PyCoMo_basics

August 7, 2023

1 PyCoMo Basics

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

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

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

1.0.1 Importing PyCoMo

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

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

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

```
[3]: #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 0x1d37c4ea370>,
      'Actinomyces_naeslundii_str_Howell_279': <Model
     Actinomyces_naeslundii_str_Howell_279 at 0x1d305463d60>,
      'Burkholderia_cepacia_GG4': <Model Burkholderia_cepacia_GG4 at 0x1d306ba0c40>,
      'Escherichia_coli_str_K_12_substr_MG1655': <Model
     Escherichia_coli_str_K_12_substr_MG1655 at 0x1d307a8a2e0>,
      'Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586': <Model
     Fusobacterium_nucleatum_subsp_nucleatum_ATCC_25586 at 0x1d30988d760>,
      'Gemella_haemolysans_ATCC_10379': <Model Gemella_haemolysans_ATCC_10379 at
     0x1d309ce47c0>,
      'Granulicatella_adiacens_ATCC_49175': <Model Granulicatella_adiacens_ATCC_49175
     at 0x1d30a340460>,
      'Haemophilus_influenzae_R2846': <Model Haemophilus_influenzae_R2846 at
     0x1d309b374c0>,
      'Neisseria_flavescens_SK114': <Model Neisseria_flavescens_SK114 at
     0x1d30b26e670>,
      'Porphyromonas_endodontalis_ATCC_35406': <Model
     Porphyromonas_endodontalis_ATCC_35406 at 0x1d30b9286a0>,
      'Prevotella_melaninogenica_ATCC_25845': <Model
     Prevotella_melaninogenica_ATCC_25845 at 0x1d30bf9a1c0>,
      'Pseudomonas_aeruginosa_NCGM2_S1': <Model Pseudomonas_aeruginosa_NCGM2_S1 at
     0x1d30c68e790>,
      'Ralstonia_sp_5_7_47FAA': <Model Ralstonia_sp_5_7_47FAA at 0x1d30d3b29a0>,
      'Rothia_mucilaginosa_DY_18': <Model Rothia_mucilaginosa_DY_18 at
     0x1d30ddcb760>,
      'Staphylococcus_aureus_subsp_aureus_USA300_FPR3757': <Model
     Staphylococcus_aureus_subsp_aureus_USA300_FPR3757 at 0x1d30e307670>,
      'Streptococcus_sanguinis_SK36': <Model Streptococcus_sanguinis_SK36 at
     0x1d30ed77be0>,
      'Veillonella_atypica_ACS_049_V_Sch6': <Model Veillonella_atypica_ACS_049_V_Sch6
     at 0x1d30f416730>}
```

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.
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 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 _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
```

in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
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 metsox_R_L. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
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WARNING: no annotation overlap found for matching metabolite 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 glycys. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 met_D. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
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WARNING: no annotation overlap found for matching metabolite 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 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 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 pb. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
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in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make
sure that the metabolite with this ID is indeed representing the same substance
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WARNING: no annotation overlap found for matching metabolite h2s. Please make
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WARNING: no annotation overlap found for matching metabolite mso3. Please make
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WARNING: no annotation overlap found for matching metabolite mops. Please make
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WARNING: no annotation overlap found for matching metabolite mnl. Please make
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WARNING: no annotation overlap found for matching metabolite glytyr. Please make
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WARNING: no annotation overlap found for matching metabolite glyglu. Please make
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WARNING: no annotation overlap found for matching metabolite ethso3. Please make
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WARNING: no annotation overlap found for matching metabolite alagln. Please make
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WARNING: no annotation overlap found for matching metabolite sulfac. Please make
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WARNING: no annotation overlap found for matching metabolite butso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
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 alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance

in all models!

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.
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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.
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Ignoring reaction 'EX_gln_L_exchg' since it already exists.
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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.
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Ignoring reaction 'EX_pydam_exchg' since it already exists.
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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.
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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.
```

Note: no products in the objective function, adding biomass to it.
WARNING: no annotation overlap found for matching metabolite alagly. Please make
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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 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 glytyr. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
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WARNING: no annotation overlap found for matching metabolite 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 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 _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 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 cobalt2. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
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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.
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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.
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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.
```

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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.
```

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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.
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 tmao. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite tma. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _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 _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 _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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

Ignoring reaction 'EX__12ppd_S_exchg' since it already exists.
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.
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 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 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 _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 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 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 _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 glycys. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 alaleu. 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__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.
```

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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.
```

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

WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 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 mg2. 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__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.
```

Note: no products in the objective function, adding biomass to it.
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 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 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 _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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _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 glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 _12dgr180. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 mg2. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!

Ignoring reaction 'EX__12dgr180_exchg' since it already exists.

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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.
```

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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.
```

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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.

Note: no products in the objective function, adding biomass to it.
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 tmao. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite tma. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 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 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 mg2. 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.

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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.
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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.
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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.
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 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 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 _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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 n2. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make sure that the metabolite with this ID is indeed representing the same substance in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 _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 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 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 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 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 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 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 alaleu. 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__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.

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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.
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.

Note: no products in the objective function, adding biomass to it.
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 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 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 _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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 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 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 mg2. 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__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.

Note: no products in the objective function, adding biomass to it.
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 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 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 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 _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 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 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 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 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 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 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 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 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 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 _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 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 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 mg2. 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__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.
```

Note: no products in the objective function, adding biomass to it.
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 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 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 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 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 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 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 _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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite _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 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 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 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 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 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 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 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 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 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 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 n2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alathr. Please make

sure that the metabolite with this ID is indeed representing the same substance in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 alaleu. 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__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.
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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.
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Ignoring reaction 'EX_fe2_exchg' since it already exists.
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Ignoring reaction 'EX_fru_exchg' since it already exists.
Ignoring reaction 'EX_fum_exchg' since it already exists.
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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.
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Ignoring reaction 'EX_mops_exchg' since it already exists.
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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.
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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.
```

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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.
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Ignoring reaction 'EX_val_L_exchg' since it already exists.
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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 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 metsox_S_L. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
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```

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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 glymet. 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 no3. Please make
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WARNING: no annotation overlap found for matching metabolite alathr. Please make
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WARNING: no annotation overlap found for matching metabolite aso3. Please make
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WARNING: no annotation overlap found for matching metabolite cellb. Please make
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WARNING: no annotation overlap found for matching metabolite glyglu. Please make
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WARNING: no annotation overlap found for matching metabolite aso4. Please make
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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 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 ethso3. Please make
sure that the metabolite with this ID is indeed representing the same substance
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WARNING: no annotation overlap found for matching metabolite alagln. Please make
sure that the metabolite with this ID is indeed representing the same substance
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substance in all models!
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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.
```

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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.
```

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

Note: no products in the objective function, adding biomass to it.
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 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 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 _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _12dgr180. Please
make sure that the metabolite with this ID is indeed representing the same
substance in all models!
WARNING: no annotation overlap found for matching metabolite glyglu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 mg2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!

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.
```

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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.
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.
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.

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

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

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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.
```

Note: no products in the objective function, adding biomass to it.
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 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 _4abz. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite cu2. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
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 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 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 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 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 glycys. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite glyasp. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite alaleu. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 _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 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 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 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 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 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 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 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 mg2. 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__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.

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 0x1d30fcaba90>

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 Summary and report

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

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

```
[10]: <cobra.summary.model_summary.ModelSummary at 0x1d30fcab1f0>
```

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

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

```
            Haemophilus_influenzae_R2846
            Neisseria_flavescens_SK114
            Porphyromonas_endodontalis_ATCC_35406
            Prevotella_melaninogenica_ATCC_25845
            Pseudomonas_aeruginosa_NCGM2_S1
            Ralstonia_sp_5_7_47FAA
            Rothia_mucilaginosa_DY_18
            Staphylococcus_aureus_subsp_aureus_USA300_FPR3757
            Streptococcus_sanguinis_SK36
            Veillonella_atypica_ACS_049_V_Sch6
    Objective in direction max:
            1.0*community_biomass - 1.0*community_biomass_reverse_44dc1
    ------------------
    Model quality
    # Reactions unbalanced: 235
    # Reactions able to carry flux without a medium: NaN
```

[11]: {'community_name': 'henson_community_model',
    'model_structure': 'fixed growth rate',
    'num_metabolites': 51659,
    'num_f_metabolites': 31969,
    'num_model_metabolites': 19690,
    'num_reactions': 55171,
    'num_f_reactions': 31968,
    'num_model_reactions': 23203,
    'num_genes': 13885,
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     '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'],
    'num_members': 17,
    'objective_expression': 1.0*community_biomass -
    1.0*community_biomass_reverse_44dc1,
    'objective_direction': 'max',

```
'unbalanced_reactions': {<Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_5DR
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    'O': -4.0},
  <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_5MTR_Achromobacter_xylosoxi
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    'O': -4.0,
    'S': -1.0},
  <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_dhptd_Achromobacter_xylosox
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    'H': -8.0,
    'O': -4.0},
  <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_hcys_L_Achromobacter_xyloso
xidans_NBRC_15126_c at 0x1d317fe2f40>: {'C': -4.0,
    'H': -9.0,
    'N': -1.0,
    'O': -2.0,
    'S': -1.0},
  <Reaction Achromobacter_xylosoxidans_NBRC_15126_EX_biomass_e_Achromobacter_xyl
osoxidans_NBRC_15126_c at 0x1d31802dca0>: {'X': -1.0},
  <Reaction Achromobacter_xylosoxidans_NBRC_15126_dreplication_Achromobacter_xyl
osoxidans_NBRC_15126_c at 0x1d3182c4d00>: {'X': 1.0},
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losoxidans_NBRC_15126_c at 0x1d3182c42e0>: {'X': 1.0},
  <Reaction Achromobacter_xylosoxidans_NBRC_15126_rtranscription_Achromobacter_x
ylosoxidans_NBRC_15126_c at 0x1d3182d8fd0>: {'X': 1.0},
  <Reaction Achromobacter_xylosoxidans_NBRC_15126_biomass489 at 0x1d3182d8400>:
{'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 0x1d31a86bf70>: {'C': -6.0,
```

```
   'H': -12.0,
   'O': -4.0,
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   'H': -6.0,
   'O': -2.0},
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   'P': -46.0},
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```

```
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lundii_str_Howell_279_c at 0x1d31b126f40>: {'X': 1.0},
    <Reaction Actinomyces_naeslundii_str_Howell_279_rtranscription_Actinomyces_nae
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    'O': -4.0},
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    'H': -12.0,
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    'O': -2.0},
    <Reaction Burkholderia_cepacia_GG4_DM_dad_5_Burkholderia_cepacia_GG4_c at
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```

```
    'H': -13.0,
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    'Mg': -0.0030965,
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    'Zn': -0.0030965},
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  <Reaction Escherichia_coli_str_K_12_substr_MG1655_DM_4HBA_Escherichia_coli_str
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    'H': -8.0,
    'O': -2.0},
```

```
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    'N': -5.0,
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    'S': -1.0},
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K_12_substr_MG1655_c at 0x1d320f1bf10>: {'C': -6.0,
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    'O': -2.0},
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    'O': -3.0,
    'S': -1.0},
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    'P': -2.0},
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    'H': -140.0,
    'O': -17.0,
    'P': -2.0},
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    'H': -156.0,
    'O': -17.0,
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rium_nucleatum_subsp_nucleatum_ATCC_25586_c at 0x1d323c3aeb0>: {'C': -6.0,
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0x1d324057fd0>: {'H': 3.552713678800501e-15},
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Gemella_haemolysans_ATCC_10379_EX_biomass_e_Gemella_haemolysans_ATCC_10379_c at
0x1d325738640>: {'X': -1.0},
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Gemella_haemolysans_ATCC_10379_TECA4S_Gemella_haemolysans_ATCC_10379_c at
0x1d325c96f10>: {'charge': -30.0,
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Gemella_haemolysans_ATCC_10379_TECAAE_Gemella_haemolysans_ATCC_10379_c at
0x1d325caf700>: {'C': -286.0,
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0x1d31c5a19d0>: {'X': 1.0},
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at 0x1d31e1b16a0>: {'X': 1.0},
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Gemella_haemolysans_ATCC_10379_sink_PGPm1_Gemella_haemolysans_ATCC_10379_c at
0x1d31d5c31c0>: {'X': -1.0},
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{'charge': -81.86880319999989,
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at 0x1d32756cf40>: {'C': -6.0,
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Granulicatella_adiacens_ATCC_49175_DM_dhptd_Granulicatella_adiacens_ATCC_49175_c
at 0x1d32757b520>: {'C': -5.0,
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  'X': 1.0},
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at 0x1d327b76c10>: {'C': -286.0,
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Granulicatella_adiacens_ATCC_49175_TECAUE_Granulicatella_adiacens_ATCC_49175_c
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cens_ATCC_49175_c at 0x1d327bdfe50>: {'X': 1.0},
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acens_ATCC_49175_c at 0x1d327c54fd0>: {'X': 1.0},
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s_ATCC_49175_c at 0x1d327c548e0>: {'X': -1.0},
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at 0x1d329693700>: {'charge': 2.0},
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at 0x1d3296bff10>: {'C': -6.0,
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at 0x1d3296bff40>: {'C': -5.0,
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0x1d3296d3400>: {'C': -4.0,
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0x1d32ba0b730>: {'C': -6.0,
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at 0x1d32ba9d610>: {'X': -1.0},
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at 0x1d32c21df40>: {'X': 1.0},
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0x1d32c244640>: {'X': 1.0},
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ica_ATCC_25845_c at 0x1d33001cfa0>: {'C': -5.0,
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0x1d332536e50>: {'charge': 1.0,
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    'P': -2.0},
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at 0x1d33254a880>: {'charge': 6.0,
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    'Zn': -0.0030965},
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0x1d334bfb790>: {'charge': 1.0,
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    'S': -1.0},
  <Reaction Ralstonia_sp_5_7_47FAA_DM_Ralstonia_sp_5_7_47FAA_clpn140_Ralstonia_s
p_5_7_47FAA_c at 0x1d334bfb850>: {'charge': 2.0,
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    'O': -17.0,
    'P': -2.0},
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p_5_7_47FAA_c at 0x1d334bfb910>: {'charge': 2.0,
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p_5_7_47FAA_c at 0x1d334bfba90>: {'charge': 2.0,
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    'P': -2.0},
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0x1d334bfbc10>: {'charge': 6.0,
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    'N': -2.0,
    'O': -38.0,
    'P': -2.0},
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0x1d3358079a0>: {'S': -1.0},
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0x1d337b02ca0>: {'C': -6.0,
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at 0x1d337b44f40>: {'X': -1.0},
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at 0x1d33819ad90>: {'X': 1.0},
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at 0x1d33819adf0>: {'X': 1.0},
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at 0x1d3381cffd0>: {'X': 1.0},
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    'O': -4.0},
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    'O': -2.0,
    'S': -1.0},
  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_EX_biomass_e_Staph
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  <Reaction Staphylococcus_aureus_subsp_aureus_USA300_FPR3757_TECA4S_Staphylococ
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  <Reaction Streptococcus_sanguinis_SK36_DM_5MTR_Streptococcus_sanguinis_SK36_c
at 0x1d33c5713d0>: {'C': -6.0,
    'H': -12.0,
    'O': -4.0,
    'S': -1.0},
  <Reaction Streptococcus_sanguinis_SK36_DM_HQN_Streptococcus_sanguinis_SK36_c
at 0x1d33c571490>: {'C': -6.0,
    'H': -6.0,
    'O': -2.0},
  <Reaction Streptococcus_sanguinis_SK36_DM_dhptd_Streptococcus_sanguinis_SK36_c
at 0x1d33c571640>: {'C': -5.0,
    'H': -8.0,
    'O': -4.0},
  <Reaction
Streptococcus_sanguinis_SK36_DM_hcys_L_Streptococcus_sanguinis_SK36_c at
0x1d33c571700>: {'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
0x1d33c5cd7c0>: {'X': -1.0},
  <Reaction Streptococcus_sanguinis_SK36_SHCHCC2_Streptococcus_sanguinis_SK36_c
at 0x1d33e46cbb0>: {'charge': -2.0},
  <Reaction Streptococcus_sanguinis_SK36_TECA4S_Streptococcus_sanguinis_SK36_c
at 0x1d33e4c24c0>: {'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 0x1d33e4aafa0>: {'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 0x1d33e4dc370>: {'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 0x1d33e4dc4c0>: {'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
0x1d33e572f10>: {'X': 1.0},
  <Reaction
Streptococcus_sanguinis_SK36_pbiosynthesis_Streptococcus_sanguinis_SK36_c at
0x1d33e572f70>: {'X': 1.0},
  <Reaction
Streptococcus_sanguinis_SK36_rtranscription_Streptococcus_sanguinis_SK36_c at
0x1d33e5d8b20>: {'X': 1.0},
  <Reaction
Streptococcus_sanguinis_SK36_sink_PGPm1_Streptococcus_sanguinis_SK36_c at
0x1d33e5d8d30>: {'X': -1.0},
  <Reaction Streptococcus_sanguinis_SK36_biomass164 at 0x1d33e5d8dc0>:
{'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 0x1d33fc37e50>: {'charge': 2.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_DM_dhptd_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x1d33fc59df0>: {'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 0x1d33fc47df0>: {'C': -4.0,
    'H': -9.0,
    'N': -1.0,
    'O': -2.0,
    'S': -1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_EX_biomass_e_Veillonella_atypica_
ACS_049_V_Sch6_c at 0x1d33fcaddc0>: {'X': -1.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_SHCHCC2_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x1d3402ea490>: {'charge': -2.0},
  <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECA4S_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x1d34033a9d0>: {'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 0x1d340355850>: {'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 0x1d3403559a0>: {'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 0x1d340355af0>: {'charge': 45.0,
    'C': -151.0,
    'H': -297.0,
    'N': -2.0,

```
    'O': -238.0,
    'P': -46.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_dreplication_Veillonella_atypica_
ACS_049_V_Sch6_c at 0x1d3403d9a90>: {'X': 1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_pbiosynthesis_Veillonella_atypica
_ACS_049_V_Sch6_c at 0x1d3403d9cd0>: {'X': 1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_rtranscription_Veillonella_atypic
a_ACS_049_V_Sch6_c at 0x1d340429ee0>: {'X': 1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_sink_PGPm1_Veillonella_atypica_AC
S_049_V_Sch6_c at 0x1d340429fa0>: {'X': -1.0},
  <Reaction Veillonella_atypica_ACS_049_V_Sch6_biomass116 at 0x1d34043b9a0>:
{'charge': -81.86882719999988,
    'C': -35.036401200000036,
    'H': 26.148670400000327,
    'N': -7.353019799999996,
    'O': 68.9789142999997,
    'P': -0.9387217000000568,
    'S': -0.21809219999999996,
    'X': -2.0018063,
    'Co': -0.0079397,
    'Ca': -0.0079397,
    'Cl': -0.0079397,
    'Cu': -0.0079397,
    'Fe': -0.0317588,
    'K': -0.0079397,
    'Mg': -0.0079397,
    'Mn': -0.0079397,
    'Zn': -0.0079397}},
 'num_unbalanced_reactions': 235,
 'reactions_in_loops': 'NaN',
 'num_loop_reactions': 'NaN'}
```

1.1.4 Setting the growth rate

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

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

[12]: <cobra.summary.model_summary.ModelSummary at 0x1d30fcab9d0>

1.1.5 Setting the community member composition

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

abundances.

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

```
[13]: <cobra.summary.model_summary.ModelSummary at 0x1d35c60ca30>
```

1.2 Saving and loading community models

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

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

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

```
[16]: com_model_obj_loaded
```

```
[16]: <pycomo.CommunityModel at 0x1d361c995b0>
```

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

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

```
[17]: <Solution 43.848 at 0x1d443291760>
```

1.2.1 Quality Checks

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

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

```
[18]: {<Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_5DRIB_Achromobacter_xylosoxi
      dans_NBRC_15126_c at 0x1d317fe2d60>: {'C': -5.0,
        'H': -10.0,
        'O': -4.0},
       <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_5MTR_Achromobacter_xylosoxid
      ans_NBRC_15126_c at 0x1d317fe2e80>: {'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 0x1d317fe2e50>: {'C': -5.0,
  'H': -8.0,
  'O': -4.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_DM_hcys_L_Achromobacter_xylosox
idans_NBRC_15126_c at 0x1d317fe2f40>: {'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 0x1d31802dca0>: {'X': -1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_dreplication_Achromobacter_xylo
soxidans_NBRC_15126_c at 0x1d3182c4d00>: {'X': 1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_pbiosynthesis_Achromobacter_xyl
osoxidans_NBRC_15126_c at 0x1d3182c42e0>: {'X': 1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_rtranscription_Achromobacter_xy
losoxidans_NBRC_15126_c at 0x1d3182d8fd0>: {'X': 1.0},
 <Reaction Achromobacter_xylosoxidans_NBRC_15126_biomass489 at 0x1d3182d8400>:
{'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 0x1d31a86bf70>: {'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 0x1d31a86bee0>: {'C': -6.0,
  'H': -6.0,
  'O': -2.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_DM_dhptd_Actinomyces_naeslundii
_str_Howell_279_c at 0x1d31a881430>: {'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 0x1d31a8814f0>: {'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 0x1d31a90e850>: {'X': -1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_TECAAE_Actinomyces_naeslundii_s
tr_Howell_279_c at 0x1d31b07d850>: {'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 0x1d31b0579d0>: {'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 0x1d31b07de80>: {'charge': 45.0,
  'C': -151.0,
  'H': -297.0,
  'N': -2.0,
  'O': -238.0,
  'P': -46.0},
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str_Howell_279_c at 0x1d31b07dee0>: {'charge': 45.0,
  'C': -630.0,
  'H': -945.0,
  'N': -45.0,
  'O': -630.0,
  'P': -45.0,
  'X': 1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_dreplication_Actinomyces_naeslu
ndii_str_Howell_279_c at 0x1d31b126f70>: {'X': 1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_pbiosynthesis_Actinomyces_naesl
undii_str_Howell_279_c at 0x1d31b126f40>: {'X': 1.0},
 <Reaction Actinomyces_naeslundii_str_Howell_279_rtranscription_Actinomyces_naes
lundii_str_Howell_279_c at 0x1d31b186f10>: {'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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0x1d31d42eb80>: {'C': -7.0,
  'H': -8.0,
  'O': -2.0},
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0x1d31d42ecd0>: {'C': -7.0,
  'H': -8.0,
  'O': -2.0},
 <Reaction Burkholderia_cepacia_GG4_DM_5DRIB_Burkholderia_cepacia_GG4_c at
0x1d31d42ee50>: {'C': -5.0,
  'H': -10.0,
  'O': -4.0},
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0x1d31d42ef40>: {'C': -6.0,
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  'O': -4.0,
  'S': -1.0},
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0x1d31d42ef10>: {'C': -2.0,
  'H': -4.0,
  'O': -2.0},
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0x1d31d4431f0>: {'C': -10.0,
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  'N': -5.0,
  'O': -3.0},
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  'H': -8.0,
  'O': -4.0},
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0x1d31d443370>: {'C': -4.0,

```
  'H': -9.0,
  'N': -1.0,
  'O': -2.0,
  'S': -1.0},
 <Reaction Burkholderia_cepacia_GG4_EX_biomass_e_Burkholderia_cepacia_GG4_c at
0x1d31d4fff10>: {'X': -1.0},
 <Reaction Burkholderia_cepacia_GG4_SHCHCC2_Burkholderia_cepacia_GG4_c at
0x1d31df53910>: {'charge': -2.0},
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0x1d31e095f70>: {'X': 1.0},
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0x1d31e0bb610>: {'X': 1.0},
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0x1d31e12b550>: {'X': 1.0},
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  'H': -62.778482500000436,
  'N': -8.576165499999949,
  'O': -14.310809000000356,
  'P': -0.8120635000000164,
  '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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K_12_substr_MG1655_c at 0x1d320ee9bb0>: {'charge': 2.0},
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K_12_substr_MG1655_c at 0x1d320f31b50>: {'C': -7.0,
  'H': -8.0,
  'O': -2.0},
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  'O': -4.0},
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K_12_substr_MG1655_c at 0x1d320f31ac0>: {'C': -15.0,
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  'N': -5.0,
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```

```
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  'H': -6.0,
  'O': -2.0},
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_12_substr_MG1655_c at 0x1d320f41340>: {'charge': 1.0,
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  'H': -15.0,
  'N': -2.0,
  'O': -3.0,
  'S': -1.0},
 <Reaction Escherichia_coli_str_K_12_substr_MG1655_DM_Escherichia_coli_str_K_12_
substr_MG1655_clpn140_Escherichia_coli_str_K_12_substr_MG1655_c at
0x1d320f41400>: {'charge': 2.0,
  'C': -65.0,
  'H': -124.0,
  'O': -17.0,
  'P': -2.0},
 <Reaction Escherichia_coli_str_K_12_substr_MG1655_DM_Escherichia_coli_str_K_12_
substr_MG1655_clpn160_Escherichia_coli_str_K_12_substr_MG1655_c at
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  'C': -73.0,
  'H': -140.0,
  'O': -17.0,
  'P': -2.0},
 <Reaction Escherichia_coli_str_K_12_substr_MG1655_DM_Escherichia_coli_str_K_12_
substr_MG1655_clpn180_Escherichia_coli_str_K_12_substr_MG1655_c at
0x1d320f41580>: {'charge': 2.0,
  'C': -81.0,
  'H': -156.0,
  'O': -17.0,
  'P': -2.0},
 <Reaction Escherichia_coli_str_K_12_substr_MG1655_DM_Escherichia_coli_str_K_12_
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0x1d320f41640>: {'charge': 2.0,
  'C': -73.0,
  'H': -140.0,
  'O': -17.0,
  'P': -2.0},
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128

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at 0x1d3331f8520>: {'X': 1.0},
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_5_7_47FAA_c at 0x1d334bfb850>: {'charge': 2.0,
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at 0x1d33819adf0>: {'X': 1.0},
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 'S': -1.0},
<Reaction
Streptococcus_sanguinis_SK36_EX_biomass_e_Streptococcus_sanguinis_SK36_c at
0x1d33c5cd7c0>: {'X': -1.0},
<Reaction Streptococcus_sanguinis_SK36_SHCHCC2_Streptococcus_sanguinis_SK36_c
at 0x1d33e46cbb0>: {'charge': -2.0},
<Reaction Streptococcus_sanguinis_SK36_TECA4S_Streptococcus_sanguinis_SK36_c at
0x1d33e4c24c0>: {'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
0x1d33e4aafa0>: {'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
0x1d33e4dc370>: {'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
0x1d33e4dc4c0>: {'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
0x1d33e572f10>: {'X': 1.0},
 <Reaction
Streptococcus_sanguinis_SK36_pbiosynthesis_Streptococcus_sanguinis_SK36_c at
0x1d33e572f70>: {'X': 1.0},
 <Reaction
Streptococcus_sanguinis_SK36_rtranscription_Streptococcus_sanguinis_SK36_c at
0x1d33e5d8b20>: {'X': 1.0},
 <Reaction
Streptococcus_sanguinis_SK36_sink_PGPm1_Streptococcus_sanguinis_SK36_c at
0x1d33e5d8d30>: {'X': -1.0},
 <Reaction Streptococcus_sanguinis_SK36_biomass164 at 0x1d33e5d8dc0>: {'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 0x1d33fc37e50>: {'charge': 2.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_DM_dhptd_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x1d33fc59df0>: {'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 0x1d33fc47df0>: {'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 0x1d33fcaddc0>: {'X': -1.0},
```

```
<Reaction
Veillonella_atypica_ACS_049_V_Sch6_SHCHCC2_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x1d3402ea490>: {'charge': -2.0},
 <Reaction
Veillonella_atypica_ACS_049_V_Sch6_TECA4S_Veillonella_atypica_ACS_049_V_Sch6_c
at 0x1d34033a9d0>: {'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 0x1d340355850>: {'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 0x1d3403559a0>: {'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 0x1d340355af0>: {'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 0x1d3403d9a90>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_pbiosynthesis_Veillonella_atypica_
ACS_049_V_Sch6_c at 0x1d3403d9cd0>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_rtranscription_Veillonella_atypica
_ACS_049_V_Sch6_c at 0x1d340429ee0>: {'X': 1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_sink_PGPm1_Veillonella_atypica_ACS
_049_V_Sch6_c at 0x1d340429fa0>: {'X': -1.0},
 <Reaction Veillonella_atypica_ACS_049_V_Sch6_biomass116 at 0x1d34043b9a0>:
{'charge': -81.86882719999988,
  'C': -35.036401200000036,
  'H': 26.148670400000327,
```

```
        'N': -7.353019799999996,
        'O': 68.9789142999997,
        'P': -0.9387217000000568,
        'S': -0.21809219999999996,
        'X': -2.0018063,
        'Co': -0.0079397,
        'Ca': -0.0079397,
        'Cl': -0.0079397,
        'Cu': -0.0079397,
        'Fe': -0.0317588,
        'K': -0.0079397,
        'Mg': -0.0079397,
        'Mn': -0.0079397,
        'Zn': -0.0079397}}
```

1.3 Analysis of community models

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

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

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

```
BM_tot.
'2PG__PEP' is not a valid SBML 'SId'.
'3PG__2PG' is not a valid SBML 'SId'.
'0Pyr__AcCoA' is not a valid SBML 'SId'.
'3PG' is not a valid SBML 'SId'.
'2PG' is not a valid SBML 'SId'.
'5CHOMPT' is not a valid SBML 'SId'.
Adding exchange reaction EX_H2_EX with default bounds for boundary metabolite:
H2_EX.
Adding exchange reaction EX_CO2_EX with default bounds for boundary metabolite:
CO2_EX.
Adding exchange reaction EX_CH4_EX with default bounds for boundary metabolite:
CH4_EX.
Adding exchange reaction EX_Ac_EX with default bounds for boundary metabolite:
Ac_EX.
Adding exchange reaction EX_MetOH_EX with default bounds for boundary
metabolite: MetOH_EX.
Adding exchange reaction EX_BM_tot with default bounds for boundary metabolite:
BM_tot.
'3PG__2PG__3PG' is not a valid SBML 'SId'.
'5CHOMPT__CHH4MPT' is not a valid SBML 'SId'.
'5CHOMPT' is not a valid SBML 'SId'.
'3PG' is not a valid SBML 'SId'.
'2PG' is not a valid SBML 'SId'.
Adding exchange reaction EX_H2_EX with default bounds for boundary metabolite:
H2_EX.
Adding exchange reaction EX_CO2_EX with default bounds for boundary metabolite:
CO2_EX.
Adding exchange reaction EX_CH4_EX with default bounds for boundary metabolite:
CH4_EX.
Adding exchange reaction EX_Form_EX with default bounds for boundary metabolite:
Form_EX.
Adding exchange reaction EX_BM_tot with default bounds for boundary metabolite:
BM_tot.
'2PG__3PG' is not a valid SBML 'SId'.
'3PG__DPG' is not a valid SBML 'SId'.
'5CHOMPT__CHH4MPT' is not a valid SBML 'SId'.
```

[20]:
```python
named_models
```

[20]:
```
{'dv': <Model CNA_DV at 0x1d443291070>,
 'mb': <Model CNA_MB at 0x1d43d4aa5e0>,
 'mh': <Model CNA_MM at 0x1d43db97e20>}
```

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

```
    single_org_models.append(single_org_model)

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

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

```
[22]: medium = {
          'EX_CO2_EX_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 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 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 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 H2_EX. Please make
sure that the metabolite with this ID is indeed representing the same substance
in all models!
WARNING: no annotation overlap found for matching metabolite 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 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 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 CH4_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.

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

```
[23]:       metabolite_id          metabolite_name  cross_feeding  produced_by  \
      0       H2_EX_exchg              H2_external           True     [dv, mh]
      1       Ac_EX_exchg         acetate_external           True         [dv]
      2      CO2_EX_exchg             CO2_external           True     [mb, mh]
      3     Form_EX_exchg         formate_external           True         [dv]
      4       SO4_EX_exchg         sulfate_external          False           []
      5      H2S_EX_exchg  hydrogensulfide_external          False           []
      6       Eth_EX_exchg         ethanol_external          False           []
      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           []

           consumed_by
      0    [dv, mb, mh]
      1            [mb]
      2    [dv, mb, mh]
      3            [mh]
      4              []
      5              []
      6            [dv]
      7              []
      8              []
      9              []
```

```
10              []
11              []
12              []
```

1.3.2 Plotting the maxiumum growth rate over the composition space

```python
[24]: import pandas as pd

      # Iterate over the fractions in steps of 0.01
      com_model_obj.convert_to_fixed_abundance()
      rows = []
      for i in range (0,100,1):  # fraction of D. vulgaris
          for j in range (0, 100-i, 1): # fraction of M. hungatei
              if (100-i-j) < 0:
                  continue

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

              # Apply the abuyndances
              com_model_obj.apply_fixed_abundance(abundances)

              # Reapply the bound restrictions of the exchange reactions
              com_model_obj.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)
```

```
C:\Users\Michi\.conda\envs\cobra_env\lib\site-packages\cobra\util\solver.py:554:
UserWarning: Solver status is 'infeasible'.
  warn(f"Solver status is '{status}'.", UserWarning)
C:\Users\Michi\.conda\envs\cobra_env\lib\site-packages\cobra\util\solver.py:554:
UserWarning: Solver status is 'infeasible'.
  warn(f"Solver status is '{status}'.", UserWarning)
C:\Users\Michi\.conda\envs\cobra_env\lib\site-packages\cobra\util\solver.py:554:
UserWarning: Solver status is 'infeasible'.
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UserWarning: Solver status is 'infeasible'.
  warn(f"Solver status is '{status}'.", UserWarning)
```

```
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  warn(f"Solver status is '{status}'.", UserWarning)
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```

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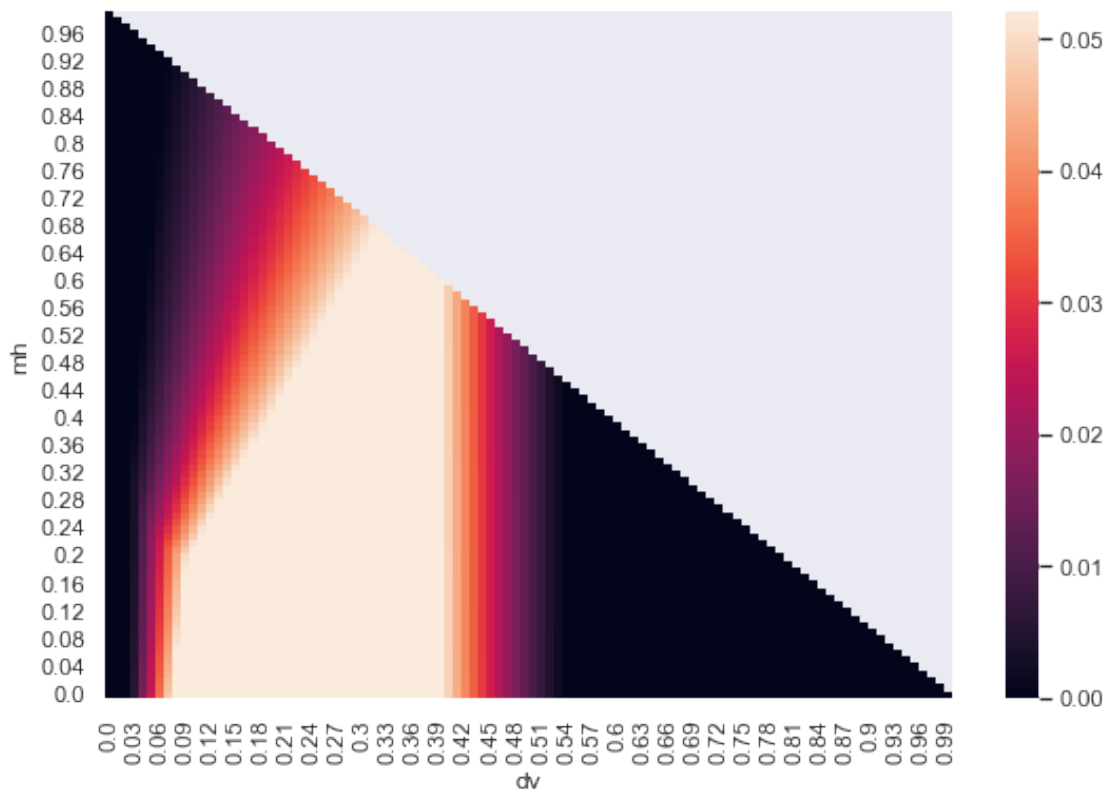[25]: import matplotlib.pyplot as plt
      import seaborn as sns
      sns.set_theme()

      # 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()
```