PyCoMo_basics

September 5, 2023

1 PyCoMo Basics

PyCoMo is a **Py**thon **Co**mmunity metabolic **Mo**delling package. In this tutorial, the core features will be presented.

The expected runtime for this notebook is approximately 10-30 minutes. ## Setting up PyCoMo ## Clone the package from github. Next, we are going to import all the packages we need in this tutorial.

[1]:
```
from pathlib import Path
import sys
import cobra
import os
```

1.0.1 Importing PyCoMo

As PyCoMo is currently only available as a local package, the direct path to the package directory needs to be used on import.

[2]:
```
path_root = "../pycomo"  # Change path according to your PyCoMo location
sys.path.append(str(path_root))
import pycomo as pycomo
```

1.1 Creating a Community Model

The creation of a community model consists of 3 steps: 1. Loading the member models 2. Preparing the member models for merging 3. Creating a community model ### Loading the member models ### The community model creation process starts with models of the individual members. Note that the quality of the community model heavily depends on the quality of the member models!

In this tutorial we are using metabolic models from the AGORA collection. The models were retrieved from www.vmh.life, and are stored in the data folder of the repository. The selection of models and the resulting community represents a cystic fibrosis airway community, as done by Henson et al. (www.doi.org/10.1128/mSystems.00026-19)

[4]:
```
test_model_dir = "../data/use_case/henson"
named_models = pycomo.load_named_models_from_dir(test_model_dir)
```

The models and file names were extracted and stored in named_models. Let's check the contents:

[5]:
```
named_models
```

[5]:
```
{'Achromobacter_xylosoxidans_NBRC_15126': <Model
Achromobacter_xylosoxidans_NBRC_15126 at 0x18fd4169d00>,
 'Actinomyces_naeslundii_str_Howell_279': <Model
Actinomyces_naeslundii_str_Howell_279 at 0x18fdc5595b0>,
 'Burkholderia_cepacia_GG4': <Model Burkholderia_cepacia_GG4 at 0x18fde7dc220>,
 'Escherichia_coli_str_K_12_substr_MG1655': <Model
Escherichia_coli_str_K_12_substr_MG1655 at 0x18fdf6b2d90>,
 'Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586': <Model
Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586 at 0x18fe14bf3d0>,
 'Gemella_haemolysans_ATCC_10379': <Model Gemella_haemolysans_ATCC_10379 at
0x18fe19553a0>,
 'Granulicatella_adiacens_ATCC_49175': <Model Granulicatella_adiacens_ATCC_49175
at 0x18fe1f44a30>,
 'Haemophilus_influenzae_R2846': <Model Haemophilus_influenzae_R2846 at
0x18fe24c0970>,
 'Neisseria_flavescens_SK114': <Model Neisseria_flavescens_SK114 at
0x18fe2e84b80>,
 'Porphyromonas_endodontalis_ATCC_35406': <Model
Porphyromonas_endodontalis_ATCC_35406 at 0x18fe369e070>,
 'Prevotella_melaninogenica_ATCC_25845': <Model
Prevotella_melaninogenica_ATCC_25845 at 0x18fe3bdc700>,
 'Pseudomonas_aeruginosa_NCGM2_S1': <Model Pseudomonas_aeruginosa_NCGM2_S1 at
0x18fe42b4a90>,
 'Ralstonia_sp_5_7_47FAA': <Model Ralstonia_sp_5_7_47FAA at 0x18fe501e460>,
 'Rothia_mucilaginosa_DY_18': <Model Rothia_mucilaginosa_DY_18 at
0x18fe59c6af0>,
 'Staphylococcus_aureus_subsp_aureus_USA300_FPR3757': <Model
Staphylococcus_aureus_subsp_aureus_USA300_FPR3757 at 0x18fe5f2b3d0>,
 'Streptococcus_sanguinis_SK36': <Model Streptococcus_sanguinis_SK36 at
0x18fe69bad00>,
 'Veillonella_atypica_ACS_049_V_Sch6': <Model Veillonella_atypica_ACS_049_V_Sch6
at 0x18fe703b3d0>}
```

1.1.1 Preparing the models for merging

With the models loaded, the next step is preparing them for merging. This is done by creating SingleOrganismModel objects. Using them, the models will be formatted for compliance with the SBML format. Further, an exchange compartment will be generated under the name *medium*.

One of the requirements for a community metabolic model is a common biomass function. To construct it, PyCoMo requires the biomass of each member represented as a single metabolite. This biomass metabolite ID can be specified when constructing the SingleOrganismModel objects. However, it can also be found or generated automatically, by setting the biomass reaction as the objective of the model. Let's check if the biomass function is the objective in all the models

[6]:
```
for model in named_models.values():
    print(model.objective)
```

```
Maximize
1.0*biomass489 - 1.0*biomass489_reverse_62d1a
Maximize
1.0*biomass492 - 1.0*biomass492_reverse_bc961
Maximize
1.0*biomass479 - 1.0*biomass479_reverse_1d1b2
Maximize
1.0*biomass525 - 1.0*biomass525_reverse_5c178
Maximize
1.0*biomass237 - 1.0*biomass237_reverse_f032e
Maximize
1.0*biomass027 - 1.0*biomass027_reverse_af8dc
Maximize
1.0*biomass091 - 1.0*biomass091_reverse_7b6db
Maximize
1.0*biomass252 - 1.0*biomass252_reverse_f6948
Maximize
1.0*biomass339 - 1.0*biomass339_reverse_45ed6
Maximize
1.0*biomass326 - 1.0*biomass326_reverse_02060
Maximize
1.0*biomass276 - 1.0*biomass276_reverse_7f92e
Maximize
1.0*biomass345 - 1.0*biomass345_reverse_e128f
Maximize
1.0*biomass525 - 1.0*biomass525_reverse_5c178
Maximize
1.0*biomass429 - 1.0*biomass429_reverse_9caa0
Maximize
1.0*biomass042 - 1.0*biomass042_reverse_2a02b
Maximize
1.0*biomass164 - 1.0*biomass164_reverse_ca493
Maximize
1.0*biomass116 - 1.0*biomass116_reverse_02324
```

With the objective being the biomass function in all models, the biomass metabolite does not need to be specified.

[7]:
```
single_org_models = []
for name, model in named_models.items():
    print(name)
    single_org_model = pycomo.SingleOrganismModel(model, name)
    single_org_models.append(single_org_model)
```

```
Achromobacter_xylosoxidans_NBRC_15126
```

```
Actinomyces_naeslundii_str_Howell_279
Burkholderia_cepacia_GG4
Escherichia_coli_str_K_12_substr_MG1655
Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586
Gemella_haemolysans_ATCC_10379
Granulicatella_adiacens_ATCC_49175
Haemophilus_influenzae_R2846
Neisseria_flavescens_SK114
Porphyromonas_endodontalis_ATCC_35406
Prevotella_melaninogenica_ATCC_25845
Pseudomonas_aeruginosa_NCGM2_S1
Ralstonia_sp_5_7_47FAA
Rothia_mucilaginosa_DY_18
Staphylococcus_aureus_subsp_aureus_USA300_FPR3757
Streptococcus_sanguinis_SK36
Veillonella_atypica_ACS_049_V_Sch6
```

1.1.2 Creating a community model

With the member models prepared, the community model can be generated. The first step is to create a CommunityModel objects from the member models. The matching of the exchange metabolites can be achieved in two ways: matching via identical metabolite IDs, or via annotation fields. In this tutorial and as all the models come from the same source, matching via identical metabolite IDs will be used.

[8]:
```
community_name = "henson_community_model"
com_model_obj = pycomo.CommunityModel(single_org_models, community_name)
```

The cobra model of the community will generated the first time it is needed. We can enforce this now, by calling it via .model

[9]:
```
com_model_obj.model
```

```
No community model generated yet. Generating now:
Note: no products in the objective function, adding biomass to it.
Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite isetac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mops. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
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sure that the metabolite with this ID is indeed representing the same substance
in all models!
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in all models!
WARNING: no annotation overlap found for matching metabolite mso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite sulfac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite ethso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
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WARNING: no annotation overlap found for matching metabolite pb. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite _4abz. Please make
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WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
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WARNING: no annotation overlap found for matching metabolite butso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
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WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
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WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hexs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__4abz_medium' since it already exists.
Ignoring reaction 'EX_Lcyst_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
```

```
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
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Ignoring reaction 'EX_alltn_medium' since it already exists.
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Ignoring reaction 'EX_arbt_medium' since it already exists.
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Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_butso3_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chol_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
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Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
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Ignoring reaction 'EX_ethso3_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
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Ignoring reaction 'EX_glu_L_medium' since it already exists.
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Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
```

```
Ignoring reaction 'EX_glyleu_medium' since it already exists.
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Ignoring reaction 'EX_h2o_medium' since it already exists.
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Ignoring reaction 'EX_hexs_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
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Ignoring reaction 'EX_ile_L_medium' since it already exists.
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Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mops_medium' since it already exists.
Ignoring reaction 'EX_mqn7_medium' since it already exists.
Ignoring reaction 'EX_mso3_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
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Ignoring reaction 'EX_no2_medium' since it already exists.
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Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
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Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xyl_D_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite isetac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
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WARNING: no annotation overlap found for matching metabolite glymet. Please make
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WARNING: no annotation overlap found for matching metabolite cd2. Please make
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WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite ethso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite arab_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
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```
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
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WARNING: no annotation overlap found for matching metabolite cu2. Please make
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in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2hyoxplac_medium' since it already exists.
Ignoring reaction 'EX__34dhpha_medium' since it already exists.
Ignoring reaction 'EX__34dhphe_medium' since it already exists.
Ignoring reaction 'EX__3mop_medium' since it already exists.
```

```
Ignoring reaction 'EX__4abz_medium' since it already exists.
Ignoring reaction 'EX__5htrp_medium' since it already exists.
Ignoring reaction 'EX_Lcyst_medium' since it already exists.
Ignoring reaction 'EX_Lkynr_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
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Ignoring reaction 'EX_ala_D_medium' since it already exists.
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Ignoring reaction 'EX_alathr_medium' since it already exists.
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Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_bhb_medium' since it already exists.
Ignoring reaction 'EX_but_medium' since it already exists.
Ignoring reaction 'EX_butso3_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cit_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_dopa_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_ethso3_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
```

```
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_galctn_D_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gthrd_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h2s_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hexs_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hista_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_ind3ac_medium' since it already exists.
Ignoring reaction 'EX_isetac_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_malthx_medium' since it already exists.
Ignoring reaction 'EX_malttr_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
```

```
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mops_medium' since it already exists.
Ignoring reaction 'EX_mso3_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pac_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_srtn_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_sulfac_medium' since it already exists.
Ignoring reaction 'EX_taur_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_trypta_medium' since it already exists.
Ignoring reaction 'EX_tsul_medium' since it already exists.
Ignoring reaction 'EX_tym_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_urea_medium' since it already exists.
```

```
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite isetac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2ddglcn. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mops. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite dhcinnm. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite _15dap. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite indole. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sulfac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
```

```
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite _3hpppn. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite tmao. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite tma. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite galctn_D. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite aso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite aso4. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite galct_D. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite ethso3. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite galur. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mantr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite butso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hexs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite dhpppn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__12ppd_S_medium' since it already exists.
Ignoring reaction 'EX__15dap_medium' since it already exists.
Ignoring reaction 'EX__2ddglcn_medium' since it already exists.
Ignoring reaction 'EX__3hpppn_medium' since it already exists.
Ignoring reaction 'EX__4hbz_medium' since it already exists.
Ignoring reaction 'EX_Lcyst_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_adn_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_akg_medium' since it already exists.
Ignoring reaction 'EX_ala_D_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_alltn_medium' since it already exists.
Ignoring reaction 'EX_arab_L_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_aso3_medium' since it already exists.
Ignoring reaction 'EX_aso4_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_but_medium' since it already exists.
Ignoring reaction 'EX_butso3_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chol_medium' since it already exists.
Ignoring reaction 'EX_cit_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
```

```
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cynt_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_ddca_medium' since it already exists.
Ignoring reaction 'EX_dhcinnm_medium' since it already exists.
Ignoring reaction 'EX_dhpppn_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_etha_medium' since it already exists.
Ignoring reaction 'EX_ethso3_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_fuc_L_medium' since it already exists.
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_galct_D_medium' since it already exists.
Ignoring reaction 'EX_galctn_D_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_galur_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_glcn_medium' since it already exists.
Ignoring reaction 'EX_glcr_medium' since it already exists.
Ignoring reaction 'EX_glcur_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glyclt_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h2s_medium' since it already exists.
```

```
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hdca_medium' since it already exists.
Ignoring reaction 'EX_hexs_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_indole_medium' since it already exists.
Ignoring reaction 'EX_isetac_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_lcts_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_malthx_medium' since it already exists.
Ignoring reaction 'EX_malttr_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_mantr_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mops_medium' since it already exists.
Ignoring reaction 'EX_mso3_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pac_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
```

```
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_sulfac_medium' since it already exists.
Ignoring reaction 'EX_taur_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_tma_medium' since it already exists.
Ignoring reaction 'EX_tmao_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_tsul_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
Ignoring reaction 'EX_tym_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_urea_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_xyl_D_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _15dap. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite indole. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__15dap_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__2obut_medium' since it already exists.
Ignoring reaction 'EX__3mop_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acac_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
```

```
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_bhb_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_but_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_etha_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_gal_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
```

```
Ignoring reaction 'EX_h2s_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_indole_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_q8_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
```

```
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_urea_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

```
in all models!
WARNING: no annotation overlap found for matching metabolite pppn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite raffin. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

```
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite melib. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__34dhphe_medium' since it already exists.
Ignoring reaction 'EX__3mop_medium' since it already exists.
Ignoring reaction 'EX__5htrp_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_ade_medium' since it already exists.
Ignoring reaction 'EX_ala_D_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_arab_L_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_dopa_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
```

```
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_glcn_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hista_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_malthx_medium' since it already exists.
Ignoring reaction 'EX_malttr_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_melib_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
```

```
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_pppn_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_q8_medium' since it already exists.
Ignoring reaction 'EX_raffin_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_srtn_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_trypta_medium' since it already exists.
Ignoring reaction 'EX_tym_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite _2ddglcn. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
```

```
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
```

```
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _12dgr180. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__12dgr180_medium' since it already exists.
Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2ddglcn_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__2obut_medium' since it already exists.
```

```
Ignoring reaction 'EX__3mop_medium' since it already exists.
Ignoring reaction 'EX__4hbz_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_ade_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_amp_medium' since it already exists.
Ignoring reaction 'EX_arab_L_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_etoh_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
```

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Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
```

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Ignoring reaction 'EX_q8_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_ribflv_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
```

```
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite fecrm. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite tmao. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite tma. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pppn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite dmso. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite dms. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__34dhphe_medium' since it already exists.
Ignoring reaction 'EX__4abz_medium' since it already exists.
Ignoring reaction 'EX__4hbz_medium' since it already exists.
Ignoring reaction 'EX__5htrp_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_acnam_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
```

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Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chol_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_dms_medium' since it already exists.
Ignoring reaction 'EX_dmso_medium' since it already exists.
Ignoring reaction 'EX_dopa_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fecrm_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_gal_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hdca_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hista_medium' since it already exists.
```

```
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_nmn_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pppn_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_srtn_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
```

```
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_tma_medium' since it already exists.
Ignoring reaction 'EX_tmao_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_trypta_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
Ignoring reaction 'EX_tym_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xyl_D_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

```
in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite n2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

```
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite n2o. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__2obut_medium' since it already exists.
Ignoring reaction 'EX__34dhphe_medium' since it already exists.
Ignoring reaction 'EX__5htrp_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_ade_medium' since it already exists.
Ignoring reaction 'EX_adn_medium' since it already exists.
Ignoring reaction 'EX_akg_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chol_medium' since it already exists.
Ignoring reaction 'EX_cit_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
```

```
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_dopa_medium' since it already exists.
Ignoring reaction 'EX_etoh_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_gal_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glyclt_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gthrd_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h2s_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hdca_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hista_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
```

```
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_n2_medium' since it already exists.
Ignoring reaction 'EX_n2o_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_q8_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_srtn_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_taur_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_trypta_medium' since it already exists.
Ignoring reaction 'EX_tsul_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
```

```
Ignoring reaction 'EX_tym_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite indole. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cro4. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__2obut_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
```

```
Ignoring reaction 'EX_ade_medium' since it already exists.
Ignoring reaction 'EX_adn_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_amp_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_but_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_cro4_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_din_medium' since it already exists.
Ignoring reaction 'EX_duri_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyclt_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
```

```
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gsn_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_indole_medium' since it already exists.
Ignoring reaction 'EX_ins_medium' since it already exists.
Ignoring reaction 'EX_isobut_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_q8_medium' since it already exists.
Ignoring reaction 'EX_ribflv_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
```

```
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite chtbs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite raffin. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite isocapr. Please
make sure that the metabolite with this ID is indeed representing the same
```

```
substance in all models!
WARNING: no annotation overlap found for matching metabolite cro4. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__2obut_medium' since it already exists.
Ignoring reaction 'EX__4abz_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_ade_medium' since it already exists.
Ignoring reaction 'EX_adn_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chtbs_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_cro4_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_din_medium' since it already exists.
Ignoring reaction 'EX_duri_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
```

```
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_gsn_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h2s_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_ins_medium' since it already exists.
Ignoring reaction 'EX_isobut_medium' since it already exists.
Ignoring reaction 'EX_isocapr_medium' since it already exists.
Ignoring reaction 'EX_isoval_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lcts_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_ocdcea_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
```

```
Ignoring reaction 'EX_q8_medium' since it already exists.
Ignoring reaction 'EX_raffin_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_tsul_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite isetac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mops. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _15dap. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

```
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sulfac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite n2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pppn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite aso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite aso4. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite galct_D. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _3hphac. Please
make sure that the metabolite with this ID is indeed representing the same
```

```
substance in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite ethso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite galur. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite butso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hexs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite n2o. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

```
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__15dap_medium' since it already exists.
Ignoring reaction 'EX__2hyoxplac_medium' since it already exists.
Ignoring reaction 'EX__34dhpha_medium' since it already exists.
Ignoring reaction 'EX__3hphac_medium' since it already exists.
Ignoring reaction 'EX__4hphac_medium' since it already exists.
Ignoring reaction 'EX__5mta_medium' since it already exists.
Ignoring reaction 'EX_HC00319_medium' since it already exists.
Ignoring reaction 'EX_Lcyst_medium' since it already exists.
Ignoring reaction 'EX_Lkynr_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_ala_D_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_alltn_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_aso3_medium' since it already exists.
Ignoring reaction 'EX_aso4_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_bhb_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_but_medium' since it already exists.
Ignoring reaction 'EX_butso3_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chol_medium' since it already exists.
```

```
Ignoring reaction 'EX_cit_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cynt_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_ddca_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_etha_medium' since it already exists.
Ignoring reaction 'EX_ethso3_medium' since it already exists.
Ignoring reaction 'EX_etoh_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_galct_D_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_galur_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_glcn_medium' since it already exists.
Ignoring reaction 'EX_glcr_medium' since it already exists.
Ignoring reaction 'EX_glcur_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_h2_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h2s_medium' since it already exists.
```

```
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hdca_medium' since it already exists.
Ignoring reaction 'EX_hexs_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_ind3ac_medium' since it already exists.
Ignoring reaction 'EX_isetac_medium' since it already exists.
Ignoring reaction 'EX_isobut_medium' since it already exists.
Ignoring reaction 'EX_isoval_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mops_medium' since it already exists.
Ignoring reaction 'EX_mqn7_medium' since it already exists.
Ignoring reaction 'EX_mso3_medium' since it already exists.
Ignoring reaction 'EX_n2_medium' since it already exists.
Ignoring reaction 'EX_n2o_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_nmn_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_no_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
```

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Ignoring reaction 'EX_pppn_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_pyr_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_sulfac_medium' since it already exists.
Ignoring reaction 'EX_taur_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_tsul_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_urea_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite isetac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mops. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sulfac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite n2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite aso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite aso4. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite galct_D. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite ethso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite galur. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cellb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite butso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hexs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite n2o. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
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sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__2hyoxplac_medium' since it already exists.
Ignoring reaction 'EX__34dhpha_medium' since it already exists.
Ignoring reaction 'EX_HC00319_medium' since it already exists.
Ignoring reaction 'EX_Lcyst_medium' since it already exists.
Ignoring reaction 'EX_Lkynr_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_akg_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_alltn_medium' since it already exists.
Ignoring reaction 'EX_arab_L_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_aso3_medium' since it already exists.
Ignoring reaction 'EX_aso4_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_bhb_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_but_medium' since it already exists.
Ignoring reaction 'EX_butso3_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cellb_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
```

```
Ignoring reaction 'EX_ddca_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_etha_medium' since it already exists.
Ignoring reaction 'EX_ethso3_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_galct_D_medium' since it already exists.
Ignoring reaction 'EX_galur_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glcr_medium' since it already exists.
Ignoring reaction 'EX_glcur_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
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Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hdca_medium' since it already exists.
Ignoring reaction 'EX_hexs_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_isetac_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
```

```
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mops_medium' since it already exists.
Ignoring reaction 'EX_mso3_medium' since it already exists.
Ignoring reaction 'EX_n2_medium' since it already exists.
Ignoring reaction 'EX_n2o_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_no_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_oxa_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sulfac_medium' since it already exists.
Ignoring reaction 'EX_taur_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_tsul_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_urea_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xyl_D_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite isetac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mops. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sulfac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite ethso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite arab_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite butso3. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hexs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__2obut_medium' since it already exists.
Ignoring reaction 'EX__4abz_medium' since it already exists.
Ignoring reaction 'EX__4hbz_medium' since it already exists.
Ignoring reaction 'EX_Lcyst_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_ala_D_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_arab_D_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_butso3_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
```

```
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_ethso3_medium' since it already exists.
Ignoring reaction 'EX_etoh_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hexs_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_inost_medium' since it already exists.
Ignoring reaction 'EX_isetac_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
```

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Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mops_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_mso3_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_q8_medium' since it already exists.
Ignoring reaction 'EX_ribflv_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_sulfac_medium' since it already exists.
Ignoring reaction 'EX_taur_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
```

```
Ignoring reaction 'EX_trp_L_medium' since it already exists.
Ignoring reaction 'EX_ttdca_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite ctbt. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite h2s. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite fecrm. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite aso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite aso4. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite actn_R. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite gbbtn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite ni2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _12dgr180. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__12dgr180_medium' since it already exists.
Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__3mop_medium' since it already exists.
Ignoring reaction 'EX__4abz_medium' since it already exists.
Ignoring reaction 'EX__4hbz_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_acnam_medium' since it already exists.
Ignoring reaction 'EX_actn_R_medium' since it already exists.
Ignoring reaction 'EX_adn_medium' since it already exists.
Ignoring reaction 'EX_akg_medium' since it already exists.
Ignoring reaction 'EX_ala_D_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_arab_L_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
```

```
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_aso3_medium' since it already exists.
Ignoring reaction 'EX_aso4_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chol_medium' since it already exists.
Ignoring reaction 'EX_cit_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_crn_medium' since it already exists.
Ignoring reaction 'EX_ctbt_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_din_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_duri_medium' since it already exists.
Ignoring reaction 'EX_etoh_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fecrm_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_gal_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gbbtn_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_glcn_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
```

```
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h2s_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_ins_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_lcts_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_malthx_medium' since it already exists.
Ignoring reaction 'EX_malttr_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_ni2_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
```

```
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_ribflv_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_urea_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_xan_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite chtbs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite stys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mantr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite q8. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
WARNING: no annotation overlap found for matching metabolite cellb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _12dgr180. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__12dgr180_medium' since it already exists.
Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__2dmmq8_medium' since it already exists.
Ignoring reaction 'EX__2obut_medium' since it already exists.
Ignoring reaction 'EX__34dhphe_medium' since it already exists.
Ignoring reaction 'EX__5htrp_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_acnam_medium' since it already exists.
Ignoring reaction 'EX_ade_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
```

```
Ignoring reaction 'EX_amp_medium' since it already exists.
Ignoring reaction 'EX_arab_L_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_arg_L_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cellb_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_chtbs_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_csn_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_cytd_medium' since it already exists.
Ignoring reaction 'EX_dad_2_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_dgsn_medium' since it already exists.
Ignoring reaction 'EX_dopa_medium' since it already exists.
Ignoring reaction 'EX_etha_medium' since it already exists.
Ignoring reaction 'EX_etoh_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_gal_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyb_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
Ignoring reaction 'EX_glyclt_medium' since it already exists.
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
```

```
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hista_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_ins_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_lcts_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_malthx_medium' since it already exists.
Ignoring reaction 'EX_malttr_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_mantr_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mqn8_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_nmn_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pnto_R_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_q8_medium' since it already exists.
```

```
Ignoring reaction 'EX_ribflv_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_srtn_medium' since it already exists.
Ignoring reaction 'EX_stys_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_thymd_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_trypta_medium' since it already exists.
Ignoring reaction 'EX_tym_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_urea_medium' since it already exists.
Ignoring reaction 'EX_uri_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite isetac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pime. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mops. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite met_D. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glymet. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

```
in all models!
WARNING: no annotation overlap found for matching metabolite mso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cd2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sulfac. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cobalt2. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite mnl. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite sheme. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite mn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite zn2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alagly. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite ethso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _26dap_M. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite alaasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite metsox_R_L. Please
make sure that the metabolite with this ID is indeed representing the same
```

```
substance in all models!
WARNING: no annotation overlap found for matching metabolite glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glytyr. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glygln. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite pb. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite butso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite no3. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite hexs. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_medium' since it already exists.
Ignoring reaction 'EX__3mop_medium' since it already exists.
Ignoring reaction 'EX__4abz_medium' since it already exists.
Ignoring reaction 'EX__4hbz_medium' since it already exists.
Ignoring reaction 'EX_Lcyst_medium' since it already exists.
Ignoring reaction 'EX_ac_medium' since it already exists.
Ignoring reaction 'EX_acald_medium' since it already exists.
```

```
Ignoring reaction 'EX_acgam_medium' since it already exists.
Ignoring reaction 'EX_adocbl_medium' since it already exists.
Ignoring reaction 'EX_akg_medium' since it already exists.
Ignoring reaction 'EX_ala_D_medium' since it already exists.
Ignoring reaction 'EX_ala_L_medium' since it already exists.
Ignoring reaction 'EX_alaasp_medium' since it already exists.
Ignoring reaction 'EX_alagln_medium' since it already exists.
Ignoring reaction 'EX_alaglu_medium' since it already exists.
Ignoring reaction 'EX_alagly_medium' since it already exists.
Ignoring reaction 'EX_alahis_medium' since it already exists.
Ignoring reaction 'EX_alaleu_medium' since it already exists.
Ignoring reaction 'EX_alathr_medium' since it already exists.
Ignoring reaction 'EX_amp_medium' since it already exists.
Ignoring reaction 'EX_arbt_medium' since it already exists.
Ignoring reaction 'EX_asn_L_medium' since it already exists.
Ignoring reaction 'EX_asp_L_medium' since it already exists.
Ignoring reaction 'EX_btn_medium' since it already exists.
Ignoring reaction 'EX_butso3_medium' since it already exists.
Ignoring reaction 'EX_ca2_medium' since it already exists.
Ignoring reaction 'EX_cbl1_medium' since it already exists.
Ignoring reaction 'EX_cbl2_medium' since it already exists.
Ignoring reaction 'EX_cd2_medium' since it already exists.
Ignoring reaction 'EX_cgly_medium' since it already exists.
Ignoring reaction 'EX_cl_medium' since it already exists.
Ignoring reaction 'EX_co2_medium' since it already exists.
Ignoring reaction 'EX_cobalt2_medium' since it already exists.
Ignoring reaction 'EX_cu2_medium' since it already exists.
Ignoring reaction 'EX_cys_L_medium' since it already exists.
Ignoring reaction 'EX_dcyt_medium' since it already exists.
Ignoring reaction 'EX_drib_medium' since it already exists.
Ignoring reaction 'EX_ethso3_medium' since it already exists.
Ignoring reaction 'EX_fe2_medium' since it already exists.
Ignoring reaction 'EX_fe3_medium' since it already exists.
Ignoring reaction 'EX_fol_medium' since it already exists.
Ignoring reaction 'EX_for_medium' since it already exists.
Ignoring reaction 'EX_fru_medium' since it already exists.
Ignoring reaction 'EX_fum_medium' since it already exists.
Ignoring reaction 'EX_galt_medium' since it already exists.
Ignoring reaction 'EX_gam_medium' since it already exists.
Ignoring reaction 'EX_gcald_medium' since it already exists.
Ignoring reaction 'EX_glc_D_medium' since it already exists.
Ignoring reaction 'EX_gln_L_medium' since it already exists.
Ignoring reaction 'EX_glu_L_medium' since it already exists.
Ignoring reaction 'EX_gly_medium' since it already exists.
Ignoring reaction 'EX_glyasn_medium' since it already exists.
Ignoring reaction 'EX_glyasp_medium' since it already exists.
Ignoring reaction 'EX_glyc3p_medium' since it already exists.
Ignoring reaction 'EX_glyc_medium' since it already exists.
```

```
Ignoring reaction 'EX_glycys_medium' since it already exists.
Ignoring reaction 'EX_glygln_medium' since it already exists.
Ignoring reaction 'EX_glyglu_medium' since it already exists.
Ignoring reaction 'EX_glyleu_medium' since it already exists.
Ignoring reaction 'EX_glymet_medium' since it already exists.
Ignoring reaction 'EX_glyphe_medium' since it already exists.
Ignoring reaction 'EX_glypro_medium' since it already exists.
Ignoring reaction 'EX_glytyr_medium' since it already exists.
Ignoring reaction 'EX_gua_medium' since it already exists.
Ignoring reaction 'EX_h2_medium' since it already exists.
Ignoring reaction 'EX_h2o_medium' since it already exists.
Ignoring reaction 'EX_h_medium' since it already exists.
Ignoring reaction 'EX_hexs_medium' since it already exists.
Ignoring reaction 'EX_hg2_medium' since it already exists.
Ignoring reaction 'EX_his_L_medium' since it already exists.
Ignoring reaction 'EX_hxan_medium' since it already exists.
Ignoring reaction 'EX_ile_L_medium' since it already exists.
Ignoring reaction 'EX_ind3ac_medium' since it already exists.
Ignoring reaction 'EX_isetac_medium' since it already exists.
Ignoring reaction 'EX_k_medium' since it already exists.
Ignoring reaction 'EX_lac_D_medium' since it already exists.
Ignoring reaction 'EX_lac_L_medium' since it already exists.
Ignoring reaction 'EX_leu_L_medium' since it already exists.
Ignoring reaction 'EX_lys_L_medium' since it already exists.
Ignoring reaction 'EX_mal_L_medium' since it already exists.
Ignoring reaction 'EX_malt_medium' since it already exists.
Ignoring reaction 'EX_man_medium' since it already exists.
Ignoring reaction 'EX_met_D_medium' since it already exists.
Ignoring reaction 'EX_met_L_medium' since it already exists.
Ignoring reaction 'EX_metala_medium' since it already exists.
Ignoring reaction 'EX_metsox_R_L_medium' since it already exists.
Ignoring reaction 'EX_metsox_S_L_medium' since it already exists.
Ignoring reaction 'EX_mg2_medium' since it already exists.
Ignoring reaction 'EX_mn2_medium' since it already exists.
Ignoring reaction 'EX_mnl_medium' since it already exists.
Ignoring reaction 'EX_mops_medium' since it already exists.
Ignoring reaction 'EX_mso3_medium' since it already exists.
Ignoring reaction 'EX_na1_medium' since it already exists.
Ignoring reaction 'EX_nac_medium' since it already exists.
Ignoring reaction 'EX_nh4_medium' since it already exists.
Ignoring reaction 'EX_no2_medium' since it already exists.
Ignoring reaction 'EX_no3_medium' since it already exists.
Ignoring reaction 'EX_o2_medium' since it already exists.
Ignoring reaction 'EX_ocdca_medium' since it already exists.
Ignoring reaction 'EX_orn_medium' since it already exists.
Ignoring reaction 'EX_pb_medium' since it already exists.
Ignoring reaction 'EX_phe_L_medium' since it already exists.
Ignoring reaction 'EX_pheme_medium' since it already exists.
```

```
Ignoring reaction 'EX_pi_medium' since it already exists.
Ignoring reaction 'EX_pime_medium' since it already exists.
Ignoring reaction 'EX_ppa_medium' since it already exists.
Ignoring reaction 'EX_ppi_medium' since it already exists.
Ignoring reaction 'EX_pro_L_medium' since it already exists.
Ignoring reaction 'EX_ptrc_medium' since it already exists.
Ignoring reaction 'EX_pydam_medium' since it already exists.
Ignoring reaction 'EX_pydx_medium' since it already exists.
Ignoring reaction 'EX_pydxn_medium' since it already exists.
Ignoring reaction 'EX_pyr_medium' since it already exists.
Ignoring reaction 'EX_rib_D_medium' since it already exists.
Ignoring reaction 'EX_salcn_medium' since it already exists.
Ignoring reaction 'EX_sbt_D_medium' since it already exists.
Ignoring reaction 'EX_ser_D_medium' since it already exists.
Ignoring reaction 'EX_ser_L_medium' since it already exists.
Ignoring reaction 'EX_sheme_medium' since it already exists.
Ignoring reaction 'EX_so4_medium' since it already exists.
Ignoring reaction 'EX_spmd_medium' since it already exists.
Ignoring reaction 'EX_succ_medium' since it already exists.
Ignoring reaction 'EX_sucr_medium' since it already exists.
Ignoring reaction 'EX_sulfac_medium' since it already exists.
Ignoring reaction 'EX_taur_medium' since it already exists.
Ignoring reaction 'EX_thm_medium' since it already exists.
Ignoring reaction 'EX_thr_L_medium' since it already exists.
Ignoring reaction 'EX_tre_medium' since it already exists.
Ignoring reaction 'EX_tyr_L_medium' since it already exists.
Ignoring reaction 'EX_ura_medium' since it already exists.
Ignoring reaction 'EX_val_L_medium' since it already exists.
Ignoring reaction 'EX_zn2_medium' since it already exists.

WARNING: Not all reactions in the model are mass and charge balanced. To check
which reactions are imbalanced, please run the get_unbalanced_reactions method
of this CommunityModel object
Generated community model.
```

[9]:
```
<Model henson_community_model at 0x18fe78d7be0>
```

The output of the community model creation contains quite some lines of info and warnings. This is to be expected. Let's have a look at the different types of info: 1. *Ignoring reaction 'EX_4abz_medium' since it already exists.* This line will come up if a reaction is present in two different community member models under the same ID. This will only happen for exchange reactions in the exchange compartment and are therefor correct behaviour. 2. *WARNING: no annotation overlap found for matching metabolite mn2. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!* This warning comes up if exchange metabolites do not contain any matching annotation field. This can be an indicator that metabolites with the same ID are merged, but they represent different chemicals. Another common cause is that no annotation was given for this metabolite in one of the models. 3. *WARNING: matching of the metabolite CO2_EX is unbalanced (mass and/or charge). Please manually curate*

this metabolite for a mass and charge balanced model! This warning means that the formula of an exchange metabolite was different between member models. This can be due to the formula being omitted in some of the models. The other reason is that the metabolites differ in their mass or charge. As this would lead to generation or loss of matter from nothing, these issues need to be resolved for a consistent metabolic model.

1.1.3 Summary and report

The community model object has two utility methods to display information on the model. - Summary behaves the same as the summary method of COBRApy, displaying the the solution of FBA and its exchange metabolites. In the CommunityModel summary, the exchange reactions of metabolites responsible for scaling the flux bounds to the community composition are hidden. - The report function displays information on the model structure: the number of metabolites, reactions, genes, etc., but also quality control measures on mass and charge balance and internal loops.

[10]:
```
com_model_obj.summary()
```

[10]:
```
<cobra.summary.model_summary.ModelSummary at 0x18fe78d7e50>
```

[11]:
```
com_model_obj.report()
```

```
Note: The model has more than 5000 reactions. Calculation of loops is skipped,
as this would take some time. If needed, please run manually via .get_loops()
Name: henson_community_model
------------------
Model overview
Model structure: fixed growth rate
# Metabolites: 51659
# Constraint (f-) Metabolites: 31969
# Model Metabolites: 19690
# Reactions: 55171
# Constraint (f-) Reactions: 31968
# Model Reactions: 23203
# Genes: 13885
# Members: 17
Members:
        Achromobacter_xylosoxidans_NBRC_15126
        Actinomyces_naeslundii_str_Howell_279
        Burkholderia_cepacia_GG4
        Escherichia_coli_str_K_12_substr_MG1655
        Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586
        Gemella_haemolysans_ATCC_10379
        Granulicatella_adiacens_ATCC_49175
        Haemophilus_influenzae_R2846
        Neisseria_flavescens_SK114
        Porphyromonas_endodontalis_ATCC_35406
        Prevotella_melaninogenica_ATCC_25845
        Pseudomonas_aeruginosa_NCGM2_S1
```

```
        Ralstonia_sp_5_7_47FAA
        Rothia_mucilaginosa_DY_18
        Staphylococcus_aureus_subsp_aureus_USA300_FPR3757
        Streptococcus_sanguinis_SK36
        Veillonella_atypica_ACS_049_V_Sch6
Objective in direction max:
        1.0*community_biomass - 1.0*community_biomass_reverse_44dc1
------------------
Model quality
# Reactions unbalanced: 235
# Reactions able to carry flux without a medium: NaN
```

[11]:

```
{'community_name': 'henson_community_model',
 'model_structure': 'fixed growth rate',
 'num_metabolites': 51659,
 'num_f_metabolites': 31969,
 'num_model_metabolites': 19690,
 'num_reactions': 55171,
 'num_f_reactions': 31968,
 'num_model_reactions': 23203,
 'num_genes': 13885,
 'member_names': ['Achromobacter_xylosoxidans_NBRC_15126',
  'Actinomyces_naeslundii_str_Howell_279',
  'Burkholderia_cepacia_GG4',
  'Escherichia_coli_str_K_12_substr_MG1655',
  'Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586',
  'Gemella_haemolysans_ATCC_10379',
  'Granulicatella_adiacens_ATCC_49175',
  'Haemophilus_influenzae_R2846',
  'Neisseria_flavescens_SK114',
  'Porphyromonas_endodontalis_ATCC_35406',
  'Prevotella_melaninogenica_ATCC_25845',
  'Pseudomonas_aeruginosa_NCGM2_S1',
  'Ralstonia_sp_5_7_47FAA',
  'Rothia_mucilaginosa_DY_18',
  'Staphylococcus_aureus_subsp_aureus_USA300_FPR3757',
  'Streptococcus_sanguinis_SK36',
  'Veillonella_atypica_ACS_049_V_Sch6'],
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at 0x18fff65cfa0>: {'charge': 45.0,
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0x18f8aa85a60>: {'C': -15.0,
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   'O': -2.0},
  <Reaction Ralstonia_sp_5_7_47FAA_DM_5DRIB_Ralstonia_sp_5_7_47FAA_c at
0x18f8d2affd0>: {'C': -5.0,
   'H': -10.0,
   'O': -4.0},
  <Reaction Ralstonia_sp_5_7_47FAA_DM_AMOB_Ralstonia_sp_5_7_47FAA_c at
0x18f8d2afe20>: {'C': -15.0,
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   'N': -5.0,
   'O': -6.0,
   'S': -1.0},
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0x18f8d2c5280>: {'charge': 1.0,
   'C': -10.0,
   'H': -15.0,
   'N': -2.0,
   'O': -3.0,
   'S': -1.0},
  <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpn140_Ralstonia_s
p_5_7_47FAA_c at 0x18f8d2c5340>: {'charge': 2.0,
   'C': -65.0,
   'H': -124.0,
   'O': -17.0,
   'P': -2.0},
  <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpn160_Ralstonia_s
p_5_7_47FAA_c at 0x18f8d2c5400>: {'charge': 2.0,
   'C': -73.0,
   'H': -140.0,
   'O': -17.0,
   'P': -2.0},
  <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpn180_Ralstonia_s
p_5_7_47FAA_c at 0x18f8d2c54c0>: {'charge': 2.0,
   'C': -81.0,
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```
   'H': -156.0,
   'O': -17.0,
   'P': -2.0},
  <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpni16_Ralstonia_s
p_5_7_47FAA_c at 0x18f8d2c5580>: {'charge': 2.0,
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   'P': -2.0},
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   'N': -5.0,
   'O': -3.0},
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0x18f8d2c5700>: {'charge': 6.0,
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   'H': -170.0,
   'N': -2.0,
   'O': -38.0,
   'P': -2.0},
  <Reaction Ralstonia_sp_5_7_47FAA_EX_biomass_e_Ralstonia_sp_5_7_47FAA_c at
0x18f8d3a5610>: {'X': -1.0},
  <Reaction Ralstonia_sp_5_7_47FAA_GLCS3_Ralstonia_sp_5_7_47FAA_c at
0x18f8d6e25b0>: {'charge': -1.0,
   'H': -1.0,
   'X': -1.0},
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0x18f8d4aa5b0>: {'charge': -2.0},
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0x18f8de33c10>: {'X': 1.0},
  <Reaction Ralstonia_sp_5_7_47FAA_pbiosynthesis_Ralstonia_sp_5_7_47FAA_c at
0x18f8de33bb0>: {'X': 1.0},
  <Reaction Ralstonia_sp_5_7_47FAA_rtranscription_Ralstonia_sp_5_7_47FAA_c at
0x18f8debcfd0>: {'X': 1.0},
  <Reaction Ralstonia_sp_5_7_47FAA_sink_s_Ralstonia_sp_5_7_47FAA_c at
0x18f8deaafd0>: {'S': -1.0},
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   'O': -15.8540166000002,
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   'Zn': -0.0078094},
  <Reaction Rothia_mucilaginosa_DY_18_DHNAOT_Rothia_mucilaginosa_DY_18_c at
0x18f900b1ac0>: {'charge': 2.0},
  <Reaction Rothia_mucilaginosa_DY_18_DM_2HYMEPH_Rothia_mucilaginosa_DY_18_c at
0x18f900d6a60>: {'C': -7.0,
   'H': -8.0,
   'O': -2.0},
  <Reaction Rothia_mucilaginosa_DY_18_DM_5MTR_Rothia_mucilaginosa_DY_18_c at
0x18f900d6b50>: {'C': -6.0,
   'H': -12.0,
   'O': -4.0,
   'S': -1.0},
  <Reaction Rothia_mucilaginosa_DY_18_DM_HQN_Rothia_mucilaginosa_DY_18_c at
0x18f900d6c10>: {'C': -6.0,
   'H': -6.0,
   'O': -2.0},
  <Reaction Rothia_mucilaginosa_DY_18_DM_dhptd_Rothia_mucilaginosa_DY_18_c at
0x18f900d6dc0>: {'C': -5.0,
   'H': -8.0,
   'O': -4.0},
  <Reaction Rothia_mucilaginosa_DY_18_DM_hcys_L_Rothia_mucilaginosa_DY_18_c at
0x18f900d6e80>: {'C': -4.0,
   'H': -9.0,
   'N': -1.0,
   'O': -2.0,
   'S': -1.0},
  <Reaction Rothia_mucilaginosa_DY_18_EX_biomass_e_Rothia_mucilaginosa_DY_18_c
at 0x18f90116fa0>: {'X': -1.0},
  <Reaction Rothia_mucilaginosa_DY_18_dreplication_Rothia_mucilaginosa_DY_18_c
at 0x18f90771d00>: {'X': 1.0},
  <Reaction Rothia_mucilaginosa_DY_18_pbiosynthesis_Rothia_mucilaginosa_DY_18_c
at 0x18f90771f10>: {'X': 1.0},
  <Reaction Rothia_mucilaginosa_DY_18_rtranscription_Rothia_mucilaginosa_DY_18_c
at 0x18f907a7df0>: {'X': 1.0},
  <Reaction Rothia_mucilaginosa_DY_18_biomass429 at 0x18f907c5e20>: {'charge':
0.8556490000000481,
   'C': -39.342995000000066,
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   'N': -8.573918499999937,
   'O': -14.310861000000338,
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   'X': -2.0,
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   'Ca': -0.0030965,
   'Cl': -0.0030965,
   'Cu': -0.0030965,
   'Fe': -0.012386,
   'K': -0.0030965,
   'Mg': -0.0030965,
   'Mn': -0.0030965,
   'Zn': -0.0030965},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DHNAOT_Staphylococ
cus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93414f70>: {'charge': 2.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DM_5MTR_Staphyloco
ccus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93447df0>: {'C': -6.0,
   'H': -12.0,
   'O': -4.0,
   'S': -1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DM_dhptd_Staphyloc
occus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93447fa0>: {'C': -5.0,
   'H': -8.0,
   'O': -4.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DM_hcys_L_Staphylo
coccus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93429ee0>: {'C': -4.0,
   'H': -9.0,
   'N': -1.0,
   'O': -2.0,
   'S': -1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_EX_biomass_e_Staph
ylococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f935074c0>: {'X': -1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECA4S_Staphylococ
cus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93606b20>: {'charge': -30.0,
   'C': -420.0,
   'H': -752.0,
   'N': -30.0,
   'O': -391.0,
   'P': -30.0,
   'X': 1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECAAE_Staphylococ
cus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f9361c880>: {'C': -286.0,
   'H': -477.0,
   'N': -47.0,
   'O': -238.0,
   'P': -46.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECAGE_Staphylococ
cus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93606ee0>: {'charge': 45.0,
```

```
   'C': -421.0,
   'H': -747.0,
   'N': -2.0,
   'O': -463.0,
   'P': -46.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECAUE_Staphylococ
cus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f9361cc40>: {'charge': 45.0,
   'C': -151.0,
   'H': -297.0,
   'N': -2.0,
   'O': -238.0,
   'P': -46.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TEICH45_Staphyloco
ccus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f9361cdf0>: {'charge': 45.0,
   'C': -630.0,
   'H': -945.0,
   'N': -45.0,
   'O': -630.0,
   'P': -45.0,
   'X': 1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_dreplication_Staph
ylococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f936d1820>: {'X': 1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_pbiosynthesis_Stap
hylococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f936e3610>: {'X': 1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_rtranscription_Sta
phylococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93fa4e50>: {'X': 1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_sink_PGPm1_Staphyl
ococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93fb6550>: {'X': -1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_biomass042 at
0x18f93fb6bb0>: {'charge': -81.86880639999987,
   'C': -35.038135600000125,
   'H': 26.14692300000044,
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   'O': 68.97884669999962,
   'P': -0.9387373000000402,
   'S': -0.21809219999999996,
   'X': -2.0018063,
   'Co': -0.0079397,
   'Ca': -0.0079397,
   'Cl': -0.0079397,
   'Cu': -0.0079397,
   'Fe': -0.0317588,
   'K': -0.0079397,
   'Mg': -0.0079397,
   'Mn': -0.0079397,
   'Zn': -0.0079397},
  <Reaction
```

```
Streptococcus_sanguinis_SK36_DM_2HYMEPH_Streptococcus_sanguinis_SK36_c at
0x18f96fc0580>: {'C': -7.0,
   'H': -8.0,
   'O': -2.0},
  <Reaction Streptococcus_sanguinis_SK36_DM_5MTR_Streptococcus_sanguinis_SK36_c
at 0x18f96fc0670>: {'C': -6.0,
   'H': -12.0,
   'O': -4.0,
   'S': -1.0},
  <Reaction Streptococcus_sanguinis_SK36_DM_HQN_Streptococcus_sanguinis_SK36_c
at 0x18f96fc0730>: {'C': -6.0,
   'H': -6.0,
   'O': -2.0},
  <Reaction Streptococcus_sanguinis_SK36_DM_dhptd_Streptococcus_sanguinis_SK36_c
at 0x18f96fc08e0>: {'C': -5.0,
   'H': -8.0,
   'O': -4.0},
  <Reaction
Streptococcus_sanguinis_SK36_DM_hcys_L_Streptococcus_sanguinis_SK36_c at
0x18f96fc09a0>: {'C': -4.0,
   'H': -9.0,
   'N': -1.0,
   'O': -2.0,
   'S': -1.0},
  <Reaction
Streptococcus_sanguinis_SK36_EX_biomass_e_Streptococcus_sanguinis_SK36_c at
0x18f9701ca60>: {'X': -1.0},
  <Reaction Streptococcus_sanguinis_SK36_SHCHCC2_Streptococcus_sanguinis_SK36_c
at 0x18f976eae50>: {'charge': -2.0},
  <Reaction Streptococcus_sanguinis_SK36_TECA4S_Streptococcus_sanguinis_SK36_c
at 0x18f97742760>: {'charge': -30.0,
   'C': -420.0,
   'H': -752.0,
   'N': -30.0,
   'O': -391.0,
   'P': -30.0,
   'X': 1.0},
  <Reaction Streptococcus_sanguinis_SK36_TECAAE_Streptococcus_sanguinis_SK36_c
at 0x18f9775a4c0>: {'C': -286.0,
   'H': -477.0,
   'N': -47.0,
   'O': -238.0,
   'P': -46.0},
  <Reaction Streptococcus_sanguinis_SK36_TECAGE_Streptococcus_sanguinis_SK36_c
at 0x18f9775a610>: {'charge': 45.0,
   'C': -421.0,
   'H': -747.0,
```

```
   'N': -2.0,
   'O': -463.0,
   'P': -46.0},
  <Reaction Streptococcus_sanguinis_SK36_TECAUE_Streptococcus_sanguinis_SK36_c
at 0x18f9775a760>: {'charge': 45.0,
   'C': -151.0,
   'H': -297.0,
   'N': -2.0,
   'O': -238.0,
   'P': -46.0},
  <Reaction
Streptococcus_sanguinis_SK36_dreplication_Streptococcus_sanguinis_SK36_c at
0x18f977f4970>: {'X': 1.0},
  <Reaction
Streptococcus_sanguinis_SK36_pbiosynthesis_Streptococcus_sanguinis_SK36_c at
0x18f977f4fa0>: {'X': 1.0},
  <Reaction
Streptococcus_sanguinis_SK36_rtranscription_Streptococcus_sanguinis_SK36_c at
0x18f97857dc0>: {'X': 1.0},
  <Reaction
Streptococcus_sanguinis_SK36_sink_PGPm1_Streptococcus_sanguinis_SK36_c at
0x18f97857fd0>: {'X': -1.0},
  <Reaction Streptococcus_sanguinis_SK36_biomass164 at 0x18f97857f70>:
{'charge': -81.86883519999986,
   'C': -35.03518620000009,
   'H': 26.14989040000043,
   'N': -7.354207799999981,
   'O': 68.97894029999964,
   'P': -0.9387157000000436,
   'S': -0.21809219999999996,
   'X': -2.0018063,
   'Co': -0.0079397,
   'Ca': -0.0079397,
   'Cl': -0.0079397,
   'Cu': -0.0079397,
   'Fe': -0.0317588,
   'K': -0.0079397,
   'Mg': -0.0079397,
   'Mn': -0.0079397,
   'Zn': -0.0079397},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_DHNAOT_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f98fa1760>: {'charge': 2.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_DM_dhptd_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f98fc49a0>: {'C': -5.0,
   'H': -8.0,
```

```
   'O': -4.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_DM_hcys_L_Veillonella_atypica_ACS
_049_V_Sch6_c at 0x18f98fc4a60>: {'C': -4.0,
   'H': -9.0,
   'N': -1.0,
   'O': -2.0,
   'S': -1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_EX_biomass_e_Veillonella_atypica_
ACS_049_V_Sch6_c at 0x18f9901b6d0>: {'X': -1.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_SHCHCC2_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f9963fd60>: {'charge': -2.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECA4S_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996a52e0>: {'charge': -30.0,
   'C': -420.0,
   'H': -752.0,
   'N': -30.0,
   'O': -391.0,
   'P': -30.0,
   'X': 1.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECAAE_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996a5f70>: {'C': -286.0,
   'H': -477.0,
   'N': -47.0,
   'O': -238.0,
   'P': -46.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECAGE_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996a5fa0>: {'charge': 45.0,
   'C': -421.0,
   'H': -747.0,
   'N': -2.0,
   'O': -463.0,
   'P': -46.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECAUE_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996c0400>: {'charge': 45.0,
   'C': -151.0,
   'H': -297.0,
   'N': -2.0,
   'O': -238.0,
   'P': -46.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_dreplication_Veillonella_atypica_
ACS_049_V_Sch6_c at 0x18f9972dca0>: {'X': 1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_pbiosynthesis_Veillonella_atypica
```

```
_ACS_049_V_Sch6_c at 0x18f99716f10>: {'X': 1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_rtranscription_Veillonella_atypic
a_ACS_049_V_Sch6_c at 0x18f99792a90>: {'X': 1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_sink_PGPm1_Veillonella_atypica_AC
S_049_V_Sch6_c at 0x18f99792c10>: {'X': -1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_biomass116 at 0x18f99792ca0>:
{'charge': -81.86882719999988,
   'C': -35.036401200000036,
   'H': 26.148670400000327,
   'N': -7.353019799999996,
   'O': 68.9789142999997,
   'P': -0.9387217000000568,
   'S': -0.21809219999999996,
   'X': -2.0018063,
   'Co': -0.0079397,
   'Ca': -0.0079397,
   'Cl': -0.0079397,
   'Cu': -0.0079397,
   'Fe': -0.0317588,
   'K': -0.0079397,
   'Mg': -0.0079397,
   'Mn': -0.0079397,
   'Zn': -0.0079397}},
 'num_unbalanced_reactions': 235,
 'reactions_in_loops': 'NaN',
 'num_loop_reactions': 'NaN'}
```

1.1.4 Setting the growth rate

By default the community model object will have the structure of fixe growth rate. This means, the fractions of the community member abundance is allowed to vary during simulations, but the individual and community growth rate is set to a fixed value (default: 1.0). The next thing we will try is to set the community growth rate to a different value and do a FBA.

[12]:
```
com_model_obj.apply_fixed_growth_rate(0.5)
com_model_obj.summary()
```

[12]:
```
<cobra.summary.model_summary.ModelSummary at 0x18fefa87250>
```

1.1.5 Setting the community member composition

The model structure can be changed to fixed abundance, but variable growth rate. To do so, a conversion function needs to be called. Here we then change the community abundance to equal abundances.

[13]:
```
com_model_obj.convert_to_fixed_abundance()
abundance_dict = com_model_obj.generate_equal_abundance_dict()
com_model_obj.apply_fixed_abundance(abundance_dict)
```

```
com_model_obj.summary()
```

[13]:
```
<cobra.summary.model_summary.ModelSummary at 0x18fb56c3f70>
```

1.2 Saving and loading community models

Community model objects can be saved and loaded into SBML files. This is different from the other available option to save the cobra model of the community model objects, as the abundance fractions of the organisms are written into the file as well. Saving and loading the community model can be done like this:

[14]:
```
com_model_obj.save("../data/toy/output/henson_com_model.xml")
```

[15]:
```
com_model_obj_loaded = pycomo.CommunityModel.load("../data/toy/output/
↪henson_com_model.xml")
```

[16]:
```
com_model_obj_loaded
```

[16]:
```
<pycomo.CommunityModel at 0x18f99e99d30>
```

[17]:
```
com_model_obj_loaded.model.optimize()
```

[17]:
```
<Solution 43.848 at 0x190c3326280>
```

1.2.1 Quality Checks

One of the quality checks that should be done is to look into all unbalanced reactions (mass and charge) in the entire model. As said before, such reactions should only exist in the case of boundary reactions, such as exchange, sink and source reactions.

[18]:
```
com_model_obj.get_unbalanced_reactions()
```

[18]:
```
{<Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_5DRIB_Achromobacter_xylosoxi
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pni16_Pseudomonas_aeruginosa_NCGM2_S1_c at 0x18f8aa9e310>: {'charge': 2.0,
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  'O': -3.0,
  'S': -1.0},
 <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpn140_Ralstonia_sp
_5_7_47FAA_c at 0x18f8d2c5340>: {'charge': 2.0,
  'C': -65.0,
  'H': -124.0,
  'O': -17.0,
  'P': -2.0},
 <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpn160_Ralstonia_sp
_5_7_47FAA_c at 0x18f8d2c5400>: {'charge': 2.0,
  'C': -73.0,
  'H': -140.0,
  'O': -17.0,
  'P': -2.0},
 <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpn180_Ralstonia_sp
_5_7_47FAA_c at 0x18f8d2c54c0>: {'charge': 2.0,
  'C': -81.0,
  'H': -156.0,
  'O': -17.0,
  'P': -2.0},
 <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpni16_Ralstonia_sp
_5_7_47FAA_c at 0x18f8d2c5580>: {'charge': 2.0,
  'C': -73.0,
  'H': -140.0,
  'O': -17.0,
  'P': -2.0},
 <Reaction Ralstonia_sp_5_7_47FAA_DM_dad_5_Ralstonia_sp_5_7_47FAA_c at
0x18f8d2c5640>: {'C': -10.0,
  'H': -13.0,
  'N': -5.0,
  'O': -3.0},
 <Reaction Ralstonia_sp_5_7_47FAA_DM_kdo2lipid4L_Ralstonia_sp_5_7_47FAA_c at
```

0x18f8d2c5700>: {'charge': 6.0,
  'C': -96.0,
  'H': -170.0,
  'N': -2.0,
  'O': -38.0,
  'P': -2.0},
 <Reaction Ralstonia_sp_5_7_47FAA_EX_biomass_e_Ralstonia_sp_5_7_47FAA_c at
0x18f8d3a5610>: {'X': -1.0},
 <Reaction Ralstonia_sp_5_7_47FAA_GLCS3_Ralstonia_sp_5_7_47FAA_c at
0x18f8d6e25b0>: {'charge': -1.0,
  'H': -1.0,
  'X': -1.0},
 <Reaction Ralstonia_sp_5_7_47FAA_SHCHCC2_Ralstonia_sp_5_7_47FAA_c at
0x18f8d4aa5b0>: {'charge': -2.0},
 <Reaction Ralstonia_sp_5_7_47FAA_dreplication_Ralstonia_sp_5_7_47FAA_c at
0x18f8de33c10>: {'X': 1.0},
 <Reaction Ralstonia_sp_5_7_47FAA_pbiosynthesis_Ralstonia_sp_5_7_47FAA_c at
0x18f8de33bb0>: {'X': 1.0},
 <Reaction Ralstonia_sp_5_7_47FAA_rtranscription_Ralstonia_sp_5_7_47FAA_c at
0x18f8debcfd0>: {'X': 1.0},
 <Reaction Ralstonia_sp_5_7_47FAA_sink_s_Ralstonia_sp_5_7_47FAA_c at
0x18f8deaafd0>: {'S': -1.0},
 <Reaction Ralstonia_sp_5_7_47FAA_biomass525 at 0x18f8decfbb0>: {'charge':
1.1166217999999846,
  'C': -41.42309740000013,
  'H': -63.2738709999998,
  'N': -10.952010200000075,
  'O': -15.8540166000002,
  'P': -1.1706787999999961,
  'S': -0.2695576,
  'X': -2.0,
  'Ca': -0.0078094,
  'Cl': -0.0078094,
  'Co': -0.0078094,
  'Cu': -0.0078094,
  'Fe': -0.0156188,
  'K': -0.0078094,
  'Mg': -0.0078094,
  'Mn': -0.0078094,
  'Zn': -0.0078094},
 <Reaction Rothia_mucilaginosa_DY_18_DHNAOT_Rothia_mucilaginosa_DY_18_c at
0x18f900b1ac0>: {'charge': 2.0},
 <Reaction Rothia_mucilaginosa_DY_18_DM_2HYMEPH_Rothia_mucilaginosa_DY_18_c at
0x18f900d6a60>: {'C': -7.0,
  'H': -8.0,
  'O': -2.0},
 <Reaction Rothia_mucilaginosa_DY_18_DM_5MTR_Rothia_mucilaginosa_DY_18_c at

0x18f900d6b50>: {'C': -6.0,
  'H': -12.0,
  'O': -4.0,
  'S': -1.0},
 <Reaction Rothia_mucilaginosa_DY_18_DM_HQN_Rothia_mucilaginosa_DY_18_c at
0x18f900d6c10>: {'C': -6.0,
  'H': -6.0,
  'O': -2.0},
 <Reaction Rothia_mucilaginosa_DY_18_DM_dhptd_Rothia_mucilaginosa_DY_18_c at
0x18f900d6dc0>: {'C': -5.0,
  'H': -8.0,
  'O': -4.0},
 <Reaction Rothia_mucilaginosa_DY_18_DM_hcys_L_Rothia_mucilaginosa_DY_18_c at
0x18f900d6e80>: {'C': -4.0,
  'H': -9.0,
  'N': -1.0,
  'O': -2.0,
  'S': -1.0},
 <Reaction Rothia_mucilaginosa_DY_18_EX_biomass_e_Rothia_mucilaginosa_DY_18_c at
0x18f90116fa0>: {'X': -1.0},
 <Reaction Rothia_mucilaginosa_DY_18_dreplication_Rothia_mucilaginosa_DY_18_c at
0x18f90771d00>: {'X': 1.0},
 <Reaction Rothia_mucilaginosa_DY_18_pbiosynthesis_Rothia_mucilaginosa_DY_18_c
at 0x18f90771f10>: {'X': 1.0},
 <Reaction Rothia_mucilaginosa_DY_18_rtranscription_Rothia_mucilaginosa_DY_18_c
at 0x18f907a7df0>: {'X': 1.0},
 <Reaction Rothia_mucilaginosa_DY_18_biomass429 at 0x18f907c5e20>: {'charge':
0.8556490000000481,
  'C': -39.342995000000066,
  'H': -62.7807935000004,
  'N': -8.573918499999937,
  'O': -14.310861000000338,
  'P': -0.8120755000000145,
  'S': -0.222525,
  'X': -2.0,
  'Co': -0.0030965,
  'Ca': -0.0030965,
  'Cl': -0.0030965,
  'Cu': -0.0030965,
  'Fe': -0.012386,
  'K': -0.0030965,
  'Mg': -0.0030965,
  'Mn': -0.0030965,
  'Zn': -0.0030965},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DHNAOT_Staphylococc
us_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93414f70>: {'charge': 2.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DM_5MTR_Staphylococ

```
cus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93447df0>: {'C': -6.0,
  'H': -12.0,
  'O': -4.0,
  'S': -1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DM_dhptd_Staphyloco
ccus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93447fa0>: {'C': -5.0,
  'H': -8.0,
  'O': -4.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_DM_hcys_L_Staphyloc
occus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93429ee0>: {'C': -4.0,
  'H': -9.0,
  'N': -1.0,
  'O': -2.0,
  'S': -1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_EX_biomass_e_Staphy
lococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f935074c0>: {'X': -1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECA4S_Staphylococc
us_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93606b20>: {'charge': -30.0,
  'C': -420.0,
  'H': -752.0,
  'N': -30.0,
  'O': -391.0,
  'P': -30.0,
  'X': 1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECAAE_Staphylococc
us_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f9361c880>: {'C': -286.0,
  'H': -477.0,
  'N': -47.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECAGE_Staphylococc
us_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93606ee0>: {'charge': 45.0,
  'C': -421.0,
  'H': -747.0,
  'N': -2.0,
  'O': -463.0,
  'P': -46.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECAUE_Staphylococc
us_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f9361cc40>: {'charge': 45.0,
  'C': -151.0,
  'H': -297.0,
  'N': -2.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TEICH45_Staphylococ
cus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f9361cdf0>: {'charge': 45.0,
  'C': -630.0,
```

```
  'H': -945.0,
  'N': -45.0,
  'O': -630.0,
  'P': -45.0,
  'X': 1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_dreplication_Staphy
lococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f936d1820>: {'X': 1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_pbiosynthesis_Staph
ylococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f936e3610>: {'X': 1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_rtranscription_Stap
hylococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93fa4e50>: {'X': 1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_sink_PGPm1_Staphylo
coccus_aureus_subsp_aureus_USA300_FPR3757_c at 0x18f93fb6550>: {'X': -1.0},
 <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_biomass042 at
0x18f93fb6bb0>: {'charge': -81.86880639999987,
  'C': -35.038135600000125,
  'H': 26.14692300000044,
  'N': -7.351355600000002,
  'O': 68.97884669999962,
  'P': -0.9387373000000402,
  'S': -0.21809219999999996,
  'X': -2.0018063,
  'Co': -0.0079397,
  'Ca': -0.0079397,
  'Cl': -0.0079397,
  'Cu': -0.0079397,
  'Fe': -0.0317588,
  'K': -0.0079397,
  'Mg': -0.0079397,
  'Mn': -0.0079397,
  'Zn': -0.0079397},
 <Reaction
Streptococcus_sanguinis_SK36_DM_2HYMEPH_Streptococcus_sanguinis_SK36_c at
0x18f96fc0580>: {'C': -7.0,
  'H': -8.0,
  'O': -2.0},
 <Reaction Streptococcus_sanguinis_SK36_DM_5MTR_Streptococcus_sanguinis_SK36_c
at 0x18f96fc0670>: {'C': -6.0,
  'H': -12.0,
  'O': -4.0,
  'S': -1.0},
 <Reaction Streptococcus_sanguinis_SK36_DM_HQN_Streptococcus_sanguinis_SK36_c at
0x18f96fc0730>: {'C': -6.0,
  'H': -6.0,
  'O': -2.0},
 <Reaction Streptococcus_sanguinis_SK36_DM_dhptd_Streptococcus_sanguinis_SK36_c
at 0x18f96fc08e0>: {'C': -5.0,
```

```
  'H': -8.0,
  'O': -4.0},
 <Reaction Streptococcus_sanguinis_SK36_DM_hcys_L_Streptococcus_sanguinis_SK36_c
at 0x18f96fc09a0>: {'C': -4.0,
  'H': -9.0,
  'N': -1.0,
  'O': -2.0,
  'S': -1.0},
 <Reaction
Streptococcus_sanguinis_SK36_EX_biomass_e_Streptococcus_sanguinis_SK36_c at
0x18f9701ca60>: {'X': -1.0},
 <Reaction Streptococcus_sanguinis_SK36_SHCHCC2_Streptococcus_sanguinis_SK36_c
at 0x18f976eae50>: {'charge': -2.0},
 <Reaction Streptococcus_sanguinis_SK36_TECA4S_Streptococcus_sanguinis_SK36_c at
0x18f97742760>: {'charge': -30.0,
  'C': -420.0,
  'H': -752.0,
  'N': -30.0,
  'O': -391.0,
  'P': -30.0,
  'X': 1.0},
 <Reaction Streptococcus_sanguinis_SK36_TECAAE_Streptococcus_sanguinis_SK36_c at
0x18f9775a4c0>: {'C': -286.0,
  'H': -477.0,
  'N': -47.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction Streptococcus_sanguinis_SK36_TECAGE_Streptococcus_sanguinis_SK36_c at
0x18f9775a610>: {'charge': 45.0,
  'C': -421.0,
  'H': -747.0,
  'N': -2.0,
  'O': -463.0,
  'P': -46.0},
 <Reaction Streptococcus_sanguinis_SK36_TECAUE_Streptococcus_sanguinis_SK36_c at
0x18f9775a760>: {'charge': 45.0,
  'C': -151.0,
  'H': -297.0,
  'N': -2.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction
Streptococcus_sanguinis_SK36_dreplication_Streptococcus_sanguinis_SK36_c at
0x18f977f4970>: {'X': 1.0},
 <Reaction
Streptococcus_sanguinis_SK36_pbiosynthesis_Streptococcus_sanguinis_SK36_c at
0x18f977f4fa0>: {'X': 1.0},
```

<Reaction
Streptococcus_sanguinis_SK36_rtranscription_Streptococcus_sanguinis_SK36_c at
0x18f97857dc0>: {'X': 1.0},
<Reaction
Streptococcus_sanguinis_SK36_sink_PGPm1_Streptococcus_sanguinis_SK36_c at
0x18f97857fd0>: {'X': -1.0},
<Reaction Streptococcus_sanguinis_SK36_biomass164 at 0x18f97857f70>: {'charge':
-81.86883519999986,
'C': -35.03518620000009,
'H': 26.14989040000043,
'N': -7.354207799999981,
'O': 68.97894029999964,
'P': -0.9387157000000436,
'S': -0.21809219999999996,
'X': -2.0018063,
'Co': -0.0079397,
'Ca': -0.0079397,
'Cl': -0.0079397,
'Cu': -0.0079397,
'Fe': -0.0317588,
'K': -0.0079397,
'Mg': -0.0079397,
'Mn': -0.0079397,
'Zn': -0.0079397},
<Reaction
Veillonella_atypica_ACS_049_V_Sch6_DHNAOT_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f98fa1760>: {'charge': 2.0},
<Reaction
Veillonella_atypica_ACS_049_V_Sch6_DM_dhptd_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f98fc49a0>: {'C': -5.0,
'H': -8.0,
'O': -4.0},
<Reaction Veillonella_atypica_ACS_049_V_Sch6_DM_hcys_L_Veillonella_atypica_ACS_
049_V_Sch6_c at 0x18f98fc4a60>: {'C': -4.0,
'H': -9.0,
'N': -1.0,
'O': -2.0,
'S': -1.0},
<Reaction Veillonella_atypica_ACS_049_V_Sch6_EX_biomass_e_Veillonella_atypica_A
CS_049_V_Sch6_c at 0x18f9901b6d0>: {'X': -1.0},
<Reaction
Veillonella_atypica_ACS_049_V_Sch6_SHCHCC2_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f9963fd60>: {'charge': -2.0},
<Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECA4S_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996a52e0>: {'charge': -30.0,
'C': -420.0,

```
  'H': -752.0,
  'N': -30.0,
  'O': -391.0,
  'P': -30.0,
  'X': 1.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECAAE_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996a5f70>: {'C': -286.0,
  'H': -477.0,
  'N': -47.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECAGE_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996a5fa0>: {'charge': 45.0,
  'C': -421.0,
  'H': -747.0,
  'N': -2.0,
  'O': -463.0,
  'P': -46.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECAUE_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x18f996c0400>: {'charge': 45.0,
  'C': -151.0,
  'H': -297.0,
  'N': -2.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_dreplication_Veillonella_atypica_A
CS_049_V_Sch6_c at 0x18f9972dca0>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_pbiosynthesis_Veillonella_atypica_
ACS_049_V_Sch6_c at 0x18f99716f10>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_rtranscription_Veillonella_atypica
_ACS_049_V_Sch6_c at 0x18f99792a90>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_sink_PGPm1_Veillonella_atypica_ACS
_049_V_Sch6_c at 0x18f99792c10>: {'X': -1.0},
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{'charge': -81.86882719999988,
  'C': -35.036401200000036,
  'H': 26.148670400000327,
  'N': -7.353019799999996,
  'O': 68.9789142999997,
  'P': -0.9387217000000568,
  'S': -0.21809219999999996,
  'X': -2.0018063,
  'Co': -0.0079397,
  'Ca': -0.0079397,
```

```
 'Cl': -0.0079397,
 'Cu': -0.0079397,
 'Fe': -0.0317588,
 'K': -0.0079397,
 'Mg': -0.0079397,
 'Mn': -0.0079397,
 'Zn': -0.0079397}}
```

1.3 Analysis of community models

PyCoMo offers the option to calculate all potential exchange metabolites and cross-feeding interactions in a community, independent of the community composition. The example for this part will be a three member community published by Koch et al. 2019 (https://doi.org/10.1371/journal.pcbi.1006759). The three member organisms are representatives of functional guilds in a biogas community. ### Creating the community model ### We repeat the steps as before.

[19]:
```
test_model_dir = "../data/use_case/koch"
named_models = pycomo.load_named_models_from_dir(test_model_dir)
```

```
'3PG' is not a valid SBML 'SId'.
'2PG' is not a valid SBML 'SId'.
Adding exchange reaction EX_H2_EX with default bounds for boundary metabolite:
H2_EX.
Adding exchange reaction EX_Ac_EX with default bounds for boundary metabolite:
Ac_EX.
Adding exchange reaction EX_CO2_EX with default bounds for boundary metabolite:
CO2_EX.
Adding exchange reaction EX_Form_EX with default bounds for boundary metabolite:
Form_EX.
Adding exchange reaction EX_SO4_EX with default bounds for boundary metabolite:
SO4_EX.
Adding exchange reaction EX_H2S_EX with default bounds for boundary metabolite:
H2S_EX.
Adding exchange reaction EX_Eth_EX with default bounds for boundary metabolite:
Eth_EX.
Adding exchange reaction EX_Lac_EX with default bounds for boundary metabolite:
Lac_EX.
Adding exchange reaction EX_Pyr_EX with default bounds for boundary metabolite:
Pyr_EX.
Adding exchange reaction EX_BM_tot with default bounds for boundary metabolite:
BM_tot.
'2PG__PEP' is not a valid SBML 'SId'.
'3PG__2PG' is not a valid SBML 'SId'.
'0Pyr__AcCoA' is not a valid SBML 'SId'.
'3PG' is not a valid SBML 'SId'.
'2PG' is not a valid SBML 'SId'.
'5CHOMPT' is not a valid SBML 'SId'.
```

```
Adding exchange reaction EX_H2_EX with default bounds for boundary metabolite:
H2_EX.
Adding exchange reaction EX_CO2_EX with default bounds for boundary metabolite:
CO2_EX.
Adding exchange reaction EX_CH4_EX with default bounds for boundary metabolite:
CH4_EX.
Adding exchange reaction EX_Ac_EX with default bounds for boundary metabolite:
Ac_EX.
Adding exchange reaction EX_MetOH_EX with default bounds for boundary
metabolite: MetOH_EX.
Adding exchange reaction EX_BM_tot with default bounds for boundary metabolite:
BM_tot.
'3PG__2PG__3PG' is not a valid SBML 'SId'.
'5CHOMPT__CHH4MPT' is not a valid SBML 'SId'.
'5CHOMPT' is not a valid SBML 'SId'.
'3PG' is not a valid SBML 'SId'.
'2PG' is not a valid SBML 'SId'.
Adding exchange reaction EX_H2_EX with default bounds for boundary metabolite:
H2_EX.
Adding exchange reaction EX_CO2_EX with default bounds for boundary metabolite:
CO2_EX.
Adding exchange reaction EX_CH4_EX with default bounds for boundary metabolite:
CH4_EX.
Adding exchange reaction EX_Form_EX with default bounds for boundary metabolite:
Form_EX.
Adding exchange reaction EX_BM_tot with default bounds for boundary metabolite:
BM_tot.
'2PG__3PG' is not a valid SBML 'SId'.
'3PG__DPG' is not a valid SBML 'SId'.
'5CHOMPT__CHH4MPT' is not a valid SBML 'SId'.
```

[20]:
```
named_models
```

[20]:
```
{'dv': <Model CNA_DV at 0x18ffe936610>,
 'mb': <Model CNA_MB at 0x190bd4b1d30>,
 'mh': <Model CNA_MM at 0x190be5ce910>}
```

[21]:
```
single_org_models = []
for name, model in named_models.items():
    single_org_model = pycomo.SingleOrganismModel(model, name)
    single_org_models.append(single_org_model)

community_name = "koch_community_model"
com_model_obj = pycomo.CommunityModel(single_org_models, community_name)
```

With the community model generated, we set the medium for the analysis, as done by Koch et al.

[22]:
```
medium = {
    'EX_CO2_EX_medium': 1000.0,
    'EX_Eth_EX_medium': 1000.0,
    'EX_BM_tot_medium': 1000.0
}
com_model_obj.medium = medium
com_model_obj.apply_medium()

# Some metabolites are not allowed to accumulate in the medium.
com_model_obj.model.reactions.get_by_id("EX_Form_EX_medium").upper_bound = 0.
com_model_obj.model.reactions.get_by_id("EX_H2_EX_medium").upper_bound = 0.
```

```
No community model generated yet. Generating now:

Ignoring reaction 'EX_H2_EX_medium' since it already exists.
Ignoring reaction 'EX_CO2_EX_medium' since it already exists.
Ignoring reaction 'EX_Ac_EX_medium' since it already exists.

WARNING: no annotation overlap found for matching metabolite CO2_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite H2_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite Ac_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX_H2_EX_medium' since it already exists.
Ignoring reaction 'EX_CO2_EX_medium' since it already exists.
Ignoring reaction 'EX_CH4_EX_medium' since it already exists.
Ignoring reaction 'EX_Form_EX_medium' since it already exists.
Ignoring reaction 'EX_BM_tot_medium' since it already exists.

WARNING: no annotation overlap found for matching metabolite Form_EX. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite H2_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite BM_tot. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite CH4_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite CO2_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
```

```
Generated community model.
```

1.3.1 Calculating potential metabolite exchange

All potential exchange metabolite fluxes and cross-feeding interactions can be calculated with the *potential_metabolite_exchanges* method. This is a single FVA, but with a minimum objective of 0 and relaxed constraints. All reaction constraints are changed to include the value 0, which circumvents cases where a specific flux through a reaction is required, leading to infeasible solutions for certain community compositions.

[23]:
```
com_model_obj.potential_metabolite_exchanges()
```

[23]:

	metabolite_id	metabolite_name	cross_feeding	produced_by	consumed_by
0	H2_EX_medium	H2_external	True	[dv, mh]	[dv, mb, mh]
1	Ac_EX_medium	acetate_external	True	[dv]	[mb]
2	CO2_EX_medium	CO2_external	True	[mb, mh]	[dv, mb, mh]
3	Form_EX_medium	formate_external	True	[dv]	[mh]
4	SO4_EX_medium	sulfate_external	False	[]	[]
5	H2S_EX_medium	hydrogensulfide_external	False	[]	[]
6	Eth_EX_medium	ethanol_external	False	[]	[]
7	Lac_EX_medium	lactate_external	False	[]	[]
8	Pyr_EX_medium	pyruvate_external	False	[]	[]
9	CH4_EX_medium	nethane_external	False	[mb, mh]	[]
10	MetOH_EX_medium	nethanol_external	False	[]	[]
11	BM_tot_medium	total_biomass	False	[]	[]
12	cpd11416_medium	Community Biomass	False	[]	[]

1.3.2 Plotting the maxiumum growth rate over the composition space

[24]:
```
import pandas as pd

# Iterate over the fractions in steps of 0.01
com_model_obj.convert_to_fixed_abundance()
```

```
rows = []
for i in range (0,100,1):  # fraction of D. vulgaris
    for j in range (0, 100-i, 1): # fraction of M. hungatei
        if (100-i-j) < 0:
            continue

        abundances = {"dv": i/100., "mh": j/100., "mb": (100-i-j)/100.}

        # Apply the abuyndances
        com_model_obj.apply_fixed_abundance(abundances)

        # Reapply the bound restrictions of the exchange reactions
        com_model_obj.model.reactions.get_by_id("EX_Form_EX_medium").
 ↪upper_bound = 0.
        com_model_obj.model.reactions.get_by_id("EX_H2_EX_medium").upper_bound␣
 ↪= 0.

        # Calculate the optimal growth rate
        solution = com_model_obj.model.optimize()
        growth = 0. if str(solution.status) == "infeasible" else solution.
 ↪objective_value
        rows.append({"dv": i/100., "mh": j/100., "growth": growth})

growth_df = pd.DataFrame(rows)
```

```
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[25]:
```python
import matplotlib.pyplot as plt
import seaborn as sns
sns.set_theme()

# Restructure dataframe for heatmap
growth_df_pivot = growth_df.pivot("mh", "dv", "growth")

# Draw a heatmap with the numeric values in each cell
```

```
f, ax = plt.subplots(figsize=(9, 6))
sns.heatmap(growth_df_pivot, ax=ax)
ax.invert_yaxis()
```