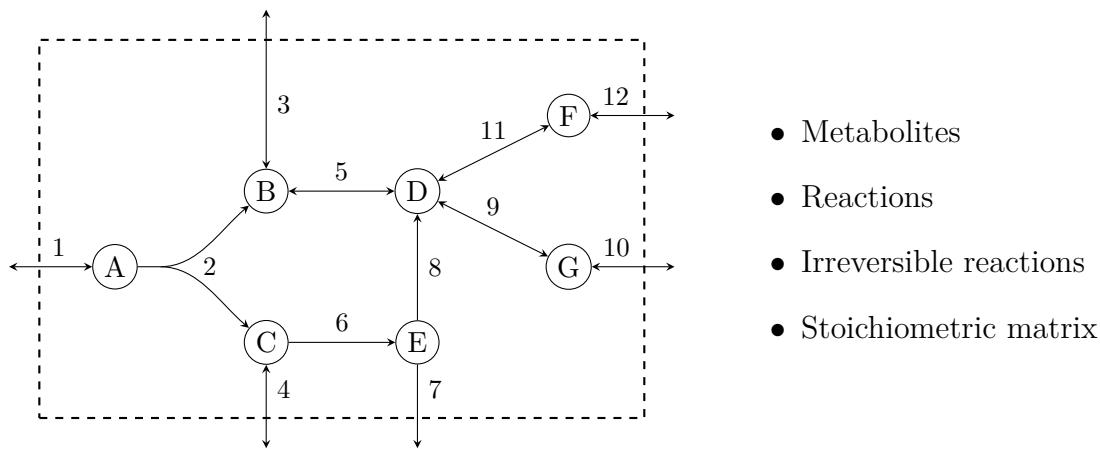


# Exercise Sheet 1

April 24, 2015

## Exercise 1. Tutorial

- a) For the following network write down the



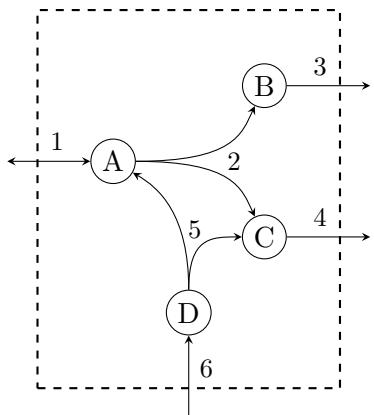
- b) What are the thermodynamic irreversibility constraints and the stoichiometric constraints for a metabolic network?
- c) Consider the subnetwork consisting of the metabolites  $\{A, B, C\}$  and the reactions  $\{1, 2, 3, 4\}$  with all coefficients equal to 1 except for the second reaction, which is  $A \rightarrow 2B + C$ . Which of the following vectors are possible flux vectors for this network?

$$v = (1, -1, 1, 0)^T \quad v' = (-1, 1, 2, 0)^T \quad v'' = (-1, 1, 2, 1)^T$$

- d) What is a steady-state flux cone? Give the flux cone for the subnetwork.

**Exercise 2.** *Tutorial*

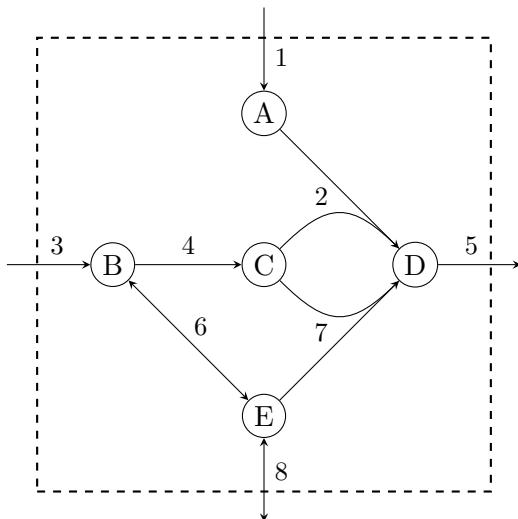
Consider the following network.



- Determine all directionally coupled reactions.
- Determine all partially coupled reactions.

**Exercise 3.** *Tutorial*

Consider the following network.



- Give an inequality description of the steady-state flux cone, assuming that all stoichiometric coefficients belong to  $\{0, 1, -1\}$ .
- Determine all directionally coupled reactions.
- Determine all partially coupled reactions.
- Determine all fully coupled reactions.
- Change the coefficients in reaction 7 to  $C + E \rightarrow 2D$ . How are the couplings affected by this change?

**Exercise 4. Homework**

Consider the following network.



- i) Draw the network.
- ii) Give an inequality description of the steady-state flux cone (It is sufficient, to give the stoichiometric matrix and the set of irreversible reactions).
- iii) Determine all directionally coupled reactions.
- iv) Determine all partially coupled reactions.
- v) Determine all fully coupled reactions.

**Exercise 5. Homework**

Program a FBA: Write a program in MATLAB, which computes an optimal steady-state flux for a given network and an objective function, that maximizes the flux in one of the reactions (typically in the biomass reaction). Construct the linear program (yourself) but use an LP-solver provided by MATLAB.

Use the following networks with the corresponding biomass function for testing:

- EcoliTextbook, biomass function is reaction No. 13
- Hpylori iIT341, biomass function is reaction No. 76
- Mtuberculosis iNJ661, biomass function is reaction No. 1025
- Scerevisiae iND750, biomass function is reaction No. 1266

The program specifications are:

**INPUT:**

- **A metabolic network:** A struct in a `.mat` file called `network` with:
  - S:** the stoichiometric matrix
  - rev:** the reversibility vector ( $rev(i) = 0$ : reaction  $i$  is not reversible,  $rev(i) = 1$ : reaction  $i$  is reversible)
  - rxns:** names of the reactions
  - lb:** lower bounds
  - ub:** upper bounds

**description:** name of the network

- **Objective function:** A number, which gives the reaction that should be maximized.
- **Output:** The name of a file where the output should be written.

**TASK:**

Compute a flux distribution that maximizes the given reaction and fulfills the steady state assumption.

**OUTPUT:**

A `.txt` file with two columns where each row contains the `reaction_id` and the corresponding rate. The first row contains the optimized reaction, the remaining reactions are ordered according to their index.

**Optional task:**

Each network contains a reaction, whose name starts with `biomass`. Typically, this reaction should be maximized. Therefore, implement the opportunity to give as second argument the name of a reaction or the keyword “BIOMASS”, and let the program find the correct reaction number.

Send the solution to the fourth exercise, the MATLAB program and the output files for the Ecoli- and Mtuberculosis-networks until Thursday, 30th, 11:00 p.m. to **Therese.Lorenz@fu-berlin.de**.