SUPPLEMENTAL DATA:

Supplemental data S1: **Quantitative Aspects of Linear Physical Programming**:

Intra-Criteria and Inter-Criteria Preference: For a given objective, once the DM decides to which class the criterion belongs, and chooses the range targets (i.e. t_{is}^{+}, t_{is}^{-}), the *intra-criterion* preference statement is complete. However, since decisions are made in a multi-objective environment, there must be an implicit or explicit *inter-criteria* preference. Linear physical programming operates within an implied inter-criteria heuristic rule that is hereby called the *One vs. Others* criteria-rule (OVO rule).

The OVO-rule entails the following inter-criteria preference for each soft criterion, g_i. If two options are considered, viz.,

Option 1: "Full improvement of g_i across a given range (say, range-3)"; and

Option 2; "Full reduction of all the other criteria across the next better range (i.e., range-2)"; then option 1 shall be preferred over option 2.

That is, the worst candidate is always helped first. Essentially, this philosophy has a built-in preemptive nature in which the minimization of the worst criterion is automatically implied. Say, for example that we are dealing with 15 criteria. The OVO rule states that: it is more beneficial for a single criterion to improve over the full *tolerable* range, than it is for the other 14 to improve over the full *desirable* range. The mathematical implication of the OVO rule is discussed later.

Development of Class Function:

In this section we define and discuss the properties of class functions (Figures 3c-f), and develop the LP model representation of generic class functions. This model will be used in the statement of the linear physical programming mathematical model. We also discuss in some detail the structure of a generic class function.

We first state the class function properties; which is followed by a discussion thereof. These properties are as follows:

(i) A lower value of a class function is preferred over a higher value thereof.

(ii) A class function is strictly positive.

(iii) A class function is continuous, piecewise linear, and convex.

(iv) The value of a class function, z_i, at a given ranges-intersection (say, *desirable-tolerable*) is the same for any class-type.

(v) The magnitude of the class-function's vertical excursion across any range must satisfy the OVO-rule.

Collectively, these properties provide the flexibility required of the linear physical programming methodology. We make the following observations:

- Since a lower value of the class function is better than a higher value thereof, *class functions* and *utility functions* have distinct structures (while fulfilling the same function).
- The positivity property of the class function allows the DM to define an *ideal* finite value, zero.

- The rationale for the convexity requirement is partially rooted in the axioms of utility theory. In our particular case, it means that the cost of traveling across, say, the *undesirable* range is always more than that of traveling across the *tolerable* range; regardless of the target values chosen by the DM. (We note that the OVO rule, alone, does not guaranty convexity.)
- The value of the class function at a given range limit (say, $z_i(t_{i2}^{+})$) is always constant (see Figure 3). From criterion to criterion, only the *location* of the limits (say t_{i2}^{+}) change, not the corresponding z_i values. As a consequence, as one *travels* across a given range-type (say *tolerable*), the change in the class-function will always be of the same magnitude, $\tilde{z}^3$, regardless of the criterion in question. This behavior of the class function values at the boundaries is the critical factor that makes each range-type have the same numerical *cost/value* for different criteria. This same behavior also has a *normalizing effect*, and results in favorable numerical conditioning properties.

Table 3 represents the mathematical representations of some of the Property (iv) of the class function discussed above is expressed by the relation

$$z^s \equiv z_i(t_{is}^{+}) \equiv z_i(t_{is}^{-}) \quad \forall i \quad ; \quad (2 \leq s \leq 5) \; ; \; z^1 \equiv 0 \tag{2}$$

where '*s*' and '*i*' respectively denote a generic range-intersection and criterion number.

(b) The change in z_i that takes place as one *travels* across the *s*-th range is always given by

$$\tilde{z}^s \equiv z^s - z^{s-1} \quad ; \quad (2 \leq s \leq 5) \; ; \; z^1 \equiv 0 \tag{3}$$

(c) To enforce the OVO rule, we apply the relationship

$$\tilde{z}^{s} > (n_{sc}-1)\tilde{z}^{s-1} \quad (3 \le s \le 5)\,;\,(n_{sc}>1) \tag{4}$$

or, equivalently

$$\tilde{z}^{s} = \beta\,(n_{sc}-1)\tilde{z}^{s-1} \quad (3 \le s \le 5)\,;\, n_{sc}>1\,;\,\beta>1 \tag{5}$$

where n_{sc} denotes the number of *soft* criteria, and β will be used as a *convexity parameter*. Equation 5 does not guaranty convexity of the class function, as the said convexity depends also on the targets chosen. To apply Equation (5), we need to be given a value for $\tilde{z}^{2}$. In practice, a small positive number will be appropriate (say, 0.1).

(d) Turning our attention to the convexity requirement, we define

$$\tilde{t}_{is}^{+} = t_{is}^{+} - t_{i(s-1)}^{+}\,;\,\tilde{t}_{is}^{-} = t_{is}^{-} - t_{i(s-1)}^{-}\,;\quad (2 \le s \le 5) \tag{6}$$

which is the length of the *s*-th range of the *i*-th criterion. With this quantity, the *magnitude* of the slopes of the class function of the generic *i*-th criterion takes the form

$$w_{is}^{+} = \tilde{z}^{s} / \tilde{t}_{is}^{+}\,;\, w_{is}^{-} = \tilde{z}^{s} / \tilde{t}_{is}^{-}\,;\quad (2 \le s \le 5) \tag{7}$$

We emphasize here that the slopes change from range to range and from criterion to criterion. Once the slopes are known, the convexity requirement can be verified by the relationship

$$\tilde{w}_{min} = \min_{i,s}\{\tilde{w}_{is}^{+}, \tilde{w}_{is}^{-}\} > 0 \quad ; \quad \begin{cases} (2 \le s \le 5) \\ i : \text{soft criteria} \end{cases} \tag{8}$$

where

$$\widetilde{w}_{is}^{+} = w_{is}^{+} - w_{i(s-1)}^{+} \; ; \; \widetilde{w}_{is}^{-} = w_{is}^{-} - w_{i(s-1)}^{-} \; ; \; w_{i1}^{-} = w_{i1}^{+} = 0 \quad \begin{cases} (2 \leq s \leq 5) \\ i : \text{soft criteria} \end{cases} \tag{9}$$

We note here that the quantities $\widetilde{w}_{is}^{+}$ and $\widetilde{w}_{is}^{-}$ are exactly the weights that will be used in the LP model of the class functions. In effect, equation (8) states that so long as all these weights are positive, the class function will be peicewise linear and convex. The important point here is to observe that convexity can always be satisfied by simply increasing the magnitude of the *convexity parameter* β.

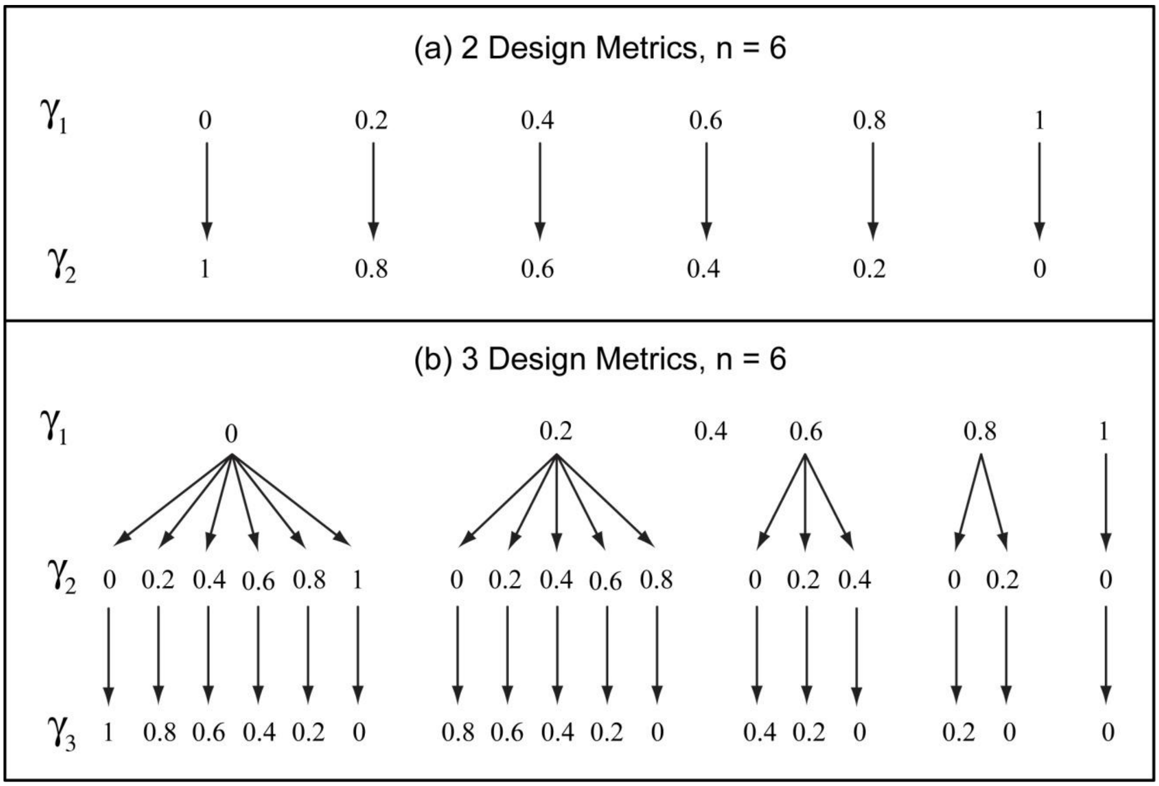

Figure S1: Non-dimensional parameters used in the generation of the Pareto optimal solutions for translating the AOF surface across the objective space.

Figure S2

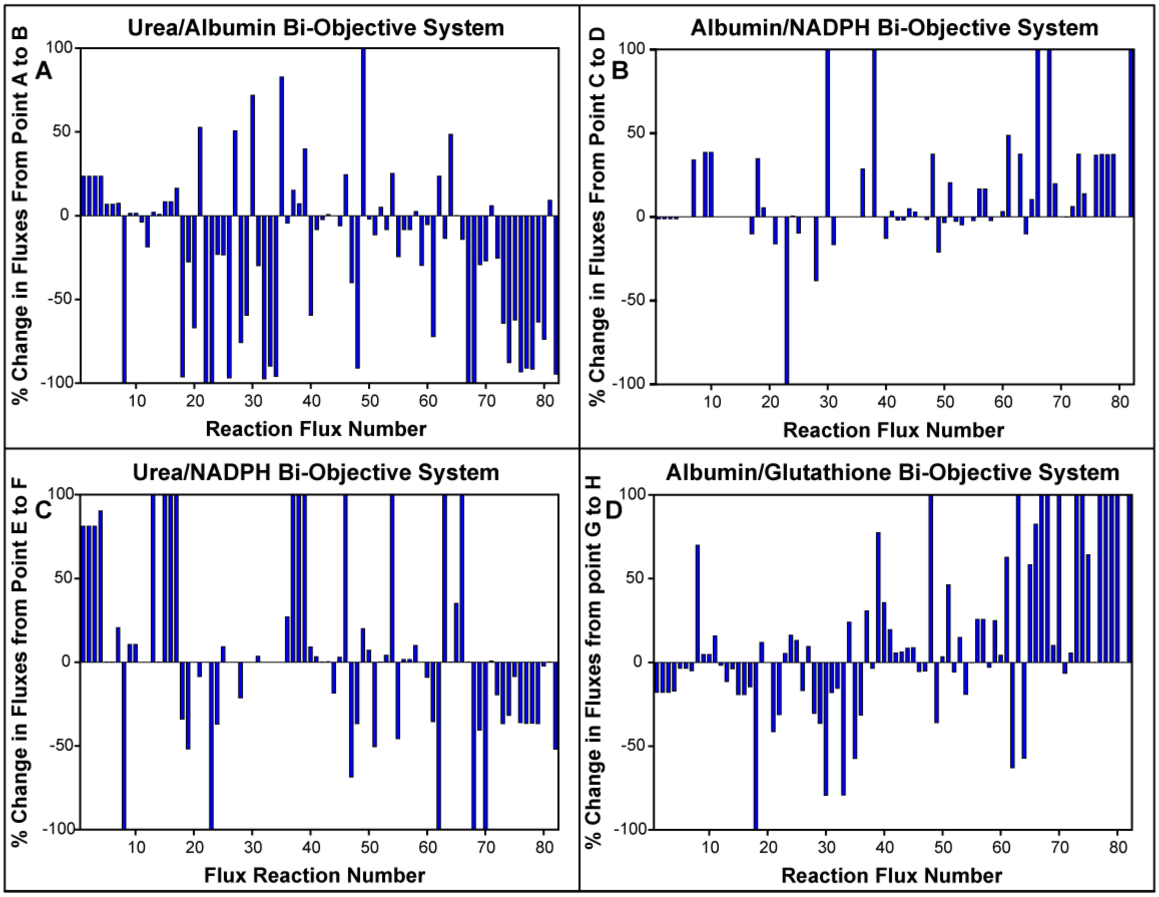

Figure S2: Metabolic profiling of percentage change in Pareto optimal fluxes for various solutions of Figure 4. These results are for various combinations of objectives and the corresponding flux values are in Table S2. Only changes up to ±100% are shown.

Figure S3

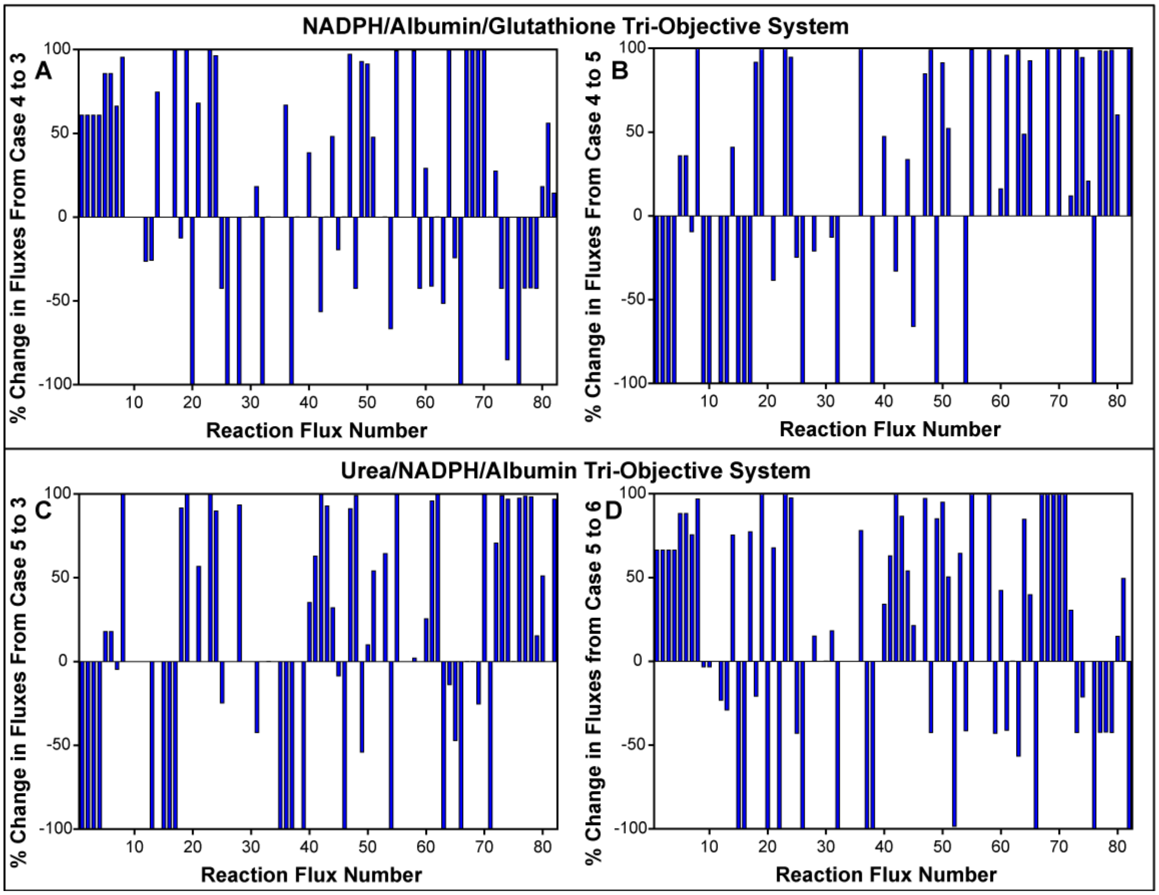

Figure S3: A-D) Metabolic profiling of percentage change in Pareto optimal fluxes for various solutions of Tables 1 and 2. These results are for various combinations of objectives and the corresponding flux values are in Table S1. Only changes up to ±100% are shown.

Table S1: Hepatic stoichiometric reactions

No	Stoichiometry
1	F6P ↔ G6P
2	F16P2 + H_2O → F6P + P_i
3	2 G3P ↔ F16P2
4	3Pglyc + NADH + H^+ + ATP ↔ G3P + P_i + NAD^+ + ADP
5	PEP ↔ 3Pglyc
6	oac + GTP → PEP + GDP + CO_2
7	pyr + CO_2 + ATP + H_2O → oac + ADP + P_i + 2 H^+
8	pyr + NADPH + CO_2 ↔ mal + $NADP^+$
9	oac + acCoA + H_2O → ctt+ CoASH
10	ctt + $NADP^+$ ↔ αkgl + CO_2 + NADPH + H^+
11	αkgl + NAD^+ + CoASH → sucCoA + CO_2 + NADH + H^+
12	sucCoA + P_i + GDP + FAD ↔ fum + GTP + $FADH_2$ + CoASH
13	fum + H_2O ↔ mal
14	mal + NAD^+ ↔ oac + NADH + H^+
15	ctr + asp + ATP → arg + fum + AMP + PP_i
16	orn + (CO_2 + NH_4^+ + 2 ATP) + H_2O → ctr+ 2 ADP + 2 P_i + 3 H^+
17	arg + H_2O → urea + orn
18	ala + 0.5 NAD^+ + 0.5 $NADP^+$ + H_2O ↔ pyr + NH_3 + 0.5 NADH + 0.5 NADPH + H^+
19	ser → pyr + NH_3
20	cys + 0.5 NAD^+ + 0.5 $NADP^+$ + H_2O + SO_3^{2-} ↔ pyr + thiosulfate + NH_4^+ + 0.5 NADPH + 0.5 NADH
21	thr + NAD^+ + ATP + CoASH → gly + acCoA + NADH + H^+ + AMP + PP_i
22	thr + NAD^+ + CoASH → propCoA + CO_2 + NADH + H^+ + NH_3 + H_2
23	2 gly + NAD^+ + THF + H_2O ↔ NTHF + H^+ + CO_2 + NH_4^+ + ser + NADH
24	3Pglyc + NAD^+ + glu + H_2O → NADH + H^+ + αkgl + ser + P_i
25	trp + 3 O_2 + 4 H_2O + 2 NAD^+ + FAD + CoASH → Formate + ala + 2 CO_2 + NH_3 + 3 NADH + $FADH_2$ + HCO_3^- + acacCoA
26	propCoA + CO_2 + ATP → ADP + P_i + sucCoA
27	lys + 2 αkgl + 2 NAD^+ + CoASH + FAD + 2 H_2O + $NADP^+$ → CO_2 + NH_3 + acacCoA + 5 NADH + $FADH_2$
28	phe + O_2 + H_4biopterin + H^+ → tyr + H_2O + H_2biopterin
29	tyr + αkgl + 2 O_2 + H_2O → glu + CO_2 + fum + acac
30	pro + 0.5 O_2 + 0.5 NAD^+ + 0.5 $NADP^+$ → glu + 0.5 NADH + 0.5 NADPH + H^+
31	his + H_4folate + 2 H_2O → NH_4^+ + N^5,N^{10}-CH_2-H_4folate + glu
32	met + ATP + ser + NAD^+ + H_2O + CoASH → PP_i + P_i + adenosine + cys + NADH + H^+ + CO_2 + NH_4^+ + propCoA
33	val + αkgl + 3 NAD^+ + 2 H_2O + FAD + CoA → glu + 2 CO_2 + 3 NADH + 2 H^+ + $FADH_2$ + CO_2 + propCoA
34	iso + αkgl + H_2O + 2 NAD^+ + FAD + 2 CoASH → glu + CO_2 + 2 NADH + 2H^+ + $FADH_2$ + acCoA + propCoA
35	leu + αkgl + H_2O + NAD^+ + FAD + ATP + CoASH + HCO_3^- → glu + CO_2 + NADH + H^+ + $FADH_2$ + acCoA + acac + ADP + P_i
36	oac + glu ↔ αkgl + asp
37	asn + H_2O → asp + NH_3
38	glu + 0.5 NAD^+ + 0.5 $NADP^+$ + H_2O ↔ NH_4^+ + αkgl + 0.5 NADPH + 0.5 NADH + H^+
39	orn + NAD^+ + $NADP^+$ + H_2O → glu + NH_4^+ + NADH + NADPH + H^+
40	gln + H_2O → glu + NH_4^+
41	palm + ATP + 7 FAD + 7 NAD^+ → 8 acCoA + 7 $FADH_2$ + 7 NADH + AMP + PP_i
42	2 acCoA ↔ acacCoA + CoA

43	acacCoA + H_2O → acac + CoA
44	NADH + H^+ + 0.5 O_2 + 3 ADP → NAD^+ + H_2O + 3 ATP
45	$FADH_2$ + 0.5 O_2 + 2 ADP → FAD + H_2O + 2 ATP
46	gol + NAD^+ + ATP ↔ G3P + NADH + H^+ + ADP + P_i
47	G6P + 12 $NADP^+$ + 7 H_2O → 6 CO_2 + 12 NADPH + 12 H^+ + P_i
48	24 arg + 32 asp + 61 ala + 24 ser + 35 cys + 57 glu + 17 gly + 21 tyr + 33 thr + 53 lys + 26 phe + 25 gln + 30 pro + 15 his + 6 met + 20 asn + trp + 35 val + 13 iso + 56 leu + 2332 ATP → albumin + 2332 ADP + 2332 P_i
49	glu + 2 ATP + cys + gly + NADPH → GSH + 2 ADP + 2 P_i + $NADP^+$ + H^+
50	gol + 3 acCoA + H_2O + ATP → 3 CoASH + P_i + TG + ADP + P_i
51	lactate + NAD^+ ↔ pyr + NADH + H^+
52	acac + NADH + H^+ ↔ β-OH-butyrate + NAD^+
53	TG + 3 H_2O → gol + 3 palm + 3 H^+
54	G6P release
55	gol uptake
56	palm release
57	cholesterol ester + H_2O → cholesterol + palm
58	TG stored
59	trp uptake
60	O_2 uptake
61	pro uptake
62	glu secretion
63	asn uptake
64	orn secretion
65	arg uptake
66	NH_4^+ uptake
67	ala uptake
68	ser uptake
69	gly uptake
70	asp uptake
71	acac production
72	thr uptake
73	lys uptake
74	phe uptake
75	his uptake
76	met uptake
77	val uptake
78	iso uptake
79	leu uptake
80	gln uptake
81	cys uptake
82	tyr uptake

Table S2: List of metabolites

No	Symbol	Metabolite
1	**G6P**	Glucose-6-phosphate
2	**F6P**	Fructose-6-phosphate
3	**F16P2**	Fructose-1,6-biphosphate
4	**G3P**	Glyceraldehyde-3-phosphate
5	**PEP**	Phosphoenolpyruvate
6	**oac**	Oxaloacetate
7	**pyr**	Pyruvate
8	**ctt**	Citrate
9	**αkgl**	α-Ketoglutarate
10	**sucCoA**	Succinyl-CoA
11	**fum**	Fumarate
12	**mal**	Malate
13	**arg**	Arginine
14	**orn**	Ornithine
15	**ctr**	Citrulline
16	$\mathbf{NH_4^+}$	Ammonium
17	**asp**	Aspartate
18	**his**	Histidine
19	**glu**	Glutamate
20	**gln**	Glutamine
21	**met**	Methionine
22	**thr**	Threonine
23	**val**	Valine
24	**iso**	Isoleucine
25	**phe**	Phenylananine
26	**trp**	Tryptophan
27	**lys**	Lysine
28	**tyr**	Tyrosine
29	**ala**	Alanine
30	**asn**	Asparagine
31	**pro**	Proline
32	**cys**	Cysteine
33	**ser**	Serine
34	**gly**	Glycine
35	**propCoA**	Propionyl-CoA
36	**acCoA**	Acetyl-CoA
37	**palm**	Palmitate
38	**acacCoA**	Acetoacetyl-Coa
39	**acac**	Acetoacetate
40	**gol**	Glycerol
41	**NADH**	Nicotinamide adenine dinucleotide, reduced form
42	**NADPH**	Nicotinamide adenine dinucleotide phosphate, reduced form
43	$\mathbf{FADH_2}$	Flavin adenine dinucleotide, reduced form
44	$\mathbf{O_2}$	Oxygen
45	**leu**	Leucine
46	**3Pglyc**	3-phosphoglycerate
47	**TG**	Triglyceride

Table S3: Lower and upper bounds for the metabolic network shown in Table SI.

Flux #	lower bound	upper bound
1	0.1	30
2	0.00001	30
3	0.00001	30
4	0.00001	30
5	0.00001	30
6	0.00001	30
7	0.00001	30
8	5	30
9	5	30
10	5	30
11	5	30
12	5	30
13	5	30
14	5	30
15	0.00001	50
16	0.00001	50
17	0.00001	100
18	-10	50
19	0.1	50
20	0.1	50
21	0.01	50
22	0.001	50
23	-1	50
24	0.001	50
25	0.00001	50
26	0.00001	50
27	0.001	50
28	0.1	50
29	0.1	50
30	0.1	50
31	0.00001	50
32	0.01	50
33	0.01	50
34	0.01	50
35	0.01	50
36	-10	50
37	0.00001	50
38	-10	-0.01
39	0.00001	50
40	0.1	50
41	0.01	50
42	-10	50
43	0.1	50
44	5	100
45	5	100
46	-10	-0.001
47	0.01	10

48	0.00001	5
49	0.001	50
50	0.001	50
51	10	50
52	0.15	20
53	0.1	50
54	1	10
55	0.01	5
56	0.01	5
57	0.01	5
58	0.01	2
59	0.5	2
60	5	100
61	0.01	5
62	-1	5
63	0.0001	10
64	-1	5
65	0.00001	10
66	0.1	20
67	-1	5
68	-1	5
69	-1	5
70	-1	10
71	0.001	10
72	0.01	10
73	0.01	10
74	0.01	5
75	0.01	5
76	0.01	5
77	0.01	5
78	0.01	5
79	0.00001	10
80	0.5	10
81	0.00001	10
82	0.00001	5

Table S4: Optimal fluxes obtained for the corresponding Pareto optimal points A, B, C, D, E, F, G, H as for Pareto frontiers shown in Figure 4.

Flux	Urea/Albumin		Albumin/NADPH		Urea/NADPH		Albumin/GSH	
#	A	B	C	D	E	F	G	H
1	7.785957	9.62067	4.501296	4.445404	4.363114	7.905927	7.096188	5.82791
2	7.785957	9.62067	4.501296	4.445404	4.363114	7.905927	7.096188	5.82791
3	7.785957	9.62067	4.501296	4.445404	4.363114	7.905927	7.096188	5.82791
4	16.46149	20.34798	9.003593	8.891809	8.727229	16.61271	15.06206	12.47793
5	25.6859	27.44478	30	30	30	30	25.43381	24.53243
6	25.6859	27.44478	30	30	30	30	25.43381	24.53243
7	15.84174	17.02678	9.384746	12.57488	12.885	15.53424	17.34341	16.46248
8	3.43E-01	1.00E-05	24.86899	24.86899	2.12E+01	1.00E-05	2.582514	4.386691
9	9.890329	10.03176	5.115472	7.081859	5.01	5.534236	14.2609	14.92683
10	9.890329	10.03176	5.115472	7.081859	5.01	5.534236	14.2609	14.92683
11	5.194161	5	5	5	5	5	6.053049	7.008817
12	6.18233	5.031	5.031	5.031	5.031	5.031	13.05307	12.82959
13	29.39198	29.99999	5.13101	5.13101	8.806001	29.99999	25.1926	22.32604
14	29.73449	30	30	30	30	30	27.77511	26.71273
15	22.96323	24.86899	1.00E-05	1.00E-05	3.675001	24.86899	10.39242	8.387028
16	22.96323	24.86899	1.00E-05	1.00E-05	3.675001	24.86899	10.39242	8.387028
17	**29.71549**	**34.57871**	3.243832	2.912113	**8.675011**	**33.35**	15.15555	12.951
18	-5.47035	-0.20091	-6.83422	-9.20522	-6.70001	-4.42406	0.811111	-5.22549
19	8.627798	6.250865	18.6902	19.6983	20.46381	9.858301	5.332216	5.966621
20	1.014155	0.335766	0.1	0.1	0.1	0.1	0.1	0.1
21	3.981159	6.082426	4.721405	3.962381	5.211021	4.76213	8.695423	5.09125
22	0.233951	0.001	0.001	0.001	0.001	0.001	0.35807	0.246111
23	0.868645	-0.24599	-0.22138	0.031534	0.24093	-1	-0.83939	-0.88344
24	9.224414	7.096801	20.99641	21.10819	21.27277	13.38729	10.37175	12.0545
25	1.335851	1.022389	0.397835	0.359593	0.4	0.436709	1.077742	1.219174
26	0.98817	0.031	0.031	0.031	0.031	0.031	7.00002	5.820776
27	1.668952	2.513036	0.001	0.001	0.001	0.001	0.795249	0.870322
28	1.003804	0.242934	1.212868	0.750487	1.215752	0.957228	1.400862	0.974177
29	0.246424	0.1	0.1	0.1	0.1	0.1	1.747107	1.109419
30	0.529266	0.910025	0.128736	0.533352	0.1	0.1	2.606292	0.534704
31	1.792243	1.258018	3.467528	2.893898	3.499998	3.624568	2.249508	1.843529
32	0.403532	0.01	0.01	0.01	0.01	0.01	4.956447	4.188065
33	0.098037	0.01	0.01	0.01	0.01	0.01	0.681909	0.141935
34	0.25265	0.01	0.01	0.01	0.01	0.01	1.003594	1.244666
35	1.422942	2.600461	0.01	0.01	0.01	0.01	2.917282	1.243652
36	-10	-9.55023	-4.26927	-5.49302	-7.875	-10	-5.42381	-3.71595
37	7.293549	8.405977	1.00E-05	1.00E-05	1.00E-05	8.53E+00	3.464113	4.528196
38	-4.69617	-5.03176	-0.11547	-2.08186	-0.01	-0.53424	-8.20785	-7.91802
39	3.668984	5.12984	1.00E-05	1.00E-05	1.00E-05	3.48E+00	1.879397	3.332831
40	4.051254	1.644505	7.44588	6.48983	7.499996	8.182755	3.4557	4.688588
41	5.816694	5.333649	6.359092	6.567185	6.319222	6.518558	4.876678	5.827587
42	17.03733	16.63322	21.11767	20.73033	21.26558	21.2813	14.798	15.62067
43	20.04214	20.16865	21.51651	21.09092	21.66658	21.71901	16.67099	17.71017
44	65.76424	65.68775	67.2779	70.56428	64.22893	52.37466	72.58421	78.68357

45	51.67762	48.52243	49.97348	51.39189	49.69656	51.12861	53.66559	58.34245
46	-0.88958	-1.10664	-0.001	-0.001	-0.001	-0.80086	-0.86968	-0.82211
47	0.190351	0.114048	**3.501296**	**3.445404**	**3.363114**	**1.057238**	0.64292	0.609452
48	**0.135323**	**0.012095**	**0.102165**	**0.140407**	0.1	0.063291	**0.007259**	**0.135323**
49	3.421764	8.829958	6.334232	4.995762	6.409994	7.694808	**14.60239**	**9.351776**
50	2.74177	2.687956	2.75444	2.659113	2.747878	2.944586	2.590945	2.677365
51	12.01265	10.64107	22.29775	26.85079	20.2152	10	13.6826	20.00803
52	15.36006	16.1376	15.37013	14.95023	15.45666	15.46315	15.2931	14.41204
53	1.127345	1.03384	1.323725	1.260914	1.309268	1.362648	0.920916	1.057511
54	7.595606	9.506622	1	1	1	6.848688	6.453268	5.218458
55	0.724848	0.547474	1.429715	1.3972	1.43761	0.781081	0.800344	0.797747
56	1.217329	1.116065	1.193958	1.392222	1.19571	1.215308	1.056965	1.327528
57	1.217329	1.116065	1.193958	1.392222	1.19571	1.215308	1.056965	1.327528
58	1.614424	1.654116	1.430715	1.3982	1.43861	1.581938	1.670028	1.619854
59	1.471173	1.034485	0.5	0.5	0.5	0.5	1.085001	1.354496
60	64.48977	61.0702	61.29643	63.27402	59.6285	54.26899	72.55635	75.6309
61	4.588942	1.272878	3.19368	4.745555	3.100005	1.998736	2.824059	4.59438
62	3.602765	4.454768	-1	-1	-1	4.620163	3.382605	1.252508
63	10	8.64788	2.043306	2.808146	2.000013	9.799933	3.609291	7.234647
64	3.083275	4.579877	3.243812	2.912093	5	5	2.883732	1.231142
65	10	10	5.695777	6.281866	7.400014	10	4.937343	7.811715
66	17.70624	15.18979	2.192294	8.172124	7.185027	19.85412	3.610539	6.59099
67	1.448473	-0.4855	-1	-1	-1	-1	0.176161	1.810015
68	2.186011	-0.29966	0.377123	1.938337	1.36011	-1	0.930517	2.231371
69	3.478377	2.461166	2.906876	3.483364	3.380838	2.008629	4.351577	4.794124
70	10	7.299824	-1	-1	-1	8.360199	1.736781	4.473204
71	6.351441	6.731517	6.256377	6.250692	6.319921	6.365859	6.042277	5.651198
72	8.680754	6.482565	8.093844	8.596805	8.512026	6.85174	9.293036	9.803005
73	8.841047	3.154078	5.415735	7.44256	5.301009	3.355434	1.17997	8.042417
74	4.522191	0.557407	3.869153	4.401063	3.815757	2.602799	1.589593	4.492563
75	3.822081	1.439445	5	5	5	4.573936	2.358391	3.873367
76	1.215467	0.082571	0.622989	0.852441	0.610001	0.389747	5	5
77	4.834326	0.433329	3.585768	4.924238	3.510006	2.225192	0.93597	4.878224
78	2.011843	0.167237	1.338142	1.835288	1.310002	0.832786	1.09796	3.003859
79	9.001005	3.277789	5.731229	7.87278	5.610009	3.554308	3.323779	8.821715
80	7.434318	1.946883	10	10	10	9.765035	3.637172	8.071652
81	8.768677	9.579053	10	10	10	10	10	10
82	2.084393	0.111064	1.032593	2.298056	0.984251	0.471887	0.498681	2.977015

Table S5: Optimal fluxes obtained for tri-objective system for the corresponding Pareto optimal cases 3, 4 and 5 from Table I, and cases 3, 5 and 6 from Table II.

Flux #	NADPH/Albumin/GSH					Urea/NADPH/Albumin					
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
1	4.324	4.442	1.767	4.504	9.059	3.278	10.100	10.311	4.442	4.504	1.515
2	4.324	4.442	1.767	4.504	9.059	3.278	10.100	10.311	4.442	4.504	1.515
3	4.324	4.442	1.767	4.504	9.059	3.278	10.100	10.311	4.442	4.504	1.515
4	8.650	8.885	3.534	9.010	18.119	6.557	20.201	22.494	8.885	9.010	3.031
5	30.000	30.000	4.310	30.000	19.237	30.000	21.245	24.628	30.000	30.000	3.552
6	30.000	30.000	4.310	30.000	19.237	30.000	21.245	24.628	30.000	30.000	3.552
7	14.395	12.589	3.108	9.210	10.077	15.010	6.255	9.638	12.589	9.210	2.252
8	20.533	24.869	1.144	24.869	0.000	8.019	0.229	0.000	24.869	24.869	0.779
9	9.906	7.027	5.010	5.010	10.923	5.010	5.010	5.010	7.027	5.010	5.178
10	9.906	7.027	5.010	5.010	10.923	5.010	5.010	5.010	7.027	5.010	5.178
11	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
12	9.367	5.031	6.359	5.031	10.015	5.031	6.714	5.031	5.031	5.031	6.196
13	9.467	5.131	6.459	5.131	17.707	21.981	29.771	30.000	5.131	5.131	6.623
14	30.000	30.000	7.603	30.000	17.707	30.000	30.000	30.000	30.000	30.000	7.402
15	0.000	0.000	0.000	0.000	7.592	16.850	22.957	24.869	0.000	0.000	0.328
16	0.000	0.000	0.000	0.000	7.592	16.850	22.957	24.869	0.000	0.000	0.328
17	0.000	0.593	0.000	0.351	7.772	**23.724**	**29.706**	**34.845**	**1.000**	**4.393**	**1.000**
18	-7.260	-9.339	-7.537	-6.700	-0.562	-8.574	-8.897	-0.562	-9.339	-6.700	-8.095
19	12.946	24.158	0.100	18.869	0.100	20.204	0.100	0.100	18.158	18.869	0.100
20	0.100	0.100	0.279	0.100	0.100	0.100	5.281	0.100	0.100	0.100	0.202
21	6.401	5.294	1.821	5.687	7.876	1.145	2.232	2.892	5.294	6.699	2.162
22	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.079
23	-0.441	1.475	-0.916	1.289	-1.000	-1.000	-1.000	-1.000	1.475	1.289	-0.903
24	21.350	21.115	0.776	20.990	1.118	23.443	1.044	2.134	21.115	20.990	0.521
25	0.391	0.357	0.570	0.400	0.499	0.370	0.365	0.499	0.357	0.400	0.572
26	4.367	0.031	1.359	0.031	5.015	0.031	1.714	0.031	0.031	0.031	1.196
27	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
28	2.165	0.100	1.293	0.100	0.121	1.614	1.478	0.100	1.293	1.524	1.293
29	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
30	0.100	0.723	0.100	0.100	0.100	0.100	0.937	0.100	0.723	0.100	0.100
31	3.365	2.861	2.861	3.500	3.949	3.047	2.497	4.985	2.861	3.500	2.861
32	4.346	0.010	1.338	0.010	4.994	0.010	1.693	0.010	0.010	0.010	1.097
33	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
34	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
35	0.010	0.010	0.010	0.010	0.010	0.010	0.010	4.692	0.010	0.010	0.010
36	-4.489	-5.562	-1.391	-4.200	2.376	-10.000	-10.000	-10.000	-5.562	-4.200	-0.924
37	0.000	0.000	0.179	0.000	0.000	7.395	7.291	8.277	0.000	0.000	0.279
38	-4.906	-2.027	-0.010	-0.010	-5.923	-0.010	-0.010	-0.010	-2.027	-0.010	-0.178

39	0.000	0.000	0.000	0.000	0.000	1.874	1.749	4.976	0.000	0.000	0.000
40	7.274	6.436	4.619	7.500	3.944	6.744	6.614	4.861	6.436	7.500	4.943
41	1.877	0.320	0.320	0.320	0.320	1.009	0.320	0.320	0.320	0.863	0.320
42	4.822	-0.258	-0.471	-0.301	-0.400	0.332	-0.266	-0.400	-0.113	1.006	-0.384
43	5.214	0.100	0.100	0.100	0.100	0.703	0.100	0.100	0.245	1.407	0.189
44	61.189	40.056	21.924	42.297	28.042	29.011	25.861	32.001	46.115	47.166	21.711
45	22.930	7.659	9.200	7.702	12.785	12.495	9.350	12.483	7.659	11.500	9.039
46	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-1.871	-0.001	-0.001	-0.001
47	**3.324**	**3.442**	**0.100**	**3.504**	**0.532**	**2.278**	**0.100**	**0.311**	**3.442**	**3.504**	**0.100**
48	**0.109**	**0.143**	**0.143**	**0.100**	**0.001**	**0.130**	**0.135**	**0.001**	**0.143**	**0.100**	**0.143**
49	**10.430**	**4.920**	**0.464**	**6.410**	**14.859**	5.352	0.929	9.875	4.920	6.410	0.957
50	0.630	0.455	0.111	1.286	0.111	1.188	0.111	1.981	0.358	2.200	0.111
51	29.142	22.539	11.411	21.810	10.439	11.299	10.000	10.000	28.539	21.810	10.825
52	0.150	0.209	0.209	0.209	0.209	0.150	0.209	0.150	0.150	0.150	0.298
53	0.619	0.100	0.100	0.100	0.100	0.330	0.100	0.100	0.100	0.281	0.100
54	1.000	1.000	1.667	1.000	8.527	1.000	10.000	10.000	1.000	1.000	1.415
55	0.010	0.354	0.010	1.185	0.010	0.857	0.010	0.010	0.257	1.918	0.010
56	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
57	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
58	0.011	0.355	0.011	1.186	0.011	0.858	0.011	1.881	0.258	1.919	0.011
59	0.500	0.500	0.713	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.715
60	45.648	25.592	18.815	26.549	22.281	23.726	20.846	24.089	29.814	32.307	18.635
61	3.371	5.000	4.377	3.100	0.130	4.007	5.000	0.130	5.000	3.100	4.377
62	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	3.157	5.000	-1.000	-1.000	-1.000
63	2.181	2.851	3.031	2.000	0.020	10.000	10.000	8.297	2.851	2.000	3.131
64	0.000	0.593	0.000	0.351	0.180	5.000	5.000	5.000	1.000	4.393	0.672
65	2.617	4.015	3.422	2.751	0.204	10.000	10.000	10.000	4.422	6.793	4.094
66	9.891	2.512	0.550	0.100	0.100	20.000	18.185	9.951	8.512	0.100	0.683
67	-1.000	-1.000	0.590	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	0.029
68	-1.000	5.000	5.000	-1.000	5.000	0.897	5.000	-1.000	-1.000	-1.000	5.000
69	5.000	5.000	-0.766	5.000	5.000	4.420	-1.000	5.000	5.000	3.988	-0.587
70	-1.000	-1.000	2.992	-1.000	10.000	3.622	10.000	6.624	-1.000	-1.000	3.687
71	5.174	0.001	0.001	0.001	0.001	0.663	0.001	4.742	0.205	1.367	0.001
72	10.000	10.000	6.527	8.988	7.910	5.444	6.703	2.926	10.000	10.000	6.946
73	5.780	7.557	7.557	5.301	0.054	6.903	7.179	0.054	7.557	5.301	7.557
74	5.000	3.807	5.000	2.700	0.147	5.000	5.000	0.126	5.000	4.124	5.000
75	5.000	5.000	5.000	5.000	3.964	5.000	4.528	5.000	5.000	5.000	5.000
76	5.000	0.865	2.193	0.610	5.000	0.791	2.506	0.016	0.865	0.610	1.952
77	3.826	5.000	5.000	3.510	0.045	4.568	4.751	0.045	5.000	3.510	5.000
78	1.427	1.863	1.863	1.310	0.023	1.703	1.771	0.023	1.863	1.310	1.863
79	6.116	7.994	7.994	5.610	0.066	7.303	7.595	4.748	7.994	5.610	7.994

80	10.000	10.000	8.184	10.000	3.969	10.000	10.000	4.886	10.000	10.000	8.508
81	10.000	10.000	4.396	10.000	10.000	10.000	9.258	10.000	10.000	10.000	5.051
82	0.224	2.994	1.801	2.100	0.000	1.221	1.466	0.021	1.801	0.676	1.801

Table S6: Optimal fluxes obtained for quad-objective system (Table III). These solutions are compared in Figure 6 with two different base cases which consider 10 measured fluxes (pink cells): the first one is obtained by one-variable optimization of flux 48 given measured values for fluxes 16, 46 and 47 (yellow cells). The second one is obtained by quad-optimization of the target fluxes using LPP.

Flux #	Case 1 (Base)	Case 2 (Base)	Case 3	Case 4	Case 5	Case 6	Case 7
1	6.6906189	4.7288333	9.4274226	4.5044601	1.9477056	9.1841297	3.2778991
2	6.6906189	4.7288333	9.4274226	4.5044601	1.9477056	9.1841297	3.2778991
3	6.6906189	4.7288333	9.4274226	4.5044601	1.9477056	9.1841297	3.2778991
4	13.711238	9.7876667	18.855845	9.0099203	3.8964111	18.369259	6.5567982
5	22.33912	30	18.856845	30	4.6972809	21.322122	30
6	22.33912	30	18.856845	30	4.6972809	21.322122	30
7	21.575667	15.01	9.63799	9.2100052	3.475044	10.319553	17.211714
8	5.1139258	14.843	1.00E-05	24.86899	1.151404	1.00E-05	5.2624954
9	20.1804	5.01	10.781145	5.01	5.01	9.0804507	7.2117143
10	20.1804	5.01	10.781145	5.01	5.01	9.0804507	7.2117143
11	10.536547	5	5	5	5	5	5
12	13.825754	5.033	5.031	5.031	6.3771852	10.015	9.3901214
13	15.722608	15.157	29.99999	5.13101	6.7841162	18.968961	24.737505
14	20.836534	30	30	30	7.9355202	18.968971	30
15	0.2329293	10.016	24.86899	1.00E-05	0.306931	8.8539613	15.247383
16	0.2329293	10.016	24.86899	1.00E-05	0.306931	8.8539613	15.247383
17	**0.57**	**20**	**34.84499**	**1**	**1**	**8.8299713**	**22.723869**
18	0.89722	0.6986667	-0.562	-6.70001	-7.2308102	-0.562	-7.0190786
19	7.5658138	19.054333	0.1	21.157091	0.1	0.781563	19.393288
20	0.1	0.1	0.1	0.1	0.2298384	0.1	0.1
21	6.841406	8.9	5.710555	1.1099971	1.6074467	7.876	6.5291678
22	0.5215514	0.001	0.001	0.001	0.001	0.001	0.001
23	-0.9143768	-1	-0.26477	-1	-0.9229703	-1	-0.4236589
24	8.6278826	20.212333	0.001	20.99008	0.8008698	2.9528628	23.443202
25	0.662954	0.4993333	0.499	0.3999998	0.4992014	0.499	0.3948536
26	3.2892067	0.033	0.031	0.031	1.3771852	5.015	4.3901214
27	0.3315745	0.001	1.0127948	0.001	0.001	0.001	0.001
28	1.643899	0.1	0.1	0.1	1.2931429	0.1	0.1
29	1.663925	0.108	0.1	0.1	0.1	0.1	0.1
30	0.11718	0.1	0.1	0.1	0.1	0.1078961	0.1
31	0.9463588	4.918	1.8306575	3.4999976	2.8614286	4.8663216	3.4228036
32	0.015436	0.012	0.01	0.01	1.3561852	4.994	4.3691214
33	1.1775832	0.01	0.01	0.01	0.01	0.01	0.01
34	1.5746361	0.01	0.01	0.01	0.01	0.01	0.01
35	0.9442141	0.01	0.01	0.01	0.01	0.01	0.01
36	0.1073195	-10	-10	-4.2000052	-1.7032833	1.1140487	-10
37	0.3372568	0.0313333	9.98	1.00E-05	0.3797766	1.00E-05	0.6841449
38	-9.6438525	-0.01	-5.7811447	-0.01	-0.01	-4.0804507	-2.2117143
39	0.3807133	4.984	4.976	1.00E-05	1.00E-05	1.00E-05	2.4764857
40	1.499408	4.9146667	1.8256575	7.499996	4.5716765	4.8613216	7.3713393
41	5.3582785	0.69	0.32	0.4701433	0.3643938	0.32	0.3306194
42	12.698394	3.32	-1.4117948	-0.3009998	-0.4002014	0.5212746	0.8193946
43	13.692923	3.8203333	0.1	0.1	0.1	1.0212746	1.2152482
44	69.068162	35.771167	37.279842	34.193956	21.868999	27.069763	32.461969
45	56.024665	10.393333	8.8127948	8.7530031	9.4581432	12.785	12.130311
46	-0.33	-0.33	-0.001	-0.001	-0.001	-0.001	-0.001
47	**0.012**	**2.4441667**	**0.1**	**3.5044601**	**0.1**	**0.7374778**	**2.2778991**
48	**9.40E-05**	**0.0006667**	**0.001**	**0.1000002**	**0.1425714**	**0.001**	**0.1051464**
49	**9.912146**	**9.8886667**	**9.4564598**	**6.4099944**	**0.4165436**	**14.859**	**10.588996**

50	2.2164321	0.93	0.111	0.1610478	0.111	0.111	0.1145398
51	18.126558	10	10	19.521914	11.52742	10	10
52	16.171062	3.8083333	0.15	0.209	0.209	1.1302746	1.3242482
53	1.3864321	0.1	0.1	0.1500478	0.1	0.1	0.1035398
54	6.6786189	2.2846667	9.3274226	1	1.8477056	8.4466519	1
55	0.5	0.5	0.01	0.01	0.01	0.01	0.01
56	0.8189823	0.01	0.01	0.01	0.0321969	0.01	0.01
57	0.38	0.38	0.01	0.01	0.0321969	0.01	0.01
58	0.83	0.83	0.011	0.011	0.011	0.011	0.011
59	0.663048	0.5	0.5	0.5	0.6417729	0.5	0.5
60	69.565615	24.94625	24.893318	23.023479	18.704318	21.778329	23.8307
61	0.12	0.12	0.13	3.1000048	4.3771429	0.1378961	3.2543929
62	2.6700085	5	5	-1	-1	-1	-1
63	0.3391368	0.0446667	10	2.0000132	3.2312052	0.02001	2.7870735
64	-0.0436426	5	5	0.99998	0.693059	-0.024	5
65	0.3393267	10	10	3.3999939	4.1147833	1.00E-05	10
66	0.3615021	5.885	20	0.1	0.8437478	0.1	20
67	0.24	0.24	-1	-1	0.9668455	-1	-1
68	-0.13	-0.13	0.39777	3.5770156	5	3.8467002	3.2663812
69	1.2435843	-1	3.2333647	5	-0.6131293	5	5
70	0.006	0.006	4.92099	-1	2.7861569	10	7.9279239
71	0.13	0.13	0.06	0.001	0.001	0.001	0.001
72	7.3660594	8.923	5.744555	4.4110024	6.3133039	7.91	10
73	0.3365565	0.0363333	1.0657948	5.3010085	7.5572857	0.054	5.5737607
74	1.646343	0.1173333	0.126	2.7000042	5	0.126	2.8338072
75	0.9477688	4.928	1.8456575	5	5	4.8813216	5
76	0.016	0.016	0.016	0.610001	2.2116138	5	5
77	1.1808732	0.0333333	0.045	3.5100056	5	0.045	3.690125
78	1.5758581	0.0186667	0.023	1.3100021	1.8634286	0.023	1.3769036
79	0.9494781	0.0473333	0.066	5.610009	7.994	0.066	5.8982
80	1.501758	4.9313333	1.8506575	10	8.1359622	4.8863216	10
81	10	10	9.5814598	10	4.2801969	10	10
82	0.022	0.022	0.021	2.1000034	1.8008571	0.021	2.208075

Table S7: Optimal fluxes obtained for quad-objective system. These solutions are compared in Figure 6 with two different base cases which consider 10 measured fluxes (pink cells): the first one is obtained by one-variable optimization of flux 48 given measured values for fluxes 16, 46 and 47 (yellow cells). The second one is obtained by quad-optimization of the target fluxes using LPP.

Flux #	Case 1 (Base)	Case 2 (Base)	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13	Case 14	Case 15	Case 16	Opt of GSH	Quad-obj opt
1	6.691	4.729	9.427	4.504	1.948	9.184	3.278	3.278	3.358	3.278	8.658	10.100	10.100	4.329	4.442	4.221	3.761	4.201
2	6.691	4.729	9.427	4.504	1.948	9.184	3.278	3.278	3.358	3.278	8.658	10.100	10.100	4.329	4.442	4.221	3.761	4.201
3	6.691	4.729	9.427	4.504	1.948	9.184	3.278	3.278	3.358	3.278	8.658	10.100	10.100	4.329	4.442	4.221	3.761	4.201
4	13.711	9.788	18.856	9.010	3.896	18.369	6.557	6.557	6.717	6.557	17.317	20.201	20.201	8.660	8.885	8.442	7.522	8.404
5	22.339	30.000	18.857	30.000	4.697	21.322	30.000	30.000	30.000	30.000	21.144	20.202	23.692	30.000	30.000	30.00	9.938	8.751
6	22.339	30.000	18.857	30.000	4.697	21.322	30.000	30.000	30.000	30.000	21.144	20.202	23.692	30.000	30.000	30.00	9.938	8.751
7	21.576	15.010	9.638	9.210	3.475	10.320	17.212	15.010	15.010	15.010	10.591	6.846	9.638	12.307	12.589	11.047	3.181	9.489
8	5.114	14.843	0.000	24.869	1.151	0.000	5.262	8.019	5.785	8.987	0.000	0.000	0.000	20.510	24.869	14.880	0.000	0.533
9	20.180	5.010	10.781	5.010	5.010	9.080	7.212	5.010	5.010	5.010	13.470	5.010	12.102	7.943	7.027	5.010	9.368	8.134
10	20.180	5.010	10.781	5.010	5.010	9.080	7.212	5.010	5.010	5.010	13.470	5.010	12.102	7.943	7.027	5.010	9.368	8.134
11	10.537	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
12	13.826	5.033	5.031	5.031	6.377	10.015	9.390	5.031	9.639	5.031	9.390	5.031	8.752	9.390	5.031	10.015	9.390	7.795
13	15.723	15.157	30.000	5.131	6.784	18.969	24.738	21.981	24.215	21.013	30.000	28.366	30.000	9.490	5.131	15.120	13.521	7.978
14	20.837	30.000	30.000	30.000	7.936	18.969	30.000	30.000	30.000	30.000	30.000	28.366	30.000	30.000	30.000	30.000	13.521	8.511
15	0.233	10.016	24.869	0.000	0.307	8.854	15.247	16.850	14.476	15.882	20.510	23.235	21.148	0.000	0.000	5.005	4.031	0.083
16	0.233	10.016	24.869	0.000	0.307	8.854	15.247	16.850	14.476	15.882	20.510	23.235	21.148	0.000	0.000	5.005	4.031	0.083
17	0.570	20.000	34.845	1.000	1.000	8.830	22.724	23.724	22.950	23.918	27.986	30.113	31.124	1.000	1.000	4.981	3.128	1.000
18	0.897	0.699	-0.562	-6.700	-7.231	-0.562	-7.019	-8.574	-4.444	-5.572	-1.019	-5.454	-0.562	-7.019	-9.339	-0.562	-7.019	-0.562
19	7.566	19.054	0.100	21.157	0.100	0.782	19.393	20.204	15.138	19.470	1.510	0.100	0.100	18.448	21.683	14.540	0.100	0.423
20	0.100	0.100	0.100	0.100	0.230	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
21	6.841	8.900	5.711	1.110	1.607	7.876	6.529	0.566	6.373	1.437	6.529	1.732	6.613	5.376	0.344	7.876	6.529	5.087
22	0.522	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
23	-0.914	-1.000	-0.265	-1.000	-0.923	-1.000	-0.424	-1.000	-1.000	-1.000	-0.424	-1.000	-1.000	-1.000	-1.000	-1.000	-0.424	-1.000
24	8.628	20.212	0.001	20.990	0.801	2.953	23.443	23.443	23.283	23.443	3.826	0.001	3.491	21.340	21.115	21.558	2.416	0.347
25	0.663	0.499	0.499	0.400	0.499	0.499	0.395	0.370	0.436	0.418	0.395	0.370	0.499	0.395	0.357	0.499	0.395	0.499
26	3.289	0.033	0.031	0.031	1.377	5.015	4.390	0.031	4.639	0.031	4.390	0.031	3.752	4.390	0.031	5.015	4.390	2.795
27	0.332	0.001	1.013	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
28	1.644	0.100	0.100	0.100	1.293	0.100	0.100	1.614	0.100	1.818	2.266	1.617	0.121	2.266	0.100	0.100	2.266	0.100
29	1.664	0.108	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
30	0.117	0.100	0.100	0.100	0.100	0.108	0.100	0.100	0.100	0.100	1.846	0.100	0.100	1.846	0.723	0.100	0.759	0.100
31	0.946	4.918	1.831	3.500	2.861	4.866	3.423	3.047	4.046	3.773	1.376	3.049	0.000	3.423	2.861	4.985	3.423	1.108
32	0.015	0.012	0.010	0.010	1.356	4.994	4.369	0.010	4.618	0.010	4.369	0.010	3.731	4.369	0.010	4.994	4.369	2.774
33	1.178	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
34	1.575	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
35	0.944	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	4.112	0.010	5.314	0.010	0.010	0.010	0.010	0.010
36	0.107	10.000	10.000	-4.200	-1.703	1.114	10.000	10.000	10.000	10.000	-5.977	10.000	-3.845	-4.365	-5.562	-6.037	2.605	-1.115
37	0.337	0.031	9.980	0.000	0.380	0.000	0.684	7.395	0.000	8.364	7.897	7.398	7.336	0.000	0.000	0.000	0.000	0.000
38	-9.644	-0.010	-5.781	-0.010	-0.010	-4.080	-2.212	-0.010	-0.010	-0.010	-8.470	-0.010	-7.102	-2.943	-2.027	-0.010	-4.368	-3.134
39	0.381	4.984	4.976	0.000	0.000	0.000	2.476	1.874	3.473	3.037	2.476	1.878	4.976	0.000	0.000	0.000	0.000	0.000
40	1.499	4.915	1.826	7.500	4.572	4.861	7.371	6.744	7.288	7.955	1.414	6.748	0.475	7.371	6.436	8.821	7.033	1.103
41	5.358	0.690	0.320	0.470	0.364	0.320	0.331	0.527	0.320	0.555	0.320	0.390	0.320	1.495	0.810	0.320	0.320	0.320
42	12.698	3.320	-1.412	-0.301	-0.400	0.521	0.819	-0.271	-0.337	0.161	-0.296	-0.271	1.031	3.953	-0.258	2.557	-0.296	-0.400
43	13.693	3.820	0.100	0.100	0.100	1.021	1.215	0.100	0.100	0.580	0.100	0.100	1.531	4.349	0.100	3.057	0.100	0.100
44	69.068	35.771	37.280	34.194	21.869	27.070	32.462	25.057	36.450	27.097	37.357	24.012	36.598	51.143	38.535	36.995	29.649	23.207
45	56.025	10.393	8.813	8.753	9.458	12.785	12.130	9.120	12.347	9.368	16.158	8.161	16.826	20.280	11.089	12.785	12.056	10.565
46	-0.330	-0.330	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
47	0.012	2.444	0.100	3.504	0.100	0.737	2.278	2.278	2.358	2.278	0.100	0.100	0.100	3.329	3.442	3.221	0.527	0.100
48	0.000	0.001	0.001	0.100	0.143	0.001	0.105	0.130	0.064	0.082	0.105	0.130	0.001	0.105	0.143	0.001	0.105	0.001
49	9.912	9.889	9.456	6.410	0.417	14.859	10.589	5.352	12.292	7.047	10.589	0.521	13.596	10.589	4.920	14.859	10.589	6.388
50	2.216	0.930	0.111	0.161	0.111	0.111	0.115	0.111	1.539	0.189	0.111	0.134	0.111	0.503	0.111	0.111	0.111	0.111
51	18.127	10.000	10.000	19.522	11.527	10.000	10.000	11.299	10.000	10.000	10.000	12.100	10.000	21.288	25.014	11.849	10.000	10.060
52	16.171	3.808	0.150	0.209	0.209	1.130	1.324	0.150	0.209	0.689	4.311	0.209	6.944	0.150	0.209	3.166	0.209	0.209
53	1.386	0.100	0.100	0.150	0.100	0.100	0.104	0.100	0.100	0.178	0.100	0.123	0.100	0.492	0.100	0.100	0.100	0.100
54	6.679	2.285	9.327	1.000	1.848	8.447	1.000	1.000	1.000	1.000	8.558	10.000	10.000	1.000	1.000	1.000	3.233	4.101
55	0.500	0.500	0.010	0.010	0.010	0.010	0.010	0.010	1.438	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
56	0.819	0.010	0.010	0.010	0.032	0.010	0.010	0.113	0.010	0.010	0.010	0.010	0.010	0.010	0.255	0.010	0.010	0.010
57	0.380	0.380	0.010	0.010	0.032	0.010	0.010	0.113	0.010	0.010	0.010	0.010	0.010	0.010	0.255	0.010	0.010	0.010
58	0.830	0.830	0.011	0.011	0.011	0.011	0.011	0.011	1.439	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
59	0.663	0.500	0.500	0.500	0.642	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
60	69.566	24.946	24.893	23.023	18.704	21.778	23.831	20.062	26.058	21.555	31.331	19.064	28.580	40.285	26.546	26.737	24.883	18.733
61	0.120	0.120	0.130	3.100	4.377	0.138	3.254	4.007	2.008	2.554	5.000	4.003	0.130	5.000	5.000	0.130	3.913	0.130
62	2.670	5.000	5.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	3.164	-1.000	3.848	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

63	0.339	0.045	10.000	2.000	3.231	0.020	2.787	10.000	1.272	10.000	10.000	10.000	7.356	2.103	2.851	0.020	2.103	0.020
64	-0.044	5.000	5.000	1.000	0.693	-0.024	5.000	5.000	5.000	5.000	5.000	5.000	5.000	1.000	1.000	-0.024	-0.903	0.917
65	0.339	10.000	10.000	3.400	4.115	0.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	3.524	4.422	0.000	1.621	0.941
66	0.362	5.885	20.000	0.100	0.844	0.100	20.000	20.000	17.979	12.648	16.453	19.915	14.494	2.428	7.462	0.100	0.100	0.100
67	0.240	0.240	-1.000	-1.000	0.967	-1.000	-1.000	-1.000	-1.000	-1.000	5.000	2.112	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
68	-0.130	-0.130	0.398	3.577	5.000	3.847	3.266	0.897	-1.000	-1.000	5.000	4.231	1.364	5.000	5.000	-1.000	5.000	3.874
69	1.244	-1.000	3.233	5.000	-0.613	5.000	5.000	5.000	5.000	5.000	5.000	-1.000	5.000	5.000	5.000	5.000	5.000	-0.682
70	0.006	0.006	4.921	-1.000	2.786	10.000	7.928	3.622	6.511	0.136	10.000	10.000	10.000	-1.000	-1.000	-1.000	10.000	-1.000
71	0.130	0.130	0.060	0.001	0.001	0.001	0.001	0.060	0.001	0.001	0.001	0.001	0.001	4.309	0.001	0.001	0.001	0.001
72	7.366	8.923	5.745	4.411	6.313	7.910	10.000	4.864	8.473	4.138	10.000	6.026	6.647	8.847	5.050	7.910	10.000	5.121
73	0.337	0.036	1.066	5.301	7.557	0.054	5.574	6.903	3.372	4.337	5.574	6.896	0.054	5.574	7.557	0.054	5.574	0.054
74	1.646	0.117	0.126	2.700	5.000	0.126	2.834	5.000	1.754	3.945	5.000	5.000	0.147	5.000	3.807	0.126	5.000	0.126
75	0.948	4.928	1.846	5.000	5.000	4.881	5.000	5.000	5.000	5.000	2.954	5.000	0.015	5.000	5.000	5.000	5.000	1.123
76	0.016	0.016	0.016	0.610	2.212	5.000	5.000	0.791	5.000	0.501	5.000	0.791	3.737	5.000	0.865	5.000	5.000	2.780
77	1.181	0.033	0.045	3.510	5.000	0.045	3.690	4.568	2.236	2.873	3.690	4.563	0.045	3.690	5.000	0.045	3.690	0.045
78	1.576	0.019	0.023	1.310	1.863	0.023	1.377	1.703	0.837	1.074	1.377	1.701	0.023	1.377	1.863	0.023	1.377	0.023
79	0.949	0.047	0.066	5.610	7.994	0.066	5.898	7.303	3.572	4.591	10.000	7.295	5.370	5.898	7.994	0.066	5.898	0.066
80	1.502	4.931	1.851	10.000	8.136	4.886	10.000	10.000	8.878	10.000	4.043	10.000	0.500	10.000	10.000	8.846	9.662	1.128
81	10.000	10.000	9.581	10.000	4.280	10.000	10.000	10.000	10.000	10.000	10.000	5.164	10.000	10.000	10.000	10.000	10.000	3.748
82	0.022	0.022	0.021	2.100	1.801	0.021	2.208	1.221	1.336	0.000	0.042	1.215	0.000	0.042	2.994	0.021	0.042	0.021

Table S8: LPP optimization results for the quad-objective system compared in Figure 6 (see Table S7). HUD is highly undesirable, UD is undesirable, T is tolerable, D is desirable and HD is highly desirable preference values of objective functions.

Case #	Priority	Flux	t1 (HD)	t2 (D)	t3 (T)	t4 (UD)	t5 (HUD)	Optimal
1 (base)	Measured	Urea						0.57
	Measured	NADPH						0.012
	Measured	Albumin						9.40E-05
	Max	GSH						9.912146
2 (base)	Mid	Urea	30	20	10	1	0.1	20
	Mid	NADPH	2.5	1.5	0.5	0.1	0.01	2.444167
	Mid	Albumin	0.1	0.05	0.005	0.0005	5.00E-05	0.000667
	Mid	GSH	10	5	1	0.5	0.1	9.888667
3	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	34.84499
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.1
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.001
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	9.45646
4	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	1
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	3.50446
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.1
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	6.409994
5	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	1
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.1
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.142571
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	0.416544
6	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	8.829971
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.737478
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.001
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	14.859
7	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	22.72387
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	2.277899
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.105146
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	10.589
8	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	23.72438
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	2.277899
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.130233
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	5.35186
9	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	22.94956
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	2.358001
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.063606
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	12.29216

10	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	23.91807
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	2.277899
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.081811
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	7.046622
11	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	27.98635
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.1
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.105146
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	10.589
12	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	30.11267
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.1
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.130096
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	0.520627
13	High	Urea	34.86875	31.81773	28.76672	25.7157	22.66469	31.12411
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.1
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.001
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	13.59588
14	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	1
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	3.32928
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.105146
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	10.589
15	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	1
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	3.442241
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.142571
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	4.92
16	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	4.98102
	High	NADPH	3.50446	3.19782	2.89118	2.584539	2.277899	3.220575
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.001
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	14.859
17	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	3.127813
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.527122
	High	Albumin	0.142571	0.130096	0.117621	0.105146	0.092671	0.105146
	High	GSH	14.89959	13.59588	12.29216	10.98845	9.684734	10.589
18	Low	Urea	1	0.750003	0.500005	0.250008	1.00E-05	1
	Low	NADPH	0.1	0.0775	0.055	0.0325	0.01	0.1
	Low	Albumin	0.001	0.000753	0.000505	0.000258	1.00E-05	0.001
	Low	GSH	0.1	0.07525	0.0505	0.02575	0.001	6.387537