adjust	FDR	Impact			
Phenylalanine metabolism	10	2.86	7	7.74E-03	2.11E+00	6.50E-01	6.50E-01	0.76			
Phenylalanine, tyrosine and tryptophan	4	1.14	3	7.31E-02	1.14E+00	1.00E+00	1.00E+00	1.00			
biosynthesis											
Tyrosine metabolism	42	12.00	14	2.96E-01	5.28E-01	1.00E+00	1.00E+00	0.43			
Linoleic acid metabolism	5	1.43	2	4.42E-01	3.54E-01	1.00E+00	1.00E+00	0.00			
Primary bile acid biosynthesis	46	13.15	14	4.45E-01	3.52E-01	1.00E+00	1.00E+00	0.21			
Retinol metabolism	17	4.86	5	5.62E-01	2.51E-01	1.00E+00	1.00E+00	0.22			
D-Arginine and D-ornithine metabolism	4	1.14	1	7.40E-01	1.31E-01	1.00E+00	1.00E+00	0.00			
Tryptophan metabolism	41	11.72	9	8.72E-01	5.95E-02	1.00E+00	1.00E+00	0.22			
alpha-Linolenic acid metabolism	13	3.72	2	9.23E-01	3.49E-02	1.00E+00	1.00E+00	0.33			
Arachidonic acid metabolism	36	10.29	7	9.26E-01	3.33E-02	1.00E+00	1.00E+00	0.21			
Valine, leucine and isoleucine biosynthesis	8	2.29	1	9.33E-01	3.02E-02	1.00E+00	1.00E+00	0.00			
Taurine and hypotaurine metabolism	8	2.29	1	9.33E-01	3.02E-02	1.00E+00	1.00E+00	0.43			
Ubiquinone and other terpenoid-quinone biosynthesis	9	2.57	1	9.52E-01	2.13E-02	1.00E+00	1.00E+00	0.00			
Vitamin B6 metabolism	9	2.57	1	9.52E-01	2.13E-02	1.00E+00	1.00E+00	0.08			
One carbon pool by folate	9	2.57	1	9.52E-01	2.13E-02	1.00E+00	1.00E+00	0.79			
Biotin metabolism	10	2.86	1	9.66E-01	1.51E-02	1.00E+00	1.00E+00	0.20			
Glycerophospholipid metabolism	36	10.29	6	9.69E-01	1.37E-02	1.00E+00	1.00E+00	0.22			
Pantothenate and CoA biosynthesis	19	5.43	2	9.86E-01	6.09E-03	1.00E+00	1.00E+00	0.01			
Lysine degradation	25	7.15	3	9.87E-01	5.48E-03	1.00E+00	1.00E+00	0.00			
Ether lipid metabolism	20	5.72	2	9.90E-01	4.53E-03	1.00E+00	1.00E+00	0.00			
Glycosylphosphatidylinositol (GPI)- anchor biosynthesis	14	4.00	1	9.91E-01	3.83E-03	1.00E+00	1.00E+00	0.00			
Arginine biosynthesis	14	4.00	1	9.91E-01	3.83E-03	1.00E+00	1.00E+00	0.23			
Arginine biosynthesis Arginine and proline metabolism	38	10.86	5	9.93E-01	2.88E-03	1.00E+00	1.00E+00 1.00E+00	0.23			
Nicotinate and nicotinamide metabolism	15	4.29	1	9.94E-01	2.72E-03	1.00E+00 1.00E+00	1.00E+00	0.00			
Steroid hormone biosynthesis	85	24.29	14	9.97E-01	1.13E-03	1.00E+00	1.00E+00	0.20			
Starch and sucrose metabolism	18	5.14	1	9.98E-01	9.76E-04	1.00E+00	1.00E+00	0.00			
Terpenoid backbone biosynthesis	18	5.14	1	9.98E-01	9.76E-04	1.00E+00	1.00E+00	0.00			
Glycine, serine and threonine metabolism	33	9.43	3	9.99E-01	5.90E-04	1.00E+00	1.00E+00	0.25			
Galactose metabolism	27	7.72	2	9.99E-01	5.40E-04	1.00E+00	1.00E+00	0.03			
Fructose and mannose metabolism	20	5.72	1	9.99E-01	4.93E-04	1.00E+00	1.00E+00	0.00			
Sphingolipid metabolism	21	6.00	1	9.99E-01	3.50E-04	1.00E+00	1.00E+00	0.00			
Biosynthesis of unsaturated fatty acids	36	10.29	3	9.99E-01	2.48E-04	1.00E+00	1.00E+00	0.00			
Steroid biosynthesis	42	12.00	4	9.99E-01	2.47E-04	1.00E+00	1.00E+00	0.07			
Porphyrin and chlorophyll metabolism	30	8.57	2	1.00E+00	2.13E-04	1.00E+00	1.00E+00	0.03			
Fatty acid degradation	39	11.15	3	1.00E+00	1.02E-04	1.00E+00	1.00E+00	0.00			
Pyrimidine metabolism	39	11.15	3	1.00E+00	1.02E-04	1.00E+00	1.00E+00	0.03			
Cysteine and methionine metabolism	33	9.43	2	1.00E+00	8.28E-05	1.00E+00	1.00E+00	0.14			
Aminoacyl-tRNA biosynthesis	48	13.72	4	1.00E+00	4.55E-05	1.00E+00	1.00E+00	0.06			
Folate biosynthesis	27	7.72	1	1.00E+00	4.48E-05	1.00E+00	1.00E+00	0.01			
Alanine, aspartate and glutamate metabolism	28	8.00	1	1.00E+00	3.17E-05	1.00E+00	1.00E+00	0.00			
Glutathione metabolism	28	8.00	1	1.00E+00	3.17E-05	1.00E+00	1.00E+00	0.09			
Fatty acid elongation	39	11.15	2	1.00E+00 1.00E+00	1.22E-05	1.00E+00 1.00E+00	1.00E+00 1.00E+00	0.09			
Fatty acid biosynthesis	47	13.43	3	1.00E+00 1.00E+00	9.16E-06	1.00E+00	1.00E+00 1.00E+00	0.00			
Glyoxylate and dicarboxylate	32	9.15	1	1.00E+00	8.01E-06	1.00E+00	1.00E+00	0.01			
metabolism	32	9.10	1	1.0012-00	0.01E-00	1.001	1.002-00	0.11			
Amino sugar and nucleotide sugar	37	10.57	1	1.00E+00	1.42E-06	1.00E+00	1.00E+00	0.00			
metabolism		15.50		1.005 : 00	F 0.4F 05	1 00E : 00	1.005 : 00	0.01			
Drug metabolism - cytochrome P450	55	15.72	3	1.00E+00	7.64E-07	1.00E+00	1.00E+00	0.01			
Valine, leucine and isoleucine degrada- tion	40	11.43	1	1.00E+00	5.02E-07	1.00E+00	1.00E+00	0.01			
Purine metabolism	65	18.58	3	1.00E+00	3.16E-08	1.00E+00	1.00E+00	0.06			
Metabolism of xenobiotics by cytochrome	68	19.43	2	1.00E+00	8.11E-10	1.00E+00	1.00E+00	0.08			
P450	""		-								
	1		-		1		<u>'</u>				

6 Appendix: R Command History

```
[1] "mSet<-InitDataObjects(\"conc\", \"pathora\", FALSE)"
[2] "cmpd.vec<-c(\"HMDBO000123\",\"HMDBO014691\",\"HMDBO031239\",\"HMDBO161401\",\"HMDBO000925\",\"]
[3] "mSet<-Setup.MapData(mSet, cmpd.vec);"
[4] "mSet<-CrossReferencing(mSet, \"hmdb\");"
[5] "mSet<-CreateMappingResultTable(mSet)"
[6] "mSet<-SetKEGG.PathLib(mSet, \"hsa\", \"current\")"
[7] "mSet<-SetMetabolomeFilter(mSet, F);"
[8] "mSet<-CalculateOraScore(mSet, \"rbc\", \"hyperg\")"
[9] "mSet<-PlotPathSummary(mSet, F, \"path_view_0_\", \"png\", 72, width=NA)"
[10] "mSet<-SaveTransformedData(mSet)"
[11] "mSet<-PreparePDFReport(mSet, \"guest5553748766599075063\")\n"</pre>
```

The report was generated on Mon May 24 12:56:06 2021 with R version 4.0.2 (2020-06-22).