Systems Biology

Bistable Switch, Oscillation

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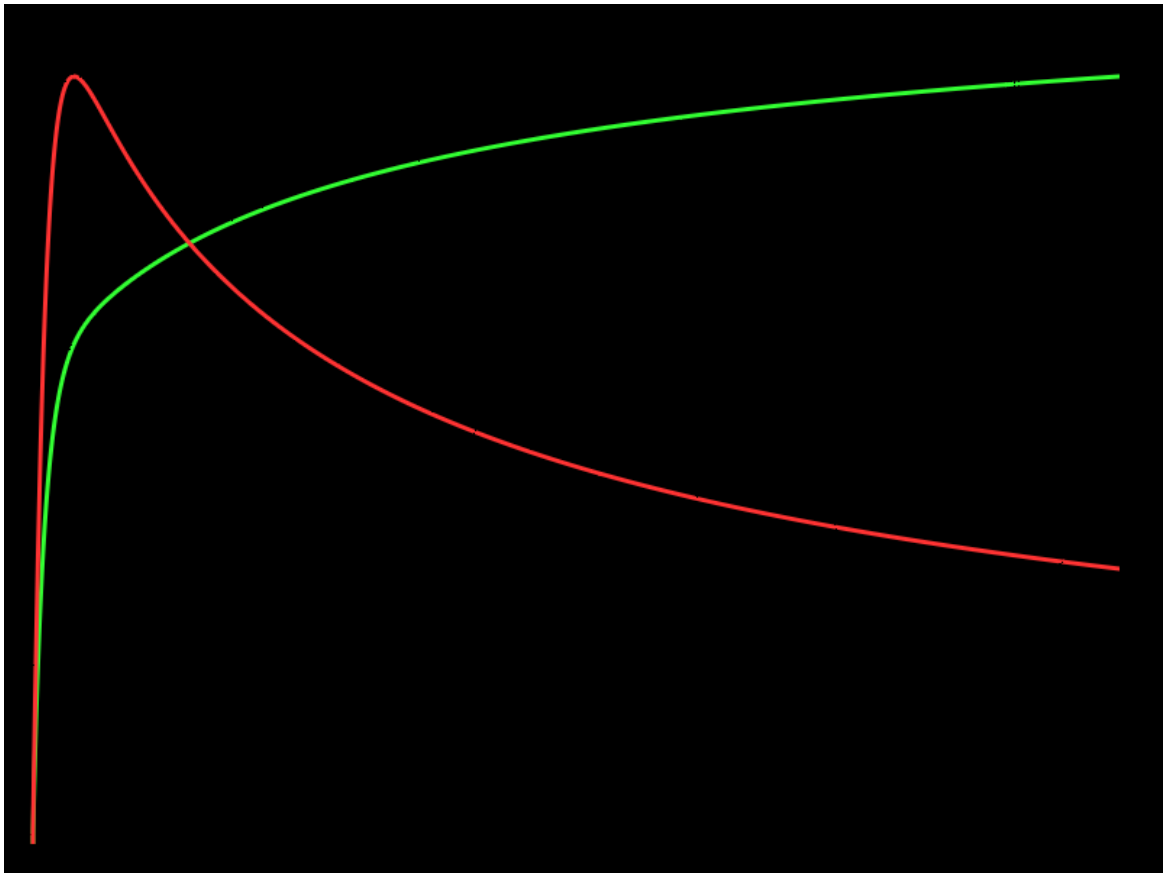
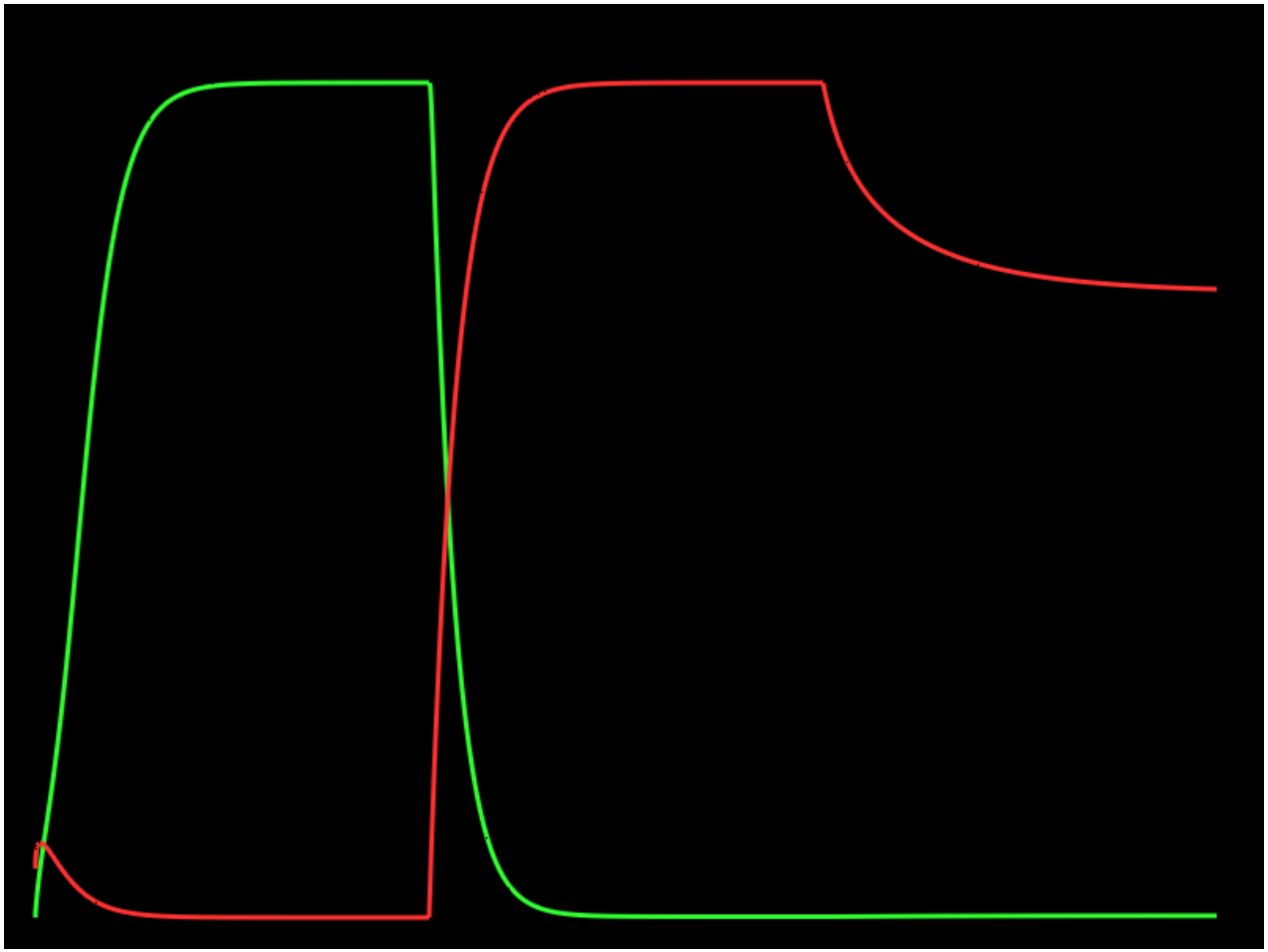
Bistable Switch

```
//Euler steps
for(float t=m_time_start; t<=m_time_end; t+=m_step_size)
{
      //get derivative
      float deriv_u,deriv_v;
      get_deriv(m_curr_u, m_curr_v,m_alpha_u, m_alpha_v,m_beta_u, m_beta_v,
                deriv_u, deriv_v)

      //update u and v
      m_curr_u+= m_step_size * deriv_u;
      m_curr_v+= m_step_size * deriv_v;
}

//Derivative
void get_deriv(float curr_u,float curr_v,float alpha_u,float alpha_v,float beta_u,float beta_v,
               float& deriv_u,float& deriv_v)
{
      deriv_u= ( alpha_u / ( 1.0 + pow( curr_v,beta_u ) ) ) - curr_u;
      deriv_v= ( alpha_v / ( 1.0 + pow( curr_u,beta_v ) ) ) - curr_v;
}
```

Problem - Not bistable...



IPTG Switch



IPTG addition IPTG removal

Oscillating expression

```
//Euler steps
for(float t=m_time_start; t<=m_time_end; t+=m_step_size)
{
      //update derivative
      update_deriv();

      //update mRNA and Protein concentrations
      m_curr_mrna_lacI+= m_step_size*m_deriv_mrna_lacI;
      //same for all mRNA/Proteins
}

void update_deriv(void)
{
      m_deriv_mrna_lacI= -m_curr_mrna_lacI+(m_alpha/( 1 + pow(m_curr_prot_cl,m_hill_coef) ) ) + m_alpha_0;
      m_deriv_mrna_tetR= -m_curr_mrna_tetR+(m_alpha/( 1 + pow(m_curr_prot_lacI,m_hill_coef) ) ) + m_alpha_0;
      m_deriv_mrna_cl= -m_curr_mrna_cl+ ( m_alpha/( 1 + pow(m_curr_prot_tetR,m_hill_coef) ) ) + m_alpha_0;
      m_deriv_prot_lacI= -m_beta * ( m_curr_prot_lacI - m_curr_mrna_lacI );
      m_deriv_prot_tetR= -m_beta * ( m_curr_prot_tetR - m_curr_mrna_tetR );
      m_deriv_prot_cl= -m_beta * ( m_curr_prot_cl - m_curr_mrna_cl );
}
```

Oscillating expression

```
//Starting conditions

float m_start_time=0.0;
float m_end_time=200.0;
float m_step_size=0.01;

float m_alpha=10.1;
float m_alpha_0=0.1;
float m_hill_coef=1.8;
float m_beta=1.1;

float m_mrna_lacI=0.0;
float m_mrna_tetR=0.0;
float m_mrna_cl=1.0;

float m_prot_lacI=0.0;
float m_prot_tetR=0.0; //reporter
float m_prot_cl=1.0;
```

Oscillating expression