**A simple model of the Circadian Clock**

This model is adapted from the following papers:

Tsumoto K, Kurosawa G, Yoshinaga T, Aihara K (2011)

**Modeling Light Adaptation in Circadian Clock: Prediction of the Response That Stabilizes Entrainment.** PLOS ONE 6(6): e20880. doi: 10.1371/journal.pone.0020880

Gonze D, Goldbeter A (2000) **Entrainment versus chaos in a model for a circadian oscillator driven by light-dark cycles**. J Stat Phys 101: 649–663.

**Model**

This is a simplified model of a circadian oscillator, in which only a single clock gene is modelled. It involves three species:

* M mRNA
* PC protein in cytosol
* PN protein in nucleus

In this model the protein encoding the clock gene inhibits its own transcription, according to the following ODE equations:

*Initial conditions (concentrations, arbitrary units)*

M=0.6 PC=0.6 PN=1.0

*Parameter values (time units in hours)*

vs=1.6 vm=0.505 Km=0.5 ks=0.5 vd=1.4

k1=0.5 k2=0.6 KI=1.0 Kd=0.13 n=4.0

**Entrainment**

In circadian systems the oscillations are synchronised to the 24 hour day/night cycle. To model this process of entrainment we modify the equations so that the rate of transcription is time dependant.

For example the following term has a 24-hour cycle and varies sinusoidally between low values (0) and high values (1) which we might associate with the differing transcription rates in darkness and daylight.

Including this dependence into the transcription rate term gives a modified ODE:

Here the coupling parameter is added to the model and controls the level of influence light level has on transcription:

no night/daylight dependence

high night/daylight dependence.

**Modelling the system**

The file simple\_circadian\_template.py contains code to simulate this system.

1. Enter the rate equations and parameter values and initial conditions as detailed above. Simulate the system setting (so that transcription rate unaffected by the day/night cycle). You should find the oscillator has a period slightly shorter than 24 hours and drifts out of sync with the night/day cycle (indicated on the lower axis).

2. Set = 1 and repeat the simulation. You should find that the oscillations fall into exact synchrony with the night/day cycle.