

Quick Intro to SBMLR

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April 23, 2010

Introduction

SBMLR reads SBML files to and from an SBML-like R list of lists core object of class SBML, and it reads and writes these core objects into R text files that are well structured and light weight for editing. It also facilitates model simulations and model summaries.

Model import, export, editing and viewing

The following code reads in Curto et al.'s purine metabolism model of 1998

```
> library(SBMLR)
> curto = readSBML(system.file("models", "curto.xml", package = "SBMLR"))
> head(summary(curto)$reactions)
```

| | index | Laws | initialFluxes |
|-------|-------|---|---------------|
| ada | 1 | aada*ATP ^f ada4 | 2.079466999 |
| ade | 2 | aade*Ade ^f ade6 | 0.009915724 |
| adna | 3 | aadna*dATP ^f dnap9*dGTP ^f dnap10 | 10.038261346 |
| adnrn | 4 | aadnrn*ATP ^f adnrn4*dATP ^f adnrn9*dGTP ^f adnrn10 | 0.201159500 |
| ampd | 5 | aampd*ATP ^f fampd4*dGTP ^f fampd8*Pi ^f fampd18 | 5.640727920 |
| aprt | 6 | aaprt*PRPP ^f faprt1*ATP ^f faprt4*Ade ^f faprt6 | 0.998075329 |

and the next two lines serialize the object *curto* of S3 class SBML (R list of lists) into a current working directory SBML (XML) file and editable R code SBMLR file. Relative to the option of using *dput* and *deparse*, *saveSBMLR* and *readSBMLR* ASCII text representations are more pleasant to look at and thus edit (the carriage returns are in the right places).

```
> saveSBML(curto, "curto.xml")
> saveSBMLR(curto, "curto.r")
```

These two files can then be read back in and compared as follows.

```
> curtoX = readSBML("curto.xml")
> curtoR = readSBMLR("curto.r")
> head((curtoX == curtoR)$species)
```

| | index | initialConcentrations | boundaryConditions |
|------|-------|-----------------------|--------------------|
| PRPP | TRUE | TRUE | TRUE |
| IMP | TRUE | TRUE | TRUE |
| SAMP | TRUE | TRUE | TRUE |
| ATP | TRUE | TRUE | TRUE |
| SAM | TRUE | TRUE | TRUE |
| Ade | TRUE | TRUE | TRUE |

```
> head((curtoX == curtoR)$reactions)
```

| | index | Laws | initialFluxes |
|-------|-------|------|---------------|
| ada | TRUE | TRUE | TRUE |
| ade | TRUE | TRUE | TRUE |
| adna | TRUE | TRUE | TRUE |
| adrnr | TRUE | TRUE | TRUE |
| ampd | TRUE | TRUE | TRUE |
| aprt | TRUE | TRUE | TRUE |

Values in these two dataframes are TRUE where the initial concentrations, fluxes, and reaction rate laws (as strings) are equal.

Model simulation

The following simulation first shows that the initial conditions is a steady state. It then shows the time course response to an increase in [PRPP] from 5 uM to 50 uM.

```
> out1 = simulate(curto, seq(-20, 0, 1))
> curto$species$PRPP$ic = 50
> out2 = simulate(curto, 0:70)
> outs = data.frame(rbind(out1, out2))
> attach(outs)
> par(mfrow = c(2, 1))
> plot(time, IMP, type = "l", xlab = "minutes", ylab = "IMP (uM)")
> plot(time, HX, type = "l", xlab = "minutes", ylab = "HX (uM)")
> par(mfrow = c(1, 1))
> detach(outs)
```

The modulator argument to *simulate* is either NULL, a vector of numbers, or a list of interpolation functions (time varying enzyme concentration boundary conditions). The vector and list lengths equal to the number of reactions; in the vector case reaction rate law amplitude parameters are multiplied by 1 at times less than zero and the corresponding vector element thereafter. The following code doubles the amplitude parameters of Curto et al's 37 reactions at t=0; concentrations then stay the same as fluxes double.

```
> curto$species$PRPP$ic = 5
> simulate(curto, (-10):10, modulator = rep(2, 37))
```

| | time | PRPP | IMP | SAMP | ATP | SAM | Ade | XMP |
|-------|------|----------|----------|-----------|----------|----------|-----------|----------|
| [1,] | -10 | 5.000000 | 98.26340 | 0.1981890 | 2475.350 | 3.991870 | 0.9847300 | 24.79300 |
| [2,] | -9 | 5.017095 | 98.25819 | 0.1981608 | 2475.352 | 3.991870 | 0.9849150 | 24.79299 |
| [3,] | -8 | 5.017228 | 98.25854 | 0.1981855 | 2475.354 | 3.991870 | 0.9848419 | 24.79298 |
| [4,] | -7 | 5.017271 | 98.25887 | 0.1981857 | 2475.354 | 3.991870 | 0.9848024 | 24.79296 |
| [5,] | -6 | 5.017300 | 98.25916 | 0.1981859 | 2475.354 | 3.991871 | 0.9847828 | 24.79295 |
| [6,] | -5 | 5.017320 | 98.25940 | 0.1981862 | 2475.354 | 3.991871 | 0.9847718 | 24.79295 |
| [7,] | -4 | 5.017340 | 98.25965 | 0.1981864 | 2475.354 | 3.991871 | 0.9847607 | 24.79294 |
| [8,] | -3 | 5.017356 | 98.25986 | 0.1981866 | 2475.354 | 3.991871 | 0.9847534 | 24.79293 |
| [9,] | -2 | 5.017367 | 98.26005 | 0.1981867 | 2475.354 | 3.991871 | 0.9847490 | 24.79292 |
| [10,] | -1 | 5.017378 | 98.26024 | 0.1981869 | 2475.354 | 3.991871 | 0.9847446 | 24.79291 |
| [11,] | 0 | 5.017385 | 98.26043 | 0.1981870 | 2475.354 | 3.991870 | 0.9847418 | 24.79291 |
| [12,] | 1 | 5.017391 | 98.26063 | 0.1981872 | 2475.354 | 3.991870 | 0.9847403 | 24.79290 |
| [13,] | 2 | 5.017396 | 98.26082 | 0.1981873 | 2475.354 | 3.991870 | 0.9847388 | 24.79289 |
| [14,] | 3 | 5.017401 | 98.26101 | 0.1981875 | 2475.354 | 3.991870 | 0.9847373 | 24.79289 |
| [15,] | 4 | 5.017406 | 98.26121 | 0.1981877 | 2475.354 | 3.991870 | 0.9847358 | 24.79288 |
| [16,] | 5 | 5.017411 | 98.26140 | 0.1981878 | 2475.354 | 3.991870 | 0.9847343 | 24.79287 |
| [17,] | 6 | 5.017414 | 98.26154 | 0.1981879 | 2475.354 | 3.991870 | 0.9847336 | 24.79287 |
| [18,] | 7 | 5.017415 | 98.26166 | 0.1981880 | 2475.354 | 3.991870 | 0.9847333 | 24.79286 |
| [19,] | 8 | 5.017416 | 98.26177 | 0.1981881 | 2475.354 | 3.991870 | 0.9847330 | 24.79286 |
| [20,] | 9 | 5.017417 | 98.26188 | 0.1981882 | 2475.354 | 3.991870 | 0.9847327 | 24.79286 |
| [21,] | 10 | 5.017418 | 98.26199 | 0.1981883 | 2475.354 | 3.991870 | 0.9847325 | 24.79285 |

| | GTP | dATP | dGTP | RNA | DNA | HX | Xa | Gua |
|-------|----------|----------|----------|----------|----------|----------|----------|----------|
| [1,] | 410.2230 | 6.014130 | 3.025810 | 28680.50 | 5179.340 | 9.517850 | 5.059410 | 5.506380 |
| [2,] | 410.2223 | 6.014135 | 3.025813 | 28680.50 | 5179.340 | 9.519836 | 5.059734 | 5.508591 |
| [3,] | 410.2235 | 6.014136 | 3.025813 | 28680.49 | 5179.340 | 9.519325 | 5.059924 | 5.508098 |
| [4,] | 410.2242 | 6.014137 | 3.025814 | 28680.49 | 5179.341 | 9.518915 | 5.059998 | 5.507735 |
| [5,] | 410.2245 | 6.014137 | 3.025814 | 28680.49 | 5179.341 | 9.518635 | 5.059997 | 5.507502 |
| [6,] | 410.2247 | 6.014138 | 3.025814 | 28680.49 | 5179.341 | 9.518427 | 5.059962 | 5.507337 |
| [7,] | 410.2248 | 6.014138 | 3.025814 | 28680.49 | 5179.341 | 9.518219 | 5.059927 | 5.507171 |
| [8,] | 410.2249 | 6.014139 | 3.025814 | 28680.49 | 5179.341 | 9.518064 | 5.059883 | 5.507048 |
| [9,] | 410.2250 | 6.014139 | 3.025814 | 28680.49 | 5179.342 | 9.517952 | 5.059833 | 5.506960 |
| [10,] | 410.2251 | 6.014139 | 3.025814 | 28680.49 | 5179.342 | 9.517841 | 5.059783 | 5.506871 |
| [11,] | 410.2251 | 6.014140 | 3.025814 | 28680.49 | 5179.342 | 9.517771 | 5.059735 | 5.506809 |
| [12,] | 410.2251 | 6.014141 | 3.025814 | 28680.49 | 5179.343 | 9.517736 | 5.059691 | 5.506769 |
| [13,] | 410.2251 | 6.014142 | 3.025814 | 28680.49 | 5179.343 | 9.517701 | 5.059646 | 5.506728 |
| [14,] | 410.2251 | 6.014143 | 3.025815 | 28680.49 | 5179.343 | 9.517667 | 5.059601 | 5.506687 |
| [15,] | 410.2251 | 6.014143 | 3.025815 | 28680.49 | 5179.344 | 9.517632 | 5.059556 | 5.506647 |
| [16,] | 410.2251 | 6.014144 | 3.025815 | 28680.49 | 5179.344 | 9.517597 | 5.059512 | 5.506606 |
| [17,] | 410.2251 | 6.014145 | 3.025815 | 28680.49 | 5179.345 | 9.517588 | 5.059487 | 5.506585 |
| [18,] | 410.2251 | 6.014146 | 3.025815 | 28680.49 | 5179.345 | 9.517594 | 5.059475 | 5.506575 |
| [19,] | 410.2251 | 6.014147 | 3.025815 | 28680.49 | 5179.345 | 9.517601 | 5.059463 | 5.506566 |
| [20,] | 410.2251 | 6.014148 | 3.025815 | 28680.49 | 5179.346 | 9.517607 | 5.059451 | 5.506556 |
| [21,] | 410.2251 | 6.014149 | 3.025815 | 28680.49 | 5179.346 | 9.517613 | 5.059438 | 5.506547 |

| | UA | ada | ade | adna | adrnr | ampd | aprt |
|------|----------|----------|-------------|----------|-----------|----------|-----------|
| [1,] | 100.2930 | 2.079467 | 0.009915724 | 10.03826 | 0.2011595 | 5.640728 | 0.9963412 |

| | | | | | | | |
|-------|----------|-----------|-------------|-----------|-----------|-----------|-----------|
| [2,] | 100.2931 | 2.079469 | 0.009916749 | 10.03827 | 0.2011596 | 5.640732 | 0.9981829 |
| [3,] | 100.2932 | 2.079470 | 0.009916344 | 10.03827 | 0.2011597 | 5.640734 | 0.9981402 |
| [4,] | 100.2933 | 2.079470 | 0.009916125 | 10.03827 | 0.2011597 | 5.640735 | 0.9981143 |
| [5,] | 100.2935 | 2.079471 | 0.009916017 | 10.03827 | 0.2011597 | 5.640735 | 0.9981021 |
| [6,] | 100.2936 | 2.079471 | 0.009915956 | 10.03827 | 0.2011597 | 5.640735 | 0.9980957 |
| [7,] | 100.2937 | 2.079471 | 0.009915895 | 10.03827 | 0.2011597 | 5.640735 | 0.9980894 |
| [8,] | 100.2937 | 2.079471 | 0.009915854 | 10.03827 | 0.2011597 | 5.640735 | 0.9980853 |
| [9,] | 100.2938 | 2.079470 | 0.009915830 | 10.03827 | 0.2011597 | 5.640735 | 0.9980831 |
| [10,] | 100.2939 | 2.079470 | 0.009915805 | 10.03827 | 0.2011597 | 5.640735 | 0.9980809 |
| [11,] | 100.2939 | 4.158941 | 0.019831580 | 20.07655 | 0.4023193 | 11.281469 | 1.9961591 |
| [12,] | 100.2939 | 4.158941 | 0.019831563 | 20.07655 | 0.4023193 | 11.281469 | 1.9961579 |
| [13,] | 100.2939 | 4.158940 | 0.019831547 | 20.07655 | 0.4023193 | 11.281469 | 1.9961567 |
| [14,] | 100.2938 | 4.158940 | 0.019831530 | 20.07655 | 0.4023193 | 11.281468 | 1.9961555 |
| [15,] | 100.2938 | 4.158940 | 0.019831513 | 20.07655 | 0.4023193 | 11.281468 | 1.9961543 |
| [16,] | 100.2938 | 4.158940 | 0.019831497 | 20.07655 | 0.4023193 | 11.281468 | 1.9961531 |
| [17,] | 100.2938 | 4.158940 | 0.019831488 | 20.07655 | 0.4023193 | 11.281468 | 1.9961525 |
| [18,] | 100.2938 | 4.158940 | 0.019831485 | 20.07656 | 0.4023193 | 11.281467 | 1.9961523 |
| [19,] | 100.2937 | 4.158940 | 0.019831482 | 20.07656 | 0.4023193 | 11.281467 | 1.9961521 |
| [20,] | 100.2937 | 4.158940 | 0.019831479 | 20.07656 | 0.4023193 | 11.281467 | 1.9961519 |
| [21,] | 100.2937 | 4.158940 | 0.019831476 | 20.07656 | 0.4023193 | 11.281467 | 1.9961517 |
| | arna | asuc | asli | dada | den | dgnuc | dnaa |
| [1,] | 1985.621 | 8.003186 | 8.003185 | 0.2004510 | 2.386351 | 0.1008502 | 10.03756 |
| [2,] | 1985.621 | 8.003012 | 8.002051 | 0.2004511 | 2.402705 | 0.1008503 | 10.03756 |
| [3,] | 1985.621 | 8.003027 | 8.003034 | 0.2004511 | 2.402830 | 0.1008504 | 10.03756 |
| [4,] | 1985.622 | 8.003040 | 8.003040 | 0.2004512 | 2.402870 | 0.1008504 | 10.03756 |
| [5,] | 1985.622 | 8.003050 | 8.003050 | 0.2004512 | 2.402897 | 0.1008504 | 10.03756 |
| [6,] | 1985.622 | 8.003059 | 8.003059 | 0.2004512 | 2.402916 | 0.1008504 | 10.03756 |
| [7,] | 1985.622 | 8.003068 | 8.003067 | 0.2004512 | 2.402935 | 0.1008504 | 10.03756 |
| [8,] | 1985.622 | 8.003075 | 8.003075 | 0.2004512 | 2.402949 | 0.1008504 | 10.03756 |
| [9,] | 1985.622 | 8.003082 | 8.003081 | 0.2004513 | 2.402959 | 0.1008504 | 10.03756 |
| [10,] | 1985.622 | 8.003088 | 8.003088 | 0.2004513 | 2.402969 | 0.1008504 | 10.03756 |
| [11,] | 3971.245 | 16.006189 | 16.006188 | 0.4009026 | 4.805953 | 0.2017008 | 20.07513 |
| [12,] | 3971.245 | 16.006202 | 16.006201 | 0.4009026 | 4.805962 | 0.2017008 | 20.07513 |
| [13,] | 3971.245 | 16.006214 | 16.006214 | 0.4009027 | 4.805971 | 0.2017008 | 20.07513 |
| [14,] | 3971.245 | 16.006227 | 16.006227 | 0.4009027 | 4.805980 | 0.2017008 | 20.07513 |
| [15,] | 3971.245 | 16.006240 | 16.006240 | 0.4009028 | 4.805990 | 0.2017008 | 20.07514 |
| [16,] | 3971.245 | 16.006253 | 16.006253 | 0.4009029 | 4.805999 | 0.2017008 | 20.07514 |
| [17,] | 3971.245 | 16.006262 | 16.006262 | 0.4009029 | 4.806003 | 0.2017008 | 20.07514 |
| [18,] | 3971.245 | 16.006269 | 16.006269 | 0.4009030 | 4.806005 | 0.2017008 | 20.07514 |
| [19,] | 3971.245 | 16.006277 | 16.006276 | 0.4009030 | 4.806007 | 0.2017008 | 20.07514 |
| [20,] | 3971.245 | 16.006284 | 16.006284 | 0.4009031 | 4.806009 | 0.2017009 | 20.07514 |
| [21,] | 3971.245 | 16.006291 | 16.006291 | 0.4009032 | 4.806011 | 0.2017009 | 20.07515 |
| | dnag | gdna | gdrnr | gmpr | gmpr | gnuc | gprr |
| [1,] | 6.826370 | 6.825859 | 0.1003440 | 0.5138721 | 1.595763 | 4.807078 | 3.738009 |
| [2,] | 6.826370 | 6.825863 | 0.1003438 | 0.5138758 | 1.595763 | 4.807071 | 3.753990 |
| [3,] | 6.826371 | 6.825864 | 0.1003439 | 0.5138767 | 1.595763 | 4.807084 | 3.753956 |

| | | | | | | | | | |
|-------|-----------|-----------|-----------|------------|----------|----------|----------|------------|--|
| [4,] | 6.826371 | 6.825864 | 0.1003440 | 0.5138772 | 1.595763 | 4.807091 | 3.753883 | | |
| [5,] | 6.826371 | 6.825865 | 0.1003440 | 0.5138774 | 1.595763 | 4.807094 | 3.753839 | | |
| [6,] | 6.826371 | 6.825865 | 0.1003440 | 0.5138775 | 1.595763 | 4.807096 | 3.753808 | | |
| [7,] | 6.826372 | 6.825865 | 0.1003440 | 0.5138776 | 1.595763 | 4.807098 | 3.753777 | | |
| [8,] | 6.826372 | 6.825866 | 0.1003440 | 0.5138776 | 1.595762 | 4.807099 | 3.753754 | | |
| [9,] | 6.826372 | 6.825866 | 0.1003440 | 0.5138777 | 1.595762 | 4.807099 | 3.753738 | | |
| [10,] | 6.826372 | 6.825866 | 0.1003440 | 0.5138777 | 1.595762 | 4.807100 | 3.753722 | | |
| [11,] | 13.652746 | 13.651733 | 0.2006880 | 1.0277553 | 3.191524 | 9.614200 | 7.507422 | | |
| [12,] | 13.652747 | 13.651734 | 0.2006879 | 1.0277553 | 3.191524 | 9.614200 | 7.507407 | | |
| [13,] | 13.652748 | 13.651735 | 0.2006879 | 1.0277552 | 3.191524 | 9.614201 | 7.507393 | | |
| [14,] | 13.652749 | 13.651736 | 0.2006879 | 1.0277551 | 3.191524 | 9.614201 | 7.507379 | | |
| [15,] | 13.652750 | 13.651737 | 0.2006878 | 1.0277551 | 3.191524 | 9.614201 | 7.507365 | | |
| [16,] | 13.652751 | 13.651738 | 0.2006878 | 1.0277550 | 3.191524 | 9.614201 | 7.507350 | | |
| [17,] | 13.652752 | 13.651739 | 0.2006877 | 1.0277550 | 3.191523 | 9.614201 | 7.507343 | | |
| [18,] | 13.652753 | 13.651740 | 0.2006877 | 1.0277549 | 3.191523 | 9.614201 | 7.507340 | | |
| [19,] | 13.652754 | 13.651741 | 0.2006877 | 1.0277548 | 3.191523 | 9.614201 | 7.507336 | | |
| [20,] | 13.652755 | 13.651742 | 0.2006876 | 1.0277547 | 3.191523 | 9.614201 | 7.507333 | | |
| [21,] | 13.652756 | 13.651743 | 0.2006876 | 1.0277547 | 3.191523 | 9.614201 | 7.507330 | | |
| | grna | gua | hprrt | hx | hxd | impd | inuc | mat | |
| [1,] | 1323.532 | 1.154277 | 3.669760 | 0.04730928 | 1.191281 | 1.595762 | 2.642505 | 14.98849 | |
| [2,] | 1323.532 | 1.154508 | 3.684107 | 0.04732034 | 1.191442 | 1.595750 | 2.642393 | 14.98850 | |
| [3,] | 1323.532 | 1.154457 | 3.684108 | 0.04731749 | 1.191401 | 1.595750 | 2.642401 | 14.98850 | |
| [4,] | 1323.532 | 1.154419 | 3.684055 | 0.04731521 | 1.191368 | 1.595751 | 2.642408 | 14.98850 | |
| [5,] | 1323.533 | 1.154394 | 3.684017 | 0.04731365 | 1.191345 | 1.595752 | 2.642414 | 14.98850 | |
| [6,] | 1323.533 | 1.154377 | 3.683987 | 0.04731250 | 1.191328 | 1.595753 | 2.642419 | 14.98850 | |
| [7,] | 1323.533 | 1.154360 | 3.683956 | 0.04731134 | 1.191311 | 1.595753 | 2.642425 | 14.98850 | |
| [8,] | 1323.533 | 1.154347 | 3.683933 | 0.04731048 | 1.191298 | 1.595754 | 2.642429 | 14.98850 | |
| [9,] | 1323.533 | 1.154337 | 3.683914 | 0.04730985 | 1.191289 | 1.595754 | 2.642433 | 14.98850 | |
| [10,] | 1323.533 | 1.154328 | 3.683896 | 0.04730923 | 1.191280 | 1.595755 | 2.642437 | 14.98850 | |
| [11,] | 2647.066 | 2.308643 | 7.367766 | 0.09461768 | 2.382549 | 3.191511 | 5.284883 | 29.97699 | |
| [12,] | 2647.066 | 2.308635 | 7.367749 | 0.09461730 | 2.382543 | 3.191512 | 5.284891 | 29.97699 | |
| [13,] | 2647.066 | 2.308626 | 7.367731 | 0.09461691 | 2.382538 | 3.191513 | 5.284900 | 29.97699 | |
| [14,] | 2647.066 | 2.308618 | 7.367713 | 0.09461652 | 2.382532 | 3.191514 | 5.284908 | 29.97699 | |
| [15,] | 2647.066 | 2.308609 | 7.367696 | 0.09461614 | 2.382526 | 3.191515 | 5.284917 | 29.97699 | |
| [16,] | 2647.066 | 2.308601 | 7.367678 | 0.09461575 | 2.382521 | 3.191516 | 5.284925 | 29.97699 | |
| [17,] | 2647.066 | 2.308596 | 7.367669 | 0.09461565 | 2.382519 | 3.191517 | 5.284931 | 29.97699 | |
| [18,] | 2647.066 | 2.308594 | 7.367666 | 0.09461572 | 2.382520 | 3.191517 | 5.284936 | 29.97699 | |
| [19,] | 2647.066 | 2.308592 | 7.367663 | 0.09461579 | 2.382521 | 3.191518 | 5.284941 | 29.97699 | |
| [20,] | 2647.066 | 2.308590 | 7.367660 | 0.09461586 | 2.382522 | 3.191518 | 5.284945 | 29.97699 | |
| [21,] | 2647.066 | 2.308588 | 7.367656 | 0.09461593 | 2.382523 | 3.191519 | 5.284950 | 29.97699 | |
| | polyam | prpps | pyr | rnaa | rnag | trans | ua | x | |
| [1,] | 1.007991 | 20.88492 | 9.99989 | 1985.551 | 1323.605 | 13.98050 | 2.314825 | 0.03071716 | |
| [2,] | 1.007991 | 20.88278 | 10.04333 | 1985.551 | 1323.605 | 13.98050 | 2.314828 | 0.03072109 | |
| [3,] | 1.007991 | 20.88275 | 10.04367 | 1985.551 | 1323.605 | 13.98050 | 2.314834 | 0.03072339 | |
| [4,] | 1.007991 | 20.88274 | 10.04378 | 1985.550 | 1323.605 | 13.98050 | 2.314842 | 0.03072430 | |
| [5,] | 1.007991 | 20.88274 | 10.04385 | 1985.550 | 1323.605 | 13.98050 | 2.314848 | 0.03072428 | |

```

[6,] 1.007991 20.88274 10.04390 1985.550 1323.605 13.98050 2.314854 0.03072385
[7,] 1.007991 20.88273 10.04395 1985.550 1323.605 13.98050 2.314859 0.03072343
[8,] 1.007991 20.88273 10.04399 1985.550 1323.605 13.98050 2.314863 0.03072290
[9,] 1.007991 20.88273 10.04402 1985.550 1323.605 13.98050 2.314866 0.03072229
[10,] 1.007991 20.88273 10.04405 1985.550 1323.605 13.98050 2.314869 0.03072168
[11,] 2.015983 41.76546 20.08814 3971.101 2647.209 27.96101 4.629740 0.06144221
[12,] 2.015983 41.76546 20.08816 3971.101 2647.209 27.96101 4.629739 0.06144113
[13,] 2.015983 41.76546 20.08819 3971.101 2647.209 27.96101 4.629738 0.06144004
[14,] 2.015983 41.76546 20.08822 3971.101 2647.209 27.96101 4.629737 0.06143895
[15,] 2.015983 41.76545 20.08824 3971.101 2647.209 27.96101 4.629736 0.06143787
[16,] 2.015983 41.76545 20.08827 3971.101 2647.209 27.96101 4.629735 0.06143678
[17,] 2.015983 41.76545 20.08828 3971.101 2647.209 27.96101 4.629733 0.06143619
[18,] 2.015983 41.76545 20.08829 3971.101 2647.209 27.96101 4.629730 0.06143589
[19,] 2.015983 41.76545 20.08829 3971.101 2647.209 27.96101 4.629727 0.06143559
[20,] 2.015983 41.76545 20.08830 3971.101 2647.209 27.96101 4.629724 0.06143530
[21,] 2.015983 41.76545 20.08830 3971.101 2647.209 27.96101 4.629721 0.06143500
      xd R5P   Pi
[1,] 2.314841 18 1400
[2,] 2.314923 18 1400
[3,] 2.314970 18 1400
[4,] 2.314989 18 1400
[5,] 2.314989 18 1400
[6,] 2.314980 18 1400
[7,] 2.314971 18 1400
[8,] 2.314960 18 1400
[9,] 2.314947 18 1400
[10,] 2.314935 18 1400
[11,] 4.629845 18 1400
[12,] 4.629823 18 1400
[13,] 4.629800 18 1400
[14,] 4.629778 18 1400
[15,] 4.629755 18 1400
[16,] 4.629733 18 1400
[17,] 4.629721 18 1400
[18,] 4.629714 18 1400
[19,] 4.629708 18 1400
[20,] 4.629702 18 1400
[21,] 4.629696 18 1400
attr(,"istate")
[1] 2

```

If half the fluxes increase and the other half decrease, both by 10 percent, both concentrations and fluxes change

```

> simulate(curto, (-10):10, modulator = c(rep(1.1, 20), rep(0.9,
+      17)))

```

| | time | PRPP | IMP | SAMP | ATP | SAM | Ade | |
|-------|----------|-----------|------------|--------------|------------|-----------|--------------|----------|
| [1,] | -10 | 5.000000 | 98.26340 | 0.198189000 | 2475.35000 | 3.991870 | 0.9847300000 | |
| [2,] | -9 | 5.017095 | 98.25819 | 0.198160810 | 2475.35236 | 3.991870 | 0.9849150437 | |
| [3,] | -8 | 5.017228 | 98.25854 | 0.198185483 | 2475.35358 | 3.991870 | 0.9848418902 | |
| [4,] | -7 | 5.017271 | 98.25887 | 0.198185683 | 2475.35413 | 3.991870 | 0.9848024315 | |
| [5,] | -6 | 5.017300 | 98.25916 | 0.198185950 | 2475.35431 | 3.991871 | 0.9847827859 | |
| [6,] | -5 | 5.017320 | 98.25940 | 0.198186169 | 2475.35433 | 3.991871 | 0.9847717607 | |
| [7,] | -4 | 5.017340 | 98.25965 | 0.198186387 | 2475.35434 | 3.991871 | 0.9847607355 | |
| [8,] | -3 | 5.017356 | 98.25986 | 0.198186571 | 2475.35432 | 3.991871 | 0.9847533693 | |
| [9,] | -2 | 5.017367 | 98.26005 | 0.198186727 | 2475.35425 | 3.991871 | 0.9847490095 | |
| [10,] | -1 | 5.017378 | 98.26024 | 0.198186883 | 2475.35419 | 3.991871 | 0.9847446496 | |
| [11,] | 0 | 5.017125 | 98.26045 | 0.198186886 | 2475.28077 | 3.991870 | 0.9847033729 | |
| [12,] | 1 | 4.942722 | 97.64947 | 0.176883682 | 2097.28388 | 3.896995 | 0.8013655252 | |
| [13,] | 2 | 5.263423 | 96.43249 | 0.156422060 | 1747.75987 | 3.757725 | 0.6110697362 | |
| [14,] | 3 | 5.678576 | 94.79475 | 0.136079232 | 1418.58080 | 3.604279 | 0.4333670888 | |
| [15,] | 4 | 6.208070 | 92.84150 | 0.115204885 | 1106.95040 | 3.431260 | 0.2850609877 | |
| [16,] | 5 | 6.906223 | 90.75119 | 0.093552802 | 813.79785 | 3.229711 | 0.1708134537 | |
| [17,] | 6 | 7.882444 | 88.89621 | 0.071061872 | 543.48489 | 2.985441 | 0.0889335656 | |
| [18,] | 7 | 9.371186 | 88.21632 | 0.048088207 | 305.51270 | 2.672575 | 0.0360469357 | |
| [19,] | 8 | 11.953794 | 91.81694 | 0.025764934 | 120.35689 | 2.240272 | 0.0088253316 | |
| [20,] | 9 | 16.535833 | 113.06818 | 0.010326413 | 28.61334 | 1.668489 | 0.0009198184 | |
| [21,] | 10 | 19.417960 | 167.89377 | 0.007564643 | 14.10909 | 1.380957 | 0.0003500508 | |
| | XMP | GTP | dATP | dGTP | RNA | DNA | HX | Xa |
| [1,] | 24.79300 | 410.2230 | 6.014130 | 3.025810 | 28680.50 | 5179.340 | 9.5178500 | 5.059410 |
| [2,] | 24.79299 | 410.2223 | 6.014135 | 3.025813 | 28680.50 | 5179.340 | 9.5198359 | 5.059734 |
| [3,] | 24.79298 | 410.2235 | 6.014136 | 3.025813 | 28680.49 | 5179.340 | 9.5193252 | 5.059924 |
| [4,] | 24.79296 | 410.2242 | 6.014137 | 3.025814 | 28680.49 | 5179.341 | 9.5189149 | 5.059998 |
| [5,] | 24.79295 | 410.2245 | 6.014137 | 3.025814 | 28680.49 | 5179.341 | 9.5186350 | 5.059997 |
| [6,] | 24.79295 | 410.2247 | 6.014138 | 3.025814 | 28680.49 | 5179.341 | 9.5184272 | 5.059962 |
| [7,] | 24.79294 | 410.2248 | 6.014138 | 3.025814 | 28680.49 | 5179.341 | 9.5182194 | 5.059927 |
| [8,] | 24.79293 | 410.2249 | 6.014139 | 3.025814 | 28680.49 | 5179.341 | 9.5180642 | 5.059883 |
| [9,] | 24.79292 | 410.2250 | 6.014139 | 3.025814 | 28680.49 | 5179.342 | 9.5179524 | 5.059833 |
| [10,] | 24.79291 | 410.2251 | 6.014139 | 3.025814 | 28680.49 | 5179.342 | 9.5178405 | 5.059783 |
| [11,] | 24.79285 | 410.2251 | 6.014140 | 3.025814 | 28680.56 | 5179.342 | 9.5178179 | 5.059732 |
| [12,] | 24.49245 | 421.2855 | 6.012597 | 3.026378 | 29048.35 | 5179.342 | 9.8444359 | 5.089213 |
| [13,] | 24.22826 | 449.4133 | 6.007924 | 3.029316 | 29371.97 | 5179.341 | 9.6202673 | 5.150226 |
| [14,] | 24.00077 | 489.7226 | 5.999331 | 3.035443 | 29664.28 | 5179.341 | 8.8684789 | 5.210686 |
| [15,] | 23.81307 | 540.3163 | 5.985946 | 3.045135 | 29929.99 | 5179.342 | 7.6660479 | 5.253933 |
| [16,] | 23.67127 | 601.3511 | 5.966937 | 3.058756 | 30168.10 | 5179.346 | 6.1109343 | 5.268473 |
| [17,] | 23.58604 | 674.7772 | 5.941311 | 3.076830 | 30372.60 | 5179.352 | 4.3427581 | 5.243750 |
| [18,] | 23.57661 | 765.1319 | 5.907549 | 3.100216 | 30530.06 | 5179.361 | 2.5829896 | 5.171288 |
| [19,] | 23.68099 | 882.3570 | 5.862859 | 3.130456 | 30611.65 | 5179.371 | 1.1873214 | 5.052278 |
| [20,] | 23.97285 | 1045.5427 | 5.802604 | 3.170452 | 30562.35 | 5179.380 | 0.5830086 | 4.921096 |
| [21,] | 24.46767 | 1241.2561 | 5.730522 | 3.222263 | 30416.42 | 5179.387 | 0.9064362 | 4.893043 |
| | Gua | UA | ada | ade | adna | adrnr | ampd | |
| [1,] | 5.506380 | 100.2930 | 2.07946700 | 0.0099157243 | 10.03826 | 0.2011595 | 5.64072792 | |

| | | | | | | | |
|-------|-----------|----------|------------|--------------|-----------|------------|------------|
| [2,] | 5.508591 | 100.2931 | 2.07946892 | 0.0099167491 | 10.03827 | 0.2011596 | 5.64073249 |
| [3,] | 5.508098 | 100.2932 | 2.07946992 | 0.0099163440 | 10.03827 | 0.2011597 | 5.64073423 |
| [4,] | 5.507735 | 100.2933 | 2.07947037 | 0.0099161254 | 10.03827 | 0.2011597 | 5.64073496 |
| [5,] | 5.507502 | 100.2935 | 2.07947051 | 0.0099160166 | 10.03827 | 0.2011597 | 5.64073515 |
| [6,] | 5.507337 | 100.2936 | 2.07947052 | 0.0099159556 | 10.03827 | 0.2011597 | 5.64073511 |
| [7,] | 5.507171 | 100.2937 | 2.07947054 | 0.0099158945 | 10.03827 | 0.2011597 | 5.64073508 |
| [8,] | 5.507048 | 100.2937 | 2.07947052 | 0.0099158537 | 10.03827 | 0.2011597 | 5.64073499 |
| [9,] | 5.506960 | 100.2938 | 2.07947046 | 0.0099158296 | 10.03827 | 0.2011597 | 5.64073485 |
| [10,] | 5.506871 | 100.2939 | 2.07947041 | 0.0099158054 | 10.03827 | 0.2011597 | 5.64073471 |
| [11,] | 5.506830 | 100.2939 | 2.28735164 | 0.0109071345 | 11.04210 | 0.2212750 | 6.20466093 |
| [12,] | 5.892429 | 100.2962 | 1.94771184 | 0.0097386677 | 11.04159 | 0.2176905 | 5.42997244 |
| [13,] | 6.367382 | 100.3093 | 1.63201638 | 0.0083896262 | 11.04152 | 0.2139882 | 4.68398160 |
| [14,] | 7.064005 | 100.3354 | 1.33295552 | 0.0069448592 | 11.04224 | 0.2100279 | 3.95361070 |
| [15,] | 8.050276 | 100.3720 | 1.04790405 | 0.0055157995 | 11.04350 | 0.2055890 | 3.23245312 |
| [16,] | 9.340340 | 100.4133 | 0.77753195 | 0.0041617868 | 11.04501 | 0.2003270 | 2.51911813 |
| [17,] | 10.921570 | 100.4519 | 0.52559237 | 0.0029065569 | 11.04652 | 0.1936392 | 1.81754141 |
| [18,] | 12.746875 | 100.4782 | 0.30060458 | 0.0017687656 | 11.04769 | 0.1843236 | 1.14214297 |
| [19,] | 14.684628 | 100.4821 | 0.12177946 | 0.0008157268 | 11.04784 | 0.1697391 | 0.53977975 |
| [20,] | 16.448516 | 100.4569 | 0.03022656 | 0.0002351954 | 11.04619 | 0.1491195 | 0.17017028 |
| [21,] | 18.788480 | 100.4120 | 0.01522409 | 0.0001382499 | 11.04728 | 0.1414428 | 0.09615959 |
| | aprt | arna | asuc | asli | dada | den | dgnuc |
| [1,] | 0.9963412 | 1985.621 | 8.003186 | 8.003185 | 0.2004510 | 2.386351 | 0.1008502 |
| [2,] | 0.9981829 | 1985.621 | 8.003012 | 8.002051 | 0.2004511 | 2.402705 | 0.1008503 |
| [3,] | 0.9981402 | 1985.621 | 8.003027 | 8.003034 | 0.2004511 | 2.402830 | 0.1008504 |
| [4,] | 0.9981143 | 1985.622 | 8.003040 | 8.003040 | 0.2004512 | 2.402870 | 0.1008504 |
| [5,] | 0.9981021 | 1985.622 | 8.003050 | 8.003050 | 0.2004512 | 2.402897 | 0.1008504 |
| [6,] | 0.9980957 | 1985.622 | 8.003059 | 8.003059 | 0.2004512 | 2.402916 | 0.1008504 |
| [7,] | 0.9980894 | 1985.622 | 8.003068 | 8.003067 | 0.2004512 | 2.402935 | 0.1008504 |
| [8,] | 0.9980853 | 1985.622 | 8.003075 | 8.003075 | 0.2004512 | 2.402949 | 0.1008504 |
| [9,] | 0.9980831 | 1985.622 | 8.003082 | 8.003081 | 0.2004513 | 2.402959 | 0.1008504 |
| [10,] | 0.9980809 | 1985.622 | 8.003088 | 8.003088 | 0.2004513 | 2.402969 | 0.1008504 |
| [11,] | 1.0978529 | 2184.181 | 8.803467 | 8.803645 | 0.2204964 | 2.643019 | 0.1109354 |
| [12,] | 1.0660253 | 2173.664 | 9.186566 | 9.207424 | 0.2204398 | 2.660519 | 0.1109561 |
| [13,] | 1.0386136 | 2172.114 | 9.673655 | 9.693909 | 0.2202685 | 3.119444 | 0.1110638 |
| [14,] | 0.9851800 | 2173.706 | 10.276055 | 10.296607 | 0.2199535 | 3.764108 | 0.1112885 |
| [15,] | 0.9175216 | 2174.529 | 11.030708 | 11.051876 | 0.2194627 | 4.699273 | 0.1116438 |
| [16,] | 0.8430160 | 2171.336 | 12.022928 | 12.046395 | 0.2187658 | 6.156006 | 0.1121432 |
| [17,] | 0.7624598 | 2160.055 | 13.443367 | 13.464610 | 0.2178263 | 8.679678 | 0.1128058 |
| [18,] | 0.6695181 | 2133.299 | 15.780745 | 15.810368 | 0.2165885 | 13.822779 | 0.1136632 |
| [19,] | 0.5545128 | 2074.302 | 20.632538 | 20.652513 | 0.2149500 | 27.525380 | 0.1147719 |
| [20,] | 0.3775478 | 1973.592 | 32.748826 | 32.701785 | 0.2127409 | 72.008700 | 0.1162383 |
| [21,] | 0.3490101 | 1948.011 | 47.040724 | 47.041159 | 0.2100981 | 111.815445 | 0.1181378 |
| | dnaa | dnag | gdna | gdrnr | gmpr | gmps | gnuc |
| [1,] | 10.03756 | 6.826370 | 6.825859 | 0.1003440 | 0.5138721 | 1.5957628 | 4.807078 |
| [2,] | 10.03756 | 6.826370 | 6.825863 | 0.1003438 | 0.5138758 | 1.5957629 | 4.807071 |
| [3,] | 10.03756 | 6.826371 | 6.825864 | 0.1003439 | 0.5138767 | 1.5957629 | 4.807084 |

| | | | | | | | |
|-------|----------|-----------|-----------|-----------|-------------|-----------|-----------|
| [4,] | 10.03756 | 6.826371 | 6.825864 | 0.1003440 | 0.5138772 | 1.5957628 | 4.807091 |
| [5,] | 10.03756 | 6.826371 | 6.825865 | 0.1003440 | 0.5138774 | 1.5957627 | 4.807094 |
| [6,] | 10.03756 | 6.826371 | 6.825865 | 0.1003440 | 0.5138775 | 1.5957626 | 4.807096 |
| [7,] | 10.03756 | 6.826372 | 6.825865 | 0.1003440 | 0.5138776 | 1.5957625 | 4.807098 |
| [8,] | 10.03756 | 6.826372 | 6.825866 | 0.1003440 | 0.5138776 | 1.5957624 | 4.807099 |
| [9,] | 10.03756 | 6.826372 | 6.825866 | 0.1003440 | 0.5138777 | 1.5957624 | 4.807099 |
| [10,] | 10.03756 | 6.826372 | 6.825866 | 0.1003440 | 0.5138777 | 1.5957623 | 4.807100 |
| [11,] | 11.04132 | 7.509010 | 7.508453 | 0.1103784 | 0.5652676 | 1.7553315 | 5.287810 |
| [12,] | 11.04132 | 7.509010 | 7.508105 | 0.1115855 | 0.5885858 | 1.7174180 | 5.415951 |
| [13,] | 11.04132 | 7.509009 | 7.508057 | 0.1145715 | 0.6300822 | 1.6773409 | 5.740334 |
| [14,] | 11.04132 | 7.509008 | 7.508551 | 0.1186866 | 0.6856203 | 1.6333923 | 6.201703 |
| [15,] | 11.04132 | 7.509010 | 7.509406 | 0.1236247 | 0.7541553 | 1.5834991 | 6.775465 |
| [16,] | 11.04133 | 7.509016 | 7.510434 | 0.1293001 | 0.8371523 | 1.5246474 | 7.460556 |
| [17,] | 11.04134 | 7.509025 | 7.511460 | 0.1357866 | 0.9389361 | 1.4517080 | 8.275615 |
| [18,] | 11.04136 | 7.509038 | 7.512251 | 0.1433424 | 1.0690116 | 1.3546668 | 9.266560 |
| [19,] | 11.04138 | 7.509052 | 7.512355 | 0.1525637 | 1.2490302 | 1.2122508 | 10.535030 |
| [20,] | 11.04140 | 7.509064 | 7.511234 | 0.1644992 | 1.4935805 | 1.0222929 | 12.273359 |
| [21,] | 11.04142 | 7.509075 | 7.511978 | 0.1777218 | 1.6420621 | 0.9422078 | 14.322906 |
| | gprt | grna | gua | hprrt | hx | hxd | impd |
| [1,] | 3.738009 | 1323.532 | 1.154277 | 3.669760 | 0.047309283 | 1.1912809 | 1.595762 |
| [2,] | 3.753990 | 1323.532 | 1.154508 | 3.684107 | 0.047320338 | 1.1914425 | 1.595750 |
| [3,] | 3.753956 | 1323.532 | 1.154457 | 3.684108 | 0.047317495 | 1.1914009 | 1.595750 |
| [4,] | 3.753883 | 1323.532 | 1.154419 | 3.684055 | 0.047315211 | 1.1913676 | 1.595751 |
| [5,] | 3.753839 | 1323.533 | 1.154394 | 3.684017 | 0.047313653 | 1.1913448 | 1.595752 |
| [6,] | 3.753808 | 1323.533 | 1.154377 | 3.683987 | 0.047312496 | 1.1913279 | 1.595753 |
| [7,] | 3.753777 | 1323.533 | 1.154360 | 3.683956 | 0.047311339 | 1.1913110 | 1.595753 |
| [8,] | 3.753754 | 1323.533 | 1.154347 | 3.683933 | 0.047310475 | 1.1912984 | 1.595754 |
| [9,] | 3.753738 | 1323.533 | 1.154337 | 3.683914 | 0.047309852 | 1.1912893 | 1.595754 |
| [10,] | 3.753722 | 1323.533 | 1.154328 | 3.683896 | 0.047309230 | 1.1912802 | 1.595755 |
| [11,] | 4.128831 | 1191.178 | 1.038891 | 3.315313 | 0.042578194 | 1.0721505 | 1.436180 |
| [12,] | 4.041294 | 1185.442 | 1.074649 | 3.332970 | 0.044217999 | 1.0959241 | 1.435266 |
| [13,] | 4.166195 | 1184.597 | 1.117120 | 3.571983 | 0.043091831 | 1.0796378 | 1.431190 |
| [14,] | 4.300092 | 1185.465 | 1.176643 | 3.791719 | 0.039338372 | 1.0240199 | 1.425053 |
| [15,] | 4.493037 | 1185.914 | 1.256101 | 3.972824 | 0.033415308 | 0.9314894 | 1.417427 |
| [16,] | 4.779875 | 1184.172 | 1.353009 | 4.088378 | 0.025921843 | 0.8038526 | 1.408822 |
| [17,] | 5.209661 | 1178.020 | 1.463059 | 4.087819 | 0.017681653 | 0.6438047 | 1.400074 |
| [18,] | 5.883946 | 1163.428 | 1.580597 | 3.879695 | 0.009881042 | 0.4592891 | 1.393250 |
| [19,] | 7.047666 | 1131.253 | 1.696488 | 3.369699 | 0.004137536 | 0.2771251 | 1.395100 |
| [20,] | 8.900278 | 1076.330 | 1.795489 | 2.843564 | 0.001865440 | 0.1745401 | 1.430468 |
| [21,] | 9.289114 | 1062.379 | 1.918957 | 2.949907 | 0.003058039 | 0.2325282 | 1.507295 |
| | inuc | mat | polyam | prpps | pyr | rnaa | rnag |
| [1,] | 2.642505 | 14.988492 | 1.0079912 | 20.88492 | 9.999890 | 1985.551 | 1323.605 |
| [2,] | 2.642393 | 14.988495 | 1.0079911 | 20.88278 | 10.043331 | 1985.551 | 1323.605 |
| [3,] | 2.642401 | 14.988496 | 1.0079913 | 20.88275 | 10.043669 | 1985.551 | 1323.605 |
| [4,] | 2.642408 | 14.988496 | 1.0079913 | 20.88274 | 10.043779 | 1985.550 | 1323.605 |
| [5,] | 2.642414 | 14.988496 | 1.0079913 | 20.88274 | 10.043851 | 1985.550 | 1323.605 |

```

[6,] 2.642419 14.988496 1.0079913 20.88274 10.043903 1985.550 1323.605
[7,] 2.642425 14.988496 1.0079913 20.88273 10.043954 1985.550 1323.605
[8,] 2.642429 14.988496 1.0079913 20.88273 10.043993 1985.550 1323.605
[9,] 2.642433 14.988496 1.0079913 20.88273 10.044021 1985.550 1323.605
[10,] 2.642437 14.988496 1.0079913 20.88273 10.044049 1985.550 1323.605
[11,] 2.378198 13.489566 0.9071922 18.79474 9.039066 1787.000 1191.247
[12,] 2.366360 13.239528 0.8877636 20.23737 8.869168 1809.915 1206.523
[13,] 2.342738 13.047290 0.8591579 21.86961 9.606308 1830.079 1219.965
[14,] 2.310853 12.830948 0.8275172 23.88594 10.578642 1848.293 1232.106
[15,] 2.272682 12.575707 0.7916784 26.53075 11.846789 1864.848 1243.142
[16,] 2.231654 12.262643 0.7497004 30.24315 13.563800 1879.684 1253.032
[17,] 2.195086 11.857998 0.6984706 35.95847 16.043723 1892.426 1261.526
[18,] 2.181645 11.293456 0.6322334 46.12489 19.985955 1902.236 1268.066
[19,] 2.252596 10.420598 0.5394004 69.23710 27.225643 1907.320 1271.455
[20,] 2.660831 9.330366 0.4137438 129.99285 41.109947 1904.248 1269.407
[21,] 3.650670 9.073414 0.3489817 176.61460 50.415535 1895.156 1263.346
      trans      ua      x      xd R5P      Pi
[1,] 13.980504 2.314825 0.03071716 2.314841 18 1400
[2,] 13.980503 2.314828 0.03072109 2.314923 18 1400
[3,] 13.980504 2.314834 0.03072339 2.314970 18 1400
[4,] 13.980504 2.314842 0.03072430 2.314989 18 1400
[5,] 13.980504 2.314848 0.03072428 2.314989 18 1400
[6,] 13.980504 2.314854 0.03072385 2.314980 18 1400
[7,] 13.980504 2.314859 0.03072343 2.314971 18 1400
[8,] 13.980504 2.314863 0.03072290 2.314960 18 1400
[9,] 13.980504 2.314866 0.03072229 2.314947 18 1400
[10,] 13.980504 2.314869 0.03072168 2.314935 18 1400
[11,] 12.582454 2.083385 0.02764896 2.083430 18 1400
[12,] 12.482971 2.083492 0.02797209 2.090098 18 1400
[13,] 12.333955 2.084089 0.02864682 2.103842 18 1400
[14,] 12.165422 2.085290 0.02932335 2.117390 18 1400
[15,] 11.969522 2.086970 0.02981212 2.127038 18 1400
[16,] 11.732785 2.088872 0.02997735 2.130273 18 1400
[17,] 11.432203 2.090645 0.02969667 2.124769 18 1400
[18,] 11.022091 2.091855 0.02888160 2.108570 18 1400
[19,] 10.398637 2.092033 0.02756756 2.081741 18 1400
[20,] 9.435041 2.090872 0.02615456 2.051836 18 1400
[21,] 8.864139 2.088808 0.02585722 2.045395 18 1400
attr(,"istate")
[1] 2

```

Clearly, this system has stability sensitivity problems.

The folate model of Morrison and Allegra (JBC 1989) can be simulated as follows

```

> morr = readSBML(file.path(system.file(package = "SBMLR"), "models/morrison.xml"))
> out1 = simulate(morr, seq(-20, 0, 1))

```

```

> morr$species$EMTX$ic = 1
> out2 = simulate(morr, 0:30)
> outs = data.frame(rbind(out1, out2))
> attach(outs)
> par(mfrow = c(3, 4))
> plot(time, FH2b, type = "l", xlab = "Hours")
> plot(time, FH2f, type = "l", xlab = "Hours")
> plot(time, DHFRf, type = "l", xlab = "Hours")
> plot(time, DHFRtot, type = "l", xlab = "Hours")
> plot(time, CHOFH4, type = "l", xlab = "Hours")
> plot(time, FH4, type = "l", xlab = "Hours")
> plot(time, CH2FH4, type = "l", xlab = "Hours")
> plot(time, CH3FH4, type = "l", xlab = "Hours")
> plot(time, AICARsyn, type = "l", xlab = "Hours")
> plot(time, MTR, type = "l", xlab = "Hours")
> plot(time, TYMS, type = "l", xlab = "Hours")
> plot(time, DHFRductase, type = "l", xlab = "Hours")
> par(mfrow = c(1, 1))
> detach(outs)

```

As final outputs in this document, the full curto summary and object are:

```

> summary(curto)

```

\$nSpecies

```
[1] 18
```

\$sIDs

```

[1] "PRPP" "IMP" "SAMP" "ATP" "SAM" "Ade" "XMP" "GTP" "dATP" "dGTP"
[11] "RNA" "DNA" "HX" "Xa" "Gua" "UA" "R5P" "Pi"

```

\$S0

| | PRPP | IMP | SAMP | ATP | SAM | Ade |
|-------------|-------------|-------------|-------------|-------------|-------------|-----|
| 5.00000e+00 | 9.82634e+01 | 1.98189e-01 | 2.47535e+03 | 3.99187e+00 | 9.84730e-01 | |
| | XMP | GTP | dATP | dGTP | RNA | DNA |
| 2.47930e+01 | 4.10223e+02 | 6.01413e+00 | 3.02581e+00 | 2.86805e+04 | 5.17934e+03 | |
| | HX | Xa | Gua | UA | R5P | Pi |
| 9.51785e+00 | 5.05941e+00 | 5.50638e+00 | 1.00293e+02 | 1.80000e+01 | 1.40000e+03 | |

\$BC

| PRPP | IMP | SAMP | ATP | SAM | Ade | XMP | GTP | dATP | dGTP | RNA | DNA | HX |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE | FALSE |
| Xa | Gua | UA | R5P | Pi | | | | | | | | |
| FALSE | FALSE | FALSE | TRUE | TRUE | | | | | | | | |

\$nStates

```
[1] 16
```

```

$y0
      PRPP      IMP      SAMP      ATP      SAM      Ade
5.00000e+00 9.82634e+01 1.98189e-01 2.47535e+03 3.99187e+00 9.84730e-01
      XMP      GTP      dATP      dGTP      RNA      DNA
2.47930e+01 4.10223e+02 6.01413e+00 3.02581e+00 2.86805e+04 5.17934e+03
      HX      Xa      Gua      UA
9.51785e+00 5.05941e+00 5.50638e+00 1.00293e+02

$Reactions
[1] 37

$rIDs
[1] "ada"  "ade"  "adna" "adrnr" "ampd" "aprt" "arna" "asuc"
[9] "asli" "dada" "den"  "dgnuc" "dnaa" "dnag" "gdna" "gdrnr"
[17] "gmpr" "gmps" "gnuc" "gprr"  "grna" "gua"  "hprt" "hx"
[25] "hxd"  "impd" "inuc" "mat"   "polya" "prpps" "pyr"  "rnaa"
[33] "rnag" "trans" "ua"   "x"     "xd"

$rLaws
      ada
      "aada*ATP^fada4"
      ade
      "aade*Ade^fade6"
      adna
      "aadna*dATP^fdnap9*dGTP^fdnap10"
      adrnr
      "aadrnr*ATP^fadrnr4*dATP^fadrnr9*dGTP^fadrnr10"
      ampd
      "aampd*ATP^fampd4*GTP^fampd8*Pi^fampd18"
      aprt
      "aaprt*PRPP^faprt1*ATP^faprt4*Ade^faprt6"
      arna
      "aarna*ATP^frnap4*GTP^frnap8"
      asuc
      "aasuc*IMP^fasuc2*ATP^fasuc4*GTP^fasuc8*Pi^fasuc18"
      asli
      "aasli*SAMP^fasli3*ATP^fasli4"
      dada
      "adada*dATP^fdada9"
      den
      "aden*PRPP^fden1*IMP^fden2*ATP^fden4*GTP^fden8*Pi^fden18"
      dgnuc
      "adgnuc*dGTP^fdgnuc10"
      dnaa
      "adnaa*DNA^fdnan12"

```

```

dnag
"adnag*DNA^fdnan12"
gdna
"agdna*dATP^fdnap9*dGTP^fdnap10"
gdrnr
"agdrnr*GTP^fgdrnr8*dATP^fgdrnr9*dGTP^fgdrnr10"
gmpr
"agmpr*IMP^fgmpr2*ATP^fgmpr4*XMP^fgmpr7*GTP^fgmpr8"
gmps
"agmps*ATP^fgmps4*XMP^fgmps7"
gnuc
"agnuc*GTP^fgnuc8*Pi^fgnuc18"
gprrt
"agprrt*PRPP^fgprrt1*GTP^fgprrt8*Gua^fgprrt15"
grna
"agrna*ATP^frnap4*GTP^frnap8"
gua
"agua*Gua^fgua15"
hprrt
"ahprrt*PRPP^fhprrt1*IMP^fhprrt2*HX^fhprrt13"
hx
"ahx*HX^fhx13"
hxd
"ahxd*HX^fhxd13"
impd
"aimpd*IMP^fimpd2*XMP^fimpd7*GTP^fimpd8"
inuc
"ainuc*IMP^finuc2*Pi^finuc18"
mat
"amat*ATP^fmat4*SAM^fmat5"
polyam
"apolyam*SAM^fpolyam5"
prpps
"aprpps*PRPP^fprpps1*ATP^fprpps4*GTP^fprpps8*R5P^fprpps17*Pi^fprpps18"
pyr
"apyr*PRPP^fpyr1"
rnaa
"arnaa*RNA^frnan11"
rnag
"arnag*RNA^frnan11"
trans
"atrans*SAM^ftrans5"
ua
"aua*UA^fua16"
x
"ax*Xa^fx14"

```

xd
"axd* X_a ^{fxd14}"

\$V0

| | | | | | | |
|--------------|--------------|--------------|--------------|--------------|--------------|-------|
| | ada | ade | adna | adrnr | ampd | aprt |
| 2.079467e+00 | 9.915724e-03 | 1.003826e+01 | 2.011595e-01 | 5.640728e+00 | 9.963412e-01 | |
| | arna | asuc | asli | dada | den | dgnuc |
| 1.985621e+03 | 8.003186e+00 | 8.003185e+00 | 2.004510e-01 | 2.386351e+00 | 1.008502e-01 | |
| | dnaa | dnag | gdna | gdrnr | gmpd | gmps |
| 1.003756e+01 | 6.826370e+00 | 6.825859e+00 | 1.003440e-01 | 5.138721e-01 | 1.595763e+00 | |
| | gnuc | gprt | grna | gua | hprt | hx |
| 4.807078e+00 | 3.738009e+00 | 1.323532e+03 | 1.154277e+00 | 3.669760e+00 | 4.730928e-02 | |
| | hxd | impd | inuc | mat | polyam | prpps |
| 1.191281e+00 | 1.595762e+00 | 2.642505e+00 | 1.498849e+01 | 1.007991e+00 | 2.088492e+01 | |
| | pyr | rnaa | rnag | trans | ua | x |
| 9.999890e+00 | 1.985551e+03 | 1.323605e+03 | 1.398050e+01 | 2.314825e+00 | 3.071716e-02 | |
| | xd | | | | | |
| 2.314841e+00 | | | | | | |

\$incid

| | [,1] | [,2] | [,3] | [,4] | [,5] | [,6] | [,7] | [,8] | [,9] | [,10] | [,11] | [,12] | [,13] | [,14] |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| PRPP | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 |
| IMP | 0 | 0 | 0 | 0 | 1 | 0 | 0 | -1 | 0 | 0 | 1 | 0 | 0 | 0 |
| SAMP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 |
| ATP | -1 | 0 | 0 | -1 | -1 | 1 | -1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| SAM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ade | 0 | -1 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| XMP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GTP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| dATP | 0 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 1 | 0 |
| dGTP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 1 |
| RNA | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DNA | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 |
| HX | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Xa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gua | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| UA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | [,15] | [,16] | [,17] | [,18] | [,19] | [,20] | [,21] | [,22] | [,23] | [,24] | [,25] | [,26] | | |
| PRPP | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | -1 | 0 | 0 | 0 | | |
| IMP | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | -1 | | |
| SAMP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| ATP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| SAM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Ade | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| XMP | 0 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| GTP | 0 | -1 | -1 | 1 | -1 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | | |

| | | | | | | | | | | | | |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| dATP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| dGTP | -1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RNA | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| DNA | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | -1 | 0 |
| Xa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| Gua | 0 | 0 | 0 | 0 | 1 | -1 | 0 | -1 | 0 | 0 | 0 | 0 |
| UA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | [,27] | [,28] | [,29] | [,30] | [,31] | [,32] | [,33] | [,34] | [,35] | [,36] | [,37] | |
| PRPP | 0 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| IMP | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| SAMP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| ATP | 0 | -1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | |
| SAM | 0 | 1 | -1 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | |
| Ade | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| XMP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| GTP | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| dATP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| dGTP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| RNA | 0 | 0 | 0 | 0 | 0 | -1 | -1 | 0 | 0 | 0 | 0 | |
| DNA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| HX | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Xa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | -1 | |
| Gua | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| UA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 1 | |

\$nRules

[1] 0

\$ruleIDs

NULL

\$species

| | index | initialConcentrations | boundaryConditions |
|------|-------|-----------------------|--------------------|
| PRPP | 1 | 5.00000e+00 | FALSE |
| IMP | 2 | 9.82634e+01 | FALSE |
| SAMP | 3 | 1.98189e-01 | FALSE |
| ATP | 4 | 2.47535e+03 | FALSE |
| SAM | 5 | 3.99187e+00 | FALSE |
| Ade | 6 | 9.84730e-01 | FALSE |
| XMP | 7 | 2.47930e+01 | FALSE |
| GTP | 8 | 4.10223e+02 | FALSE |
| dATP | 9 | 6.01413e+00 | FALSE |
| dGTP | 10 | 3.02581e+00 | FALSE |
| RNA | 11 | 2.86805e+04 | FALSE |
| DNA | 12 | 5.17934e+03 | FALSE |

| | | | |
|-----|----|-------------|-------|
| HX | 13 | 9.51785e+00 | FALSE |
| Xa | 14 | 5.05941e+00 | FALSE |
| Gua | 15 | 5.50638e+00 | FALSE |
| UA | 16 | 1.00293e+02 | FALSE |
| R5P | 17 | 1.80000e+01 | TRUE |
| Pi | 18 | 1.40000e+03 | TRUE |

\$reactions

| | index |
|--------|-------|
| ada | 1 |
| ade | 2 |
| adna | 3 |
| adrnr | 4 |
| ampd | 5 |
| aprt | 6 |
| arna | 7 |
| asuc | 8 |
| asli | 9 |
| dada | 10 |
| den | 11 |
| dgnuc | 12 |
| dnaa | 13 |
| dnag | 14 |
| gdna | 15 |
| gdrnr | 16 |
| gmp | 17 |
| gmps | 18 |
| gnuc | 19 |
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| grna | 21 |
| gua | 22 |
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| hxd | 25 |
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| polyam | 29 |
| prpps | 30 |
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| rnag | 33 |
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| | | Laws |
|--------|--|---|
| ada | | aada*ATP^fada4 |
| ade | | aade*Ade^fade6 |
| adna | | aadna*dATP^fdnap9*dGTP^fdnap10 |
| adrnr | | aadrnr*ATP^fadrnr4*dATP^fadrnr9*dGTP^fadrnr10 |
| ampd | | aampd*ATP^fampd4*GTP^fampd8*Pi^fampd18 |
| aprt | | aaprt*PRPP^faprt1*ATP^faprt4*Ade^faprt6 |
| arna | | aarna*ATP^frnap4*GTP^frnap8 |
| asuc | | aasuc*IMP^fasuc2*ATP^fasuc4*GTP^fasuc8*Pi^fasuc18 |
| asli | | aasli*SAMP^fasli3*ATP^fasli4 |
| dada | | adada*dATP^fdada9 |
| den | | aden*PRPP^fden1*IMP^fden2*ATP^fden4*GTP^fden8*Pi^fden18 |
| dgnuc | | adgnuc*dGTP^fdgnuc10 |
| dnaa | | adnaa*DNA^fdnan12 |
| dnag | | adnag*DNA^fdnan12 |
| gdna | | agdna*dATP^fdnap9*dGTP^fdnap10 |
| gdrnr | | agdrnr*GTP^fgdrnr8*dATP^fgdrnr9*dGTP^fgdrnr10 |
| gmpr | | agmpr*IMP^fgmpr2*ATP^fgmpr4*XMP^fgmpr7*GTP^fgmpr8 |
| gmpr | | agmps*ATP^fgmps4*XMP^fgmps7 |
| gnuc | | agnuc*GTP^fgnuc8*Pi^fgnuc18 |
| gprrt | | agprrt*PRPP^fgprrt1*GTP^fgprrt8*Gua^fgprrt15 |
| grna | | agrna*ATP^frnap4*GTP^frnap8 |
| gua | | agua*Gua^fgua15 |
| hprt | | ahprt*PRPP^fhprt1*IMP^fhprt2*HX^fhprt13 |
| hx | | ahx*HX^fhx13 |
| hxd | | ahxd*HX^fhxd13 |
| impd | | aimpd*IMP^fimpd2*XMP^fimpd7*GTP^fimpd8 |
| inuc | | ainuc*IMP^finuc2*Pi^finuc18 |
| mat | | amat*ATP^fmat4*SAM^fmat5 |
| polyam | | apolyam*SAM^fpolyam5 |
| prpps | aprpps*PRPP^fprpps1*ATP^fprpps4*GTP^fprpps8*R5P^fprpps17*Pi^fprpps18 | |
| pyr | | apyr*PRPP^fpyr1 |
| rnaa | | arnaa*RNA^frnan11 |
| rnag | | arnag*RNA^frnan11 |
| trans | | atrans*SAM^ftrans5 |
| ua | | aua*UA^fua16 |
| x | | ax*Xa^fx14 |
| xd | | axd*Xa^fxd14 |
| | initialFluxes | |
| ada | 2.079467e+00 | |
| ade | 9.915724e-03 | |
| adna | 1.003826e+01 | |
| adrnr | 2.011595e-01 | |
| ampd | 5.640728e+00 | |
| aprt | 9.963412e-01 | |
| arna | 1.985621e+03 | |

```

asuc      8.003186e+00
asli      8.003185e+00
dada      2.004510e-01
den       2.386351e+00
dgnuc     1.008502e-01
dnaa      1.003756e+01
dnag      6.826370e+00
gdna      6.825859e+00
gdrnr     1.003440e-01
gmpr      5.138721e-01
gmps      1.595763e+00
gnuc      4.807078e+00
gprr      3.738009e+00
grna      1.323532e+03
gua       1.154277e+00
hprr      3.669760e+00
hx        4.730928e-02
hxd       1.191281e+00
impd      1.595762e+00
inuc      2.642505e+00
mat       1.498849e+01
polyam    1.007991e+00
prpps     2.088492e+01
pyr       9.999890e+00
rnaa      1.985551e+03
rnag      1.323605e+03
trans     1.398050e+01
ua        2.314825e+00
x         3.071716e-02
xd        2.314841e+00

```

```
> curto
```

```
$sbml
```

```

                                xmlns          level
"http://www.sbml.org/sbml/level2"          "2"
                                version
                                "1"

```

```
$id
```

```
[1] "curto"
```

```
$notes
```

```

[1] "This is a purine metabolism model that is geared toward studies of gout."
[2] "The model is fully described in Curto et al., MBSC 151 (1998) pp 1-49"
[3] "The model uses Generalized Mass Action (GMA;i.e. power law) descriptions of reaction ra

```

```

[4] "Such descriptions are local approximations that assume independent substrate binding."
[5] "The de novo purine flux vden= 2.39 is in umole/min/KG, i.e. 2.4*60=144 uM/h if we let e
[6] "liter of water. Morrison and Allegra (JBC, 1989) have vden at 650 uM/h (model) and 415
[7] "The IC's below have been set to the system's steady state."
[8] "The units in this model are micromolar(uM) and minutes."
[9] "A cell volume of 1 is used so that amounts and concentrations are the same thing."

```

```

$compartments
$compartments$cell
$compartments$cell$id
[1] "cell"

```

```

$compartments$cell$size
[1] 1

```

```

$species
$species$PRPP
$species$PRPP$id
[1] "PRPP"

```

```

$species$PRPP$ic
[1] 5

```

```

$species$PRPP$compartment
[1] "cell"

```

```

$species$PRPP$bc
[1] FALSE

```

```

$species$IMP
$species$IMP$id
[1] "IMP"

```

```

$species$IMP$ic
[1] 98.2634

```

```

$species$IMP$compartment
[1] "cell"

```

```

$species$IMP$bc
[1] FALSE

```

```

$species$SAMP
$species$SAMP$id
[1] "SAMP"

$species$SAMP$ic
[1] 0.198189

$species$SAMP$compartment
[1] "cell"

$species$SAMP$bc
[1] FALSE

$species$ATP
$species$ATP$id
[1] "ATP"

$species$ATP$ic
[1] 2475.35

$species$ATP$compartment
[1] "cell"

$species$ATP$bc
[1] FALSE

$species$SAM
$species$SAM$id
[1] "SAM"

$species$SAM$ic
[1] 3.99187

$species$SAM$compartment
[1] "cell"

$species$SAM$bc
[1] FALSE

$species$Ade
$species$Ade$id
[1] "Ade"

```

```

$species$Ade$ic
[1] 0.98473

$species$Ade$compartment
[1] "cell"

$species$Ade$bc
[1] FALSE

$species$XMP
$species$XMP$id
[1] "XMP"

$species$XMP$ic
[1] 24.793

$species$XMP$compartment
[1] "cell"

$species$XMP$bc
[1] FALSE

$species$GTP
$species$GTP$id
[1] "GTP"

$species$GTP$ic
[1] 410.223

$species$GTP$compartment
[1] "cell"

$species$GTP$bc
[1] FALSE

$species$dATP
$species$dATP$id
[1] "dATP"

$species$dATP$ic
[1] 6.01413

$species$dATP$compartment

```

```

[1] "cell"

$species$dATP$bc
[1] FALSE

$species$dGTP
$species$dGTP$id
[1] "dGTP"

$species$dGTP$ic
[1] 3.02581

$species$dGTP$compartment
[1] "cell"

$species$dGTP$bc
[1] FALSE

$species$RNA
$species$RNA$id
[1] "RNA"

$species$RNA$ic
[1] 28680.5

$species$RNA$compartment
[1] "cell"

$species$RNA$bc
[1] FALSE

$species$DNA
$species$DNA$id
[1] "DNA"

$species$DNA$ic
[1] 5179.34

$species$DNA$compartment
[1] "cell"

$species$DNA$bc
[1] FALSE

```

```

$species$HX
$species$HX$id
[1] "HX"

$species$HX$ic
[1] 9.51785

$species$HX$compartment
[1] "cell"

$species$HX$bc
[1] FALSE

$species$Xa
$species$Xa$id
[1] "Xa"

$species$Xa$ic
[1] 5.05941

$species$Xa$compartment
[1] "cell"

$species$Xa$bc
[1] FALSE

$species$Gua
$species$Gua$id
[1] "Gua"

$species$Gua$ic
[1] 5.50638

$species$Gua$compartment
[1] "cell"

$species$Gua$bc
[1] FALSE

$species$UA
$species$UA$id

```

```

[1] "UA"

$species$UA$ic
[1] 100.293

$species$UA$compartment
[1] "cell"

$species$UA$bc
[1] FALSE

$species$R5P
$species$R5P$id
[1] "R5P"

$species$R5P$ic
[1] 18

$species$R5P$compartment
[1] "cell"

$species$R5P$bc
[1] TRUE

$species$Pi
$species$Pi$id
[1] "Pi"

$species$Pi$ic
[1] 1400

$species$Pi$compartment
[1] "cell"

$species$Pi$bc
[1] TRUE

$globalParameters
list()

$rules
list()

```



```

$reactions
$reactions$aada
$reactions$aada$id
[1] "ada"

$reactions$aada$reversible
[1] FALSE

$reactions$aada$reactants
[1] "ATP"

$reactions$aada$products
[1] "HX"

$reactions$aada$parameters
      aada      fada4
0.001062 0.970000

$reactions$aada$mathmlLaw
<apply>
  <times/>
  <ci>aada</ci>
  <apply>
    <power/>
    <ci>ATP</ci>
    <ci>fada4</ci>
  </apply>
</apply>

$reactions$aada$exprLaw
aada * ATP^fada4

$reactions$aada$strLaw
[1] "aada*ATP^fada4"

$reactions$aada$law
function (r, p = NULL)
{
  aada = p["aada"]
  fada4 = p["fada4"]
  ATP = r["ATP"]
  aada * ATP^fada4
}
<environment: 0x00000000275b430>

```

```

$reactions$ade
$reactions$ade$id
[1] "ade"

$reactions$ade$reversible
[1] FALSE

$reactions$ade$reactants
[1] "Ade"

$reactions$ade$parameters
aade fade6
0.01 0.55

$reactions$ade$mathmlLaw
<apply>
  <times/>
  <ci>aade</ci>
  <apply>
    <power/>
    <ci>Ade</ci>
    <ci>fade6</ci>
  </apply>
</apply>

$reactions$ade$exprLaw
aade * Ade^fade6

$reactions$ade$strLaw
[1] "aade*Ade^fade6"

$reactions$ade$law
function (r, p = NULL)
{
  aade = p["aade"]
  fade6 = p["fade6"]
  Ade = r["Ade"]
  aade * Ade^fade6
}
<environment: 0x0000000017707d0>

$reactions$adna
$reactions$adna$id
[1] "adna"

```

```

$reactions$adna$reversible
[1] FALSE

$reactions$adna$reactants
[1] "dATP"

$reactions$adna$modifiers
[1] "dGTP"

$reactions$adna$products
[1] "DNA"

$reactions$adna$parameters
  aadna  fdnap9 fdnap10
3.2789  0.4200  0.3300

$reactions$adna$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <ci>aadna</ci>
    <apply>
      <power/>
      <ci>dATP</ci>
      <ci>fdnap9</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>dGTP</ci>
    <ci>fdnap10</ci>
  </apply>
</apply>

$reactions$adna$exprLaw
aadna * dATP^fdnap9 * dGTP^fdnap10

$reactions$adna$strLaw
[1] "aadna*dATP^fdnap9*dGTP^fdnap10"

$reactions$adna$law
function (r, p = NULL)
{
  aadna = p["aadna"]

```

```

    fdnap9 = p["fdnap9"]
    fdnap10 = p["fdnap10"]
    dATP = r["dATP"]
    dGTP = r["dGTP"]
    aadna * dATP^fdnap9 * dGTP^fdnap10
  }
<environment: 0x0000000029b83e8>

```

```

$reactions$adrnr
$reactions$adrnr$id
[1] "adrnr"

```

```

$reactions$adrnr$reversible
[1] FALSE

```

```

$reactions$adrnr$reactants
[1] "ATP"

```

```

$reactions$adrnr$modifiers
[1] "dGTP" "dATP"

```

```

$reactions$adrnr$products
[1] "dATP"

```

```

$reactions$adrnr$parameters
    aadrnr  fadrnr4  fadrnr9 fadrnr10
    0.0602   0.1000  -0.3000   0.8700

```

```

$reactions$adrnr$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <ci>aadrnr</ci>
      <apply>
        <power/>
        <ci>ATP</ci>
        <ci>fadrnr4</ci>
      </apply>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>dATP</ci>
  </apply>

```

```

      <ci>fadrnr9</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>dGTP</ci>
    <ci>fadrnr10</ci>
  </apply>
</apply>

$reactions$adrnr$exprLaw
aadrnr * ATP^fadrnr4 * dATP^fadrnr9 * dGTP^fadrnr10

$reactions$adrnr$strLaw
[1] "aadrnr*ATP^fadrnr4*dATP^fadrnr9*dGTP^fadrnr10"

$reactions$adrnr$law
function (r, p = NULL)
{
  aadrnr = p["aadrnr"]
  fadrnr4 = p["fadrnr4"]
  fadrnr9 = p["fadrnr9"]
  fadrnr10 = p["fadrnr10"]
  ATP = r["ATP"]
  dGTP = r["dGTP"]
  dATP = r["dATP"]
  aadrnr * ATP^fadrnr4 * dATP^fadrnr9 * dGTP^fadrnr10
}
<environment: 0x000000002a52a18>

$reactions$ampd
$reactions$ampd$id
[1] "ampd"

$reactions$ampd$reversible
[1] FALSE

$reactions$ampd$reactants
[1] "ATP"

$reactions$ampd$modifiers
[1] "GTP" "Pi"

$reactions$ampd$products
[1] "IMP"

```

```

$reactions$ampd$parameters
      aampd      fampd4      fampd8      fampd18
0.02688  0.80000 -0.03000 -0.10000

$reactions$ampd$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <ci>aampd</ci>
      <apply>
        <power/>
        <ci>ATP</ci>
        <ci>fampd4</ci>
      </apply>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>GTP</ci>
    <ci>fampd8</ci>
  </apply>
</apply>
<apply>
  <power/>
  <ci>Pi</ci>
  <ci>fampd18</ci>
</apply>
</apply>

$reactions$ampd$exprLaw
aampd * ATP^fampd4 * GTP^fampd8 * Pi^fampd18

$reactions$ampd$strLaw
[1] "aampd*ATP^fampd4*GTP^fampd8*Pi^fampd18"

$reactions$ampd$law
function (r, p = NULL)
{
  aampd = p["aampd"]
  fampd4 = p["fampd4"]
  fampd8 = p["fampd8"]
  fampd18 = p["fampd18"]
  ATP = r["ATP"]

```

```

    GTP = r["GTP"]
    Pi = r["Pi"]
    aampd * ATP^fampd4 * GTP^fampd8 * Pi^fampd18
  }
<environment: 0x0000000020bf0b8>

```

```

$reactions$aprt
$reactions$aprt$id
[1] "aprt"

```

```

$reactions$aprt$reversible
[1] FALSE

```

```

$reactions$aprt$reactants
[1] "PRPP" "Ade"

```

```

$reactions$aprt$modifiers
[1] "ATP"

```

```

$reactions$aprt$products
[1] "ATP"

```

```

$reactions$aprt$parameters
aaprt faprt1 faprt4 faprt6
233.80 0.50 -0.80 0.75

```

```

$reactions$aprt$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <ci>aaprt</ci>
      <apply>
        <power/>
        <ci>PRPP</ci>
        <ci>faprt1</ci>
      </apply>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>ATP</ci>
    <ci>faprt4</ci>
  </apply>

```

```

</apply>
<apply>
  <power/>
  <ci>Ade</ci>
  <ci>faprt6</ci>
</apply>
</apply>

$reactions$aprt$exprLaw
aaprt * PRPP^faprt1 * ATP^faprt4 * Ade^faprt6

$reactions$aprt$strLaw
[1] "aaprt*PRPP^faprt1*ATP^faprt4*Ade^faprt6"

$reactions$aprt$law
function (r, p = NULL)
{
  aaprt = p["aaprt"]
  faprt1 = p["faprt1"]
  faprt4 = p["faprt4"]
  faprt6 = p["faprt6"]
  PRPP = r["PRPP"]
  Ade = r["Ade"]
  ATP = r["ATP"]
  aaprt * PRPP^faprt1 * ATP^faprt4 * Ade^faprt6
}
<environment: 0x000000001fcf9d8>

$reactions$arna
$reactions$arna$id
[1] "arna"

$reactions$arna$reversible
[1] FALSE

$reactions$arna$reactants
[1] "ATP"

$reactions$arna$modifiers
[1] "GTP"

$reactions$arna$products
[1] "RNA"

$reactions$arna$parameters

```



```
aarna frnap4 frnap8
614.50 0.05 0.13
```

```
$reactions$aarna$mathmlLaw
```

```
<apply>
<times/>
<apply>
<times/>
<ci>aarna</ci>
<apply>
<power/>
<ci>ATP</ci>
<ci>frnap4</ci>
</apply>
</apply>
<apply>
<power/>
<ci>GTP</ci>
<ci>frnap8</ci>
</apply>
</apply>
```

```
$reactions$aarna$exprLaw
```

```
aarna * ATP^frnap4 * GTP^frnap8
```

```
$reactions$aarna$strLaw
```

```
[1] "aarna*ATP^frnap4*GTP^frnap8"
```

```
$reactions$aarna$law
```

```
function (r, p = NULL)
{
  aarna = p["aarna"]
  frnap4 = p["frnap4"]
  frnap8 = p["frnap8"]
  ATP = r["ATP"]
  GTP = r["GTP"]
  aarna * ATP^frnap4 * GTP^frnap8
}
<environment: 0x000000001ec2ac8>
```

```
$reactions$asuc
```

```
$reactions$asuc$id
```

```
[1] "asuc"
```

```
$reactions$asuc$reversible
```

```

[1] FALSE

$reactions$asuc$reactants
[1] "IMP"

$reactions$asuc$modifiers
[1] "ATP" "GTP" "Pi"

$reactions$asuc$products
[1] "SAMP"

$reactions$asuc$parameters
      aasuc  fasuc2  fasuc4  fasuc8 fasuc18
      3.5932  0.4000 -0.2400  0.2000 -0.0500

$reactions$asuc$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <apply>
        <times/>
        <ci>aasuc</ci>
        <apply>
          <power/>
          <ci>IMP</ci>
          <ci>fasuc2</ci>
        </apply>
      </apply>
    </apply>
    <apply>
      <power/>
      <ci>ATP</ci>
      <ci>fasuc4</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>GTP</ci>
    <ci>fasuc8</ci>
  </apply>
</apply>
<apply>
  <power/>
  <ci>Pi</ci>

```

```

    <ci>fasuc18</ci>
  </apply>
</apply>

$reactions$asuc$exprLaw
aasuc * IMP^fasuc2 * ATP^fasuc4 * GTP^fasuc8 * Pi^fasuc18

$reactions$asuc$strLaw
[1] "aasuc*IMP^fasuc2*ATP^fasuc4*GTP^fasuc8*Pi^fasuc18"

$reactions$asuc$law
function (r, p = NULL)
{
  aasuc = p["aasuc"]
  fasuc2 = p["fasuc2"]
  fasuc4 = p["fasuc4"]
  fasuc8 = p["fasuc8"]
  fasuc18 = p["fasuc18"]
  IMP = r["IMP"]
  ATP = r["ATP"]
  GTP = r["GTP"]
  Pi = r["Pi"]
  aasuc * IMP^fasuc2 * ATP^fasuc4 * GTP^fasuc8 * Pi^fasuc18
}
<environment: 0x00000000150e578>

$reactions$asli
$reactions$asli$id
[1] "asli"

$reactions$asli$reversible
[1] FALSE

$reactions$asli$reactants
[1] "SAMP"

$reactions$asli$modifiers
[1] "ATP"

$reactions$asli$products
[1] "ATP"

$reactions$asli$parameters
  aasli  fasli3  fasli4
66544.00    0.99   -0.95

```

```

$reactions$asli$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <ci>aasli</ci>
    <apply>
      <power/>
      <ci>SAMP</ci>
      <ci>fasli3</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>ATP</ci>
    <ci>fasli4</ci>
  </apply>
</apply>

$reactions$asli$exprLaw
aasli * SAMP^fasli3 * ATP^fasli4

$reactions$asli$strLaw
[1] "aasli*SAMP^fasli3*ATP^fasli4"

$reactions$asli$law
function (r, p = NULL)
{
  aasli = p["aasli"]
  fasli3 = p["fasli3"]
  fasli4 = p["fasli4"]
  SAMP = r["SAMP"]
  ATP = r["ATP"]
  aasli * SAMP^fasli3 * ATP^fasli4
}
<environment: 0x000000002a27908>

$reactions$dada
$reactions$dada$id
[1] "dada"

$reactions$dada$reversible
[1] FALSE

```

```

$reactions$dada$reactants
[1] "dATP"

$reactions$dada$products
[1] "HX"

$reactions$dada$parameters
      adada  fdada9
0.03333 1.00000

$reactions$dada$mathmlLaw
<apply>
  <times/>
  <ci>adada</ci>
  <apply>
    <power/>
    <ci>dATP</ci>
    <ci>fdada9</ci>
  </apply>
</apply>

$reactions$dada$exprLaw
adada * dATP^fdada9

$reactions$dada$strLaw
[1] "adada*dATP^fdada9"

$reactions$dada$law
function (r, p = NULL)
{
  adada = p["adada"]
  fdada9 = p["fdada9"]
  dATP = r["dATP"]
  adada * dATP^fdada9
}
<environment: 0x000000001eab978>

$reactions$den
$reactions$den$id
[1] "den"

$reactions$den$reversible
[1] FALSE

$reactions$den$reactants

```

```

[1] "PRPP"

$reactions$den$modifiers
[1] "dGTP" "IMP"  "ATP"  "GTP"  "Pi"

$reactions$den$products
[1] "IMP"

$reactions$den$parameters
      aden  fden1  fden2  fden4  fden8  fden18
5.2728  2.0000 -0.0600 -0.2500 -0.2000 -0.0800

$reactions$den$mathmlLaw
<apply>
<times/>
<apply>
<times/>
<apply>
<times/>
<apply>
<times/>
<apply>
<times/>
<ci>aden</ci>
<apply>
<power/>
<ci>PRPP</ci>
<ci>fden1</ci>
</apply>
</apply>
<apply>
<power/>
<ci>IMP</ci>
<ci>fden2</ci>
</apply>
</apply>
<apply>
<power/>
<ci>ATP</ci>
<ci>fden4</ci>
</apply>
</apply>
<apply>
<power/>
<ci>GTP</ci>
<ci>fden8</ci>

```

```

    </apply>
  </apply>
  <apply>
    <power/>
    <ci>Pi</ci>
    <ci>fden18</ci>
  </apply>
</apply>

$reactions$den$exprLaw
aden * PRPP^fden1 * IMP^fden2 * ATP^fden4 * GTP^fden8 * Pi^fden18

$reactions$den$strLaw
[1] "aden*PRPP^fden1*IMP^fden2*ATP^fden4*GTP^fden8*Pi^fden18"

$reactions$den$law
function (r, p = NULL)
{
  aden = p["aden"]
  fden1 = p["fden1"]
  fden2 = p["fden2"]
  fden4 = p["fden4"]
  fden8 = p["fden8"]
  fden18 = p["fden18"]
  PRPP = r["PRPP"]
  dGTP = r["dGTP"]
  IMP = r["IMP"]
  ATP = r["ATP"]
  GTP = r["GTP"]
  Pi = r["Pi"]
  aden * PRPP^fden1 * IMP^fden2 * ATP^fden4 * GTP^fden8 * Pi^fden18
}
<environment: 0x000000001a8fbe0>

$reactions$dgnuc
$reactions$dgnuc$id
[1] "dgnuc"

$reactions$dgnuc$reversible
[1] FALSE

$reactions$dgnuc$reactants
[1] "dGTP"

$reactions$dgnuc$products

```

```

[1] "Gua"

$reactions$dgnuc$parameters
  adgnuc fdgnuc10
0.03333 1.00000

$reactions$dgnuc$mathmlLaw
<apply>
  <times/>
  <ci>adgnuc</ci>
  <apply>
    <power/>
    <ci>dGTP</ci>
    <ci>fdgnuc10</ci>
  </apply>
</apply>

$reactions$dgnuc$exprLaw
adgnuc * dGTP^fdgnuc10

$reactions$dgnuc$strLaw
[1] "adgnuc*dGTP^fdgnuc10"

$reactions$dgnuc$law
function (r, p = NULL)
{
  adgnuc = p["adgnuc"]
  fdgnuc10 = p["fdgnuc10"]
  dGTP = r["dGTP"]
  adgnuc * dGTP^fdgnuc10
}
<environment: 0x00000000150b2f0>

$reactions$dnaa
$reactions$dnaa$id
[1] "dnaa"

$reactions$dnaa$reversible
[1] FALSE

$reactions$dnaa$reactants
[1] "DNA"

$reactions$dnaa$products
[1] "dATP"

```



```

$reactions$dnaa$parameters
      adnaa fdnan12
0.001938 1.000000

$reactions$dnaa$mathmlLaw
<apply>
  <times/>
  <ci>adnaa</ci>
  <apply>
    <power/>
    <ci>DNA</ci>
    <ci>fdnan12</ci>
  </apply>
</apply>

$reactions$dnaa$exprLaw
adnaa * DNA^fdnan12

$reactions$dnaa$strLaw
[1] "adnaa*DNA^fdnan12"

$reactions$dnaa$law
function (r, p = NULL)
{
  adnaa = p["adnaa"]
  fdnan12 = p["fdnan12"]
  DNA = r["DNA"]
  adnaa * DNA^fdnan12
}
<environment: 0x0000000001bc3f10>

$reactions$dnag
$reactions$dnag$id
[1] "dnag"

$reactions$dnag$reversible
[1] FALSE

$reactions$dnag$reactants
[1] "DNA"

$reactions$dnag$products
[1] "dGTP"

```

```

$reactions$dnag$parameters
  adnag fdnan12
0.001318 1.000000

$reactions$dnag$mathmlLaw
<apply>
  <times/>
  <ci>adnag</ci>
  <apply>
    <power/>
    <ci>DNA</ci>
    <ci>fdnan12</ci>
  </apply>
</apply>

$reactions$dnag$exprLaw
adnag * DNA^fdnan12

$reactions$dnag$strLaw
[1] "adnag*DNA^fdnan12"

$reactions$dnag$law
function (r, p = NULL)
{
  adnag = p["adnag"]
  fdnan12 = p["fdnan12"]
  DNA = r["DNA"]
  adnag * DNA^fdnan12
}
<environment: 0x000000002a58648>

$reactions$gdna
$reactions$gdna$id
[1] "gdna"

$reactions$gdna$reversible
[1] FALSE

$reactions$gdna$reactants
[1] "dGTP"

$reactions$gdna$modifiers
[1] "dATP"

$reactions$gdna$products

```

```

[1] "DNA"

$reactions$gdna$parameters
  agdna  fdnap9 fdnap10
  2.2296  0.4200  0.3300

$reactions$gdna$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <ci>agdna</ci>
    <apply>
      <power/>
      <ci>dATP</ci>
      <ci>fdnap9</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>dGTP</ci>
    <ci>fdnap10</ci>
  </apply>
</apply>

$reactions$gdna$exprLaw
agdna * dATP^fdnap9 * dGTP^fdnap10

$reactions$gdna$strLaw
[1] "agdna*dATP^fdnap9*dGTP^fdnap10"

$reactions$gdna$law
function (r, p = NULL)
{
  agdna = p["agdna"]
  fdnap9 = p["fdnap9"]
  fdnap10 = p["fdnap10"]
  dGTP = r["dGTP"]
  dATP = r["dATP"]
  agdna * dATP^fdnap9 * dGTP^fdnap10
}
<environment: 0x000000002317ad0>

$reactions$gdrnr
$reactions$gdrnr$id

```

```

[1] "gdrnr"

$reactions$gdrnr$reversible
[1] FALSE

$reactions$gdrnr$reactants
[1] "GTP"

$reactions$gdrnr$modifiers
[1] "dATP" "dGTP"

$reactions$gdrnr$products
[1] "dGTP"

$reactions$gdrnr$parameters
  agdrnr  fgdrnr8  fgdrnr9 fgdrnr10
  0.1199   0.4000  -1.2000  -0.3900

$reactions$gdrnr$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <ci>agdrnr</ci>
      <apply>
        <power/>
        <ci>GTP</ci>
        <ci>fgdrnr8</ci>
      </apply>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>dATP</ci>
    <ci>fgdrnr9</ci>
  </apply>
</apply>
  <apply>
    <power/>
    <ci>dGTP</ci>
    <ci>fgdrnr10</ci>
  </apply>
</apply>

$reactions$gdrnr$exprLaw

```

```

agdrnr * GTP^fgdrnr8 * dATP^fgdrnr9 * dGTP^fgdrnr10

$reactions$gdrnr$strLaw
[1] "agdrnr*GTP^fgdrnr8*dATP^fgdrnr9*dGTP^fgdrnr10"

$reactions$gdrnr$law
function (r, p = NULL)
{
  agdrnr = p["agdrnr"]
  fgdrnr8 = p["fgdrnr8"]
  fgdrnr9 = p["fgdrnr9"]
  fgdrnr10 = p["fgdrnr10"]
  GTP = r["GTP"]
  dATP = r["dATP"]
  dGTP = r["dGTP"]
  agdrnr * GTP^fgdrnr8 * dATP^fgdrnr9 * dGTP^fgdrnr10
}
<environment: 0x0000000027a0678>

$reactions$gmpr
$reactions$gmpr$id
[1] "gmpr"

$reactions$gmpr$reversible
[1] FALSE

$reactions$gmpr$reactants
[1] "GTP"

$reactions$gmpr$modifiers
[1] "XMP" "ATP" "IMP"

$reactions$gmpr$products
[1] "IMP"

$reactions$gmpr$parameters
  agmpr fgmpr2 fgmpr4 fgmpr7 fgmpr8
0.3005 -0.1500 -0.0700 -0.7600 0.7000

$reactions$gmpr$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>

```

```

<times/>
<apply>
  <times/>
  <ci>agmpr</ci>
  <apply>
    <power/>
    <ci>IMP</ci>
    <ci>fgmpr2</ci>
  </apply>
</apply>
<apply>
  <power/>
  <ci>ATP</ci>
  <ci>fgmpr4</ci>
</apply>
</apply>
<apply>
  <power/>
  <ci>XMP</ci>
  <ci>fgmpr7</ci>
</apply>
</apply>
<apply>
  <power/>
  <ci>GTP</ci>
  <ci>fgmpr8</ci>
</apply>
</apply>

$reactions$gmpr$exprLaw
agmpr * IMP^fgmpr2 * ATP^fgmpr4 * XMP^fgmpr7 * GTP^fgmpr8

$reactions$gmpr$strLaw
[1] "agmpr*IMP^fgmpr2*ATP^fgmpr4*XMP^fgmpr7*GTP^fgmpr8"

$reactions$gmpr$law
function (r, p = NULL)
{
  agmpr = p["agmpr"]
  fgmpr2 = p["fgmpr2"]
  fgmpr4 = p["fgmpr4"]
  fgmpr7 = p["fgmpr7"]
  fgmpr8 = p["fgmpr8"]
  GTP = r["GTP"]
  XMP = r["XMP"]
  ATP = r["ATP"]

```

```

    IMP = r["IMP"]
    agmpr * IMP^fgmpr2 * ATP^fgmpr4 * XMP^fgmpr7 * GTP^fgmpr8
  }
<environment: 0x0000000021aedb0>

```

```

$reactions$gmps
$reactions$gmps$id
[1] "gmps"

```

```

$reactions$gmps$reversible
[1] FALSE

```

```

$reactions$gmps$reactants
[1] "XMP"

```

```

$reactions$gmps$modifiers
[1] "ATP"

```

```

$reactions$gmps$products
[1] "GTP"

```

```

$reactions$gmps$parameters
agmps fgmps4 fgmps7
0.3738 0.1200 0.1600

```

```

$reactions$gmps$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <ci>agmps</ci>
    <apply>
      <power/>
      <ci>ATP</ci>
      <ci>fgmps4</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>XMP</ci>
    <ci>fgmps7</ci>
  </apply>
</apply>

```

```

$reactions$gmps$exprLaw

```

```

agmps * ATP^fgmps4 * XMP^fgmps7

$reactions$gmps$strLaw
[1] "agmps*ATP^fgmps4*XMP^fgmps7"

$reactions$gmps$law
function (r, p = NULL)
{
  agmps = p["agmps"]
  fgmps4 = p["fgmps4"]
  fgmps7 = p["fgmps7"]
  XMP = r["XMP"]
  ATP = r["ATP"]
  agmps * ATP^fgmps4 * XMP^fgmps7
}
<environment: 0x000000001b1c820>

$reactions$gnuc
$reactions$gnuc$id
[1] "gnuc"

$reactions$gnuc$reversible
[1] FALSE

$reactions$gnuc$reactants
[1] "GTP"

$reactions$gnuc$modifiers
[1] "Pi"

$reactions$gnuc$products
[1] "Gua"

$reactions$gnuc$parameters
  agnuc  fg nuc8 fg nuc18
0.2511  0.9000 -0.3400

$reactions$gnuc$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <ci>agnuc</ci>
    <apply>
      <power/>

```



```

      <ci>GTP</ci>
      <ci>fgnuc8</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>Pi</ci>
    <ci>fgnuc18</ci>
  </apply>
</apply>

$reactions$gnuc$exprLaw
agnuc * GTP^fgnuc8 * Pi^fgnuc18

$reactions$gnuc$strLaw
[1] "agnuc*GTP^fgnuc8*Pi^fgnuc18"

$reactions$gnuc$law
function (r, p = NULL)
{
  agnuc = p["agnuc"]
  fgnuc8 = p["fgnuc8"]
  fgnuc18 = p["fgnuc18"]
  GTP = r["GTP"]
  Pi = r["Pi"]
  agnuc * GTP^fgnuc8 * Pi^fgnuc18
}
<environment: 0x0000000018621e0>

$reactions$gpert
$reactions$gpert$id
[1] "gpert"

$reactions$gpert$reversible
[1] FALSE

$reactions$gpert$reactants
[1] "Gua" "PRPP"

$reactions$gpert$modifiers
[1] "GTP"

$reactions$gpert$products
[1] "GTP"

```

```

$reactions$gpert$parameters
  agprt  fgprt1  fgprt8  fgprt15
361.69    1.20   -1.20    0.42

$reactions$gpert$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <ci>agprt</ci>
      <apply>
        <power/>
        <ci>PRPP</ci>
        <ci>fgprt1</ci>
      </apply>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>GTP</ci>
    <ci>fgprt8</ci>
  </apply>
</apply>
<apply>
  <power/>
  <ci>Gua</ci>
  <ci>fgprt15</ci>
</apply>
</apply>

$reactions$gpert$exprLaw
agprt * PRPP^fgprt1 * GTP^fgprt8 * Gua^fgprt15

$reactions$gpert$strLaw
[1] "agprt*PRPP^fgprt1*GTP^fgprt8*Gua^fgprt15"

$reactions$gpert$law
function (r, p = NULL)
{
  agprt = p["agprt"]
  fgprt1 = p["fgprt1"]
  fgprt8 = p["fgprt8"]
  fgprt15 = p["fgprt15"]
  Gua = r["Gua"]
  PRPP = r["PRPP"]

```

```

      GTP = r["GTP"]
      agprt * PRPP^fgprt1 * GTP^fgprt8 * Gua^fgprt15
    }
    <environment: 0x000000002abb290>

```

```

$reactions$grna
$reactions$grna$id
[1] "grna"

```

```

$reactions$grna$reversible
[1] FALSE

```

```

$reactions$grna$reactants
[1] "GTP"

```

```

$reactions$grna$modifiers
[1] "ATP"

```

```

$reactions$grna$products
[1] "RNA"

```

```

$reactions$grna$parameters
agrna frnap4 frnap8
409.60 0.05 0.13

```

```

$reactions$grna$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <ci>agrna</ci>
    <apply>
      <power/>
      <ci>ATP</ci>
      <ci>frnap4</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>GTP</ci>
    <ci>frnap8</ci>
  </apply>
</apply>

```

```

$reactions$grna$exprLaw

```

```

agrna * ATP^frnap4 * GTP^frnap8

$reactions$grna$strLaw
[1] "agrna*ATP^frnap4*GTP^frnap8"

$reactions$grna$law
function (r, p = NULL)
{
  agrna = p["agrna"]
  frnap4 = p["frnap4"]
  frnap8 = p["frnap8"]
  GTP = r["GTP"]
  ATP = r["ATP"]
  agrna * ATP^frnap4 * GTP^frnap8
}
<environment: 0x0000000002211940>

$reactions$gua
$reactions$gua$id
[1] "gua"

$reactions$gua$reversible
[1] FALSE

$reactions$gua$reactants
[1] "Gua"

$reactions$gua$products
[1] "Xa"

$reactions$gua$parameters
  agua fgua15
0.4919 0.5000

$reactions$gua$mathmlLaw
<apply>
  <times/>
  <ci>agua</ci>
  <apply>
    <power/>
    <ci>Gua</ci>
    <ci>fgua15</ci>
  </apply>
</apply>

```

```

$reactions$gua$exprLaw
agua * Gua^fgua15

$reactions$gua$strLaw
[1] "agua*Gua^fgua15"

$reactions$gua$law
function (r, p = NULL)
{
  agua = p["agua"]
  fgua15 = p["fgua15"]
  Gua = r["Gua"]
  agua * Gua^fgua15
}
<environment: 0x0000000001676800>

```

```

$reactions$hprt
$reactions$hprt$id
[1] "hprt"

$reactions$hprt$reversible
[1] FALSE

```

```

$reactions$hprt$reactants
[1] "HX" "PRPP"

```

```

$reactions$hprt$modifiers
[1] "IMP"

```

```

$reactions$hprt$products
[1] "IMP"

```

```

$reactions$hprt$parameters
  ahprt fhprt1 fhprt2 fhprt13
12.569  1.100 -0.890  0.480

```

```

$reactions$hprt$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <ci>ahprt</ci>
    <apply>

```

```

    <power/>
    <ci>PRPP</ci>
    <ci>fhprt1</ci>
  </apply>
</apply>
<apply>
  <power/>
  <ci>IMP</ci>
  <ci>fhprt2</ci>
</apply>
</apply>
<apply>
  <power/>
  <ci>HX</ci>
  <ci>fhprt13</ci>
</apply>
</apply>

$reactions$hpirt$exprLaw
ahprt * PRPP^fhprt1 * IMP^fhprt2 * HX^fhprt13

$reactions$hpirt$strLaw
[1] "ahprt*PRPP^fhprt1*IMP^fhprt2*HX^fhprt13"

$reactions$hpirt$law
function (r, p = NULL)
{
  ahprt = p["ahprt"]
  fhprt1 = p["fhprt1"]
  fhprt2 = p["fhprt2"]
  fhprt13 = p["fhprt13"]
  HX = r["HX"]
  PRPP = r["PRPP"]
  IMP = r["IMP"]
  ahprt * PRPP^fhprt1 * IMP^fhprt2 * HX^fhprt13
}
<environment: 0x0000000001afd8f0>

$reactions$hxx
$reactions$hxx$id
[1] "hx"

$reactions$hxx$reversible
[1] FALSE

```

```

$reactions$hreactants
[1] "HX"

$reactions$hparameters
      ahx      fhx13
0.003793 1.120000

$reactions$hmathmlLaw
<apply>
  <times/>
  <ci>ahx</ci>
  <apply>
    <power/>
    <ci>HX</ci>
    <ci>fhx13</ci>
  </apply>
</apply>

$reactions$hexprLaw
ahx * HX^fhx13

$reactions$hstrLaw
[1] "ahx*HX^fhx13"

$reactions$hlaw
function (r, p = NULL)
{
  ahx = p["ahx"]
  fhx13 = p["fhx13"]
  HX = r["HX"]
  ahx * HX^fhx13
}
<environment: 0x0000000029c0fe8>

$reactions$hxd
$reactions$hxd$id
[1] "hxd"

$reactions$hxd$reversible
[1] FALSE

$reactions$hxd$reactants
[1] "HX"

$reactions$hxd$products

```

```

[1] "Xa"

$reactions$hxd$parameters
  ahxd fhxd13
0.2754 0.6500

$reactions$hxd$mathmlLaw
<apply>
  <times/>
  <ci>ahxd</ci>
  <apply>
    <power/>
    <ci>HX</ci>
    <ci>fhxd13</ci>
  </apply>
</apply>

$reactions$hxd$exprLaw
ahxd * HX^fhxd13

$reactions$hxd$strLaw
[1] "ahxd*HX^fhxd13"

$reactions$hxd$law
function (r, p = NULL)
{
  ahxd = p["ahxd"]
  fhxd13 = p["fhxd13"]
  HX = r["HX"]
  ahxd * HX^fhxd13
}
<environment: 0x0000000022d0ec8>

$reactions$impd
$reactions$impd$id
[1] "impd"

$reactions$impd$reversible
[1] FALSE

$reactions$impd$reactants
[1] "IMP"

$reactions$impd$modifiers
[1] "GTP" "XMP"

```



```

$reactions$impd$products
[1] "XMP"

$reactions$impd$parameters
      aimpd  fimpd2  fimpd7  fimpd8
1.2823  0.1500 -0.0900 -0.0300

$reactions$impd$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <apply>
      <times/>
      <ci>aimpd</ci>
    <apply>
      <power/>
      <ci>IMP</ci>
      <ci>fimpd2</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>XMP</ci>
    <ci>fimpd7</ci>
  </apply>
</apply>
<apply>
  <power/>
  <ci>GTP</ci>
  <ci>fimpd8</ci>
</apply>
</apply>

$reactions$impd$exprLaw
aimpd * IMP^fimpd2 * XMP^fimpd7 * GTP^fimpd8

$reactions$impd$strLaw
[1] "aimpd*IMP^fimpd2*XMP^fimpd7*GTP^fimpd8"

$reactions$impd$law
function (r, p = NULL)
{
  aimpd = p["aimpd"]
  fimpd2 = p["fimpd2"]

```

```

    fimpd7 = p["fimpd7"]
    fimpd8 = p["fimpd8"]
    IMP = r["IMP"]
    GTP = r["GTP"]
    XMP = r["XMP"]
    aimpd * IMP^fimpd2 * XMP^fimpd7 * GTP^fimpd8
  }
<environment: 0x000000002a9f438>

```

```

$reactions$inuc
$reactions$inuc$id
[1] "inuc"

```

```

$reactions$inuc$reversible
[1] FALSE

```

```

$reactions$inuc$reactants
[1] "IMP"

```

```

$reactions$inuc$modifiers
[1] "Pi"

```

```

$reactions$inuc$products
[1] "HX"

```

```

$reactions$inuc$parameters
  ainuc  finuc2 finuc18
0.9135  0.8000 -0.3600

```

```

$reactions$inuc$mathmlLaw
<apply>
  <times/>
  <apply>
    <times/>
    <ci>ainuc</ci>
    <apply>
      <power/>
      <ci>IMP</ci>
      <ci>finuc2</ci>
    </apply>
  </apply>
<apply>
  <power/>
  <ci>Pi</ci>
  <ci>finuc18</ci>

```

```

</apply>
</apply>

$reactions$inuc$exprLaw
ainuc * IMP^finuc2 * Pi^finuc18

$reactions$inuc$strLaw
[1] "ainuc*IMP^finuc2*Pi^finuc18"

$reactions$inuc$law
function (r, p = NULL)
{
  ainuc = p["ainuc"]
  finuc2 = p["finuc2"]
  finuc18 = p["finuc18"]
  IMP = r["IMP"]
  Pi = r["Pi"]
  ainuc * IMP^finuc2 * Pi^finuc18
}
<environment: 0x0000000001785098>

$reactions$mat
$reactions$mat$id
[1] "mat"

$reactions$mat$reversible
[1] FALSE

$reactions$mat$reactants
[1] "ATP"

$reactions$mat$modifiers
[1] "SAM"

$reactions$mat$products
[1] "SAM"

$reactions$mat$parameters
  amat   fmat4   fmat5
7.2067  0.2000 -0.6000

$reactions$mat$mathmlLaw
<apply>
<times/>
<apply>

```

```

    <times/>
    <ci>amat</ci>
    <apply>
      <power/>
      <ci>ATP</ci>
      <ci>fmat4</ci>
    </apply>
  </apply>
  <apply>
    <power/>
    <ci>SAM</ci>
    <ci>fmat5</ci>
  </apply>
</apply>

$reactions$mat$exprLaw
amat * ATP^fmat4 * SAM^fmat5

$reactions$mat$strLaw
[1] "amat*ATP^fmat4*SAM^fmat5"

$reactions$mat$law
function (r, p = NULL)
{
  amat = p["amat"]
  fmat4 = p["fmat4"]
  fmat5 = p["fmat5"]
  ATP = r["ATP"]
  SAM = r["SAM"]
  amat * ATP^fmat4 * SAM^fmat5
}
<environment: 0x000000002a71c98>

$reactions$polyam
$reactions$polyam$id
[1] "polyam"

$reactions$polyam$reversible
[1] FALSE

$reactions$polyam$reactants
[1] "SAM"

$reactions$polyam$products
[1] "Ade"

```

```

$reactions$polyam$parameters
  apolyam fpolyam5
    0.29    0.90

$reactions$polyam$mathmlLaw
<apply>
  <times/>
  <ci>apolyam</ci>
<apply>
  <power/>
  <ci>SAM</ci>
  <ci>fpolyam5</ci>
</apply>
</apply>

$reactions$polyam$exprLaw
apolyam * SAM^fpolyam5

$reactions$polyam$strLaw
[1] "apolyam*SAM^fpolyam5"

$reactions$polyam$law
function (r, p = NULL)
{
  apolyam = p["apolyam"]
  fpolyam5 = p["fpolyam5"]
  SAM = r["SAM"]
  apolyam * SAM^fpolyam5
}
<environment: 0x0000000026b8608>

$reactions$prpps
$reactions$prpps$id
[1] "prpps"

$reactions$prpps$reversible
[1] FALSE

$reactions$prpps$reactants
[1] "R5P"

$reactions$prpps$modifiers
[1] "ATP" "GTP" "Pi" "PRPP"

```

```
$reactions$prpps$products
```

```
[1] "PRPP"
```

```
$reactions$prpps$parameters
```

```
aprpps fprpps1 fprpps4 fprpps8 fprpps17 fprpps18  
0.90 -0.03 -0.45 -0.04 0.65 0.70
```

```
$reactions$prpps$mathmlLaw
```

```
<apply>  
<times/>  
<apply>  
<times/>  
<apply>  
<times/>  
<apply>  
<times/>  
<apply>  
<times/>  
<ci>aprpps</ci>  
<apply>  
<power/>  
<ci>PRPP</ci>  
<ci>fprpps1</ci>  
</apply>  
</apply>  
<apply>  
<power/>  
<ci>ATP</ci>  
<ci>fprpps4</ci>  
</apply>  
</apply>  
<apply>  
<power/>  
<ci>GTP</ci>  
<ci>fprpps8</ci>  
</apply>  
</apply>  
<apply>  
<power/>  
<ci>R5P</ci>  
<ci>fprpps17</ci>  
</apply>  
</apply>  
<apply>  
<power/>  
<ci>Pi</ci>
```

```

    <ci>fprpps18</ci>
  </apply>
</apply>

$reactions$prpps$exprLaw
aprpps * PRPP^fprpps1 * ATP^fprpps4 * GTP^fprpps8 * R5P^fprpps17 *
  Pi^fprpps18

$reactions$prpps$strLaw
[1] "aprpps*PRPP^fprpps1*ATP^fprpps4*GTP^fprpps8*R5P^fprpps17*Pi^fprpps18"

$reactions$prpps$law
function (r, p = NULL)
{
  aprpps = p["aprpps"]
  fprpps1 = p["fprpps1"]
  fprpps4 = p["fprpps4"]
  fprpps8 = p["fprpps8"]
  fprpps17 = p["fprpps17"]
  fprpps18 = p["fprpps18"]
  R5P = r["R5P"]
  ATP = r["ATP"]
  GTP = r["GTP"]
  Pi = r["Pi"]
  PRPP = r["PRPP"]
  aprpps * PRPP^fprpps1 * ATP^fprpps4 * GTP^fprpps8 * R5P^fprpps17 *
    Pi^fprpps18
}
<environment: 0x000000002269a20>

$reactions$pyr
$reactions$pyr$id
[1] "pyr"

$reactions$pyr$reversible
[1] FALSE

$reactions$pyr$reactants
[1] "PRPP"

$reactions$pyr$parameters
  apyr  fpyr1
1.2951 1.2700

$reactions$pyr$mathmlLaw

```

```

<apply>
  <times/>
  <ci>apyr</ci>
</apply>
  <power/>
  <ci>PRPP</ci>
  <ci>fpyr1</ci>
</apply>
</apply>

$reactions$pyr$exprLaw
apyr * PRPP^fpyr1

$reactions$pyr$strLaw
[1] "apyr*PRPP^fpyr1"

$reactions$pyr$law
function (r, p = NULL)
{
  apyr = p["apyr"]
  fpyr1 = p["fpyr1"]
  PRPP = r["PRPP"]
  apyr * PRPP^fpyr1
}
<environment: 0x00000000169d8f0>

$reactions$rnaa
$reactions$rnaa$id
[1] "rnaa"

$reactions$rnaa$reversible
[1] FALSE

$reactions$rnaa$reactants
[1] "RNA"

$reactions$rnaa$products
[1] "ATP"

$reactions$rnaa$parameters
  arnaa frnan11
0.06923 1.00000

$reactions$rnaa$mathmlLaw
<apply>

```



```

<times/>
<ci>arnaa</ci>
<apply>
  <power/>
  <ci>RNA</ci>
  <ci>frnan11</ci>
</apply>
</apply>

$reactions$rnaa$exprLaw
arnaa * RNA^frnan11

$reactions$rnaa$strLaw
[1] "arnaa*RNA^frnan11"

$reactions$rnaa$law
function (r, p = NULL)
{
  arnaa = p["arnaa"]
  frnan11 = p["frnan11"]
  RNA = r["RNA"]
  arnaa * RNA^frnan11
}
<environment: 0x000000000183f060>

$reactions$rnag
$reactions$rnag$id
[1] "rnag"

$reactions$rnag$reversible
[1] FALSE

$reactions$rnag$reactants
[1] "RNA"

$reactions$rnag$products
[1] "GTP"

$reactions$rnag$parameters
  arnag frnan11
0.04615 1.00000

$reactions$rnag$mathmlLaw
<apply>
  <times/>

```

```

<ci>arnag</ci>
<apply>
  <power/>
  <ci>RNA</ci>
  <ci>frnan11</ci>
</apply>
</apply>

$reactions$rnag$exprLaw
arnag * RNA^frnan11

$reactions$rnag$strLaw
[1] "arnag*RNA^frnan11"

$reactions$rnag$law
function (r, p = NULL)
{
  arnag = p["arnag"]
  frnan11 = p["frnan11"]
  RNA = r["RNA"]
  arnag * RNA^frnan11
}
<environment: 0x00000000214e420>

$reactions$trans
$reactions$trans$id
[1] "trans"

$reactions$trans$reversible
[1] FALSE

$reactions$trans$reactants
[1] "SAM"

$reactions$trans$products
[1] "ATP"

$reactions$trans$parameters
atrans ftrans5
8.8539 0.3300

$reactions$trans$mathmlLaw
<apply>
  <times/>
  <ci>atrans</ci>

```

```

<apply>
  <power/>
  <ci>SAM</ci>
  <ci>ftrans5</ci>
</apply>
</apply>

$reactions$trans$exprLaw
atrans * SAM^ftrans5

$reactions$trans$strLaw
[1] "atrans*SAM^ftrans5"

$reactions$trans$law
function (r, p = NULL)
{
  atrans = p["atrans"]
  ftrans5 = p["ftrans5"]
  SAM = r["SAM"]
  atrans * SAM^ftrans5
}
<environment: 0x00000000190a3e0>

$reactions$ua
$reactions$ua$id
[1] "ua"

$reactions$ua$reversible
[1] FALSE

$reactions$ua$reactants
[1] "UA"

$reactions$ua$parameters
      aua      fua16
8.744e-05 2.210e+00

$reactions$ua$mathmlLaw
<apply>
  <times/>
  <ci>aua</ci>
  <apply>
    <power/>
    <ci>UA</ci>
    <ci>fua16</ci>
  
```

```

</apply>
</apply>

$reactions$ua$exprLaw
  aua * UA^fua16

$reactions$ua$strLaw
[1] "aua*UA^fua16"

$reactions$ua$law
function (r, p = NULL)
{
  aua = p["aua"]
  fua16 = p["fua16"]
  UA = r["UA"]
  aua * UA^fua16
}
<environment: 0x00000000028273a0>

$reactions$x
$reactions$x$id
[1] "x"

$reactions$x$reversible
[1] FALSE

$reactions$x$reactants
[1] "Xa"

$reactions$x$parameters
  ax  fx14
0.0012 2.0000

$reactions$x$mathmlLaw
<apply>
  <times/>
  <ci>ax</ci>
  <apply>
    <power/>
    <ci>Xa</ci>
    <ci>fx14</ci>
  </apply>
</apply>

$reactions$x$exprLaw

```

```

ax * Xa^fx14

$reactions$x$strLaw
[1] "ax*Xa^fx14"

$reactions$x$law
function (r, p = NULL)
{
  ax = p["ax"]
  fx14 = p["fx14"]
  Xa = r["Xa"]
  ax * Xa^fx14
}
<environment: 0x000000002043220>

$reactions$xd
$reactions$xd$id
[1] "xd"

$reactions$xd$reversible
[1] FALSE

$reactions$xd$reactants
[1] "Xa"

$reactions$xd$products
[1] "UA"

$reactions$xd$parameters
  axd fxd14
0.949 0.550

$reactions$xd$mathmlLaw
<apply>
  <times/>
  <ci>axd</ci>
  <apply>
    <power/>
    <ci>Xa</ci>
    <ci>fxd14</ci>
  </apply>
</apply>

$reactions$xd$exprLaw
axd * Xa^fxd14

```

```

$reactions$xd$strLaw
[1] "axd*Xa^fxd14"

$reactions$xd$law
function (r, p = NULL)
{
  axd = p["axd"]
  fxd14 = p["fxd14"]
  Xa = r["Xa"]
  axd * Xa^fxd14
}
<environment: 0x00000000028afa70>

```

```

$htmlNotes
<notes>
<body xmlns="http://www.w3.org/1999/xhtml">
  <p>This is a purine metabolism model that is geared toward studies of gout.</p>
  <p>The model is fully described in Curto et al., MBSC 151 (1998) pp 1-49</p>
  <p>The model uses Generalized Mass Action (GMA;i.e. power law) descriptions of reaction ra
  <p>Such descriptions are local approximations that assume independent substrate binding.</p>
  <p/>
  <p>The de novo purine flux vden= 2.39 is in umole/min/KG, i.e. 2.4*60=144 uM/h if we let e
  <p>liter of water. Morrison and Allegra (JBC, 1989) have vden at 650 uM/h (model) and 415
  <p>The IC&apos;s below have been set to the system&apos;s steady state.</p>
  <p>The units in this model are micromolar(uM) and minutes.</p>
  <p>A cell volume of 1 is used so that amounts and concentrations are the same thing.</p>
</body>
</notes>

attr(,"class")
[1] "SBML"

```