

Computation and analysis of rescued lethal gene deletions in a host-microbe model

Note: This tutorial is a draft and needs completion. Contributions welcome!

Author: Almut Heinken, Molecular Systems Physiology Group, University of Luxembourg.

```
% Constraint-based modeling has useful applications for predicting the
% metabolic interactions between a mammalian host and its commensal gut
% microbes. For example, the potential of a human gut microbe to rescue
% lethal gene defects in the mouse has been predicted. Some of these rescued
% gene defects correspond to human inborn errors of metabolism (IEMs)
% (Heinken et al., Gut Microbes (2020) 4(1):28-50). A variety of IEMs are
% documented in human and can be browsed at https://www.vmh.life/ROGases.
```

```
% This tutorial demonstrates how to predict the potential of a commensal
% gut microbe to rescue lethal gene deletions in a mammalian host. For this
% purpose, a microbe is joined with a mouse host.
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```
% We will use the AGORA resource (Magnusdottir et al., Nat Biotechnol. 2017
% 35(11):102-110) in this tutorial. Please download AGORA from
% https://www.vmh.life/Downloadview
% and place the models into a folder.
```

```
% As the host model, the global mouse reconstruction
% (Nikurdian et al., BMC Systems Biology (2008) 4:108)
% will be used. Please download the mouse reconstruction from
% https://www.ncbi.nlm.nih.gov/pmc/articles/PMC251190/.
```

```
% Define the path to the folder where you stored the AGORA models.
```

```
modelPath = "YOUR_PATH_TO_AGORA/";
```

```
% Initialize the COBRA toolbox.
```

```
initializeCobra
```


% Join the micrute with the model.

[modelToJoin] = createMutaTagSpeciesModeL(modelIs, 'nameTagModels', 'nameTagModels', 'modelInact', 'modelInact', 'nameTagInact', 'nameTagInact', 'mergeName

The following fields are missing in several models, they will not be merged

Warnings: Metabolic 15mase[h] not in model - added to the model

2M6C9H16 h2u[s] + 15mase[s] → atp[s] → atp[s] + h[s] + pi[s] + 15mase[h]

EX_15mase[h] 15mase[h] →

Warnings: Metabolic 210ph[h] not in model - added to the model

2M6P9H6 210ph[h] → 210ph[s]

EX_210ph[h] 210ph[h] →

Warnings: Metabolic 21275hviid2[h] not in model - added to the model

2L_210HVT702H 21275hviid2[s] → 21275hviid2[h]

EX_21275hviid2[h] 21275hviid2[h] →

Warnings: Metabolic 21275hviid3[h] not in model - added to the model

2L_210HVT702H 21275hviid3[s] → 21275hviid3[h]

EX_21275hviid3[h] 21275hviid3[h] →

Warnings: Metabolic 210hviid2[h] not in model - added to the model

2M6T7216 210hviid2[s] → 210hviid2[h]

2M6T7216h 210hviid2[h] → 210hviid2[s]

EX_210hviid2[h] 210hviid2[h] →

Warnings: Metabolic 210hviid3[h] not in model - added to the model

2M6T7216 210hviid3[s] → 210hviid3[h]

2M6T7216h 210hviid3[h] → 210hviid3[s]

EX_210hviid3[h] 210hviid3[h] →

Warnings: Metabolic 25h[h] not in model - added to the model

Warnings: Metabolic h[h] not in model - added to the model

2M6126 25h[h] + h[h] → h[s] + 25h[s]

EX_25h[h] 25h[h] →

Warnings: Reaction with the same name already exists in the model, updating the reaction

2M6126 25h[h] + h[h] → h[s] + 25h[s]

Warnings: Metabolic dhpsu_17[h] not in model - added to the model

dhpsu_17h h[h] + dhpsu_17[h] → h[s] + dhpsu_17[s]

Warnings: Metabolic d6u[h] not in model - added to the model

AM0712-6 h[h] + d6u[h] → h[s] + d6u[s]

Warnings: Metabolic asac[h] not in model - added to the model

AC06126 h[h] + asac[h] → h[s] + asac[s]

Warnings: Metabolic ascorone[h] not in model - added to the model

AC072M0126 h[h] + ascorone[h] → h[s] + ascorone[s]

Warnings: Metabolic ash[h] not in model - added to the model

Warnings: Metabolic h2u[h] not in model - added to the model

Warnings: Metabolic ac[h] not in model - added to the model

Warnings: Metabolic chu[h] not in model - added to the model

AC066 ash[h] + h2u[h] → h[s] + ac[h] + chu[h]

AC066 h[h] + ac[h] → h[s] + ac[s]

Warnings: Metabolic ade[h] not in model - added to the model

Warnings: Metabolic iav[h] not in model - added to the model

Warnings: Metabolic rhd[h] not in model - added to the model

AD066 h[h] + h2u[h] + ade[h] → iav[h] + rhd[h]

Warnings: Metabolic a1a_1[h] not in model - added to the model

AL0126 h[h] + a1a_1[h] → h[s] + a1a_1[s]

Warnings: Metabolic na1[h] not in model - added to the model

AL066 h[h] + a1a_1[h] + 2 na1[h] → 2 na1[s] + a1a_1[s] + h[h]

Warnings: Metabolic arg_1[h] not in model - added to the model

AL066 arg_1[h] + h[h] + a1a_1[h] → h[s] + a1a_1[s] + arg_1[h]

Warnings: Metabolic asu_1[h] not in model - added to the model

AM066 h[h] + 2 na1[h] + asu_1[h] → 2 na1[s] + asu_1[s] + h[h]

Warnings: Metabolic asp_2[h] not in model - added to the model

Warnings: Metabolic h[h] not in model - added to the model

ASP016 h[h] + h[h] + 3 na1[h] + asp_2[h] → h[s] + 3 na1[s] + asp_2[s] + h[h]

Warnings: Metabolic asp_1[h] not in model - added to the model

ASP06 h[h] + h[h] + 3 na1[h] + asp_1[h] → h[s] + 3 na1[s] + asp_1[s] + h[h]

Warnings: Metabolic atp[h] not in model - added to the model

Warnings: Metabolic asp[h] not in model - added to the model

Warnings: Metabolic pi[h] not in model - added to the model

ATP016 2 h2u[h] + atp[h] → 2 h[h] + asp[h] + 2 pi[h]

Warnings: Metabolic adp[h] not in model - added to the model

ATP026 h2u[h] + adp[h] → h[h] + asp[h] + pi[h]

Warnings: Metabolic hgl[h] not in model - added to the model

GLC16 h[h] + hgl[h] → h[s] + hgl[s]

Warnings: Metabolic g1gph[h] not in model - added to the model

GL05C9H6 h[h] + g1gph[h] → h[s] + g1gph[s]

Warnings: Metabolic g1tchu[h] not in model - added to the model

GL07C9H6 h[h] + g1tchu[h] → h[s] + g1tchu[s]

Warnings: Metabolic g1tchu[h] not in model - added to the model

GL0728C9H6 h[h] + g1tchu[h] → h[s] + g1tchu[s]

Warnings: Metabolic h4h[h] not in model - added to the model

0M06 h[h] + h4h[h] → h[s] + h4h[s]

Warnings: Metabolic h6h[h] not in model - added to the model

0T0626 h[h] + h6h[h] → h[s] + h6h[s]

0T0616 h[h] + h6h[h] → h[s] + h6h[s]

Warnings: Metabolic hui[h] not in model - added to the model

0UT216 h[h] + hui[h] → h[s] + hui[s]

Warnings: Metabolic ca1[h] not in model - added to the model

CA07P96 h2u[s] + atp[s] + 2 ca1[h] → adp[s] + pi[s] + h[h] + 2 ca1[h]

Warnings: Metabolic cpy[h] not in model - added to the model

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GLV12_2_h 2 h[k] = op1y[k] -> 2 h[s] + op1y[s]
Warnings: Metastable cre[k] not in model - added to the model
CM00ab cre[s] = h[k] -> h[s] + cre[k]
Warnings: Metastable dnd_2[k] not in model - added to the model
Warnings: Metastable dnd[k] not in model - added to the model
D000b h[k] + h2a[k] + dnd_2[k] -> dnd[k] + dnd[k]
Warnings: Metastable afa_2[k] not in model - added to the model
D0012ab h[k] + afa_2[k] -> h[s] + afa_2[s]
Warnings: Metastable lac_2[k] not in model - added to the model
D_0012ab h[k] + lac_2[k] -> h[s] + lac_2[s]
E0_h00b h[k] ->
Warnings: Metastable asch_1[k] not in model - added to the model
Warnings: Metastable fe[k] not in model - added to the model
Warnings: Metastable abdash[k] not in model - added to the model
Warnings: Metastable fe2[k] not in model - added to the model
FER2ab asch_1[k] + 2 fe2[k] -> 2 h[k] + abdash[k] + 2 fe2[k]
Warnings: Metastable gal[k] not in model - added to the model
GL02_2b 2 h[k] + gal[k] -> 2 h[s] + gal[s]
Warnings: Metastable gla_2[k] not in model - added to the model
GL02_2b 2 h[k] + gla_2[k] -> 2 h[s] + gla_2[s]
GL02vb h[k] + gla_2[k] -> h[s] + gla_2[s]
Warnings: Metastable gla_1[k] not in model - added to the model
GL00b h[s] + 2 na1[k] + gla_1[k] -> 2 na1[s] + gla_1[s] + h[k]
GL0L0T0b arg_1[s] + h[k] + gla_1[k] -> h[s] + gla_1[s] + arg_1[k]
Warnings: Metastable gla_1[k] not in model - added to the model
GL00b h[s] + h[s] + 2 na1[k] + gla_1[k] -> h[s] + 2 na1[s] + gla_1[s] + h[k]
Warnings: Metastable gpgpy[k] not in model - added to the model
GL00F0b h[k] + gpgpy[k] -> h[s] + gpgpy[s]
Warnings: Metastable gpgpe[k] not in model - added to the model
GL00F0b h[k] + gpgpe[k] -> h[s] + gpgpe[s]
Warnings: Metastable gpyar[k] not in model - added to the model
GL00F0b h[k] + gpyar[k] -> h[s] + gpyar[s]
Warnings: Metastable gpy[k] not in model - added to the model
GL02vb h[k] + gpy[k] -> h[s] + gpy[s]
Warnings: Metastable qamchac[k] not in model - added to the model
G0000b h[k] + qamchac[k] -> h[s] + qamchac[s]
Warnings: Metastable qamphat[k] not in model - added to the model
G0000b h[k] + qamphat[k] -> h[s] + qamphat[s]
Warnings: Metastable qamchac[k] not in model - added to the model
G0000b h[k] + qamchac[k] -> h[s] + qamchac[s]
Warnings: Metastable qam[k] not in model - added to the model
G00b h[k] + qam[k] -> h[s] + qam[s]
Warnings: Metastable hia_1[k] not in model - added to the model
H000b h[s] + 2 na1[k] + hia_1[k] -> 2 na1[s] + hia_1[s] + h[k]
H00L0T0b arg_1[s] + h[k] + hia_1[k] -> h[s] + hia_1[s] + arg_1[k]
H00b h2a[s] + aip[s] + h[k] -> aip[s] + pi[s] + h[s] + h[k]
Warnings: Metastable invs[k] not in model - added to the model
I0012ab h[k] + invs[k] -> h[s] + invs[s]
Warnings: Metastable laeqy[k] not in model - added to the model
L000F0b h[k] + laeqy[k] -> h[s] + laeqy[s]
Warnings: Metastable laeqs[k] not in model - added to the model
L000F0b h[k] + laeqs[k] -> h[s] + laeqs[s]
Warnings: Metastable lae_1[k] not in model - added to the model
L00L0T0b arg_1[s] + h[k] + lae_1[k] -> h[s] + lae_1[s] + arg_1[k]
Warnings: Metastable dag_h[k] not in model - added to the model
Warnings: Metastable Rklat[k] not in model - added to the model
Warnings: Metastable mag_h[k] not in model - added to the model
L000b h2a[k] + dag_h[k] -> h[s] + Rklat[k] + mag_h[k]
Warnings: Metastable Rklat12[k] not in model - added to the model
Warnings: Metastable gpy[k] not in model - added to the model
L000b h2a[k] + mag_h[k] -> h[s] + Rklat12[k] + gpy[k]
Warnings: Metastable pgpy_h[k] not in model - added to the model
Warnings: Metastable lgpy_h[k] not in model - added to the model
L000b h2a[k] + pgpy_h[k] -> h[k] + Rklat12[k] + lgpy_h[k]
Warnings: Metastable lag_h[k] not in model - added to the model
Warnings: Metastable Rklat12[k] not in model - added to the model
L000b h2a[k] + lag_h[k] -> h[k] + dag_h[k] + Rklat12[k]
Warnings: Metastable lac_1[k] not in model - added to the model
L_0012vb h[k] + lac_1[k] -> h[s] + lac_1[s]
Warnings: Metastable nel_1[k] not in model - added to the model
M00L0T0b arg_1[s] + h[k] + nel_1[k] -> h[s] + nel_1[s] + arg_1[k]
Warnings: Metastable nad[k] not in model - added to the model
Warnings: Metastable adprk[k] not in model - added to the model
Warnings: Metastable scam[k] not in model - added to the model
M000b h2a[k] + nad[k] -> h[s] + adprk[k] + scam[k]
Warnings: Metastable nadp[k] not in model - added to the model
Warnings: Metastable adprp[k] not in model - added to the model
M000b h2a[k] + nadp[k] -> h[k] + scam[k] + adprp[k]
Warnings: Metastable hnd[k] not in model - added to the model
Warnings: Metastable c1[k] not in model - added to the model
M0000_M0000 h[s] + c1[s] + na2[k] + hnd[k] -> hnd[s] + na1[s] + h[k] + c1[k]
M00_2b na1[s] + h[k] -> h[s] + na1[k]
Warnings: Metastable idp[k] not in model - added to the model
Warnings: Metastable ip[k] not in model - added to the model
M0000b h2a[k] + idp[k] -> h[k] + pi[k] + ip[k]
Warnings: Metastable gpy[k] not in model - added to the model

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[illegible]

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HCE2_NaHc nat[h] + 2 hsc[h] ~> 2 hsc[s] + nat[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction

HCE2_NaHc nat[h] + 2 hsc[h] ~> 2 hsc[s] + nat[s]
AMT14_2_c0 dnat[h] + 2 nat[h] ~> 2 nat[s] + dnat[s]
AMT14c nat[h] + nat[h] ~> nat[s] + nat[s]
AMT14c nat[h] + 2 nat[h] ~> 2 nat[s] + nat[s]
Warning: Metabolite atg[h] not in model - added to the model

AMT14_2c 2 nat[h] + atg[h] ~> atg[s] + 2 nat[s]
ALDH3Hsdh atg_1[h] + atg_1[h] + nat[h] ~> nat[s] + atg_1[s] + atg_1[h]
Warning: Metabolite cys_1[h] not in model - added to the model

ALDH3Hsdh cys_1[h] + atg_1[h] + nat[h] ~> nat[s] + atg_1[s] + cys_1[h]
ALDH3Hsdh gln_1[h] + atg_1[h] + nat[h] ~> nat[s] + atg_1[s] + gln_1[h]
ALDH3Hsdh ser_1[h] + atg_1[h] + nat[h] ~> nat[s] + atg_1[s] + ser_1[h]
Warning: Metabolite thr_1[h] not in model - added to the model

ALDH3Hsdh thr_1[h] + atg_1[h] + nat[h] ~> nat[s] + atg_1[s] + thr_1[h]
ALDH3c atg_1[h] + nat[h] ~> nat[s] + atg_1[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction

ALDH3c h[s] + atg_1[h] + 2 nat[h] ~> 2 nat[s] + atg_1[s] + h[h]
ALDH3Hsdh arg_1[s] + atg_1[h] + nat[h] ~> nat[s] + atg_1[s] + arg_1[h]
AMT14c nat[h] + arg_1[h] ~> nat[s] + arg_1[s]
ASCR10c nat[h] + asch_1[h] ~> nat[s] + asch_1[s]
AMT14Hsdh atg_1[h] + nat[h] + asg_1[h] ~> nat[s] + asg_1[s] + atg_1[h]
AMT14Hsdh cys_1[h] + nat[h] + asg_1[h] ~> nat[s] + asg_1[s] + cys_1[h]
AMT14Hsdh gln_1[h] + nat[h] + asg_1[h] ~> nat[s] + asg_1[s] + gln_1[h]
AMT14Hsdh ser_1[h] + nat[h] + asg_1[h] ~> nat[s] + asg_1[s] + ser_1[h]
AMT14Hsdh thr_1[h] + nat[h] + asg_1[h] ~> nat[s] + asg_1[s] + thr_1[h]
AMT14c nat[h] + asg_1[h] ~> nat[s] + asg_1[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction

AMT14c h[s] + 2 nat[h] + asg_1[h] ~> 2 nat[s] + asg_1[s] + h[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

AMT14c h[s] + h[h] + 3 nat[h] + asg_1[h] ~> h[s] + 3 nat[s] + asg_1[s] + h[h]
BTH14c h2c[s] + atp[s] + 2 nat[h] + h2c[h] ~> atp[h] + h[s] + pi[s] + 2 nat[s] + h2c[s] + h2c[h]
CET14c nat[s] + 3 nat[h] ~> 3 nat[s] + nat[h]
Warning: Metabolite cholate[h] not in model - added to the model

CHL14T12b 2 nat[h] + cholate[h] ~> 2 nat[s] + cholate[s]
CHL14c chot[h] + nat[h] ~> nat[s] + chot[s]
Warning: Metabolite cit[h] not in model - added to the model

CET14_2b 2 nat[h] + cit[h] ~> 2 nat[s] + cit[s]
CET14_4b 4 nat[h] + cit[h] ~> 4 nat[s] + cit[s]
Warning: Metabolite creat[h] not in model - added to the model

CHMT14_2_c0 2 nat[h] + creat[h] ~> 2 nat[s] + creat[s]
CHMT14c nat[h] + creat[h] ~> nat[s] + creat[s]
CYH14Hsdh atg_1[h] + nat[h] + cys_1[h] ~> nat[s] + cys_1[s] + atg_1[h]
CYH14Hsdh asp_1[h] + nat[h] + cys_1[h] ~> nat[s] + cys_1[s] + asp_1[h]
CYH14Hsdh gln_1[h] + nat[h] + cys_1[h] ~> nat[s] + cys_1[s] + gln_1[h]
CYH14Hsdh ser_1[h] + nat[h] + cys_1[h] ~> nat[s] + cys_1[s] + ser_1[h]
CYH14Hsdh thr_1[h] + nat[h] + cys_1[h] ~> nat[s] + cys_1[s] + thr_1[h]
CYH14c nat[h] + cys_1[h] ~> nat[s] + cys_1[s]
Warning: Metabolite cys4[h] not in model - added to the model

CYH14c nat[h] + cys4[h] ~> nat[s] + cys4[s]
CYH14c 2 nat[h] + cys4[h] ~> 2 nat[s] + cys4[s]
Warning: Metabolite dapsa[h] not in model - added to the model

DOP14_2_c0 2 nat[h] + dapsa[h] ~> 2 nat[s] + dapsa[s]
Warning: Metabolite estrones[h] not in model - added to the model

EUTR00112b 2 nat[h] + estrones[h] ~> 2 nat[s] + estrones[s]
EU_nad5r[h] nat[h] ~>
Warning: Metabolite hbaa[h] not in model - added to the model

HUP14c nat[s] + hbaa[s] ~> nat[h] + hbaa[h]
Warning: Metabolite ndma[h] not in model - added to the model

HUP14c nat[s] + ndma[s] ~> nat[h] + ndma[h]
Warning: Metabolite ndma[h] not in model - added to the model

HUP14c nat[s] + ndma[s] ~> nat[h] + ndma[h]
Warning: Metabolite arach[h] not in model - added to the model

HUP14c nat[s] + arach[h] ~> nat[h] + arach[h]
Warning: Metabolite arach[h] not in model - added to the model

HUP14c nat[s] + arach[h] ~> nat[h] + arach[h]
Warning: Metabolite adn=h[h] not in model - added to the model

HUP14c nat[s] + adn=s[h] ~> nat[h] + adn=h[h]
Warning: Metabolite cren=h[h] not in model - added to the model

HUP14c nat[s] + cren=s[h] ~> nat[h] + cren=h[h]
Warning: Metabolite lgs=h[h] not in model - added to the model

HUP14c nat[s] + lgs=s[h] ~> nat[h] + lgs[h]
Warning: Metabolite cren=h[h] not in model - added to the model

HUP14c nat[s] + cren=s[h] ~> nat[h] + cren=h[h]
Warning: Metabolite fru[h] not in model - added to the model

PHL14c nat[h] + fru[h] ~> nat[s] + fru[s]
GLD14c nat[h] + gal[h] ~> nat[s] + gal[s]
GLD14_2b 2 nat[h] + gal[h] ~> 2 nat[s] + gal[s]
Warning: Metabolite ghafe[h] not in model - added to the model

GMD1412b 2 nat[h] + ghafe[h] ~> 2 nat[s] + ghafe[s]
GLD14c nat[h] + gln_2[h] ~> nat[s] + gln_2[s]
GLD14_2b 2 nat[h] + gln_2[h] ~> 2 nat[s] + gln_2[s]

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[illegible]

Warning: Metabolite succ[k] not in model - added to the model
 $\text{SUCC14_2h} \ 2 \ \text{succ}[k] + \text{succ}[k] \rightarrow 2 \ \text{succ}[x] + \text{succ}[x]$
 $\text{SUCC14_3h} \ 3 \ \text{succ}[k] + \text{succ}[k] \rightarrow 3 \ \text{succ}[x] + \text{succ}[x]$
 Warning: Metabolite taur[k] not in model - added to the model
 $\text{TBAH1_2_2h} \ 2 \ \text{taur}[k] + \text{taur}[k] \rightarrow 2 \ \text{taur}[x] + \text{taur}[x]$
 Warning: Metabolite tcheta[k] not in model - added to the model
 $\text{TCHLAC12h} \ 2 \ \text{tcheta}[k] + \text{tcheta}[k] \rightarrow 2 \ \text{tcheta}[x] + \text{tcheta}[x]$
 Warning: Metabolite thymd[k] not in model - added to the model
 $\text{THYH1h} \ \text{taur}[k] + \text{thymd}[k] \rightarrow \text{taur}[x] + \text{thymd}[x]$
 $\text{THYH1h} \ 2 \ \text{taur}[k] + \text{thymd}[k] \rightarrow 2 \ \text{taur}[x] + \text{thymd}[x]$
 $\text{THYH1h} \ \text{thymd}[k] + \text{taur}[k] + \text{thr}_L[k] \rightarrow \text{taur}[x] + \text{thr}_L[k] + \text{ata}_L[k]$
 $\text{THYH1h} \ \text{thymd}[k] + \text{taur}[k] + \text{thr}_L[k] \rightarrow \text{taur}[x] + \text{thr}_L[k] + \text{asa}_L[k]$
 $\text{THYH1h} \ \text{thymd}[k] + \text{taur}[k] + \text{thr}_L[k] \rightarrow \text{taur}[x] + \text{thr}_L[k] + \text{cys}_L[k]$
 $\text{THYH1h} \ \text{thymd}[k] + \text{taur}[k] + \text{thr}_L[k] \rightarrow \text{taur}[x] + \text{thr}_L[k] + \text{gln}_L[k]$
 $\text{THYH1h} \ \text{thymd}[k] + \text{taur}[k] + \text{thr}_L[k] \rightarrow \text{taur}[x] + \text{thr}_L[k] + \text{ser}_L[k]$
 $\text{THYH1h} \ \text{taur}[k] + \text{thr}_L[k] \rightarrow \text{taur}[x] + \text{thr}_L[k]$
 Warning: Metabolite trp_L[k] not in model - added to the model
 $\text{TRPH1h} \ \text{taur}[k] + \text{trp}_L[k] \rightarrow \text{taur}[x] + \text{trp}_L[k]$
 Warning: Metabolite tval[k] not in model - added to the model
 $\text{TVAL1h} \ 3 \ \text{taur}[k] + \text{tval}[k] \rightarrow 3 \ \text{taur}[x] + \text{tval}[x]$
 Warning: Metabolite tpr_L[k] not in model - added to the model
 $\text{TPRH1h} \ \text{taur}[k] + \text{tpr}_L[k] \rightarrow \text{taur}[x] + \text{tpr}_L[k]$
 Warning: Metabolite uric[k] not in model - added to the model
 $\text{URCH1h} \ \text{taur}[k] + \text{uric}[k] \rightarrow \text{taur}[x] + \text{uric}[x]$
 $\text{URCH1h} \ 2 \ \text{taur}[k] + \text{uric}[k] \rightarrow 2 \ \text{taur}[x] + \text{uric}[x]$
 Warning: Metabolite val_L[k] not in model - added to the model
 $\text{VALH1h} \ \text{taur}[k] + \text{val}_L[k] \rightarrow \text{taur}[x] + \text{val}_L[k]$
 Warning: Metabolite zmcit[k] not in model - added to the model
 $\text{ZMCIT1h} \ 2 \ \text{mcit}[x] \rightarrow 2 \ \text{zmcit}[k]$
 $\text{EZ_zmcit}[x] \ 2 \ \text{zmcit}[k] \rightarrow$
 Warning: Metabolite 3dthiazopyg[k] not in model - added to the model
 $\text{3DTHIAPYD1h} \ 3 \ \text{dthiazopyg}[x] \rightarrow 3 \ \text{dthiazopyg}[k]$
 $\text{EZ_3dthiazopyg}[x] \ 3 \ \text{dthiazopyg}[k] \rightarrow$
 Warning: Metabolite 3ach[k] not in model - added to the model
 $\text{3ACH1h} \ 3 \ \text{ach}[x] \rightarrow 3 \ \text{ach}[k]$
 $\text{EZ_3ach}[x] \ 3 \ \text{ach}[k] \rightarrow$
 Warning: Metabolite 3alide[k] not in model - added to the model
 $\text{3ALID1h} \ 3 \ \text{alide}[x] \rightarrow 3 \ \text{alide}[k]$
 $\text{EZ_3alide}[x] \ 3 \ \text{alide}[k] \rightarrow$
 Warning: Metabolite 3dthiazopygine[k] not in model - added to the model
 $\text{3DTHIAPYD1h} \ 3 \ \text{dthiazopygine}[x] \rightarrow 3 \ \text{dthiazopygine}[k]$
 $\text{EZ_3dthiazopygine}[x] \ 3 \ \text{dthiazopygine}[k] \rightarrow$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction
 $\text{4DPRD_171h} \ h[x] + \text{4dpru}_L17[k] \rightarrow h[x] + \text{4dpru}_L17[x]$
 Warning: Metabolite 4dpruL[k] not in model - added to the model
 $\text{4DPR1h} \ \text{4dpru}[x] \rightarrow 4 \ \text{dpruL}[k]$
 $\text{EZ_4dpruL}[x] \ 4 \ \text{dpruL}[k] \rightarrow$
 Warning: Metabolite 4dethiolamide[k] not in model - added to the model
 $\text{4DTHUTAM121h} \ 4 \ \text{dethiolamide}[k] \rightarrow 4 \ \text{dethiolamide}[x]$
 $\text{EZ_4dethiolamide}[x] \ 4 \ \text{dethiolamide}[k] \rightarrow$
 Warning: Metabolite 4dphf[k] not in model - added to the model
 $\text{4DPH1h} \ 4 \ \text{dphf}[k] \rightarrow 4 \ \text{dphf}[x]$
 $\text{EZ_4dphf}[x] \ 4 \ \text{dphf}[k] \rightarrow$
 Warning: Metabolite 4dph[k] not in model - added to the model
 $\text{4DPH1h} \ 4 \ \text{dph}[k] \rightarrow 4 \ \text{dph}[x]$
 $\text{EZ_4dph}[x] \ 4 \ \text{dph}[k] \rightarrow$
 Warning: Metabolite 4pyrda[k] not in model - added to the model
 $\text{4PYR12h} \ h_2a[x] + \text{4pyr}[x] + \text{4pyrda}[x] \rightarrow \text{4py}[x] + h[x] + \text{pi}[x] + \text{4pyrda}[k]$
 $\text{EZ_4pyrda}[x] \ 4 \ \text{pyrda}[k] \rightarrow$
 Warning: Metabolite 5adivisierueng[k] not in model - added to the model
 $\text{5ADIVISIERUENG12h} \ h_2a[x] + \text{5adp}[x] + \text{5adivisierueng}[x] \rightarrow \text{5adp}[x] + h[x] + \text{pi}[x] + \text{5adivisierueng}[k]$
 $\text{EZ_5adivisierueng}[x] \ 5 \ \text{adivisierueng}[k] \rightarrow$
 Warning: Metabolite 5adivisieruene[k] not in model - added to the model
 $\text{5ADIVISIERUENG12h} \ 5 \ \text{adivisieruene}[x] \rightarrow 5 \ \text{adivisieruene}[k]$
 $\text{EZ_5adivisieruene}[x] \ 5 \ \text{adivisieruene}[k] \rightarrow$
 Warning: Metabolite 5adivisieruene[k] not in model - added to the model
 $\text{5ADIVISIERUENG12h} \ 5 \ \text{adivisieruene}[k] \rightarrow 5 \ \text{adivisieruene}[x]$
 $\text{EZ_5adivisieruene}[x] \ 5 \ \text{adivisieruene}[k] \rightarrow$
 Warning: Metabolite 5fthf[k] not in model - added to the model
 Warning: Metabolite 5h1[k] not in model - added to the model
 $\text{5FTH12h} \ \text{5h1}[x] + \text{5fthf}[k] \rightarrow \text{5fthf}[x] + \text{5h1}[k]$
 $\text{EZ_5fthf}[x] \ 5 \ \text{fthf}[k] \rightarrow$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction
 $\text{5FTH12h} \ \text{5h1}[x] + \text{5fthf}[k] \rightarrow \text{5fthf}[x] + \text{5h1}[k]$
 Warning: Metabolite 5ethf[k] not in model - added to the model
 $\text{5ETH12h} \ \text{5h1}[x] + \text{5ethf}[k] \rightarrow \text{5ethf}[x] + \text{5h1}[k]$
 $\text{CLD1m12h} \ \text{5h1}[x] + 2 \ \text{c1}[k] \rightarrow 2 \ \text{c1}[x] + \text{5h1}[k]$
 $\text{EZ_5h1} \ 5 \ \text{h1}[k] \rightarrow$
 Warning: Metabolite 5u1[k] not in model - added to the model
 $\text{5UL12h} \ \text{5h1}[x] + \text{5u1}[k] \rightarrow \text{5u1}[x] + \text{5h1}[k]$
 Warning: Metabolite 5thf[k] not in model - added to the model
 $\text{5TH12h} \ \text{5h1}[x] + \text{5thf}[k] \rightarrow \text{5thf}[x] + \text{5h1}[k]$
 Warning: Metabolite 5thmp[k] not in model - added to the model
 $\text{5THMP12h} \ \text{5h1}[x] + \text{5thmp}[k] \rightarrow \text{5thmp}[x] + \text{5h1}[k]$
 Warning: Metabolite 5thpy[k] not in model - added to the model
 $\text{5THPY12h} \ \text{5h1}[x] + 5 \ \text{thpy}[k] \rightarrow 5 \ \text{thpy}[x] + \text{5h1}[k]$

[illegible]

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Warnings: Metabolite m01[k] not in model - added to the model
GMPtoS h2u[k] + g1pp0[k] -> Tpr_gpp[k] + m01[k]
Warnings: Metabolite 10Tich7ygu[k] not in model - added to the model
Warnings: Metabolite 10Tich7[k] not in model - added to the model
G2K_10TTPW15L2Ld4 h2u[k] + 10Tich7ygu[k] -> 4 gla_1[k] + 10Tich7[k]
Warnings: Metabolite 10Tich7ygu[k] not in model - added to the model
G2K_10TTPW15L2Ld4 h2u[k] + 10Tich7ygu[k] -> gla_1[k] + 10Tich7ygu[k]
Warnings: Metabolite 10Tich7ygu[k] not in model - added to the model
G2K_10TTPW15L2Ld4 h2u[k] + 10Tich7ygu[k] -> gla_1[k] + 10Tich7ygu[k]
Warnings: Metabolite h0f[k] not in model - added to the model
Warnings: Metabolite dhf[k] not in model - added to the model
G2K_2S0H9v h2u[k] + h0f[k] -> 4 gla_1[k] + dhf[k]
Warnings: Metabolite h1bf[k] not in model - added to the model
G2K_2T0H9v h2u[k] + h0f[k] -> 4 gla_1[k] + h1bf[k]
Warnings: Metabolite h0f[k] not in model - added to the model
G2K_2S0H9v h2u[k] + h0f[k] -> gla_1[k] + h0f[k]
Warnings: Metabolite h1bf[k] not in model - added to the model
G2K_2T0H9v h2u[k] + h1bf[k] -> gla_1[k] + h0f[k]
Warnings: Metabolite h0f[k] not in model - added to the model
G2K_2T0H9v h2u[k] + h0f[k] -> gla_1[k] + h0f[k]
Warnings: Metabolite h1bf[k] not in model - added to the model
G2K_2T0H9v h2u[k] + h1bf[k] -> gla_1[k] + h0f[k]
Warnings: Metabolite gth0d[k] not in model - added to the model
Warnings: Metabolite gth0u[k] not in model - added to the model
GTH9v h2u[k] + 2 gth0d[k] -> 2 h2u[k] + gth0u[k]
H2Oto h2u[k] -> h2u[k]
Warnings: Metabolite lcu[k] not in model - added to the model
LAC2v h2u[k] + lcu[k] -> ga5[k] + gla_2[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
LPI2v h2u[k] + dng_hu[k] -> h[k] + Rstata1[k] + sng_hu[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
LPI3v h2u[k] + sng_hu[k] -> h[k] + Rstata12[k] + g1pc[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
LPI4v h2u[k] + pg1pc_hu[k] -> h[k] + Rstata12[k] + 1g1pc_hu[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
LPI6v h2u[k] + sng_hu[k] -> h[k] + dng_hu[k] + Rstata13[k]
PLA7v h2u[k] + m01[k] -> 2 gla_2[k]
Warnings: Metabolite m01[k] not in model - added to the model
PLT1v h2u[k] + m01[k] -> gla_2[k] + m01[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
N2H9v h2u[k] + nad[k] -> h[k] + adp0u[k] + ncam[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
N2P0v h2u[k] + nadp[k] -> h[k] + ncam[k] + adp0u[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
N2P2v h2u[k] + ldp[k] -> h[k] + pu[k] + ldp[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
N2P3v h2u[k] + gdp[k] -> h[k] + pi[k] + gmp[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
N2P4v h2u[k] + udp[k] -> h[k] + pi[k] + ump[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
N2P5v h2u[k] + udp[k] -> h[k] + pi[k] + udp[k]
N722v h2u[k] + ump[k] -> pi[k] + uru[k]
Warnings: Metabolite ump[k] not in model - added to the model
N724v h2u[k] + ump[k] -> pi[k] + cytd[k]
N725v h2u[k] + ump[k] -> adu[k] + pu[k]
N726v h2u[k] + gmp[k] -> pi[k] + gsu[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
N7P1v h2u[k] + gdp[k] -> h[k] + pi[k] + gdp[k]
G0H1v h2u[k] + g1pp0[k] -> gla_2[k] + g1pp0[k]
G0H2v h2u[k] + s0u02[k] -> gla_2[k] + m01[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
H0P0v h2u[k] + p0f_hu[k] -> h[k] + m[k] + d021p0f0_hu[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
H7H1v h2u[k] + H_six_refu[k] -> h[k] + Rstata12[k] + retinol_H_six[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
H7H2v h2u[k] + H_six_refu[k] -> h[k] + Rstata12[k] + retinol_six_12[k]
Warnings: Reaction with the same name already exists in the model,
updating the reaction
H7H3v h2u[k] + retu[k] -> h[k] + Rstata12[k] + retinol[k]
Warnings: Metabolite ucu[k] not in model - added to the model
UCR9v h2u[k] + ucu[k] -> gla_2[k] + Fru[k]
Warnings: Metabolite fru[k] not in model - added to the model
T8H9v h2u[k] + fru[k] -> 2 gla_2[k]
Warnings: Metabolite urcu[k] not in model - added to the model

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GMS1b h2s[h] + urms[h] -> s2s[s] + urms[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ACM6b ash[h] + h2s[h] -> h[h] + as[h] + shat[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ACG6b h[h] + as[h] -> h[s] + as[s]
EG_ash[h] as[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PAP6b h2s[h] + gas_ha[h] -> h[h] + as[h] + sh2gshat_ha[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ACM6b ash[h] + h2s[h] -> h[h] + as[h] + shat[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CMS1b shat[h] + nat[h] -> nat[s] + shat[s]
CMS1b shat[h] -> shat[s]
EG_shat[h] shat[h] ->
Warning: Metabolite ac2lasepalgside_ha[h] not in model - added to the
model
ACM1bCMS1bGMS1b ac2lasepalgside_ha[s] -> ac2lasepalgside_ha[h]
EG_ac2lasepalgside_ha[h] ac2lasepalgside_ha[h] ->
Warning: Metabolite ac2lasepalgside_ha[h] not in model - added to the
model
ACM1bCMS1bGMS1b ac2lasepalgside_ha[s] -> ac2lasepalgside_ha[h]
EG_ac2lasepalgside_ha[h] ac2lasepalgside_ha[h] ->
Warning: Metabolite acanapal1lasepalgside_ha[h] not in model - added
to the model
ACM1bCMS1bGMS1b acanapal1lasepalgside_ha[s] -> acanapal1lasepalgside_ha[h]
EG_acanapal1lasepalgside_ha[h] acanapal1lasepalgside_ha[h] ->
Warning: Metabolite acanapal1lasepalgside_ha[h] not in model - added to the
model
ACM1bCMS1bGMS1b acanapal1lasepalgside_ha[s] -> acanapal1lasepalgside_ha[h]
EG_acanapal1lasepalgside_ha[h] acanapal1lasepalgside_ha[h] ->
Warning: Metabolite acanapal1lasepalgside_ha[h] not in model - added to the
model
ACM1bCMS1bGMS1b acanapal1lasepalgside_ha[s] -> acanapal1lasepalgside_ha[h]
EG_acanapal1lasepalgside_ha[h] acanapal1lasepalgside_ha[h] ->
Warning: Metabolite acanapal1lasepalgside_ha[h] not in model - added to the
model
ACM1bCMS1bGMS1b acanapal1lasepalgside_ha[s] -> acanapal1lasepalgside_ha[h]
EG_acanapal1lasepalgside_ha[h] acanapal1lasepalgside_ha[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
ADM6b h[h] + h2s[h] + ads[h] -> ias[h] + shd[h]
ADM6b ads[h] -> ads[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ADM1b ads[h] + nat[h] -> nat[s] + ads[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ADM1b ads[h] + 2 nat[h] -> 2 nat[s] + ads[s]
EG_ads[h] ads[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
NDS1b h2s[h] + asp[h] -> ads[h] + gs[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ADM6b h[h] + h2s[h] + ads[h] -> ias[h] + shd[h]
EG_ias[h] ias[h] ->
ZWS1b ias[h] -> ias[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ZWS1b ias[h] + nat[h] -> nat[s] + ias[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ZWS1b ias[h] + 2 nat[h] -> 2 nat[s] + ias[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ADM6b h[h] + h2s[h] + ads[h] -> ias[h] + shd[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ADM6b h[h] + h2s[h] + shd_2[h] -> shd[h] + dls[h]
EG_shd[h] shd[h] ->
KCC1b shd[h] + cl[h] -> shd[cl] + cl[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NVS1b nat[s] + shd[h] -> shd[cl] + nat[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NCS1b 4 nat[s] + shd[h] + nat[h] -> shd[cl] + nat[s] + 3 nat[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NMS1b shd[cl] + h[h] -> h[cl] + shd[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NCC1b shd[h] + nat[h] + 2 cl[h] -> shd[cl] + nat[s] + 2 cl[s]
Warning: Metabolite ads[h] not in model - added to the model
ADM6b ads[h] -> ads[s]
EG_ads[h] ads[h] ->

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[illegible]

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===== gln_2[glu] + asn_1[asn] -> asn_2[asn] + gln_1[glu]
ALGGL1672isk ala_1[ala] + asn_1[asn] -> asn_1[asn] + ala_1[ala]
ANPPL1672isk phe_1[phe] + asn_1[asn] -> asn_1[asn] + phe_1[phe]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANPPL1672isk ser_1[ser] + asn_1[asn] -> asn_1[asn] + ser_1[ser]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANPPL1672isk thr_1[thr] + asn_1[asn] -> asn_1[asn] + thr_1[thr]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANPPL1672isk val_1[val] + asn_1[asn] -> asn_1[asn] + val_1[val]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANPPL1672isk h[his] + 2 asn_1[asn] + asn_1[asn] -> 2 asn_1[asn] + asn_1[asn] + h[his]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYSGL1672isk asu_1[asu] + asn_1[asn] + cys_1[cys] -> asn_1[asn] + cys_1[cys] + asu_1[asu]
EL_asu_1[el] asu_1[asn] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
GLNGL1672isk asu_1[asu] + asn_1[asn] + gla_1[gla] -> asn_1[asn] + gla_1[gla] + asu_1[asu]
Warning: Reaction with the same name already exists in the model,
updating the reaction
LISGL1672isk asu_1[asu] + asn_1[asn] + ser_1[ser] -> asn_1[asn] + ser_1[ser] + asu_1[asu]
Warning: Reaction with the same name already exists in the model,
updating the reaction
THSGL1672isk asu_1[asu] + asn_1[asn] + thr_1[thr] -> asn_1[asn] + thr_1[thr] + asu_1[asu]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ALCY1672isk cys_1[cys] + ala_1[ala] + asn_1[asn] -> asn_1[asn] + ala_1[ala] + cys_1[cys]
Warning: Reaction with the same name already exists in the model,
updating the reaction
APP1672isk h2o[h2o] + gtp[gtp] -> gtp[gtp] + cys_1[cys]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANCY1672isk cys_1[cys] + asn_1[asn] + asu_1[asu] -> asn_1[asn] + asu_1[asu] + cys_1[cys]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYGL1672isk ala_1[ala] + asn_1[asn] + cys_1[cys] -> asn_1[asn] + cys_1[cys] + ala_1[ala]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYGL1672isk asu_1[asu] + asn_1[asn] + cys_1[cys] -> asn_1[asn] + cys_1[cys] + asu_1[asu]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYGL1672isk gla_1[gla] + asn_1[asn] + cys_1[cys] -> asn_1[asn] + cys_1[cys] + gla_1[gla]
CYGL1672isk h2o[h2o] + cys_1[cys] -> cys_1[cys] + gla_1[gla]
CYGL1672isk gtp[gtp] + gtp[gtp] -> gtp[gtp] + cys_1[cys]
CYGL1672isk cys_1[cys] + gtp[gtp] -> gtp[gtp] + cys_1[cys]
CYGL1672isk ala_1[ala] + cys_1[cys] -> cys_1[cys] + ala_1[ala]
CYPL1672isk phe_1[phe] + cys_1[cys] -> cys_1[cys] + phe_1[phe]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYPL1672isk ser_1[ser] + asn_1[asn] + cys_1[cys] -> asn_1[asn] + cys_1[cys] + ser_1[ser]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYPL1672isk thr_1[thr] + asn_1[asn] + cys_1[cys] -> asn_1[asn] + cys_1[cys] + thr_1[thr]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYPL1672isk val_1[val] + cys_1[cys] -> asn_1[asn] + cys_1[cys]
CYPL1672isk cys_1[cys] -> cys_1[cys]
EL_cys_1[el] cys_1[asn] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
GLCY1672isk cys_1[cys] + asn_1[asn] + gla_1[gla] -> asn_1[asn] + gla_1[gla] + cys_1[cys]
Warning: Reaction with the same name already exists in the model,
updating the reaction
MRCY1672isk cys_1[cys] + asn_1[asn] + ser_1[ser] -> asn_1[asn] + ser_1[ser] + cys_1[cys]
Warning: Reaction with the same name already exists in the model,
updating the reaction
THRCY1672isk cys_1[cys] + asn_1[asn] + thr_1[thr] -> asn_1[asn] + thr_1[thr] + cys_1[cys]
ALGL1672isk gla_1[gla] + ala_2[ala] -> ala_2[ala] + gla_1[gla]
ALGL1672isk gtp[gtp] + ala_2[ala] -> ala_2[ala] + gtp[gtp]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SGL1672isk h[his] + ala_2[ala] -> h[his] + ala_2[ala]
EL_ala_2[el] ala_2[asn] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
ALGL1672isk gla_1[gla] + ala_2[ala] -> ala_2[ala] + gla_1[gla]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ALGL1672isk gla_1[gla] + ala_2[ala] + asn_1[asn] -> asn_1[asn] + ala_2[ala] + gla_1[gla]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ALGL1672isk gla_1[gla] + ala_2[ala] -> ala_2[ala] + gla_1[gla]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANGL1672isk gla_1[gla] + asn_1[asn] + asu_1[asu] -> asn_1[asn] + asu_1[asu] + gla_1[gla]
Warning: Reaction with the same name already exists in the model,
updating the reaction

```

$\text{CPH2Methb } \text{gla}_1\text{[s]} + \text{na}[k] + \text{cys}_1\text{[k]} \rightarrow \text{na}[s] + \text{cys}_1\text{[s]} + \text{gla}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{CPH2Methb } \text{gla}_1\text{[s]} + \text{cys}_1\text{[k]} \rightarrow \text{cys}_1\text{[s]} + \text{gla}_1\text{[k]}$
 $\text{R}_1\text{gla}_1\text{[v]} \text{h } \text{gla}_1\text{[k]} \rightarrow$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GABMethb } \text{ata}_1\text{[s]} + \text{na}[k] + \text{gla}_1\text{[k]} \rightarrow \text{na}[s] + \text{gla}_1\text{[s]} + \text{ata}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GABMethb } \text{asa}_1\text{[s]} + \text{na}[k] + \text{gla}_1\text{[k]} \rightarrow \text{na}[s] + \text{gla}_1\text{[s]} + \text{asa}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GACYMethb } \text{cys}_1\text{[s]} + \text{na}[k] + \text{gla}_1\text{[k]} \rightarrow \text{na}[s] + \text{gla}_1\text{[s]} + \text{cys}_1\text{[k]}$
 $\text{GABMELAT72isk } \text{ile}_1\text{[s]} + \text{gla}_1\text{[k]} \rightarrow \text{gla}_1\text{[s]} + \text{ile}_1\text{[k]}$
 $\text{GLAPMELAT72isk } \text{phe}_1\text{[s]} + \text{gla}_1\text{[k]} \rightarrow \text{gla}_1\text{[s]} + \text{phe}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GABMethb } \text{ser}_1\text{[s]} + \text{na}[k] + \text{gla}_1\text{[k]} \rightarrow \text{na}[s] + \text{gla}_1\text{[s]} + \text{ser}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLAPMethb } \text{thr}_1\text{[s]} + \text{na}[k] + \text{gla}_1\text{[k]} \rightarrow \text{na}[s] + \text{gla}_1\text{[s]} + \text{thr}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GABib } \text{na}[k] + \text{gla}_1\text{[k]} \rightarrow \text{na}[s] + \text{gla}_1\text{[s]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLAMBib } \text{h}[s] + 2 \text{ na}[k] + \text{gla}_1\text{[k]} \rightarrow 2 \text{ na}[s] + \text{gla}_1\text{[s]} + \text{h}[k]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLAPLAT72isk } \text{arg}_1\text{[s]} + \text{na}[k] + \text{gla}_1\text{[k]} \rightarrow \text{na}[s] + \text{gla}_1\text{[s]} + \text{arg}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLAPLAT72isk } \text{arg}_1\text{[s]} + \text{h}[k] + \text{gla}_1\text{[k]} \rightarrow \text{h}[s] + \text{gla}_1\text{[s]} + \text{arg}_1\text{[k]}$
 Warning: Metabolite ser_2[h] not in model - added to the model

$\text{HMGGLMethb } \text{gla}_1\text{[s]} + \text{ser}_2\text{[k]} \rightarrow \text{ser}_2\text{[s]} + \text{gla}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{HMGGLMethb } \text{gla}_1\text{[s]} + \text{na}[k] + \text{ser}_2\text{[k]} \rightarrow \text{na}[s] + \text{ser}_2\text{[s]} + \text{gla}_1\text{[k]}$
 $\text{HMGGLMethb } \text{gla}_1\text{[s]} + \text{ser}_2\text{[k]} \rightarrow \text{ser}_2\text{[s]} + \text{gla}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{THMGGLMethb } \text{gla}_1\text{[s]} + \text{na}[k] + \text{thr}_1\text{[k]} \rightarrow \text{na}[s] + \text{thr}_1\text{[s]} + \text{gla}_1\text{[k]}$
 $\text{THMGGLMethb } \text{gla}_1\text{[s]} + \text{thr}_1\text{[k]} \rightarrow \text{thr}_1\text{[s]} + \text{gla}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{ALMGLMethb } \text{gtp}[s] + \text{ata}_2\text{[k]} \rightarrow \text{ata}_2\text{[s]} + \text{gtp}[k]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{ALMGLMethb } \text{gtp}[s] + \text{ata}_1\text{[k]} \rightarrow \text{ata}_1\text{[s]} + \text{gtp}[k]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{ADPGLMethb } \text{h}_2\text{a}[k] + \text{gtp}[k] \rightarrow \text{gtp}[k] + \text{cys}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{CPH2Methb } \text{cys}_1\text{[s]} + \text{gtp}[k] \rightarrow \text{gtp}[s] + \text{cys}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{CPH2Methb } \text{cys}_1\text{[s]} + \text{gtp}[k] \rightarrow \text{gtp}[s] + \text{cys}_1\text{[k]}$
 $\text{R}_1\text{gtp}[k] \text{h } \text{gtp}[k] \rightarrow$
 $\text{GLYOSMETH } \text{h}_2\text{a}[s] + \text{atp}[s] + 3 \text{ gtp}[s] \rightarrow \text{atp}[s] + \text{h}[s] + \text{ps}[s] + 3 \text{ gtp}[k]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLY2vh } \text{h}[k] + \text{gtp}[k] \rightarrow \text{h}[s] + \text{gtp}[s]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLYib } \text{na}[k] + \text{gtp}[k] \rightarrow \text{na}[s] + \text{gtp}[s]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLUT_212_rh } 2 \text{ na}[k] + \text{gtp}[k] + \text{ct}[k] \rightarrow 2 \text{ na}[s] + \text{ct}[s] + \text{gtp}[k]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GLUT_212_rh } 3 \text{ na}[k] + \text{gtp}[k] + \text{ct}[k] \rightarrow 3 \text{ na}[s] + \text{ct}[s] + \text{gtp}[k]$
 $\text{HMGGLMethb } \text{gtp}[s] + \text{ser}_2\text{[k]} \rightarrow \text{ser}_2\text{[s]} + \text{gtp}[k]$
 $\text{HMGGLMethb } \text{gtp}[s] + \text{ser}_1\text{[k]} \rightarrow \text{ser}_1\text{[s]} + \text{gtp}[k]$
 $\text{THMGGLMethb } \text{gtp}[s] + \text{thr}_1\text{[k]} \rightarrow \text{thr}_1\text{[s]} + \text{gtp}[k]$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{ALMELAT72isk } \text{ile}_1\text{[s]} + \text{ata}_1\text{[k]} \rightarrow \text{ata}_1\text{[s]} + \text{ile}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{AMMELAT72isk } \text{ile}_1\text{[s]} + \text{asa}_1\text{[k]} \rightarrow \text{asa}_1\text{[s]} + \text{ile}_1\text{[k]}$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{CPH2ELAT72isk } \text{ile}_1\text{[s]} + \text{cys}_1\text{[k]} \rightarrow \text{cys}_1\text{[s]} + \text{ile}_1\text{[k]}$
 $\text{R}_1\text{ile}_1\text{[v]} \text{h } \text{ile}_1\text{[k]} \rightarrow$
 Warning: Reaction with the same name already exists in the model,
 updating the reaction

$\text{GABMELAT72isk } \text{ile}_1\text{[s]} + \text{gla}_1\text{[k]} \rightarrow \text{gla}_1\text{[s]} + \text{ile}_1\text{[k]}$
 $\text{HMGELAT72isk } \text{ile}_1\text{[s]} + \text{h}_2\text{a}[k] \rightarrow \text{h}_2\text{a}[s] + \text{ile}_1\text{[k]}$

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ILH0H1ick 2 na[i] + c[i] + iLe_L[h] -> 2 na[i] + c[i] + iLe_L[h]
ILPH0L72ick phe_L[i] + iLe_L[h] -> iLe_L[h] + phe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ILH0h na[i] + iLe_L[h] -> na[i] + iLe_L[h]
ILH0ck iLe_L[h] -> iLe_L[h]
ILH0L72ick iLe_L[i] + iLe_L[h] -> iLe_L[h] + iLe_L[h]
MUT0L72ick iLe_L[i] + na[i] -> na[i] + iLe_L[h]
PH0L72ick iLe_L[i] + phe_L[h] -> phe_L[h] + iLe_L[h]
SER0L72ick iLe_L[i] + ser_L[h] -> ser_L[h] + iLe_L[h]
TH0L72ick iLe_L[i] + iLe_L[h] -> iLe_L[h] + iLe_L[h]
TYP0L72ick iLe_L[i] + iLe_L[h] -> iLe_L[h] + iLe_L[h]
TYR0L72ick iLe_L[i] + iLe_L[h] -> iLe_L[h] + iLe_L[h]
VAL0L72ick iLe_L[i] + na[i] -> na[i] + iLe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ALPH0L72ick phe_L[i] + aLe_L[h] -> aLe_L[h] + phe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANPH0L72ick phe_L[i] + aa_L[h] -> aa_L[h] + phe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYPH0L72ick phe_L[i] + cys_L[h] -> cys_L[h] + phe_L[h]
EL_phe_L[i]ick phe_L[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
GLPH0L72ick phe_L[i] + gla_L[h] -> gla_L[h] + phe_L[h]
HCPH0L72ick phe_L[i] + his_L[h] -> his_L[h] + phe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ILPH0L72ick phe_L[i] + iLe_L[h] -> iLe_L[h] + phe_L[h]
ILPH0L72ick phe_L[i] + iLe_L[h] -> iLe_L[h] + phe_L[h]
MUTPH0L72ick phe_L[i] + na[i] -> na[i] + phe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
PH0L72ick iLe_L[i] + phe_L[h] -> phe_L[h] + iLe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
PH0h na[i] + phe_L[h] -> na[i] + phe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
PH0L72ick arg_L[i] + na[i] + phe_L[h] -> na[i] + phe_L[h] + arg_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
PH0L72ick arg_L[i] + h[i] + phe_L[h] -> h[i] + phe_L[h] + arg_L[h]
SERPH0L72ick phe_L[i] + ser_L[h] -> ser_L[h] + phe_L[h]
THPH0L72ick phe_L[i] + iLe_L[h] -> iLe_L[h] + phe_L[h]
TYPH0L72ick phe_L[i] + iLe_L[h] -> iLe_L[h] + phe_L[h]
TYRPH0L72ick phe_L[i] + iLe_L[h] -> iLe_L[h] + phe_L[h]
VALPH0L72ick phe_L[i] + na[i] -> na[i] + phe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ALH0H0adu na[i] + aLe_L[h] + na[i] -> na[i] + aLe_L[h] + ser_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
ANH0H0adu na[i] + na[i] + aa_L[h] -> na[i] + aa_L[h] + ser_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CYH0H0adu na[i] + na[i] + cys_L[h] -> na[i] + cys_L[h] + ser_L[h]
Warning: Metabolite lysine[h] not in model - added to the model
CYH0H0adu na[i] + lysine[h] -> lysine[h] + ser_L[h]
EL_ser_L[i]ick ser_L[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
GLH0H0adu na[i] + na[i] + gla_L[h] -> na[i] + gla_L[h] + ser_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERL0adu aLe_L[h] + na[i] + ser_L[h] -> na[i] + ser_L[h] + aLe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERH0adu aa_L[h] + na[i] + ser_L[h] -> na[i] + ser_L[h] + aa_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERCY0adu cys_L[h] + na[i] + ser_L[h] -> na[i] + ser_L[h] + cys_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERGL0adu gla_L[h] + na[i] + ser_L[h] -> na[i] + ser_L[h] + gla_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERH0adu gla_L[h] + ser_L[h] -> ser_L[h] + gla_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERGL0adu gtp[h] + ser_L[h] -> ser_L[h] + gtp[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERL0L72ick iLe_L[i] + ser_L[h] -> ser_L[h] + iLe_L[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
SERLY0adu tps_L[h] + na[i] + ser_L[h] -> na[i] + ser_L[h] + tps_L[h]
Warning: Reaction with the same name already exists in the model,

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opening the reaction

THPRLAT71ick phe_L[s] + ser_L[h] \rightarrow ser_L[s] + phe_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis thr_L[s] + nal[h] + ser_L[h] \rightarrow nal[s] + ser_L[s] + thr_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLH nal[h] + ser_L[h] \rightarrow nal[s] + ser_L[s]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLH h[s] + 2 nal[h] + ser_L[h] \rightarrow 2 nal[s] + ser_L[s] + h[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis ser_L[s] + nal[h] + thr_L[h] \rightarrow nal[s] + thr_L[s] + ser_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

ALHSHaddis thr_L[s] + ala_L[h] + nal[h] \rightarrow nal[s] + ala_L[s] + thr_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

ALHSHaddis thr_L[s] + nal[h] + asp_L[h] \rightarrow nal[s] + asp_L[s] + thr_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

CYSRHaddis thr_L[s] + nal[h] + cys_L[h] \rightarrow nal[s] + cys_L[s] + thr_L[h]

RR_thr_L[with_thr_L[h] \rightarrow

Warning: Reaction with the same name already exists in the model,

updating the reaction

GLNTHaddis thr_L[s] + nal[h] + gla_L[h] \rightarrow nal[s] + gla_L[s] + thr_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis thr_L[s] + nal[h] + ser_L[h] \rightarrow nal[s] + ser_L[s] + thr_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis ala_L[s] + nal[h] + thr_L[h] \rightarrow nal[s] + thr_L[s] + ala_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis asp_L[s] + nal[h] + thr_L[h] \rightarrow nal[s] + thr_L[s] + asp_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis cys_L[s] + nal[h] + thr_L[h] \rightarrow nal[s] + thr_L[s] + cys_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis gla_L[s] + nal[h] + thr_L[h] \rightarrow nal[s] + thr_L[s] + gla_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis gly[s] + thr_L[h] \rightarrow thr_L[s] + gly[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLAT71ick thr_L[s] + thr_L[h] \rightarrow thr_L[s] + thr_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLAT71ick phe_L[s] + thr_L[h] \rightarrow thr_L[s] + phe_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLHaddis ser_L[s] + nal[h] + thr_L[h] \rightarrow nal[s] + thr_L[s] + ser_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

THPRLH nal[h] + thr_L[h] \rightarrow nal[s] + thr_L[s]

Warning: Reaction with the same name already exists in the model,

updating the reaction

ALPGLAT71ick arg_L[s] + ala_L[h] + nal[h] \rightarrow nal[s] + ala_L[s] + arg_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

ALPGLAT71ick arg_L[s] + h[h] + ala_L[h] \rightarrow h[s] + ala_L[s] + arg_L[h]

ARGLThresh lps_L[s] + arg_L[h] \rightarrow arg_L[s] + lps_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

ARGLH nal[h] + arg_L[h] \rightarrow nal[s] + arg_L[s]

ARGLHb arg_L[h] \rightarrow arg_L[s]

ARGLSPH arg_L[h] \rightarrow arg_L[s]

RR_arg_L[with_arg_L[h] \rightarrow

Warning: Reaction with the same name already exists in the model,

updating the reaction

GLPGLAT71ick arg_L[s] + nal[h] + gla_L[h] \rightarrow nal[s] + gla_L[s] + arg_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

GLPGLAT71ick arg_L[s] + h[h] + gla_L[h] \rightarrow h[s] + gla_L[s] + arg_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

H2PGLAT71ick arg_L[s] + nal[h] + his_L[h] \rightarrow nal[s] + his_L[s] + arg_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

H2PGLAT71ick arg_L[s] + h[h] + his_L[h] \rightarrow h[s] + his_L[s] + arg_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction

LEPGLAT71ick arg_L[s] + h[h] + leu_L[h] \rightarrow h[s] + leu_L[s] + arg_L[h]

Warning: Reaction with the same name already exists in the model,

updating the reaction


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LHqLk7t1ck arg_1[x] + na2[h] + 5na_1[h] -> na2[h] + 5na_1[x] + arg_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

PHqLk7t1ck arg_1[x] + na2[h] + met_1[h] -> na2[h] + met_1[x] + arg_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

PHqLk7t1ck arg_1[x] + h[h] + met_1[h] -> h[x] + met_1[x] + arg_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

PHqLk7t1ck arg_1[x] + na2[h] + phe_1[h] -> na2[h] + phe_1[x] + arg_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

PHqLk7t1ck arg_1[x] + h[h] + phe_1[h] -> h[x] + phe_1[x] + arg_1[h]
Warning: Metabolite a1d1ro[h] not in model - added to the model

ALZtW1ck a1d1ro[h] -> a1d1ro[h]
EX_a1d1ro[h] a1d1ro[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction

JPPtA2C2ck h2u[h] + og1p[h] -> g1p[h] + xps_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

GLZt13_2_h 2 h[h] + og1p[h] -> 2 h[x] + og1p[h]
EX_og1p[h] og1p[h] ->
Warning: Metabolite g1a2a[h] not in model - added to the model

G2MLTck a1a_1[x] + g1a2a[h] -> og1p[h] + g1a2a[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

JPPtck E h2u[h] + a1roh1[h] -> E g1a_2[h] + a1roh2[h]
EX_a1roh1[h] a1roh1[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction

JPPtck E h2u[h] + a1roh1[h] -> E g1a_2[h] + a1roh2[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

JPPtck E h2u[h] + g1ypp2[h] -> E g1a_2[h] + g1ypp4[h]
EX_g1a2[h] g1a_2[h] ->
GLZt1roth g1a_2[x] -> g1a_2[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

GLZt_2h 2 h[h] + g1a_2[h] -> 2 h[x] + g1a_2[x]
Warning: Reaction with the same name already exists in the model,
updating the reaction

GLZt4h h[h] + g1a_2[h] -> h[x] + g1a_2[x]
Warning: Reaction with the same name already exists in the model,
updating the reaction

GLZt4h na1[h] + g1a_2[h] -> na1[x] + g1a_2[x]
Warning: Reaction with the same name already exists in the model,
updating the reaction

GLZt_2h 2 na1[h] + g1a_2[h] -> 2 na1[x] + g1a_2[x]
Warning: Reaction with the same name already exists in the model,
updating the reaction

LkC2ck h2u[h] + lcku[h] -> g4u[h] + g1a_2[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

PGLTck h2u[h] + na1[h] -> 2 g1a_2[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

MUTt1ck h2u[h] + na1[h] -> g1a_2[h] + na1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

G2MLck h2u[h] + g1ypp4[h] -> g1a_2[h] + g1ypp4[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

G2MLck h2u[h] + a1roh2[h] -> g1a_2[h] + na1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

LkCtck h2u[h] + uac[h] -> g1a_2[h] + fru[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

TH2ck h2u[h] + fru[h] -> 2 g1a_2[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

JPPtck E h2u[h] + a1roh1[h] -> E g1a_2[h] + a1roh2[h]
EX_a1roh2[h] a1roh2[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction

G2MLck h2u[h] + a1roh2[h] -> g1a_2[h] + na1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction

JPPtck E h2u[h] + g1ypp2[h] -> E g1a_2[h] + g1ypp4[h]
EX_g1ypp2[h] g1ypp2[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction

JPPtck E h2u[h] + g1ypp2[h] -> E g1a_2[h] + g1ypp4[h]
EX_g1ypp4[h] g1ypp4[h] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction

G2MLck h2u[h] + g1ypp4[h] -> g1a_2[h] + g1ypp4[h]
Warning: Metabolite a1ro1ro[h] not in model - added to the model

JPPtA2C2ck h2u[h] + a1roh1[h] + a1roh2[h] -> a1roh1[h] + h2u[h] + a1roh2[h] + a1roh2[h]

```



```

@prologue amp[a]   ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
ATP9de6 h2o[h] + atp[at]   ~> 2 h[h] + amp[amp] + 2 pi[p]
Moving: Reaction with the same name already exists in the model,
updating the reaction
ATP9de6 h2o[h] + adp[ad]   ~> h[h] + amp[amp] + pi[p]
EI_aps[iat] amp[am] ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
NTP9de6 h2o[h] + amp[ap]   ~> ade[ade] + p[c]
Moving: Reaction with the same name already exists in the model,
updating the reaction
ATP7de6 h2o[h] + atp[at]   ~> 2 h[h] + amp[amp] + 2 pi[p]
Moving: Reaction with the same name already exists in the model,
updating the reaction
ATP7de6 h2o[h] + adp[ad]   ~> h[h] + amp[amp] + pi[p]
EI_gif[iak] gi[g] ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
NDP2de6 h2o[h] + idp[id]   ~> h[h] + p[c] + ip[ip]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NDP3de6 h2o[h] + gdp[gd]   ~> h[h] + pi[p] + gmp[gm]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NDP3de6 h2o[h] + adp[ad]   ~> h[h] + pi[p] + amp[am]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NDP3de6 h2o[h] + atp[at]   ~> h[h] + pi[p] + u[d]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NFY2de6 h2o[h] + ump[um]   ~> p[c] + urc[ur]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NTS4de6 h2o[h] + up[u]     ~> pi[p] + cyta[cyt]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NFY3de6 h2o[h] + amp[ap]   ~> ade[ade] + p[c]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NFY3de6 h2o[h] + gmp[gm]   ~> p[c] + qm[qm]
Moving: Reaction with the same name already exists in the model,
updating the reaction
NFY3de6 h2o[h] + gdp[gd]   ~> h[h] + pi[p] + gmp[gm]
Moving: Reaction with the same name already exists in the model,
updating the reaction
PCU7e 3 na[n] + p[c][pi] ~> pi[p] + 3 na[n][n]
Moving: Reaction with the same name already exists in the model,
updating the reaction
PCU7ir 3 na[n] + pi[p]    ~> pi[p] + 3 na[n][n]
Moving: Reaction with the same name already exists in the model,
updating the reaction
PGH8 2.5 na[n] + pi[p]    ~> pi[p] + 2.5 na[n][n]
Moving: Reaction with the same name already exists in the model,
updating the reaction
PGH8 2 na[n] + p[c][pi] ~> pi[p] + 2 na[n][n]
Moving: Reaction with the same name already exists in the model,
updating the reaction
ATP9de6 h2o[h] + adp[ad]   ~> h[h] + amp[amp] + pi[p]
EI_aps_aps[iat] ~>
Moving: Relationship acitE[acit] not in model - added to the model
AUTZT0is aviteE[av] ~> aviteE[av]
EI_aviteE[erik aviteE[av]] ~>
VTB11k h2o[h] + atp[at] + aviteE[av] ~> adp[ad] + h[h] + pi[p] + aviteE[av]
Moving: Relationship aviteE[av] not in model - added to the model
AUTZT0is aviteE[av] ~> aviteE[av]
EI_aviteE[erik aviteE[av]] ~>
Moving: Relationship ala_R[ala] not in model - added to the model
BALGVCUCRk h2o[h] + atp[at] + 3 ala_R[al] ~> adp[ad] + h[h] + pi[p] + 3 ala_R[al]
EI_ala_R[erik ala_R[al]] ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
BLC1rk h[h] + hg[lg] [hg] ~> h[h] + lg[lg][l]
EI_hg[le] [erik hg[lg] [hg]] ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
ELIGLGRhk h[h] + glq[gl] [gl] ~> h[h] + glq[gl] [gl]
EI_glq[gl] [erik glq[gl] [gl]] ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
GLGTTCR1k h[h] + glt[gl] [gl] ~> h[h] + glt[gl] [gl]
EI_glt[gl] [erik glt[gl] [gl]] ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
GLGTTCMCRk h[h] + glt[gl] [gl] ~> h[h] + glt[gl] [gl]
EI_glt[gl] [erik glt[gl] [gl]] ~>
Moving: Reaction with the same name already exists in the model,
updating the reaction
ROM1k h[h] = hh[h] ~> h[h] + hh[h][h]

```

```

E120Hk[e] h k[k] ~>
Mappings: MetabolicLike hklglgaur[h] not in model - added to the model
E12LGLGlnw h k[s] + atp[s] + hklglgaur[s] ~> adp[s] + h[s] + pi[s] + hklglgaur[s]
EK_hklglgaur[e] h hklglgaur[h] ~>
Mappings: MetabolicLike hklglgaur[h] not in model - added to the model
E12LGLGlnw h k[s] + atp[s] + hklglgaur[s] ~> adp[s] + h[s] + pi[s] + hklglgaur[s]
EK_hklglgaur[e] h hklglgaur[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction
E12SIRub12b head[s] + hlliruh[h] ~> hlliruh[s] + head[h]
EK_hlliruh[e] h hlliruh[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction
ETMdb S2e[h] + hincyt[h] ~> hte[h] + lps_u[h]
EK_hincyte[h] h incyt[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction
ETMdb S2e[h] + hincyt[h] ~> hte[h] + lps_u[h]
ETMdb hte[s] ~> hte[h]
Mappings: Reaction with the same name already exists in the model,
updating the reaction
ETMdb h[h] + hte[h] ~> hte[s] + hte[s]
Mappings: Reaction with the same name already exists in the model,
updating the reaction
ETMdb hte[s] + atp[s] + 2 sa2[h] + hte[h] ~> adp[s] + h[s] + pi[s] + 2 sa2[h] + hte[h]
Mappings: Reaction with the same name already exists in the model,
updating the reaction
ETMdb hte[s] + hte[h] ~> hte[s] + h[h]
EK_hte[e] h hte[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction
EU7Crv h k[h] + hut[h] ~> h k[s] + hut[s]
EK_hut[e] h hut[h] ~>
Mappings: MetabolicLike hvite[h] not in model - added to the model
EU7Crv hvite[h] ~> hvite[s]
EK_hvite[e] h hvite[h] ~>
Mappings: MetabolicLike hu[h] not in model - added to the model
EZb hu[h] ~> hu[s]
EK_hu[e] h hu[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction
CAZPDB S2a[s] + atp[s] + 2 ca2[h] ~> adp[s] + pi[s] + h[s] + 2 ca2[h]
Mappings: Reaction with the same name already exists in the model,
updating the reaction
CA7Cr ca2[s] + 3 na2[h] ~> 3 na2[s] + ca2[h]
EK_ca2[e] h ca2[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction
NCN6 4 na2[s] + h[h] + ca2[h] ~> h k[s] + ca2[s] + 4 na2[h]
Mappings: Reaction with the same name already exists in the model,
updating the reaction
NCN6 4 na2[s] + shd[h] + ca2[h] ~> shd[s] + ca2[s] + 4 na2[h]
Mappings: MetabolicLike camp[h] not in model - added to the model
CMPPh S2a[s] + atp[s] + camp[s] ~> adp[s] + h[s] + pi[s] + camp[h]
EK_camp[e] h camp[h] ~>
Mappings: MetabolicLike carv[h] not in model - added to the model
CM9Crv carv[h] ~> carv[s]
EK_carv[e] h carv[h] ~>
Mappings: MetabolicLike caromt[h] not in model - added to the model
CM9Crv1eb caromt[h] ~> caromt[s]
EK_caromt[e] h caromt[h] ~>
Mappings: MetabolicLike adhokt[h] not in model - added to the model
CELTE_rk adhokt[s] ~> adhokt[h]
EK_adhokt[e] h adhokt[h] ~>
Mappings: MetabolicLike csa_d3[h] not in model - added to the model
CTA_D3B csa_d3[s] ~> csa_d3[h]
EK_csa_d3[e] h csa_d3[h] ~>
Mappings: MetabolicLike H3app[h] not in model - added to the model
CMPPh S2e[s] + atp[s] + H3app[h] ~> adp[s] + h[s] + pi[s] + H3app[h]
EK_H3app[e] h H3app[h] ~>
Mappings: MetabolicLike chivertu[h] not in model - added to the model
CHL8ACLeib S2a[s] + atp[s] + chivertu[s] ~> adp[s] + h[s] + pi[s] + chivertu[h]
CHL8FUTTeb chivertu[s] ~> chivertu[h]
CH8FRTLLS S2a[s] + atp[s] + chivertu[h] ~> adp[s] + h[s] + pi[s] + chivertu[h]
EK_chivertu[e] h chivertu[h] ~>
Mappings: MetabolicLike pshetl_ba[h] not in model - added to the model
Mappings: MetabolicLike lpshef_ba[h] not in model - added to the model
Mappings: MetabolicLike acstetl_ba[h] not in model - added to the model
LGFTeb chivertu[h] + pshetl_ba[h] ~> lpshef_ba[h] + acstetl_ba[h]
Mappings: Reaction with the same name already exists in the model,
updating the reaction
CHL8ATB12b 2 na2[h] + chulate[h] ~> 2 na2[s] + chulate[s]
CHL8ATB13b S2a[s] + atp[s] + chulate[h] ~> adp[s] + h[s] + pi[s] + chulate[h]
EK_chulate[e] h chulate[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction
CHYABReb 2 k2o[h] + chin[h] ~> 3 argos[h]
EK_chin[e] h chin[h] ~>
Mappings: Reaction with the same name already exists in the model,
updating the reaction

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```

CMT04a2b 2 k[a][c] + c[b][a] -> 2 a[gne][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CMT04_2b 2 na[ic][c] + ci[a][b] -> 2 na[ic][c] + ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CMT04_8d 4 na[ic][c] + ci[a][b] -> 4 na[ic][c] + ci[a][b]
Warning: Metabolite fur[c] not in model - added to the model
CLP04a2b 2 far[s][c] + ci[a][b] -> ci[a][c] + 2 far[b][c]
CLP04a2b far[s][c] + 2 ci[a][b] -> 2 ci[a][c] + far[b][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CLC02a2b2b head[s][c] + 2 ci[a][b] -> 2 ci[a][c] + head[b][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CLC02a2b 2 head[s][c] + ci[a][b] -> ci[a][c] + 2 head[b][c]
CLZ1a2b 2 i[a][c] + ci[a][b] -> ci[a][c] + 2 i[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CLM04a2b sh[i][c] + 2 ci[a][b] -> 2 ci[a][c] + sh[i][b]
CLM04a2b aaq[s][c] + 2 ci[a][b] -> 2 ci[a][c] + aaq[b][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
GLWT_Z12_c 2 na[ic][c] + gi[y][b] + ci[a][b] -> 2 na[ic][c] + ci[a][c] + gi[y][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
GLWT_Z12_r 2 na[ic][c] + gi[y][b] + ci[a][b] -> 2 na[ic][c] + ci[a][c] + gi[y][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
HCE1_C1k ci[a][c] + head[b][c] -> head[s][c] + ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
HC21a sh[i][c] + ci[a][b] -> sh[i][c] + ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
HCC1b h[a][c] + ci[a][b] -> ci[a][c] + h[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NACX0_HCL1b h[a][c] + ci[a][b] + na[ic][c] + head[b][c] -> head[s][c] + na[ic][c] + h[a][b] + ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NCX1b na[ic][c] + ci[a][b] -> na[ic][c] + ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NCC21b sh[i][c] + na[ic][c] + 2 ci[a][b] -> sh[i][c] + na[ic][c] + 2 ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NCC21b na[ic][c] + h[a][c] + 2 ci[a][b] -> na[ic][c] + 2 ci[a][b] + h[a][b]
NCC1a2b ci[a][c] + 2 na[ic][c] -> 2 na[ic][c] + ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CLP04a2b 2 far[s][c] + ci[a][b] -> ci[a][c] + 2 far[b][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CLP04a2b far[s][c] + 2 ci[a][b] -> 2 ci[a][c] + far[b][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CLZ1a2b 2 i[a][c] + ci[a][b] -> ci[a][c] + 2 i[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NCC1b 2 na[ic][c] + ci[a][b] -> 2 na[ic][c] + ci[a][b]
Warning: Reaction with the same name already exists in the model,
updating the reaction
CLM04a2b aaq[s][c] + 2 ci[a][b] -> 2 ci[a][c] + aaq[b][c]
Warning: Reaction with the same name already exists in the model,
updating the reaction
GSM02a2b 2 head[s][c] + aaq[b][c] -> aaq[s][c] + 2 head[b][c]
SDEK02a2b aaq[s][c] + 2 na[ic][c] -> 2 na[ic][c] + aaq[b][c]
Warning: Metabolite s[epe][b] not in model - added to the model
CLP04a s[epe][b] -> s[epe][c]
Warning: Metabolite s[epe][b] not in model - added to the model
CS21b na[ic][c] -> na[ic][b]
Warning: Metabolite s[epe][b] not in model - added to the model
CS01b na[ic][c] -> na[ic][b]
Warning: Metabolite s[epe][b] not in model - added to the model
CS01b na[ic][c] -> na[ic][b]
Warning: Metabolite s[epe][b] not in model - added to the model
CS071a s[epe][b] -> s[epe][b]

```

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

```

updating the reaction
GDPH6Hk h[k] + glyphe[h] ~> h[s] + glyphe[s]
Warning: RetainableLike gLypru[h] not in model - added to the model
EI_gLypru[e] gLypru[h] ~>
EI_gLypru[e] gLypru[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
GLYMR6k h[k] + gLypru[h] ~> h[s] + gLypru[s]
EI_gypir[e] gyp[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
NDP3eek h2u[h] + gdp[h] ~> h[k] + pi[h] + gmp[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NTP9ek h2u[h] + gmp[h] ~> pi[h] + gmp[h]
Warning: RetainableLike gmuor[e] not in model - added to the model
EI_gmuor[e] gmuor[el] ~> gmuor[el]
Warning: RetainableLike gmuor[e] not in model - added to the model
EI_gmuor2[e] gmuor2[h] ~>
NCOR2Elk gmuor2[g] ~> gmuor2[h]
Warning: RetainableLike gpL_ha[h] not in model - added to the model
EI_gpL_ha[h] gpL_ha[h] ~>
GPCLek gpL_ha[s] ~> gpL_ha[h]
Warning: RetainableLike gpL_ha[h] not in model - added to the model
EI_gpGcApha_ha[h] gpL_ha[h] ~>
GPCLAP0Leik gpL_ha[h] ~> gpL_ha[h]
Warning: RetainableLike gpL_ha[h] not in model - added to the model
EI_gpL_ha[h] gpL_ha[h] ~>
QZLlek gpL_ha[s] ~> gpL_ha[h]
Warning: RetainableLike gpL_ha[h] not in model - added to the model
EI_gpL_ha[h] gpL_ha[h] ~>
QZLAP0Leik gpL_ha[h] ~> gpL_ha[h]
EI_gyoic[e] gyo[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
GM6Ik naL[h] + gao[h] ~> naL[s] + gao[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
GM6Ik 2 naL[h] + gao[h] ~> 2 naL[s] + gao[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NTP9ek h2u[h] + gmp[h] ~> pi[h] + gmp[h]
Warning: RetainableLike gTLa_ha[h] not in model - added to the model
EI_gTLa_ha[h] gTLa_ha[h] ~>
GTZLeek gTLa_ha[s] ~> gTLa_ha[h]
EI_gTbas[e]k gTbas[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
CTFPeK h2d[h] + 2 gTbas[h] ~> 2 h2u[h] + gTbas[h]
EI_gTbas[e] k gTas[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
CTFPeK h2d[h] + 2 gTbas[h] ~> 2 h2u[h] + gTbas[h]
EI_gTp[e]k gTp[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
NTP9ek h2u[h] + gtp[h] ~> h[h] + pi[h] + gdp[h]
Warning: RetainableLike gua[h] not in model - added to the model
EI_guaic[e] qua[h] ~>
GD8Ik qua[h] ~> qua[s]
EI_guaic[e] qua[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
GD8Ik h[h] + qua[h] ~> h[s] + qua[s]
EI_gumthaic[e]k gumthaic[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
GDPCORElk h[h] + gumthaic[h] ~> h[s] + gumthaic[s]
EI_gumghaifw[k] gumghaifw[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
GDPCORElk h[h] + gumghaifw[h] ~> h[s] + gumghaifw[s]
EI_gumthaic[e]k gumthaic[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
GDTCORElk h[h] + gumthaic[h] ~> h[s] + gumthaic[s]
EI_h2u2[e]k h2u2[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
CTFPek h2d[h] + 2 gTbas[h] ~> 2 h2u[h] + gTbas[h]
GC2Elk h2d[h] ~> h2d[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
UFPPeK 2 h[h] + 2 s2u[h] ~> h2d[h] + c2[h]
Warning: RetainableLike ha[h] not in model - added to the model
EI_s2u[h]k ha[h] ~>
Warning: RetainableLike va[crit] not in model - added to the model

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[illegible]

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EX_hsl_dmg1w1b hsl_dmg1[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
FUCHS2w h2u[h] + hsl[h] ~> fuc_2[h] + hsl_dmg1[h]
Warning: Metabolite hsl_dmg1[h] not in model - added to the model
EX_hsl_sure2w1b hsl_sure2[h] ~>
K2Z1_CDR21b hsl_sure2[g] ~> hsl_sure2[h]
K2Z1_CDR21t1b hsl_sure2[h] ~> hsl_sure2[t1]
Warning: Metabolite hsl_sure2[h] not in model - added to the model
EX_hsl_sure4w1b hsl_sure4[h] ~>
K2Z1_CDR41b hsl_sure4[g] ~> hsl_sure4[h]
K2Z1_CDR41t1b hsl_sure4[h] ~> hsl_sure4[t1]
EX_lac_1w1b lac_1[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
L_LAC12rb h[h] + lac_1[h] ~> h[s] + lac_1[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
L_LAC14rb nal[h] + lac_1[h] ~> nal[s] + lac_1[s]
EX_lala1w1b lala[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
LAC2w h2u[h] + lala[h] ~> gal[h] + glc_R[h]
LCTHigh lala[g] ~> lala[h]
EX_lau_1w1b lau_1[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
LLEHLLA721sb lAu_1[s] + lau_1[h] ~> lau_1[s] + lAu_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
LLEPHLLA721sb phe_1[s] + lau_1[h] ~> lau_1[s] + phe_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
LEH1b nal[h] + lau_1[h] ~> nal[s] + lau_1[s]
LEH2sb lau_1[h] ~> lau_1[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
LEH3L721sb arg_1[s] + h[h] + lau_1[h] ~> h[s] + lau_1[s] + arg_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
LEH4L721sb arg_1[s] + nal[h] + lau_1[h] ~> nal[s] + lau_1[s] + arg_1[h]
PMTL2sb lau_1[s] + met_1[h] ~> met_1[s] + lau_1[h]
EX_leup1w1b leup1[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
LEH5F1b h[h] + leup1[h] ~> h[s] + leup1[s]
Warning: Metabolite leu1d4[h] not in model - added to the model
EX_leu1d4w1b leu1d4[h] ~>
LEH7H41b leu1d4[h] ~> leu1d4[s]
Warning: Metabolite leu1d4[h] not in model - added to the model
EX_leu1d4w1b leu1d4[h] ~>
LEH7H41b leu1d4[h] ~> leu1d4[s]
Warning: Metabolite leu1d4[h] not in model - added to the model
EX_leu1d4w1b leu1d4[h] ~>
LEH7H41b leu1d4[h] ~> leu1d4[s]
Warning: Metabolite leu1d4[h] not in model - added to the model
EX_leu1d4w1b leu1d4[h] ~>
LEH7H41b leu1d4[h] ~> leu1d4[s]
Warning: Metabolite leu1d4[h] not in model - added to the model
EX_leu1d4w1b leu1d4[h] ~>
LEH7H41b leu1d4[h] ~> leu1d4[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
LEH8F1b h[h] + leu1d4[h] ~> h[s] + leu1d4[s]
EX_1gna1w1b 1gna[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
FUTP1b nal[s] + 1gna[s] ~> nal[h] + 1gna[h]
UNCL1b 1gna[h] ~> 1gna[s]
Warning: Metabolite 1imeaa[h] not in model - added to the model
EX_1imeaa1w1b 1imeaa[h] ~>
LIM2w1b 1imeaa[h] ~> 1imeaa[s]
EX_1igad1w1b 1igade[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
LIP11b h2u[s] + atp[s] + 2 nal[h] + 1igade[h] ~> adp[s] + h[s] + gal[s] + 2 nal[s] + 1igade[s]
Warning: Metabolite 1e1d4[h] not in model - added to the model
EX_1e1d4w1b 1e1d4[h] ~>
UNL2C1b 1e1d4[h] ~> 1e1d4[s]
Warning: Metabolite 1e1a[h] not in model - added to the model
EX_1e1a1w1b 1e1a[h] ~>
UNL21b 1e1a[h] ~> 1e1a[s]
Warning: Metabolite 1e1uca[h] not in model - added to the model
EX_1e1uca1w1b 1e1uca[h] ~>
UNL2C1b 1e1uca[h] ~> 1e1uca[s]
Warning: Metabolite 1e1ug[h] not in model - added to the model

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EI_sphat6[e]k lctang[a]    ~>
UNACD6k lctang[a]    ~> lctang[s]
EI_sphat6_ha[e] sphat6_ha[k]    ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction:
LCTT6k sphat6_l[a] + sphat6_ha[k]    ~> sphat6_ha[k] + autot62_ha[k]
LPCOL6k sphat6_ha[k]    ~> sphat6_ha[s]
EI_mag_ha[e] mag_ha[k]    ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction:
LPQ26k h2o[k] + mag_ha[k]    ~> h[k] + Hstat6[k] + mag_ha[k]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
LPQ26k h2o[k] + mag_ha[k]    ~> h[k] + Hstat62[k] + glys[k]
P60H6k mag_ha[k]    ~> mag_ha[s]
EI_naf1[e]w k naf1[k]    ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction:
G69H6k h2o[k] + gqqqq[a]    ~> Tpr_aps[k] + naf1[k]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
M7376k h2o[k] + naf1[k]    ~> 2 g_h2o[k]
PLU7126k naf1[k]    ~> naf1[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PLU716k h2o[k] + naf1R[k]    ~> gla_R[k] + naf1[k]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
G8HC26k h2o[k] + sfvK2[k]    ~> gla_R[k] + naf1[k]
EI_naf1R[e]k naf1R[k]    ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PLU716k h2o[k] + naf1R[k]    ~> gla_R[k] + naf1[k]
EI_nafR[e]k nafR[k]    ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction:
P60H6k naf[k] + naf[k]    ~> naf[s] + naf[s]
Warning: Retainable asph[k] not in model - added to the model
EI_asph[e]k asph[k]    ~>
P60H26k asph[k]    ~> asph[s]
Warning: Retainable aspi[k] not in model - added to the model
EI_aspi[e]k aspi[k]    ~>
PPF2PVH16k 2 h2o[s] + 2 atp[s] + 3 aspi[s]    ~> 3 atp[s] + 2 h[s] + 2 pi[s] + 3 aspi[s]
Warning: Retainable nervglasy[s] not in model - added to the model
EI_nervglasy[e]k nervglasy[k]    ~>
PERCFLACT26k nervglasy[s]    ~> nervglasy[k]
EI_met_i[e]k met_i[k]    ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PETPFLAET26k glc_i[s] + met_i[k]    ~> met_i[s] + ile_u[k]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PETLDESH6k leu_i[s] + met_i[k]    ~> met_i[s] + leu_i[k]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PETPFLAET26k phe_i[s] + met_i[k]    ~> met_i[s] + glu_i[k]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PETH6k naf[k] + met_i[k]    ~> naf[s] + met_i[s]
PETV6k met_i[k]    ~> met_i[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PETPFLAET26k arg_i[s] + naf[k] + met_i[k]    ~> naf[s] + met_i[s] + arg_i[k]
Warning: Reaction with the same name already exists in the model,
updating the reaction:
PETPFLAET26k h[s] + met_i[k]    ~> h[s] + met_i[s] + arg_i[k]
Warning: Retainable asp10[k] not in model - added to the model
EI_asp10[e]k asp10[k]    ~>
PKC86k asp10[k]    ~> asp10[s]
Warning: Retainable asp11[k] not in model - added to the model
EI_asp11[e]k asp11[k]    ~>
PKC216k asp11[s]    ~> asp11[k]
Warning: Retainable asp7[k] not in model - added to the model
EI_asp7[e]k asp7[k]    ~>
PKC76k asp7[k]    ~> asp7[s]
Warning: Retainable asp8[k] not in model - added to the model
EI_asp8[e]k asp8[k]    ~>
PKB6k asp8[s]    ~> asp8[k]
Warning: Retainable asp9[k] not in model - added to the model
EI_asp9[e]k asp9[k]    ~>
PKB6k asp9[k]    ~> asp9[k]
Warning: Retainable sthpa[k] not in model - added to the model
EI_sthpa[e]k sthpa[k]    ~>
PTHKGL6k sthpa[s]    ~> sthpa[k]
Warning: Retainable c2c2mase[k] not in model - added to the model
EI_c2c2mase[e]k c2c2mase[k]    ~>
NCCHPMU106k c2c2mase[s]    ~> c2c2mase[k]
NCCHPMU106k c2c2mase[s]    ~> c2c2mase[t]
Warning: Retainable app [k] not in model - added to the model

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[illegible]


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PCN0726b cholester[1k] + pi_u1_ha[hk] -> lqphat_ha[hk] + arlen12_ha[hk]
PCN08726b pchut_ha[sx] -> pchut_ha[hk]
PC10_ h2a[sx] + adp[sx] + pchut_ha[hk] -> adp[sx] + h[sx] + pi[sx] + pchut_ha[hk]
Warning: Metabolite pm_ha[hk] not in model - added to the model
EI_gpi_ha[sx] pm_ha[hk] ->
PEFLP6_ h2a[sx] + adp[sx] + gm_ha[hk] -> adp[sx] + h[sx] + pi[sx] + gm_ha[sx]
PE10_ gm_ha[hk] -> gm_ha[sx]
EI_gpi_ha[sx] pect[1k] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEC171b h[sx] + gpi[1k] -> h[sx] + gpi[k][s]
EI_gpi_indichas[rx] pecindichas[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEC209b h[sx] + gpi_indichas[hk] -> h[sx] + gpi_indichas[s]
EI_gpi_indichas[rx] pecindichas[1k] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEC2081b h[sx] + gpi_indichas[1k] -> h[sx] + gpi_indichas[s]
EI_gpi_indichas[rx] pecindichas[1k] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEC2081b h[sx] + gpi_indichas[1k] -> h[sx] + gpi_indichas[s]
Warning: Metabolite pglyp[1k] not in model - added to the model
EI_pgpyt[rx] pglyp[1k] ->
PEPLV00k pglyp[1k] -> pglyp[sx]
Warning: Metabolite pglyty[1k] not in model - added to the model
EI_pgpyt[rx] pglyty[1k] ->
PEGLL5161b pglyty[1k] -> pglyty[sx]
EI_glyp_ha[sx] pglyty_ha[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
LP104b h2a[hk] + pglyty_ha[hk] -> h[hk] + Rhaat12[hk] + lglyty_ha[hk]
PEL31b pglyty_ha[hk] -> pglyty_ha[hk]
Warning: Metabolite pheagac[hk] not in model - added to the model
EI_gheagac[rx] pheagac[hk] ->
PEHCC121b pheagac[sx] -> pheagac[hk]
Warning: Metabolite pheagac[hk] not in model - added to the model
EI_gheac[rx] pheagac[hk] ->
PEHPI1b pheag[hk] -> pheag[sx]
Warning: Metabolite phyQ[hk] not in model - added to the model
EI_phyQ[rx] phyQ[hk] ->
PEH11b h2a[sx] + adp[sx] + phyQ[hk] -> adp[sx] + h[sx] + pi[sx] + phyQ[sx]
VEH11b phyQ[sx] -> phyQ[hk]
Warning: Metabolite phyI[hk] not in model - added to the model
EI_phyI[rx] phyI[hk] ->
PEOT1b phyI[hk] -> phyI[sx]
EI_gota_R[rx] gota_R[hk] ->
PEOTD0b gota_R[hk] -> gota_R[hk]
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEU121b h2a[sx] + adp[sx] + 2 na1[hk] + gota_R[hk] -> adp[sx] + h[sx] + pi[sx] + 2 na1[sx] + gota_R[hk]
Warning: Metabolite ppz[hk] not in model - added to the model
EI_ppz[rx] ppz[hk] ->
PP10b ppz[hk] -> ppz[sx]
Warning: Metabolite prgxin[hk] not in model - added to the model
EI_gprgxin[rx] prgxin[hk] ->
PEH270b prgxin[hk] -> prgxin[sx]
EI_gpx_R[rx] prg_R[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH121b h[sx] + prg_R[hk] -> h[sx] + prg_R[hk]
EI_gpx_R[rx] prg_R[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH27b h[sx] + prg_R[hk] -> h[sx] + prg_R[sx]
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH1b na1[hk] + prg_R[hk] -> na1[sx] + prg_R[hk]
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH121r1b 2 na1[hk] + prg_R[hk] -> 2 na1[sx] + prg_R[sx]
EI_gprgR[rx] prgR[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH121b h[sx] + prgR[hk] -> h[sx] + prgR[sx]
EI_gprgR2[rx] prgR2[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH271b h2a[sx] + gpiacG2[hk] -> gpiacG2[sx] + h2a[hk]
EI_gpiacG2[rx] gpiacG2[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH271b h2a[sx] + gpiacG2[hk] -> gpiacG2[sx] + h2a[hk]
PEH271r1b h2a[sx] + atp[sx] + gpiacG2[hk] -> adp[sx] + h[sx] + pi[sx] + gpiacG2[hk]
EI_gpiacG2[rx] gpiacG2[hk] ->
Warning: Reaction with the same name already exists in the model,
updating the reaction
PEH271b h2a[sx] + gpiacG2[hk] -> gpiacG2[sx] + h2a[hk]
PEH271r1b gpiacG2[hk] -> gpiacG2[hk]
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[illegible]

[illegible]

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EI_5aa1(e|h 5aa1[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
TBL14_2b 2 aa1[h] + 5aa1[h] ~> 2 aa1[s] + 5aa1[s]
Warning: Metabolite 5aa1[h] not in model - added to the model
EI_5ttaa(e|h 5ttaa[h] ~>
TTC24b 5ttaa[h] ~> 5ttaa[s]
TTC24b 5ttaa[h] ~> 5ttaa[s]
Warning: Metabolite 5aa2[h] not in model - added to the model
EI_5aa2(e|h 5aa2[h] ~>
TGT14b 5aa2[h] ~> 5aa2[s]
Warning: Metabolite 5ypa[h] not in model - added to the model
EI_5ypa(e|h 5ypa[h] ~>
TYP14b 5ypa[h] ~> 5ypa[s]
EI_5yr_1(e|h 5yr_1[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
TYR14L1721ab 4yr_1[s] + 5yr_1[h] ~> 5yr_1[s] + 4yr_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
TYR14L1721ab phe_1[s] + 5yr_1[h] ~> 5yr_1[s] + phe_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
TYR14b aa1[h] + 5yr_1[h] ~> aa1[s] + 5yr_1[s]
EI_5up(e|h 5up[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
NDP14ab h2a[h] + 5up[h] ~> h[h] + pi[h] + 5up[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NDP14ab h2a[h] + 5up[h] ~> h[h] + pi[h] + 5up[h]
EI_5up(e|h 5up[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
NDP14ab h2a[h] + 5up[h] ~> h[h] + pi[h] + 5up[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
NT22eb h2a[h] + 5up[h] ~> pi[h] + uru[h]
Warning: Metabolite ura[h] not in model - added to the model
EI_5ura(e|h ura[h] ~>
URH14b ura[h] ~> ura[s]
Warning: Metabolite urate[h] not in model - added to the model
EI_5urate(e|h urate[h] ~>
URH214b urate[s] ~> urate[h]
EI_5urata(e|h urata[h] ~>
URH14b urata[h] ~> urata[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
URH14b h2a[h] + urata[h] ~> h2a[s] + urata[s]
EI_5uri(e|h uri[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
NT22eb h2a[h] + 5up[h] ~> pi[h] + uru[h]
URH14b uru[h] ~> uri[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
URH214b aa1[h] + uri[h] ~> aa1[s] + uri[s]
Warning: Reaction with the same name already exists in the model,
updating the reaction
URH214b 2 aa1[h] + uri[h] ~> 2 aa1[s] + uri[s]
EI_5up(e|h 5up[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
NDP14ab h2a[h] + 5up[h] ~> h[h] + pi[h] + 5up[h]
Warning: Metabolite vma[h] not in model - added to the model
EI_5vma(e|h vma[h] ~>
VMT14b vma[h] ~> vma[s]
EI_5va1_1(e|h va1_1[h] ~>
Warning: Reaction with the same name already exists in the model,
updating the reaction
VBL14L1721ab 4va_1[s] + va1_1[h] ~> va1_1[s] + 4va_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
VBL14L1721ab phe_1[s] + va1_1[h] ~> va1_1[s] + phe_1[h]
Warning: Reaction with the same name already exists in the model,
updating the reaction
VBL14b aa1[h] + va1_1[h] ~> aa1[s] + va1_1[s]
VBL14ab va1_1[h] ~> va1_1[s]
Warning: Metabolite vit42[h] not in model - added to the model
EI_5vit42(e|h vit42[h] ~>
VTE14b vit42[s] ~> vit42[h]
Warning: Metabolite vit43[h] not in model - added to the model
EI_5vit43(e|h vit43[h] ~>
VTE174b vit43[s] ~> vit43[h]
VTE14b vit43[s] ~> vit43[h]
VTE142b vit43[h] ~> vit43[s]
Warning: Metabolite ubd4a[h] not in model - added to the model
EI_5ubd4a(e|h ubd4a[h] ~>
WBC14eb ubd4a[h] ~> ubd4a[s]
Warning: Metabolite ubd4a[h] not in model - added to the model

```

[illegible]

[illegible]

```
% Run the prediction of rescued genes. This will take some time.
[gyr100,gyr1010,gyr1020,gyr1030,rescuedgenes,fusedgenes]=computeRescuedGenes('model2.txt',model2.txt,'Rax','Mouse_himansu_aa_1_no_glycine','Rax')
```

Merminga Brazilian_Eucherichia_spl_019_022_substr_002403_0799 not in model
 Merminga Brazilian_Rouse_001_019_022 not in model
 Merminga Brazilian_Rouse_00200001 not in model

```
% Show the mouse genes that caused a lethal phenotype when deleted in
% germline mice but not in presence of the microbe:
RescueGenes,Mouse Litter as 1 no glyco,RescueLethalGenes
```


