PyCoMo_basics

July 21, 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 5 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
```

Now we will check if PyCoMo was loaded correctly. For this, we will run the help function on the PyCoMo package.

[ ]:
```
help(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 0x2078b2840d0>,
 'Actinomyces_naeslundii_str_Howell_279': <Model
Actinomyces_naeslundii_str_Howell_279 at 0x207941cad30>,
 'Burkholderia_cepacia_GG4': <Model Burkholderia_cepacia_GG4 at 0x20794939970>,
 'Escherichia_coli_str_K_12_substr_MG1655': <Model
Escherichia_coli_str_K_12_substr_MG1655 at 0x207967ee670>,
 'Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586': <Model
Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586 at 0x207985f3430>,
 'Gemella_haemolysans_ATCC_10379': <Model Gemella_haemolysans_ATCC_10379 at
0x20798a47670>,
 'Granulicatella_adiacens_ATCC_49175': <Model Granulicatella_adiacens_ATCC_49175
at 0x207990a80d0>,
 'Haemophilus_influenzae_R2846': <Model Haemophilus_influenzae_R2846 at
0x2079889e250>,
 'Neisseria_flavescens_SK114': <Model Neisseria_flavescens_SK114 at
0x20799fd66d0>,
 'Porphyromonas_endodontalis_ATCC_35406': <Model
Porphyromonas_endodontalis_ATCC_35406 at 0x2079a7de310>,
 'Prevotella_melaninogenica_ATCC_25845': <Model
Prevotella_melaninogenica_ATCC_25845 at 0x2079acff070>,
 'Pseudomonas_aeruginosa_NCGM2_S1': <Model Pseudomonas_aeruginosa_NCGM2_S1 at
0x2079b3f42b0>,
 'Ralstonia_sp_5_7_47FAA': <Model Ralstonia_sp_5_7_47FAA at 0x2079c116880>,
 'Rothia_mucilaginosa_DY_18': <Model Rothia_mucilaginosa_DY_18 at
0x2079cb2d5b0>,
 'Staphylococcus_aureus_subsp_aureus_USA300_FPR3757': <Model
Staphylococcus_aureus_subsp_aureus_USA300_FPR3757 at 0x2079d06e250>,
 'Streptococcus_sanguinis_SK36': <Model Streptococcus_sanguinis_SK36 at
0x2079dada250>,
 'Veillonella_atypica_ACS_049_V_Sch6': <Model Veillonella_atypica_ACS_049_V_Sch6
at 0x2079e2d66a0>}
```

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 *exchg*.

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 .community_model

[9]:
```
com_model_obj.community_model
```

```
No constrained community model set yet. Using the unconstrained model instead.
No unconstrained 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.

Ignoring reaction 'EX__4abz_exchg' since it already exists.
Ignoring reaction 'EX_Lcyst_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
```

```
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_alltn_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_butso3_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_chol_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_ethso3_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
```

```
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gthrd_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hexs_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_isetac_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mops_exchg' since it already exists.
Ignoring reaction 'EX_mqn7_exchg' since it already exists.
Ignoring reaction 'EX_mso3_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
```

```
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_sulfac_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xyl_D_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 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 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 alaasp. Please make
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WARNING: no annotation overlap found for matching metabolite glygln. Please make
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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 mg2. Please make
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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 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 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 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 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 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 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 isetac. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite butso3. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite glyasn. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
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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 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 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 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 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 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 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 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 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 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 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 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 sulfac. Please make
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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 glytyr. Please make
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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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2hyoxplac_exchg' since it already exists.
Ignoring reaction 'EX__34dhpha_exchg' since it already exists.
Ignoring reaction 'EX__34dhphe_exchg' since it already exists.
Ignoring reaction 'EX__3mop_exchg' since it already exists.
Ignoring reaction 'EX__4abz_exchg' since it already exists.
Ignoring reaction 'EX__5htrp_exchg' since it already exists.
Ignoring reaction 'EX_Lcyst_exchg' since it already exists.
Ignoring reaction 'EX_Lkynr_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acac_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_akg_exchg' since it already exists.

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 _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 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 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 alagln. Please make
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WARNING: no annotation overlap found for matching metabolite glygln. Please make
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WARNING: no annotation overlap found for matching metabolite mn2. Please make
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WARNING: no annotation overlap found for matching metabolite mg2. Please make
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WARNING: no annotation overlap found for matching metabolite _4abz. Please make
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WARNING: no annotation overlap found for matching metabolite cobalt2. Please
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```

```
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WARNING: no annotation overlap found for matching metabolite glyasn. Please make
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in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
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WARNING: no annotation overlap found for matching metabolite alaglu. Please make
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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 cd2. Please make
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WARNING: no annotation overlap found for matching metabolite zn2. Please make
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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 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 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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX_ala_D_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_alltn_exchg' since it already exists.
Ignoring reaction 'EX_arab_D_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_bhb_exchg' since it already exists.
Ignoring reaction 'EX_but_exchg' since it already exists.
Ignoring reaction 'EX_butso3_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_cit_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_dopa_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
```

```
Ignoring reaction 'EX_ethso3_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_galctn_D_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gthrd_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hexs_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hista_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_ind3ac_exchg' since it already exists.
Ignoring reaction 'EX_isetac_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
```

```
Ignoring reaction 'EX_malthx_exchg' since it already exists.
Ignoring reaction 'EX_malttr_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mops_exchg' since it already exists.
Ignoring reaction 'EX_mso3_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pac_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_srtn_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_sulfac_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
```

```
Ignoring reaction 'EX_trypta_exchg' since it already exists.
Ignoring reaction 'EX_tsul_exchg' since it already exists.
Ignoring reaction 'EX_tym_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_urea_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__12ppd_S_exchg' since it already exists.

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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__15dap_exchg' since it already exists.
Ignoring reaction 'EX__2ddglcn_exchg' since it already exists.
Ignoring reaction 'EX__3hpppn_exchg' since it already exists.
Ignoring reaction 'EX__4hbz_exchg' since it already exists.
Ignoring reaction 'EX_Lcyst_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_adn_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_akg_exchg' since it already exists.
Ignoring reaction 'EX_ala_D_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_alltn_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_aso3_exchg' since it already exists.
Ignoring reaction 'EX_aso4_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_but_exchg' since it already exists.
Ignoring reaction 'EX_butso3_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
```

```
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_chol_exchg' since it already exists.
Ignoring reaction 'EX_cit_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cynt_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_ddca_exchg' since it already exists.
Ignoring reaction 'EX_dhcinnm_exchg' since it already exists.
Ignoring reaction 'EX_dhpppn_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_etha_exchg' since it already exists.
Ignoring reaction 'EX_ethso3_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fuc_L_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_galct_D_exchg' since it already exists.
Ignoring reaction 'EX_galctn_D_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_galur_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_glcn_exchg' since it already exists.
Ignoring reaction 'EX_glcr_exchg' since it already exists.
Ignoring reaction 'EX_glcur_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glyclt_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
```

```
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hdca_exchg' since it already exists.
Ignoring reaction 'EX_hexs_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_indole_exchg' since it already exists.
Ignoring reaction 'EX_isetac_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_lcts_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_malthx_exchg' since it already exists.
Ignoring reaction 'EX_malttr_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_mantr_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mops_exchg' since it already exists.
Ignoring reaction 'EX_mso3_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pac_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
```

```
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_sulfac_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_tma_exchg' since it already exists.
Ignoring reaction 'EX_tmao_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_tsul_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tym_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_urea_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
Ignoring reaction 'EX_xyl_D_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__15dap_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__2obut_exchg' since it already exists.
Ignoring reaction 'EX__3mop_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acac_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
```

```
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_bhb_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_but_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_etha_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_gal_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
```

```
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_indole_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
```

```
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_urea_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__34dhphe_exchg' since it already exists.
Ignoring reaction 'EX__3mop_exchg' since it already exists.
Ignoring reaction 'EX__5htrp_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_ade_exchg' since it already exists.
Ignoring reaction 'EX_ala_D_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
```

```
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_dopa_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_glcn_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hista_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_malthx_exchg' since it already exists.
Ignoring reaction 'EX_malttr_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
```

```
Ignoring reaction 'EX_melib_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_pppn_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
Ignoring reaction 'EX_raffin_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_srtn_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_trypta_exchg' since it already exists.
Ignoring reaction 'EX_tym_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
```

```
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 glycys. Please make
```

```
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__12dgr180_exchg' since it already exists.
Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2ddglcn_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__2obut_exchg' since it already exists.
Ignoring reaction 'EX__3mop_exchg' since it already exists.
Ignoring reaction 'EX__4hbz_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_ade_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_amp_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_etoh_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
```

```
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
```

```
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_ribflv_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 _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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.
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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 dms. Please make
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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__34dhphe_exchg' since it already exists.
Ignoring reaction 'EX__4abz_exchg' since it already exists.
Ignoring reaction 'EX__4hbz_exchg' since it already exists.
Ignoring reaction 'EX__5htrp_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_acnam_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
```

```
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_chol_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_dms_exchg' since it already exists.
Ignoring reaction 'EX_dmso_exchg' since it already exists.
Ignoring reaction 'EX_dopa_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fecrm_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_gal_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
```

```
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hdca_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hista_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_nmn_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pppn_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
```

```
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_srtn_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_tma_exchg' since it already exists.
Ignoring reaction 'EX_tmao_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_trypta_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tym_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xyl_D_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__2obut_exchg' since it already exists.
Ignoring reaction 'EX__34dhphe_exchg' since it already exists.
Ignoring reaction 'EX__5htrp_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_ade_exchg' since it already exists.
Ignoring reaction 'EX_adn_exchg' since it already exists.
Ignoring reaction 'EX_akg_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
```

```
Ignoring reaction 'EX_chol_exchg' since it already exists.
Ignoring reaction 'EX_cit_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_dopa_exchg' since it already exists.
Ignoring reaction 'EX_etoh_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_gal_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glyclt_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gthrd_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hdca_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hista_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
```

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Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_n2_exchg' since it already exists.
Ignoring reaction 'EX_n2o_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_srtn_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
```

```
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_trypta_exchg' since it already exists.
Ignoring reaction 'EX_tsul_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tym_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__2obut_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_ade_exchg' since it already exists.
Ignoring reaction 'EX_adn_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_amp_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_but_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_cro4_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
```

```
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_din_exchg' since it already exists.
Ignoring reaction 'EX_duri_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyclt_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gsn_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_indole_exchg' since it already exists.
Ignoring reaction 'EX_ins_exchg' since it already exists.
Ignoring reaction 'EX_isobut_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
```

```
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
Ignoring reaction 'EX_ribflv_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__2obut_exchg' since it already exists.
Ignoring reaction 'EX__4abz_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_ade_exchg' since it already exists.
Ignoring reaction 'EX_adn_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_chtbs_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_cro4_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_din_exchg' since it already exists.
Ignoring reaction 'EX_duri_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
```

```
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_gsn_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_ins_exchg' since it already exists.
Ignoring reaction 'EX_isobut_exchg' since it already exists.
Ignoring reaction 'EX_isocapr_exchg' since it already exists.
Ignoring reaction 'EX_isoval_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lcts_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_ocdcea_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
```

```
Ignoring reaction 'EX_raffin_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_tsul_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 _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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 _2dmmq8. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__15dap_exchg' since it already exists.
Ignoring reaction 'EX__2hyoxplac_exchg' since it already exists.
Ignoring reaction 'EX__34dhpha_exchg' since it already exists.
Ignoring reaction 'EX__3hphac_exchg' since it already exists.
Ignoring reaction 'EX__4hphac_exchg' since it already exists.
Ignoring reaction 'EX__5mta_exchg' since it already exists.
Ignoring reaction 'EX_HC00319_exchg' since it already exists.
Ignoring reaction 'EX_Lcyst_exchg' since it already exists.
Ignoring reaction 'EX_Lkynr_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_ala_D_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
```

```
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_alltn_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_aso3_exchg' since it already exists.
Ignoring reaction 'EX_aso4_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_bhb_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_but_exchg' since it already exists.
Ignoring reaction 'EX_butso3_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_chol_exchg' since it already exists.
Ignoring reaction 'EX_cit_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cynt_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_ddca_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_etha_exchg' since it already exists.
Ignoring reaction 'EX_ethso3_exchg' since it already exists.
Ignoring reaction 'EX_etoh_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_galct_D_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_galur_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_glcn_exchg' since it already exists.
Ignoring reaction 'EX_glcr_exchg' since it already exists.
```

```
Ignoring reaction 'EX_glcur_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_h2_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hdca_exchg' since it already exists.
Ignoring reaction 'EX_hexs_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_ind3ac_exchg' since it already exists.
Ignoring reaction 'EX_isetac_exchg' since it already exists.
Ignoring reaction 'EX_isobut_exchg' since it already exists.
Ignoring reaction 'EX_isoval_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mops_exchg' since it already exists.
```

```
Ignoring reaction 'EX_mqn7_exchg' since it already exists.
Ignoring reaction 'EX_mso3_exchg' since it already exists.
Ignoring reaction 'EX_n2_exchg' since it already exists.
Ignoring reaction 'EX_n2o_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_nmn_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_no_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pppn_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_pyr_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_sulfac_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_tsul_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.

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 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 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 _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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX_urea_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

Note: no products in the objective function, adding biomass to it.
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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__2hyoxplac_exchg' since it already exists.
Ignoring reaction 'EX__34dhpha_exchg' since it already exists.
Ignoring reaction 'EX_HC00319_exchg' since it already exists.
Ignoring reaction 'EX_Lcyst_exchg' since it already exists.
Ignoring reaction 'EX_Lkynr_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_akg_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_alltn_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_aso3_exchg' since it already exists.
Ignoring reaction 'EX_aso4_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_bhb_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_but_exchg' since it already exists.
Ignoring reaction 'EX_butso3_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cellb_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
```

```
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_ddca_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_etha_exchg' since it already exists.
Ignoring reaction 'EX_ethso3_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_galct_D_exchg' since it already exists.
Ignoring reaction 'EX_galur_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glcr_exchg' since it already exists.
Ignoring reaction 'EX_glcur_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_h2_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hdca_exchg' since it already exists.
Ignoring reaction 'EX_hexs_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_isetac_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
```

```
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mops_exchg' since it already exists.
Ignoring reaction 'EX_mso3_exchg' since it already exists.
Ignoring reaction 'EX_n2_exchg' since it already exists.
Ignoring reaction 'EX_n2o_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_no_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_oxa_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sulfac_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_tsul_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_urea_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xyl_D_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.
```

```
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__2obut_exchg' since it already exists.
Ignoring reaction 'EX__4abz_exchg' since it already exists.
Ignoring reaction 'EX__4hbz_exchg' since it already exists.
Ignoring reaction 'EX_Lcyst_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_ala_D_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_arab_D_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_butso3_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_ethso3_exchg' since it already exists.
Ignoring reaction 'EX_etoh_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
```

```
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hexs_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_inost_exchg' since it already exists.
Ignoring reaction 'EX_isetac_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mops_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_mso3_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
```

```
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
Ignoring reaction 'EX_ribflv_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_sulfac_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trp_L_exchg' since it already exists.
Ignoring reaction 'EX_ttdca_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 _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 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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__12dgr180_exchg' since it already exists.
Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__3mop_exchg' since it already exists.
Ignoring reaction 'EX__4abz_exchg' since it already exists.
Ignoring reaction 'EX__4hbz_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_acnam_exchg' since it already exists.
Ignoring reaction 'EX_actn_R_exchg' since it already exists.
Ignoring reaction 'EX_adn_exchg' since it already exists.
Ignoring reaction 'EX_akg_exchg' since it already exists.
Ignoring reaction 'EX_ala_D_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_aso3_exchg' since it already exists.
Ignoring reaction 'EX_aso4_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_chol_exchg' since it already exists.
```

```
Ignoring reaction 'EX_cit_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_crn_exchg' since it already exists.
Ignoring reaction 'EX_ctbt_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_din_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_duri_exchg' since it already exists.
Ignoring reaction 'EX_etoh_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fecrm_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_gal_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gbbtn_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_glcn_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h2s_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
```

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Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_ins_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_lcts_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_malthx_exchg' since it already exists.
Ignoring reaction 'EX_malttr_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_ni2_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_ribflv_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
```

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Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_urea_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_xan_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 _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 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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__12dgr180_exchg' since it already exists.
Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__2dmmq8_exchg' since it already exists.
Ignoring reaction 'EX__2obut_exchg' since it already exists.
Ignoring reaction 'EX__34dhphe_exchg' since it already exists.
Ignoring reaction 'EX__5htrp_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_acnam_exchg' since it already exists.
Ignoring reaction 'EX_ade_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
```

```
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_amp_exchg' since it already exists.
Ignoring reaction 'EX_arab_L_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_arg_L_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cellb_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_chtbs_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_csn_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_cytd_exchg' since it already exists.
Ignoring reaction 'EX_dad_2_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_dgsn_exchg' since it already exists.
Ignoring reaction 'EX_dopa_exchg' since it already exists.
Ignoring reaction 'EX_etha_exchg' since it already exists.
Ignoring reaction 'EX_etoh_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_gal_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyb_exchg' since it already exists.
```

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Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glyclt_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hista_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_ins_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_lcts_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_malthx_exchg' since it already exists.
Ignoring reaction 'EX_malttr_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_mantr_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mqn8_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_nmn_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pnto_R_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
```

```
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_q8_exchg' since it already exists.
Ignoring reaction 'EX_ribflv_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_srtn_exchg' since it already exists.
Ignoring reaction 'EX_stys_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_thymd_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_trypta_exchg' since it already exists.
Ignoring reaction 'EX_tym_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_urea_exchg' since it already exists.
Ignoring reaction 'EX_uri_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 _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 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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
Note: no products in the objective function, adding biomass to it.

Ignoring reaction 'EX__26dap_M_exchg' since it already exists.
Ignoring reaction 'EX__3mop_exchg' since it already exists.
Ignoring reaction 'EX__4abz_exchg' since it already exists.
Ignoring reaction 'EX__4hbz_exchg' since it already exists.
Ignoring reaction 'EX_Lcyst_exchg' since it already exists.
Ignoring reaction 'EX_ac_exchg' since it already exists.
Ignoring reaction 'EX_acald_exchg' since it already exists.
Ignoring reaction 'EX_acgam_exchg' since it already exists.
Ignoring reaction 'EX_adocbl_exchg' since it already exists.
Ignoring reaction 'EX_akg_exchg' since it already exists.
Ignoring reaction 'EX_ala_D_exchg' since it already exists.
Ignoring reaction 'EX_ala_L_exchg' since it already exists.
Ignoring reaction 'EX_alaasp_exchg' since it already exists.
Ignoring reaction 'EX_alagln_exchg' since it already exists.
Ignoring reaction 'EX_alaglu_exchg' since it already exists.
Ignoring reaction 'EX_alagly_exchg' since it already exists.
Ignoring reaction 'EX_alahis_exchg' since it already exists.
```

```
Ignoring reaction 'EX_alaleu_exchg' since it already exists.
Ignoring reaction 'EX_alathr_exchg' since it already exists.
Ignoring reaction 'EX_amp_exchg' since it already exists.
Ignoring reaction 'EX_arbt_exchg' since it already exists.
Ignoring reaction 'EX_asn_L_exchg' since it already exists.
Ignoring reaction 'EX_asp_L_exchg' since it already exists.
Ignoring reaction 'EX_btn_exchg' since it already exists.
Ignoring reaction 'EX_butso3_exchg' since it already exists.
Ignoring reaction 'EX_ca2_exchg' since it already exists.
Ignoring reaction 'EX_cbl1_exchg' since it already exists.
Ignoring reaction 'EX_cbl2_exchg' since it already exists.
Ignoring reaction 'EX_cd2_exchg' since it already exists.
Ignoring reaction 'EX_cgly_exchg' since it already exists.
Ignoring reaction 'EX_cl_exchg' since it already exists.
Ignoring reaction 'EX_co2_exchg' since it already exists.
Ignoring reaction 'EX_cobalt2_exchg' since it already exists.
Ignoring reaction 'EX_cu2_exchg' since it already exists.
Ignoring reaction 'EX_cys_L_exchg' since it already exists.
Ignoring reaction 'EX_dcyt_exchg' since it already exists.
Ignoring reaction 'EX_drib_exchg' since it already exists.
Ignoring reaction 'EX_ethso3_exchg' since it already exists.
Ignoring reaction 'EX_fe2_exchg' since it already exists.
Ignoring reaction 'EX_fe3_exchg' since it already exists.
Ignoring reaction 'EX_fol_exchg' since it already exists.
Ignoring reaction 'EX_for_exchg' since it already exists.
Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
Ignoring reaction 'EX_galt_exchg' since it already exists.
Ignoring reaction 'EX_gam_exchg' since it already exists.
Ignoring reaction 'EX_gcald_exchg' since it already exists.
Ignoring reaction 'EX_glc_D_exchg' since it already exists.
Ignoring reaction 'EX_gln_L_exchg' since it already exists.
Ignoring reaction 'EX_glu_L_exchg' since it already exists.
Ignoring reaction 'EX_gly_exchg' since it already exists.
Ignoring reaction 'EX_glyasn_exchg' since it already exists.
Ignoring reaction 'EX_glyasp_exchg' since it already exists.
Ignoring reaction 'EX_glyc3p_exchg' since it already exists.
Ignoring reaction 'EX_glyc_exchg' since it already exists.
Ignoring reaction 'EX_glycys_exchg' since it already exists.
Ignoring reaction 'EX_glygln_exchg' since it already exists.
Ignoring reaction 'EX_glyglu_exchg' since it already exists.
Ignoring reaction 'EX_glyleu_exchg' since it already exists.
Ignoring reaction 'EX_glymet_exchg' since it already exists.
Ignoring reaction 'EX_glyphe_exchg' since it already exists.
Ignoring reaction 'EX_glypro_exchg' since it already exists.
Ignoring reaction 'EX_glytyr_exchg' since it already exists.
Ignoring reaction 'EX_gua_exchg' since it already exists.
Ignoring reaction 'EX_h2_exchg' since it already exists.
```

```
Ignoring reaction 'EX_h2o_exchg' since it already exists.
Ignoring reaction 'EX_h_exchg' since it already exists.
Ignoring reaction 'EX_hexs_exchg' since it already exists.
Ignoring reaction 'EX_hg2_exchg' since it already exists.
Ignoring reaction 'EX_his_L_exchg' since it already exists.
Ignoring reaction 'EX_hxan_exchg' since it already exists.
Ignoring reaction 'EX_ile_L_exchg' since it already exists.
Ignoring reaction 'EX_ind3ac_exchg' since it already exists.
Ignoring reaction 'EX_isetac_exchg' since it already exists.
Ignoring reaction 'EX_k_exchg' since it already exists.
Ignoring reaction 'EX_lac_D_exchg' since it already exists.
Ignoring reaction 'EX_lac_L_exchg' since it already exists.
Ignoring reaction 'EX_leu_L_exchg' since it already exists.
Ignoring reaction 'EX_lys_L_exchg' since it already exists.
Ignoring reaction 'EX_mal_L_exchg' since it already exists.
Ignoring reaction 'EX_malt_exchg' since it already exists.
Ignoring reaction 'EX_man_exchg' since it already exists.
Ignoring reaction 'EX_met_D_exchg' since it already exists.
Ignoring reaction 'EX_met_L_exchg' since it already exists.
Ignoring reaction 'EX_metala_exchg' since it already exists.
Ignoring reaction 'EX_metsox_R_L_exchg' since it already exists.
Ignoring reaction 'EX_metsox_S_L_exchg' since it already exists.
Ignoring reaction 'EX_mg2_exchg' since it already exists.
Ignoring reaction 'EX_mn2_exchg' since it already exists.
Ignoring reaction 'EX_mnl_exchg' since it already exists.
Ignoring reaction 'EX_mops_exchg' since it already exists.
Ignoring reaction 'EX_mso3_exchg' since it already exists.
Ignoring reaction 'EX_na1_exchg' since it already exists.
Ignoring reaction 'EX_nac_exchg' since it already exists.
Ignoring reaction 'EX_nh4_exchg' since it already exists.
Ignoring reaction 'EX_no2_exchg' since it already exists.
Ignoring reaction 'EX_no3_exchg' since it already exists.
Ignoring reaction 'EX_o2_exchg' since it already exists.
Ignoring reaction 'EX_ocdca_exchg' since it already exists.
Ignoring reaction 'EX_orn_exchg' since it already exists.
Ignoring reaction 'EX_pb_exchg' since it already exists.
Ignoring reaction 'EX_phe_L_exchg' since it already exists.
Ignoring reaction 'EX_pheme_exchg' since it already exists.
Ignoring reaction 'EX_pi_exchg' since it already exists.
Ignoring reaction 'EX_pime_exchg' since it already exists.
Ignoring reaction 'EX_ppa_exchg' since it already exists.
Ignoring reaction 'EX_ppi_exchg' since it already exists.
Ignoring reaction 'EX_pro_L_exchg' since it already exists.
Ignoring reaction 'EX_ptrc_exchg' since it already exists.
Ignoring reaction 'EX_pydam_exchg' since it already exists.
Ignoring reaction 'EX_pydx_exchg' since it already exists.
Ignoring reaction 'EX_pydxn_exchg' since it already exists.
Ignoring reaction 'EX_pyr_exchg' since it already exists.
```

```
Ignoring reaction 'EX_rib_D_exchg' since it already exists.
Ignoring reaction 'EX_salcn_exchg' since it already exists.
Ignoring reaction 'EX_sbt_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_D_exchg' since it already exists.
Ignoring reaction 'EX_ser_L_exchg' since it already exists.
Ignoring reaction 'EX_sheme_exchg' since it already exists.
Ignoring reaction 'EX_so4_exchg' since it already exists.
Ignoring reaction 'EX_spmd_exchg' since it already exists.
Ignoring reaction 'EX_succ_exchg' since it already exists.
Ignoring reaction 'EX_sucr_exchg' since it already exists.
Ignoring reaction 'EX_sulfac_exchg' since it already exists.
Ignoring reaction 'EX_taur_exchg' since it already exists.
Ignoring reaction 'EX_thm_exchg' since it already exists.
Ignoring reaction 'EX_thr_L_exchg' since it already exists.
Ignoring reaction 'EX_tre_exchg' since it already exists.
Ignoring reaction 'EX_tyr_L_exchg' since it already exists.
Ignoring reaction 'EX_ura_exchg' since it already exists.
Ignoring reaction 'EX_val_L_exchg' since it already exists.
Ignoring reaction 'EX_zn2_exchg' since it already exists.

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 _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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
No constrained community model set yet. Using the unconstrained model instead.
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 unconstrained community model.
```

[9]: `<Model henson_community_model at 0x2079ea11400>`

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_exchg' 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 Setting the community member composition

For the bounds of the model and the normalisation to be correct, the fractions of all community members must be set (and sum up to 1.0). A quick way to do this is to set the abundance fractions equal for all community members.

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

[10]:
```
<Model henson_community_model at 0x2079ea11a60>
```

Now let us check if the biomass function was updated accordingly as well

[11]:
```
com_model_obj.community_model.reactions.get_by_id("community_biomass").reaction
```

[11]:
```
'0.058823529411764705 Achromobacter_xylosoxidans_NBRC_15126_cpd11416_Achromobact
er_xylosoxidans_NBRC_15126_exchg + 0.058823529411764705 Actinomyces_naeslundii_s
tr_Howell_279_cpd11416_Actinomyces_naeslundii_str_Howell_279_exchg +
0.058823529411764705
Burkholderia_cepacia_GG4_cpd11416_Burkholderia_cepacia_GG4_exchg +
0.058823529411764705 Escherichia_coli_str_K_12_substr_MG1655_cpd11416_Escherichi
a_coli_str_K_12_substr_MG1655_exchg + 0.058823529411764705 Fusobacterium_nucleat
um_subsp_nucleatum_ATCC_25586_cpd11416_Fusobacterium_nucleatum_subsp_nucleatum_A
TCC_25586_exchg + 0.058823529411764705
Gemella_haemolysans_ATCC_10379_cpd11416_Gemella_haemolysans_ATCC_10379_exchg +
0.058823529411764705 Granulicatella_adiacens_ATCC_49175_cpd11416_Granulicatella_
adiacens_ATCC_49175_exchg + 0.058823529411764705
Haemophilus_influenzae_R2846_cpd11416_Haemophilus_influenzae_R2846_exchg +
0.058823529411764705
Neisseria_flavescens_SK114_cpd11416_Neisseria_flavescens_SK114_exchg +
0.058823529411764705 Porphyromonas_endodontalis_ATCC_35406_cpd11416_Porphyromona
s_endodontalis_ATCC_35406_exchg + 0.058823529411764705 Prevotella_melaninogenica
_ATCC_25845_cpd11416_Prevotella_melaninogenica_ATCC_25845_exchg +
0.058823529411764705
Pseudomonas_aeruginosa_NCGM2_S1_cpd11416_Pseudomonas_aeruginosa_NCGM2_S1_exchg +
0.058823529411764705
Ralstonia_sp_5_7_47FAA_cpd11416_Ralstonia_sp_5_7_47FAA_exchg +
```

```
0.058823529411764705
Rothia_mucilaginosa_DY_18_cpd11416_Rothia_mucilaginosa_DY_18_exchg +
0.058823529411764705 Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_cpd11416_
Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_exchg + 0.058823529411764705
Streptococcus_sanguinis_SK36_cpd11416_Streptococcus_sanguinis_SK36_exchg +
0.058823529411764705 Veillonella_atypica_ACS_049_V_Sch6_cpd11416_Veillonella_aty
pica_ACS_049_V_Sch6_exchg --> cpd11416_exchg'
```

As can be seen above, the biomass function now takes an equal amount of all 17 community members, 1/17th or 0.0588...

1.1.4 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.

[12]:
```
com_model_obj.get_unbalanced_reactions()
```

[12]:
```
{<Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_5DRIB_Achromobacter_xylosoxi
dans_NBRC_15126_c at 0x207b787bfa0>: {'C': -5.0,
  'H': -10.0,
  'O': -4.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_5MTR_Achromobacter_xylosoxid
ans_NBRC_15126_c at 0x207b7876100>: {'C': -6.0,
  'H': -12.0,
  'O': -4.0,
  'S': -1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_dhptd_Achromobacter_xylosoxi
dans_NBRC_15126_c at 0x207b78766a0>: {'C': -5.0,
  'H': -8.0,
  'O': -4.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_hcys_L_Achromobacter_xylosox
idans_NBRC_15126_c at 0x207b7876760>: {'C': -4.0,
  'H': -9.0,
  'N': -1.0,
  'O': -2.0,
  'S': -1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_EX_biomass_e_Achromobacter_xylo
soxidans_NBRC_15126_c at 0x207b9b99ac0>: {'X': -1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_dreplication_Achromobacter_xylo
soxidans_NBRC_15126_c at 0x207baa4c6d0>: {'X': 1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_pbiosynthesis_Achromobacter_xyl
osoxidans_NBRC_15126_c at 0x207baa4cb20>: {'X': 1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_rtranscription_Achromobacter_xy
losoxidans_NBRC_15126_c at 0x207baa619a0>: {'X': 1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_biomass489 at 0x207baa61b50>:
{'charge': 0.8556250000000518,
```

```
  'C': -39.34040300000007,
  'H': -62.7781865000005,
  'N': -8.576429499999936,
  'O': -14.310783000000422,
  'P': -0.8120575000000315,
  '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 Actinomyces_naeslundii_str_Howell_279_DM_5MTR_Actinomyces_naeslundii_
str_Howell_279_c at 0x207bab56e20>: {'C': -6.0,
  'H': -12.0,
  'O': -4.0,
  'S': -1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_DM_HQN_Actinomyces_naeslundii_s
tr_Howell_279_c at 0x207bab56ee0>: {'C': -6.0,
  'H': -6.0,
  'O': -2.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_DM_dhptd_Actinomyces_naeslundii
_str_Howell_279_c at 0x207bab56eb0>: {'C': -5.0,
  'H': -8.0,
  'O': -4.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_DM_hcys_L_Actinomyces_naeslundi
i_str_Howell_279_c at 0x207bab56fa0>: {'C': -4.0,
  'H': -9.0,
  'N': -1.0,
  'O': -2.0,
  'S': -1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_EX_biomass_e_Actinomyces_naeslu
ndii_str_Howell_279_c at 0x207bab77dc0>: {'X': -1.0},
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tr_Howell_279_c at 0x207bad01c70>: {'C': -286.0,
  'H': -477.0,
  'N': -47.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_TECAGE_Actinomyces_naeslundii_s
tr_Howell_279_c at 0x207bad01e20>: {'charge': 45.0,
  'C': -421.0,
  'H': -747.0,
```

```
  'N': -2.0,
  'O': -463.0,
  'P': -46.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_TECAUE_Actinomyces_naeslundii_s
tr_Howell_279_c at 0x207bad01fd0>: {'charge': 45.0,
  'C': -151.0,
  'H': -297.0,
  'N': -2.0,
  'O': -238.0,
  'P': -46.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_TEICH45_Actinomyces_naeslundii_
str_Howell_279_c at 0x207bad01400>: {'charge': 45.0,
  'C': -630.0,
  'H': -945.0,
  'N': -45.0,
  'O': -630.0,
  'P': -45.0,
  'X': 1.0},
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ndii_str_Howell_279_c at 0x207bad2f8e0>: {'X': 1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_pbiosynthesis_Actinomyces_naesl
undii_str_Howell_279_c at 0x207bad2fc10>: {'X': 1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_rtranscription_Actinomyces_naes
lundii_str_Howell_279_c at 0x207bad43610>: {'X': 1.0},
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{'charge': 0.8556250000000518,
  'C': -39.34030000000005,
  'H': -62.77808350000042,
  'N': -8.57653249999996,
  'O': -14.310783000000422,
  'P': -0.8120575000000315,
  '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},
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0x207baebd640>: {'C': -7.0,
  'H': -8.0,
  'O': -2.0},
 <Reaction Burkholderia_cepacia_GG4_DM_4HBA_Burkholderia_cepacia_GG4_c at
```

```
0x207baebd580>: {'C': -7.0,
  'H': -8.0,
  'O': -2.0},
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0x207baebdfd0>: {'C': -5.0,
  'H': -10.0,
  'O': -4.0},
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  'H': -12.0,
  'O': -4.0,
  'S': -1.0},
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  'O': -2.0},
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  'H': -13.0,
  'N': -5.0,
  'O': -3.0},
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  'H': -8.0,
  'O': -4.0},
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  'H': -9.0,
  'N': -1.0,
  'O': -2.0,
  'S': -1.0},
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0x207baefb850>: {'X': -1.0},
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0x207bb1447f0>: {'charge': -2.0},
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 <Reaction Burkholderia_cepacia_GG4_pbiosynthesis_Burkholderia_cepacia_GG4_c at
0x207bb1a1730>: {'X': 1.0},
 <Reaction Burkholderia_cepacia_GG4_rtranscription_Burkholderia_cepacia_GG4_c at
0x207bb1be820>: {'X': 1.0},
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  'C': -39.340694000000134,
  'H': -62.778482500000436,
  'N': -8.576165499999949,
  'O': -14.310809000000356,
```

```
  'P': -0.8120635000000164,
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  '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},
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  'H': -8.0,
  'O': -2.0},
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at 0x207bbc193a0>: {'C': -6.0,
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at 0x207bbc19370>: {'C': -5.0,
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ATCC_49175_c at 0x207bbc195b0>: {'C': -4.0,
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hylococcus_aureus_subsp_aureus_USA300_FPR3757_c at 0x207bd34ad00>: {'X': 1.0},
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coccus_aureus_subsp_aureus_USA300_FPR3757_c at 0x207bd34adc0>: {'X': -1.0},
```

<Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_biomass042 at
0x207bd34afa0>: {'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
0x207bd41ec70>: {'C': -7.0,
'H': -8.0,
'O': -2.0},
<Reaction Streptococcus_sanguinis_SK36_DM_5MTR_Streptococcus_sanguinis_SK36_c
at 0x207bd41e1f0>: {'C': -6.0,
'H': -12.0,
'O': -4.0,
'S': -1.0},
<Reaction Streptococcus_sanguinis_SK36_DM_HQN_Streptococcus_sanguinis_SK36_c at
0x207bd41ec40>: {'C': -6.0,
'H': -6.0,
'O': -2.0},
<Reaction Streptococcus_sanguinis_SK36_DM_dhptd_Streptococcus_sanguinis_SK36_c
at 0x207bd41ef10>: {'C': -5.0,
'H': -8.0,
'O': -4.0},
<Reaction Streptococcus_sanguinis_SK36_DM_hcys_L_Streptococcus_sanguinis_SK36_c
at 0x207bd41efa0>: {'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
0x207bd4372e0>: {'X': -1.0},
<Reaction Streptococcus_sanguinis_SK36_SHCHCC2_Streptococcus_sanguinis_SK36_c
at 0x207bd6eb2e0>: {'charge': -2.0},

<Reaction Streptococcus_sanguinis_SK36_TECA4S_Streptococcus_sanguinis_SK36_c at
0x207bd6f9f40>: {'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
0x207bd702a30>: {'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
0x207bd702af0>: {'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
0x207bd702bb0>: {'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
0x207bd72ed60>: {'X': 1.0},
<Reaction
Streptococcus_sanguinis_SK36_pbiosynthesis_Streptococcus_sanguinis_SK36_c at
0x207bd72e220>: {'X': 1.0},
<Reaction
Streptococcus_sanguinis_SK36_rtranscription_Streptococcus_sanguinis_SK36_c at
0x207bd746fd0>: {'X': 1.0},
<Reaction
Streptococcus_sanguinis_SK36_sink_PGPm1_Streptococcus_sanguinis_SK36_c at
0x207bd746f10>: {'X': -1.0},
<Reaction Streptococcus_sanguinis_SK36_biomass164 at 0x207bd74c340>: {'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 0x207bd7ef9a0>: {'charge': 2.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_DM_dhptd_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x207bd7f6eb0>: {'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 0x207bd7f6340>: {'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 0x207bd80dc10>: {'X': -1.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_SHCHCC2_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x207bd9424f0>: {'charge': -2.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECA4S_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x207bd957610>: {'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 0x207bd957d90>: {'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 0x207bd957e50>: {'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 0x207bd957f10>: {'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 0x207bd978b50>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_pbiosynthesis_Veillonella_atypica_
ACS_049_V_Sch6_c at 0x207bd978c10>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_rtranscription_Veillonella_atypica
_ACS_049_V_Sch6_c at 0x207bd98fc40>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_sink_PGPm1_Veillonella_atypica_ACS
_049_V_Sch6_c at 0x207bd98fdf0>: {'X': -1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_biomass116 at 0x207bd98feb0>:
{'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}}
```

1.2 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:

[13]:
```
com_model_obj.save("../data/toy/output/henson_com_model.xml")
```

[14]:
```
com_model_obj_loaded = pycomo.CommunityModel.load("../data/toy/output/
↪henson_com_model.xml")
```

[15]:
```
com_model_obj_loaded.community_model.summary()
```

[15]:
```
<cobra.summary.model_summary.ModelSummary at 0x2083ddfc4f0>
```

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.

[16]:
```
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'.
```

[17]:
```
named_models
```

[17]:
```
{'dv': <Model CNA_DV at 0x208408cf8b0>,
 'mb': <Model CNA_MB at 0x20840929ca0>,
 'mh': <Model CNA_MM at 0x20842866f40>}
```

[18]:
```
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.

[19]:
```
medium = {
    'EX_CO2_EX_exchg': 1000.0,
    'EX_Eth_EX_exchg': 1000.0,
    'EX_BM_tot_exchg': 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.community_model.reactions.get_by_id("EX_Form_EX_exchg").
 ↪upper_bound = 0.
com_model_obj.community_model.reactions.get_by_id("EX_H2_EX_exchg").upper_bound␣
 ↪= 0.
```

```
No constrained community model set yet. Using the unconstrained model instead.
No unconstrained community model generated yet. Generating now:

Ignoring reaction 'EX_H2_EX_exchg' since it already exists.
Ignoring reaction 'EX_CO2_EX_exchg' since it already exists.
Ignoring reaction 'EX_Ac_EX_exchg' since it already exists.

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!
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!

Ignoring reaction 'EX_H2_EX_exchg' since it already exists.
Ignoring reaction 'EX_CO2_EX_exchg' since it already exists.
Ignoring reaction 'EX_CH4_EX_exchg' since it already exists.
Ignoring reaction 'EX_Form_EX_exchg' since it already exists.
Ignoring reaction 'EX_BM_tot_exchg' 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 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 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 H2_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
No constrained community model set yet. Using the unconstrained model instead.
Generated unconstrained 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.

[20]:
```
com_model_obj.potential_metabolite_exchanges()
```

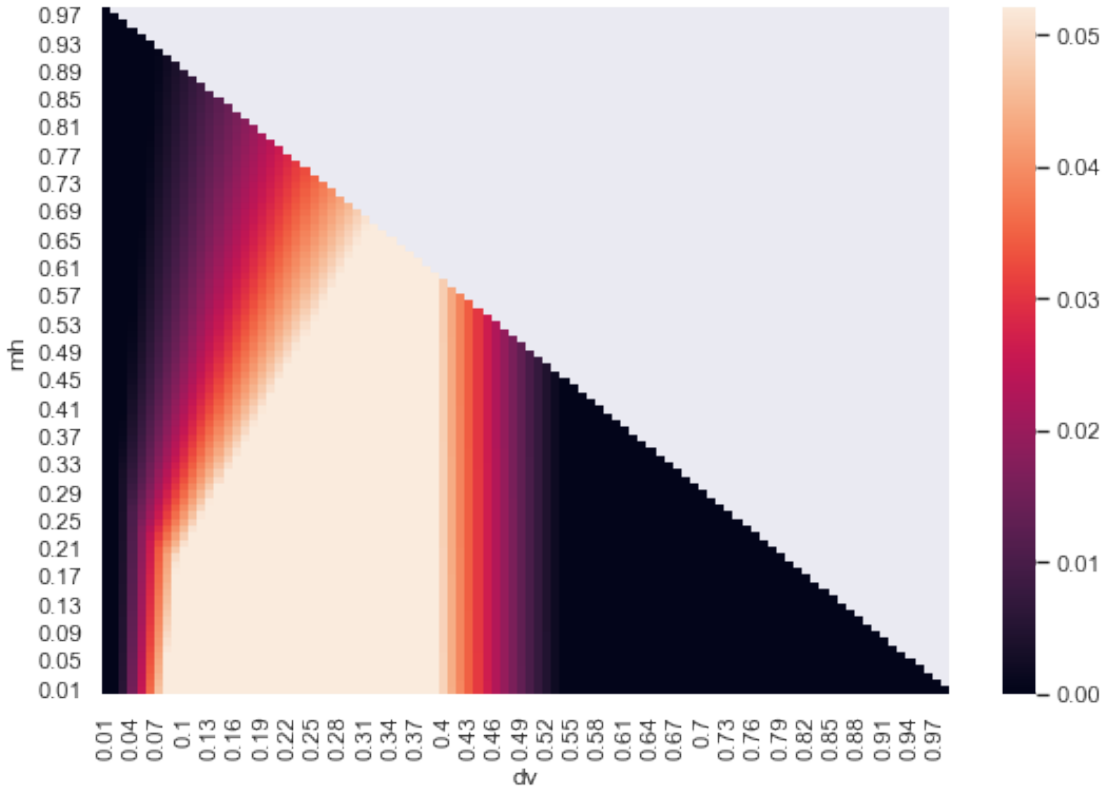
[20]:

	metabolite_id	metabolite_name	cross_feeding	produced_by	consumed_by
0	H2_EX_exchg	H2_external	True	[dv, mh]	[dv, mb, mh]
1	Ac_EX_exchg	acetate_external	True	[dv]	[mb]
2	CO2_EX_exchg	CO2_external	True	[mb, mh]	[dv, mb, mh]
3	Form_EX_exchg	formate_external	True	[dv]	[mh]
4	SO4_EX_exchg	sulfate_external	False	[]	[]
5	H2S_EX_exchg	hydrogensulfide_external	False	[]	[]
6	Eth_EX_exchg	ethanol_external	False	[]	[dv]
7	Lac_EX_exchg	lactate_external	False	[]	[]
8	Pyr_EX_exchg	pyruvate_external	False	[]	[]
9	CH4_EX_exchg	nethane_external	False	[mb, mh]	[]
10	MetOH_EX_exchg	nethanol_external	False	[]	[]
11	BM_tot_exchg	total_biomass	False	[]	[]
12	cpd11416_exchg	Community Biomass	False	[]	[]

1.3.2 Plotting the maxiumum growth rate over the composition space

[ ]:
```
import pandas as pd

# Iterate over the fractions in steps of 0.01
rows = []
for i in range (1,100,1):  # fraction of D. vulgaris
    for j in range (1, 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_abundance(abundances)

        # Reapply the bound restrictions of the exchange reactions
        com_model_obj.community_model.reactions.get_by_id("EX_Form_EX_exchg").
 ↪upper_bound = 0.
        com_model_obj.community_model.reactions.get_by_id("EX_H2_EX_exchg").
 ↪upper_bound = 0.

        # Calculate the optimal growth rate
        solution = com_model_obj.community_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)
```

[23]:
```
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()
```


mh
0.97
0.93
0.89
0.85
0.81
0.77
0.73
0.69
0.65
0.61
0.57
0.53
0.49
0.45
0.41
0.37
0.33
0.29
0.25
0.21
0.17
0.13
0.09
0.05
0.01
dv
0.01
0.04
0.07
0.1
0.13
0.16
0.19
0.22
0.25
0.28
0.31
0.34
0.37
0.4
0.43
0.46
0.49
0.52
0.55
0.58
0.61
0.64
0.67
0.7
0.73
0.76
0.79
0.82
0.85
0.88
0.91
0.94
0.97
0.05
0.04
0.03
0.02
0.01
0.00

[ ]: