

# Positive Feedback and Bistability

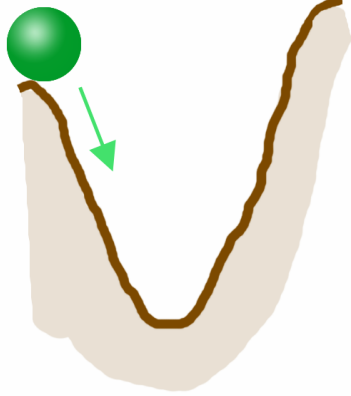
1-23-09

Systems and Synthetic Biology

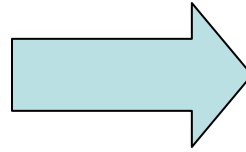
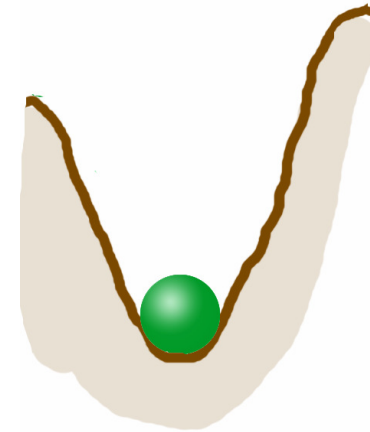
BIOE 498A

# Stable state

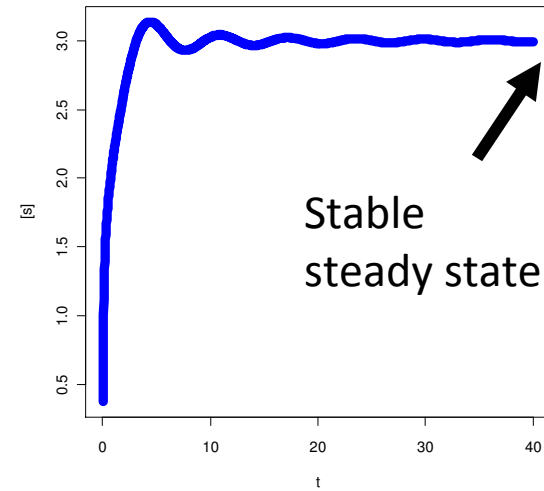
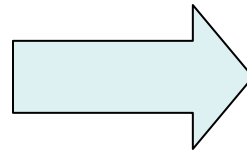
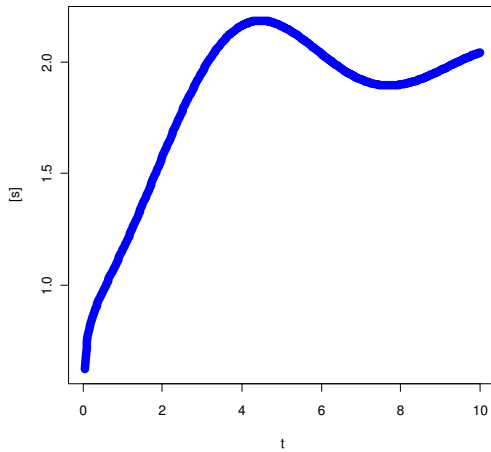
Transient state



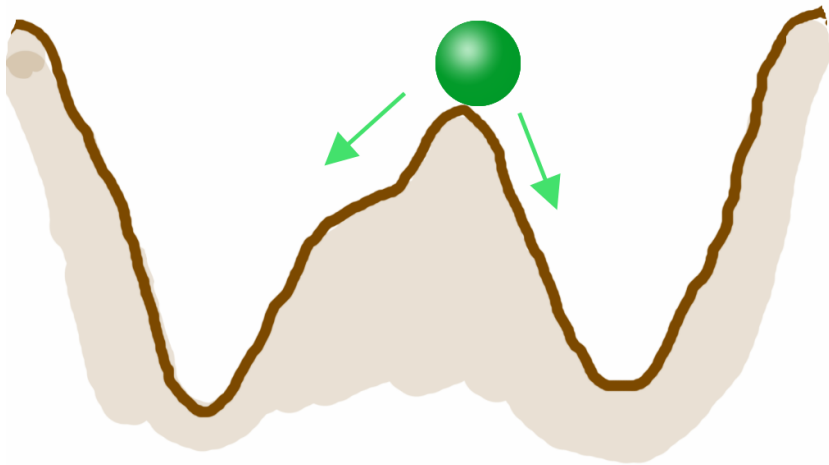
Stable state



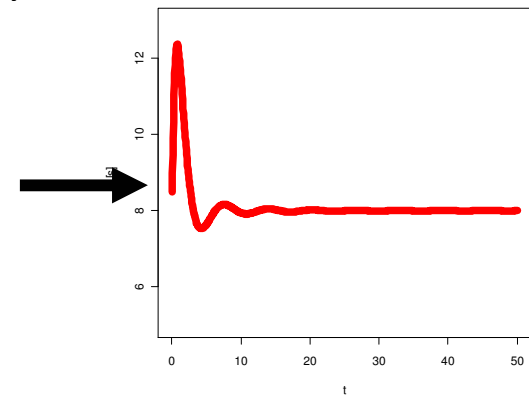
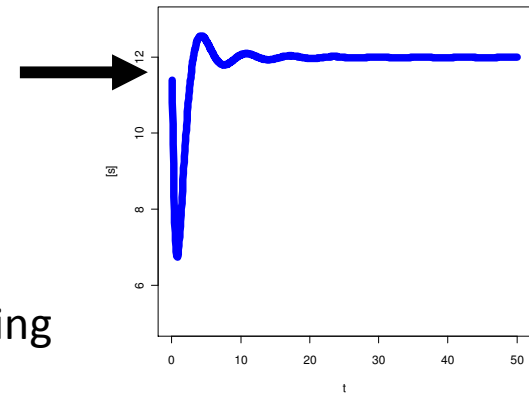
Simulation of biochemical network



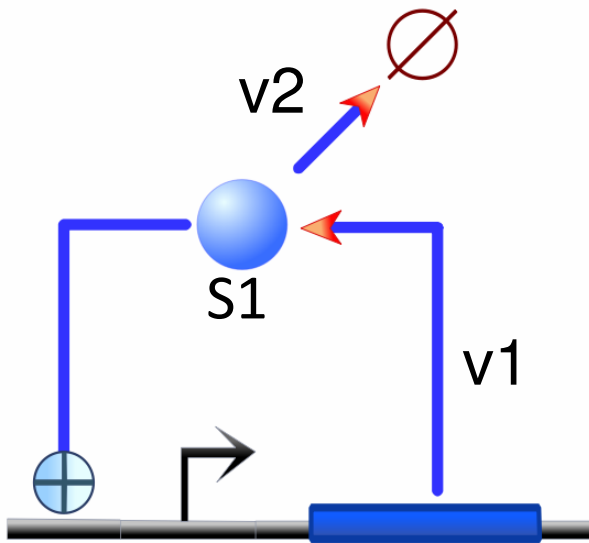
# Multiple stable states



Different starting points lead to different steady states



# Positive Feedback



$$v1 = ?$$

$$v2 = ?$$

$$dS1/dt = ?$$

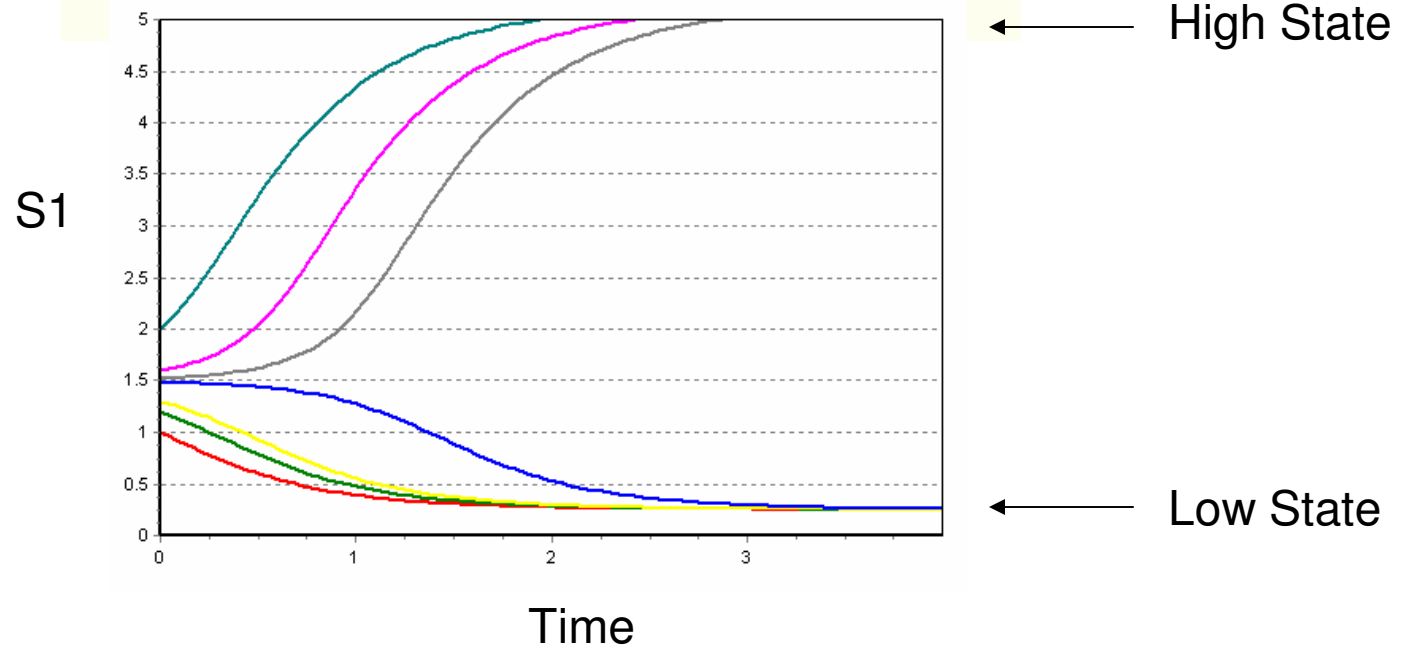
# Positive Feedback



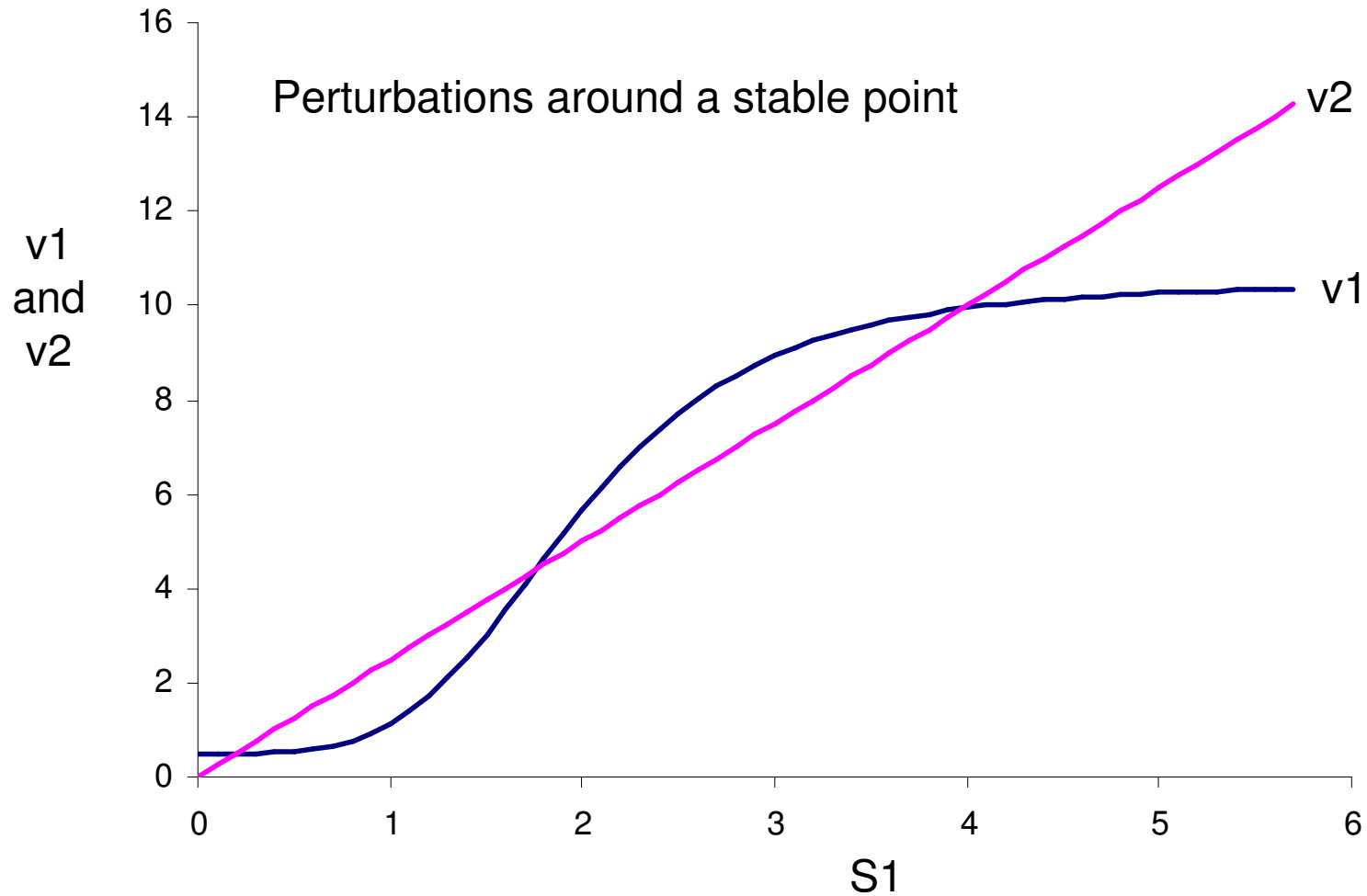
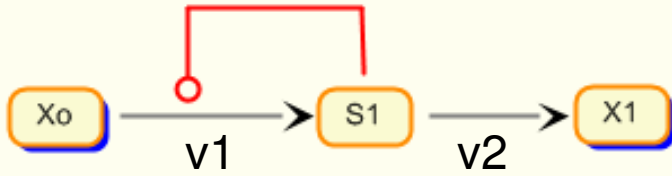
```
p = defn cell
  $Xo -> S1; 0.5 + Vmax*S1^n/(15 + S1^n);
  S1 -> $X1; k1*S1;
end;
```

```
p.Xo = 1;
p.X1 = 0;
p.S1 = 1;
p.n = 4;
p.Vmax = 10;
p.k1 = 2;
```

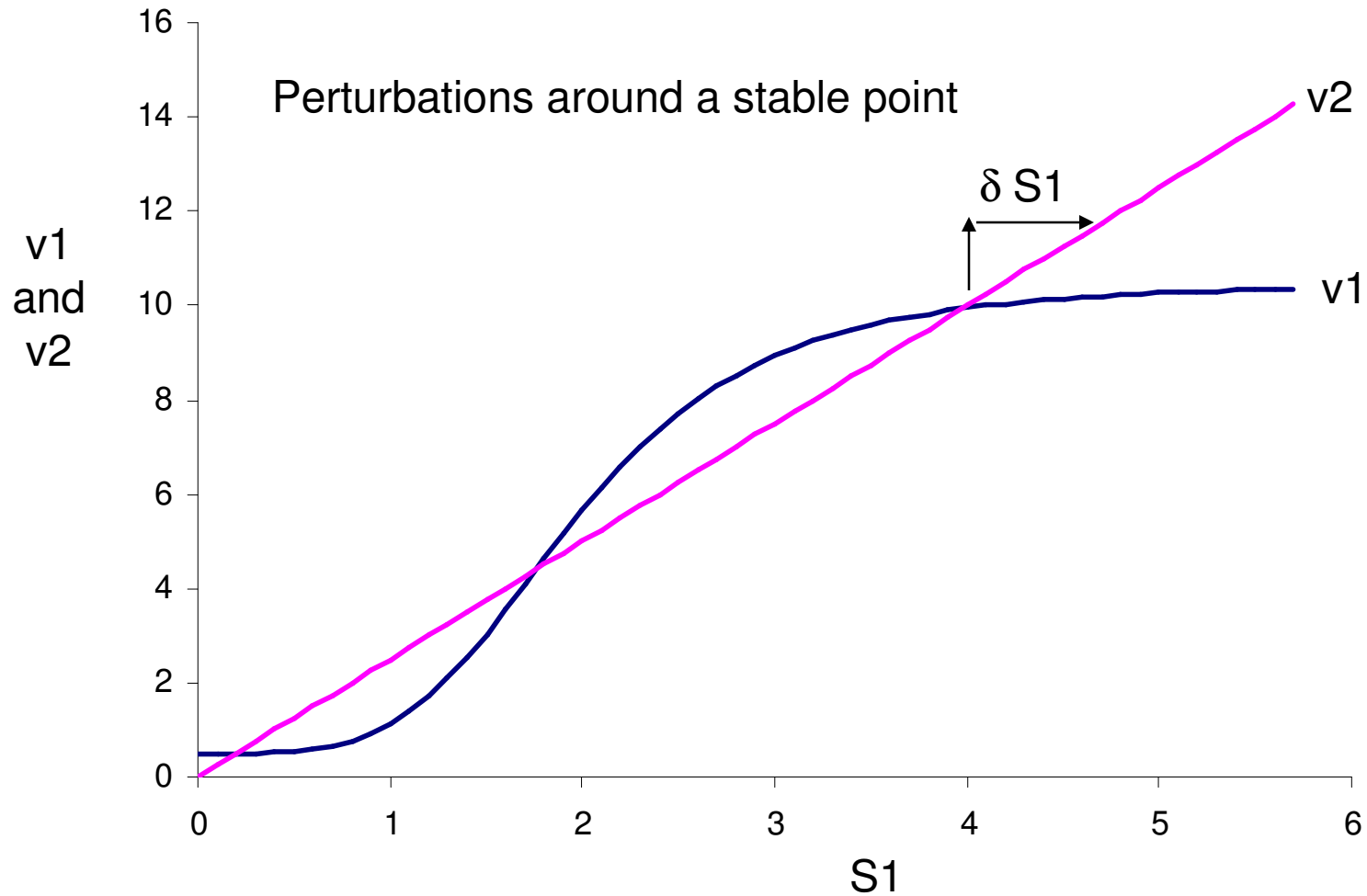
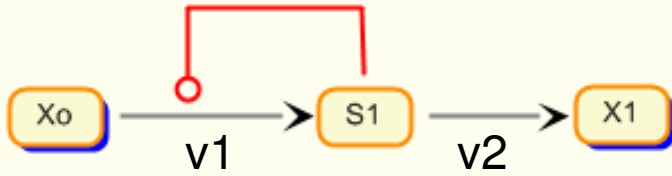
# Positive Feedback



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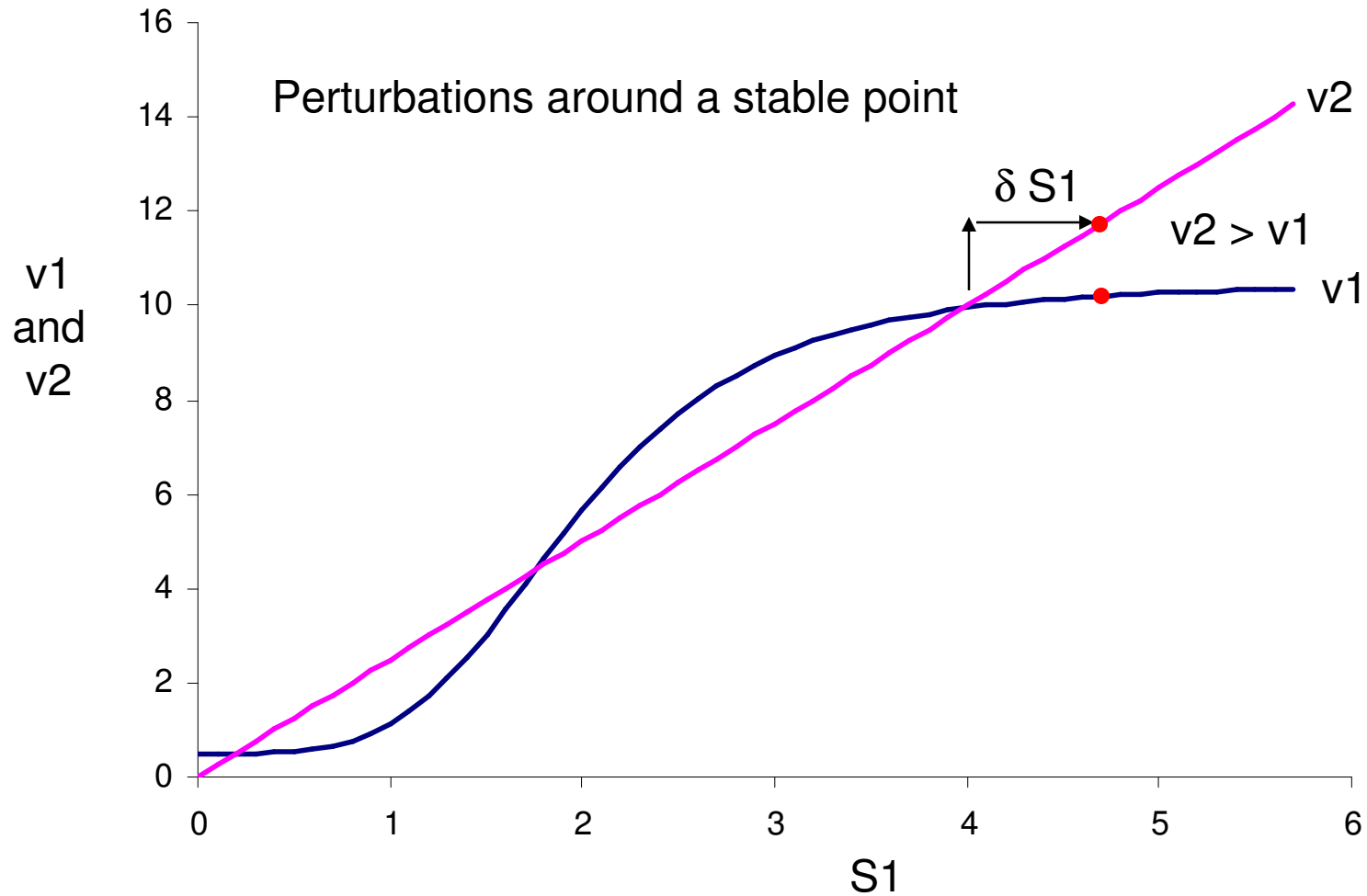
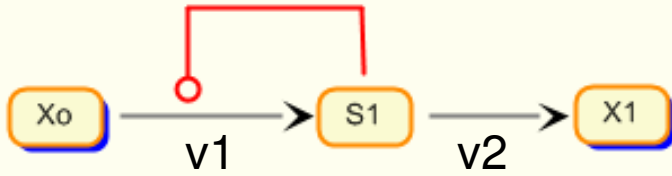


# Positive Feedback

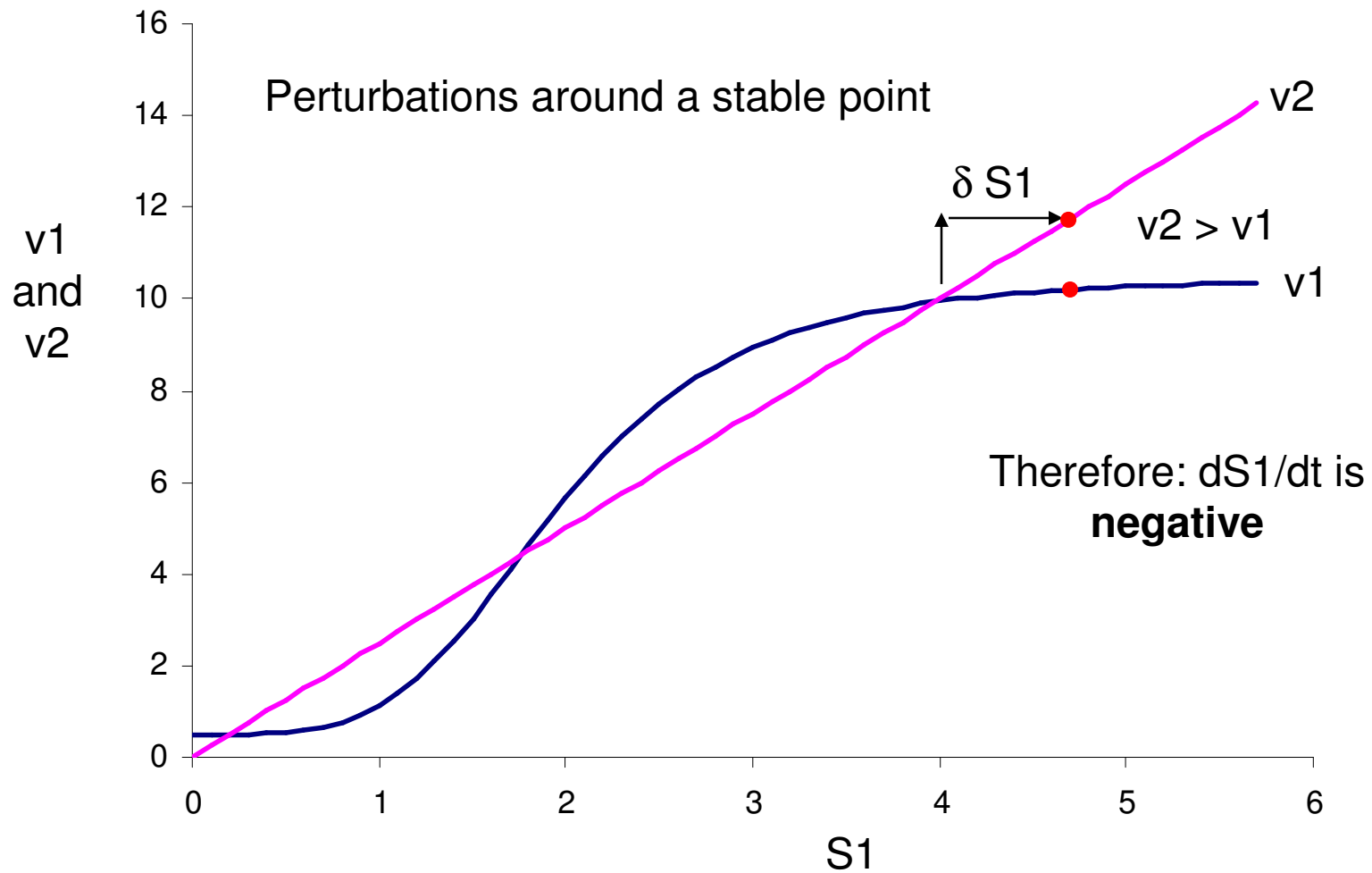
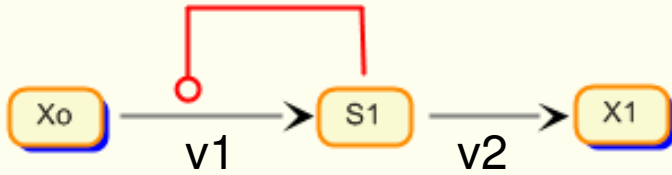




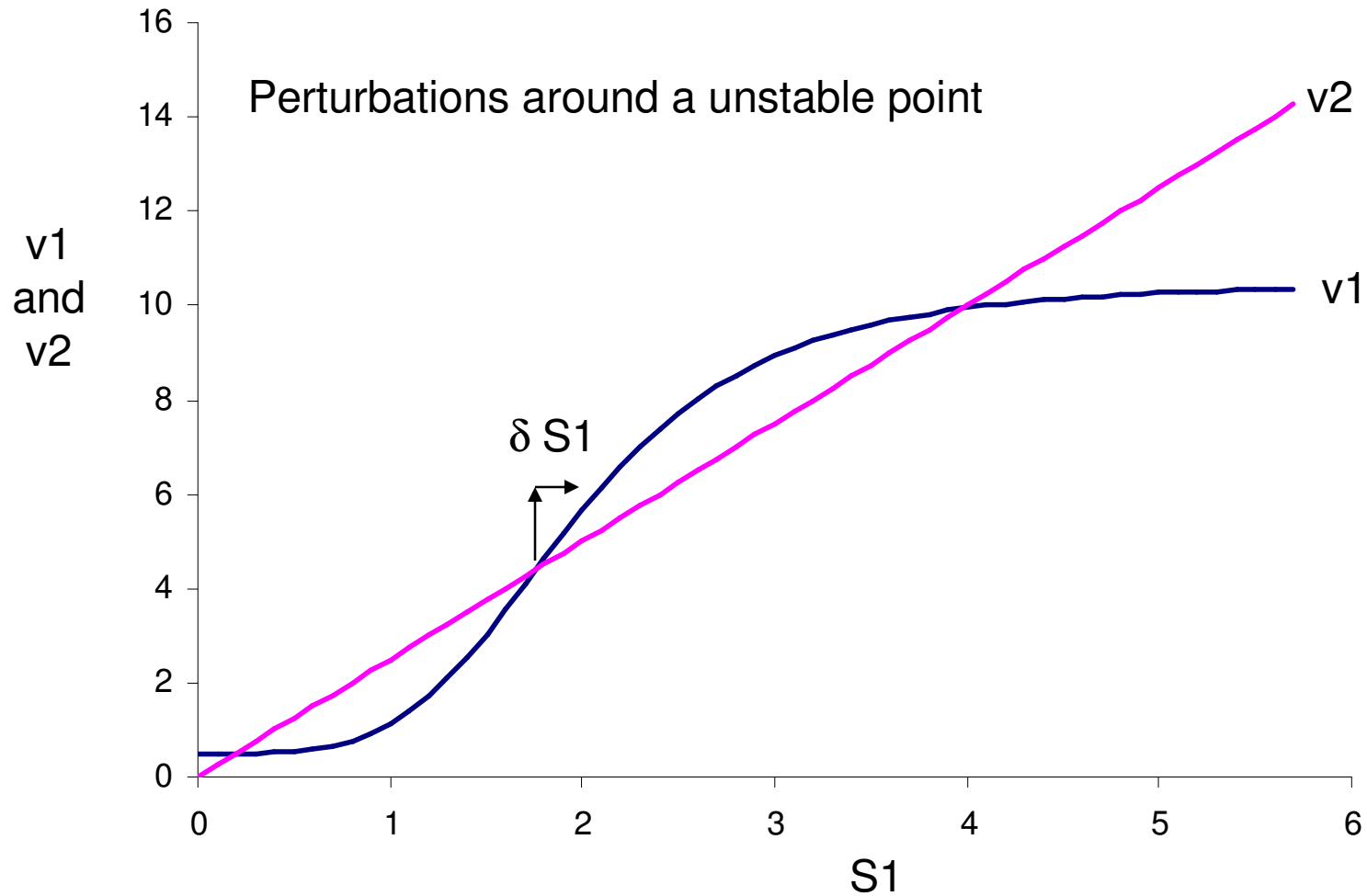
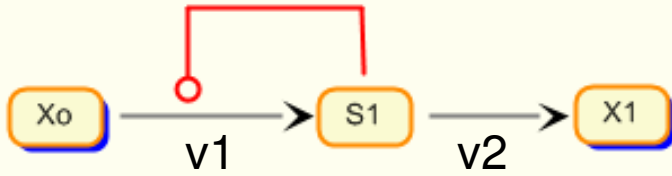
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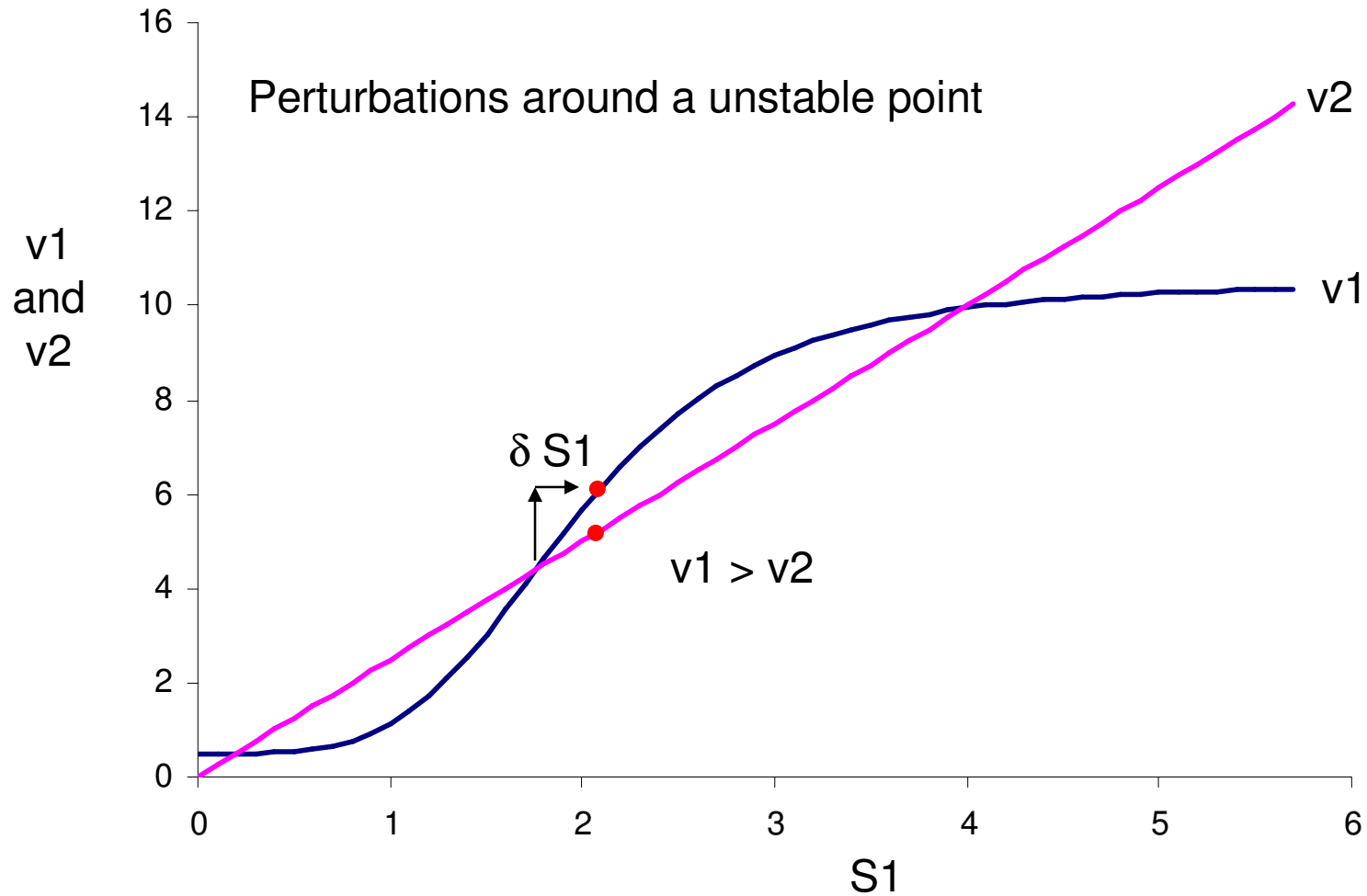
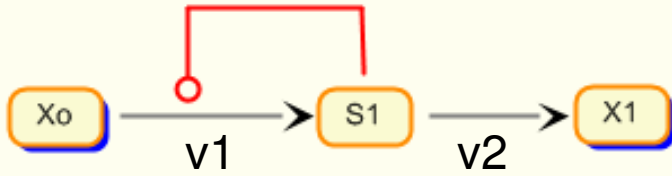
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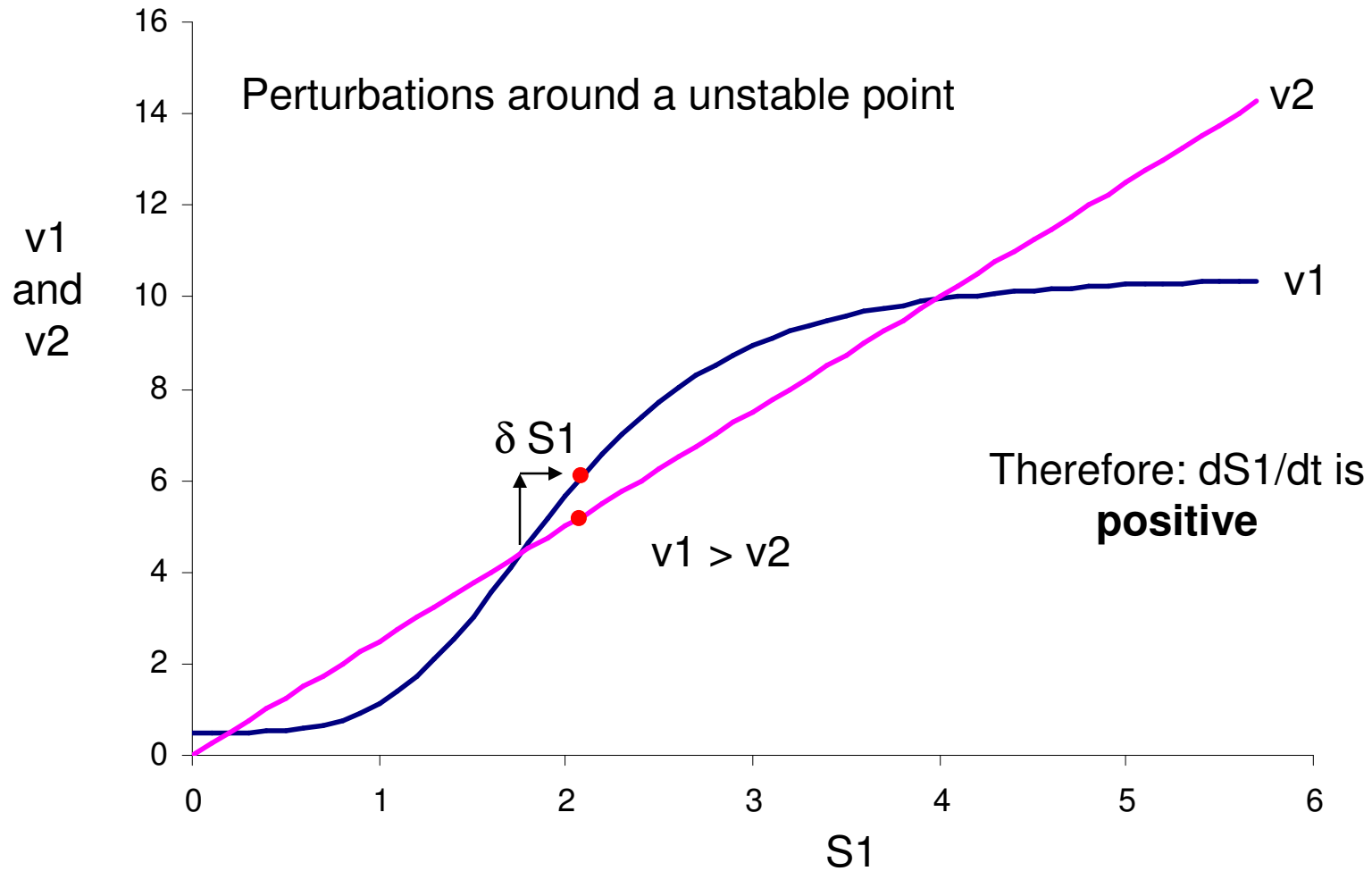
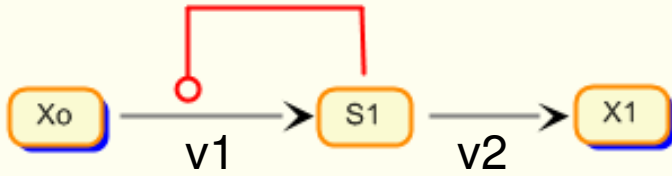
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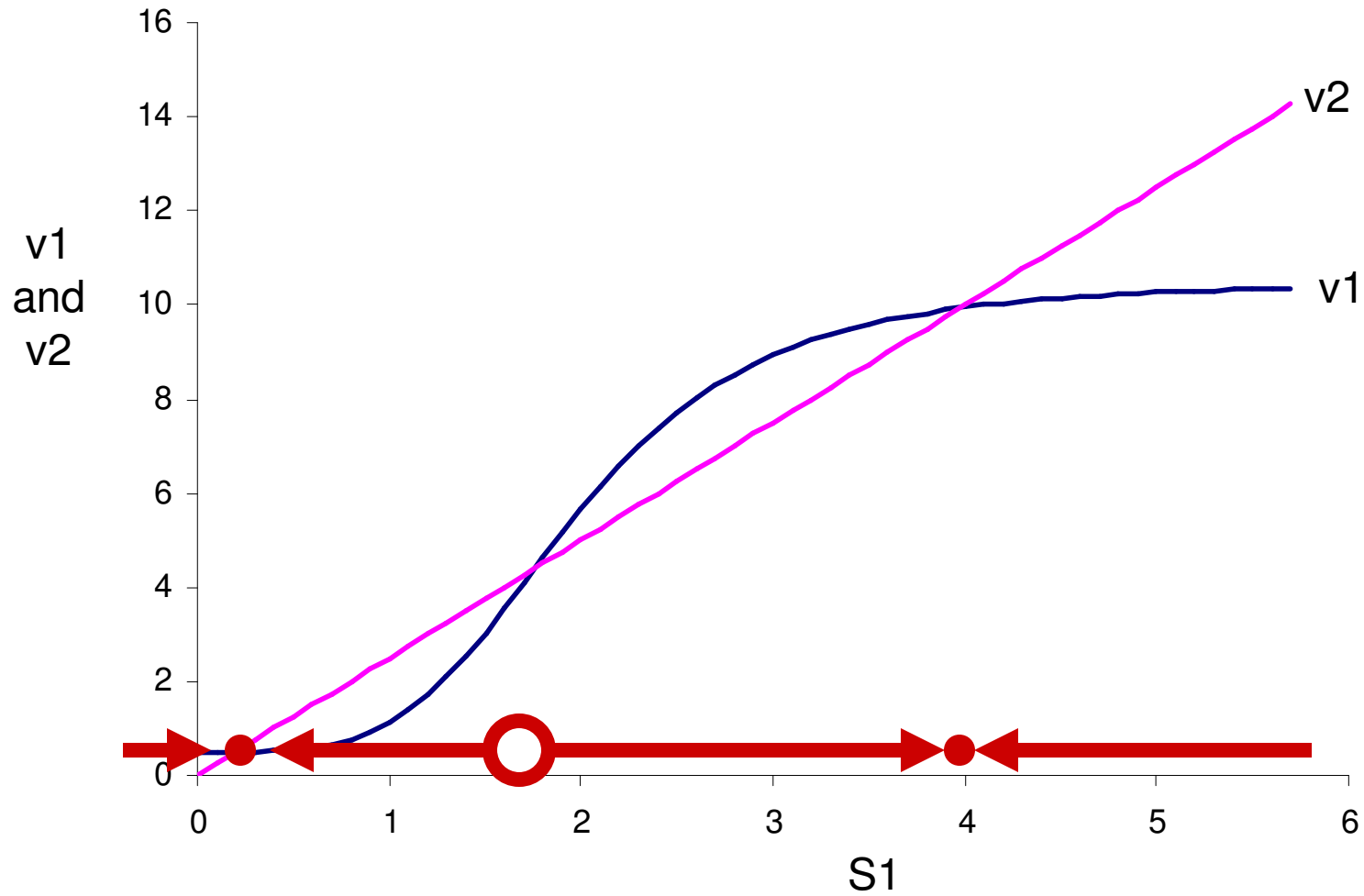
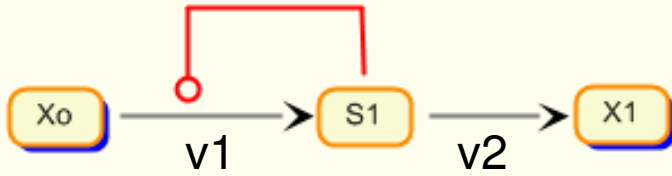
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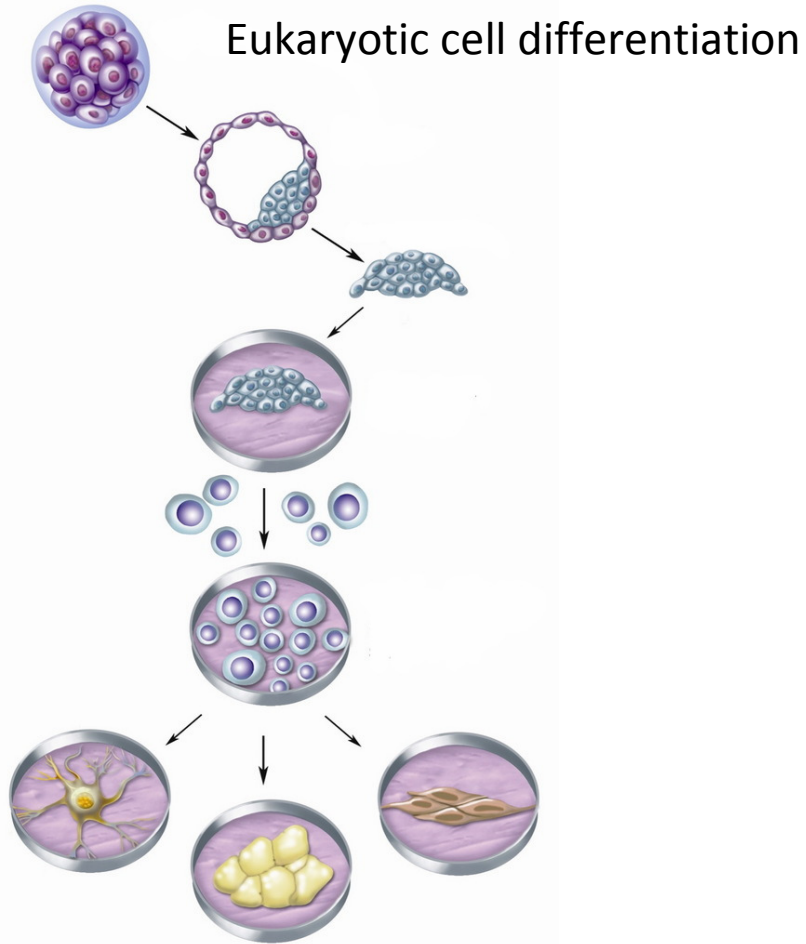
# Positive Feedback



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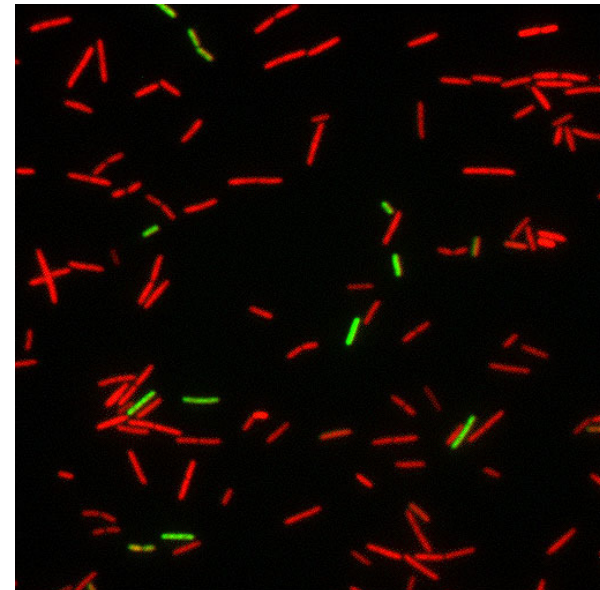


# Where in nature do we find multiple steady states?



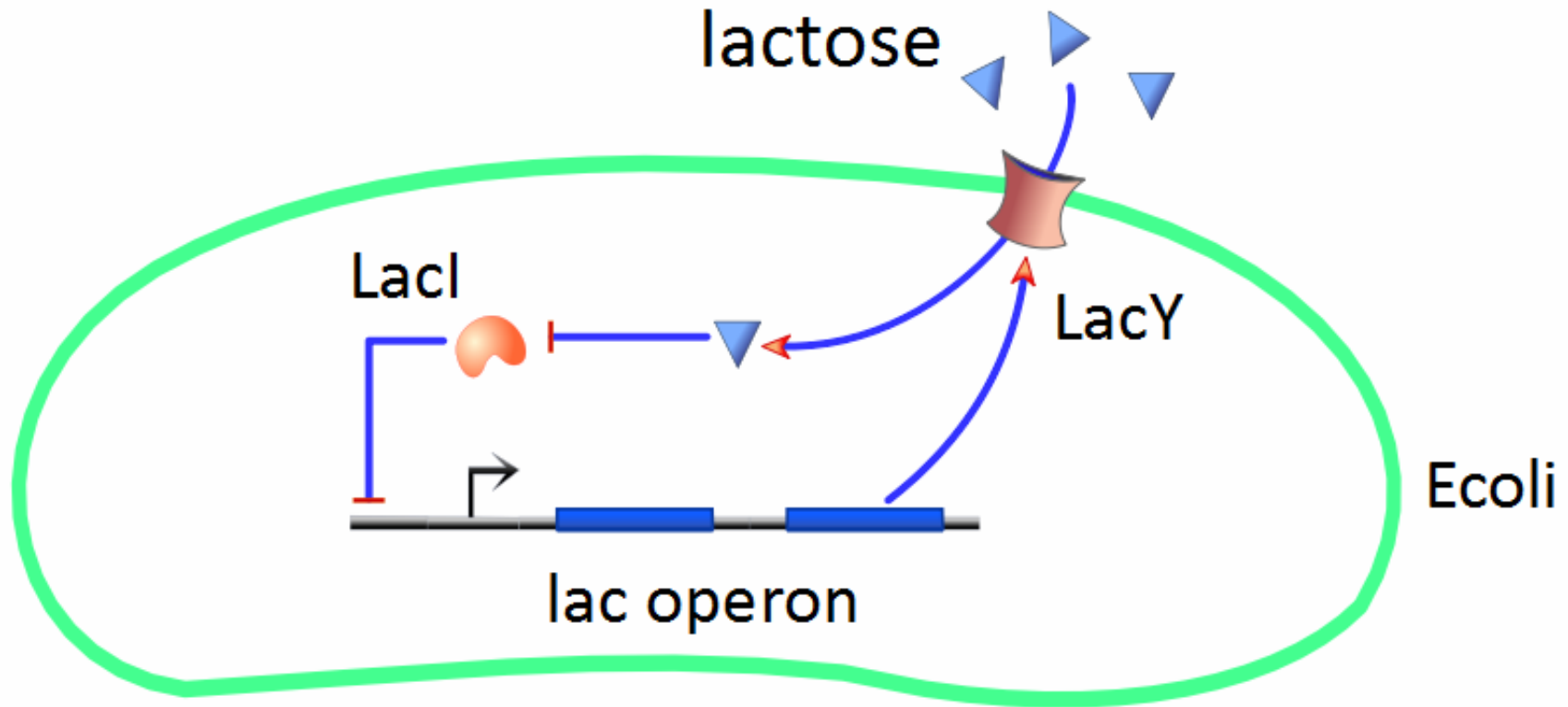
<http://weirdscience.ca/2007/>

Bacterial differentiation and adaptation



[www.phri.org/research/res\\_pidubnau.asp](http://www.phri.org/research/res_pidubnau.asp)

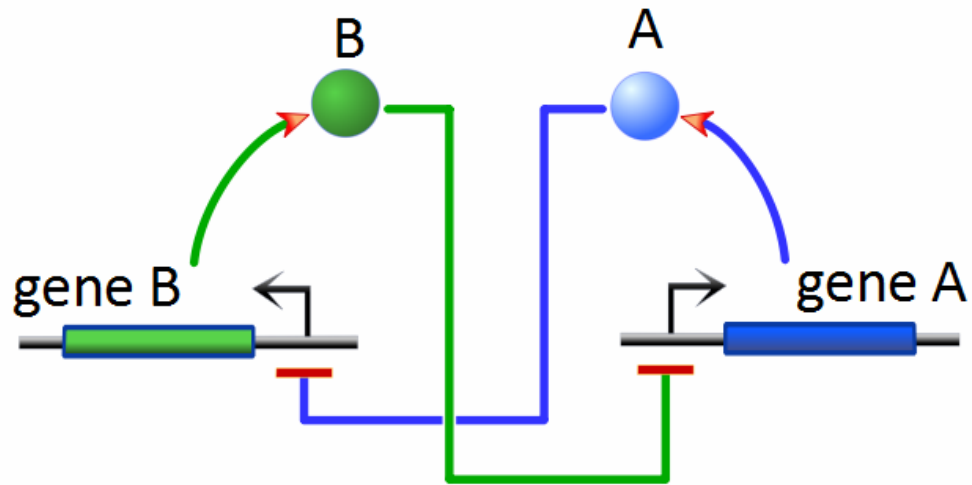
# Bistability of the lac operon



Where is the positive feedback?



# Genetic Toggle Switch



$$dA/dt = ?$$

$$dB/dt = ?$$

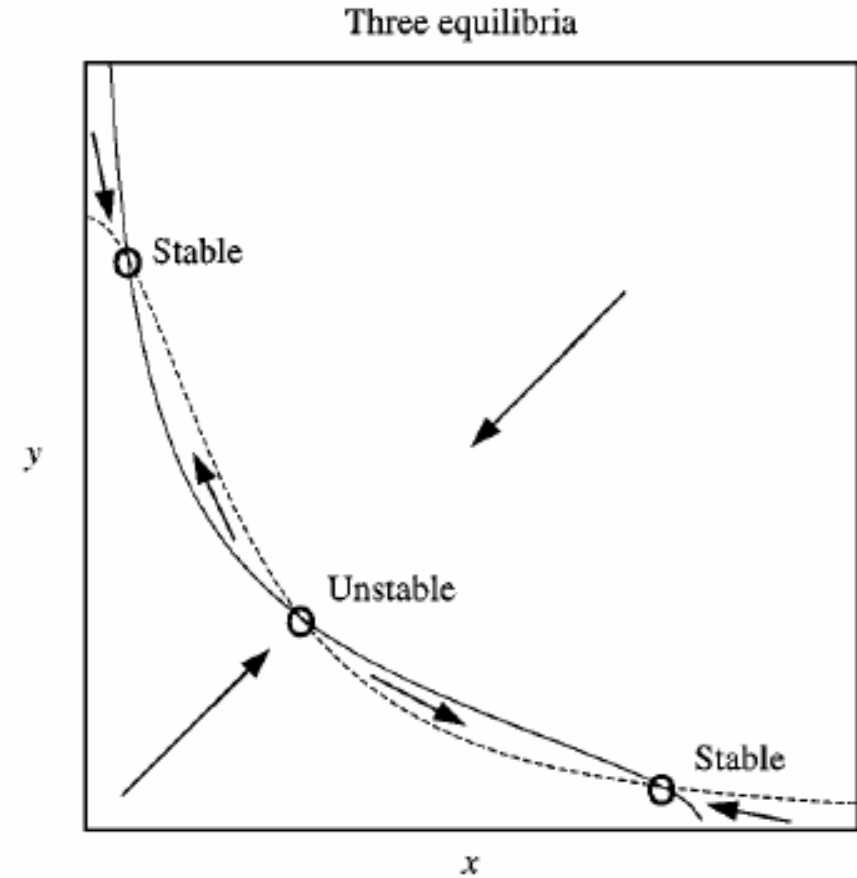
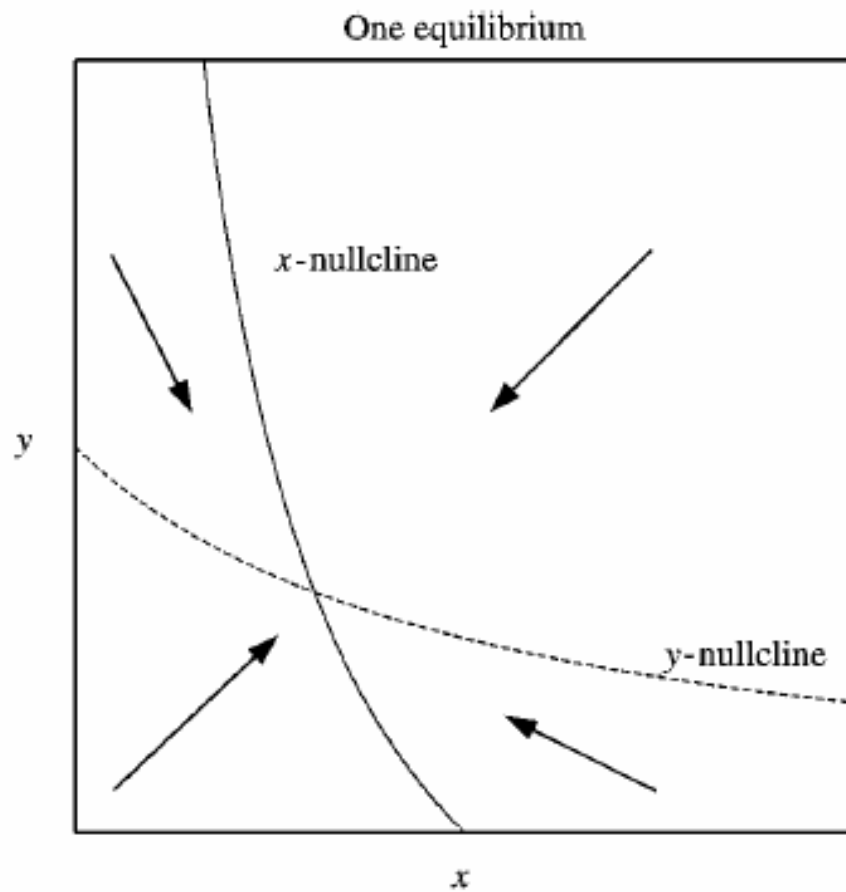
Where is the positive feedback?

Synthetic toggle switch has been built using lacI and tetR repressors.

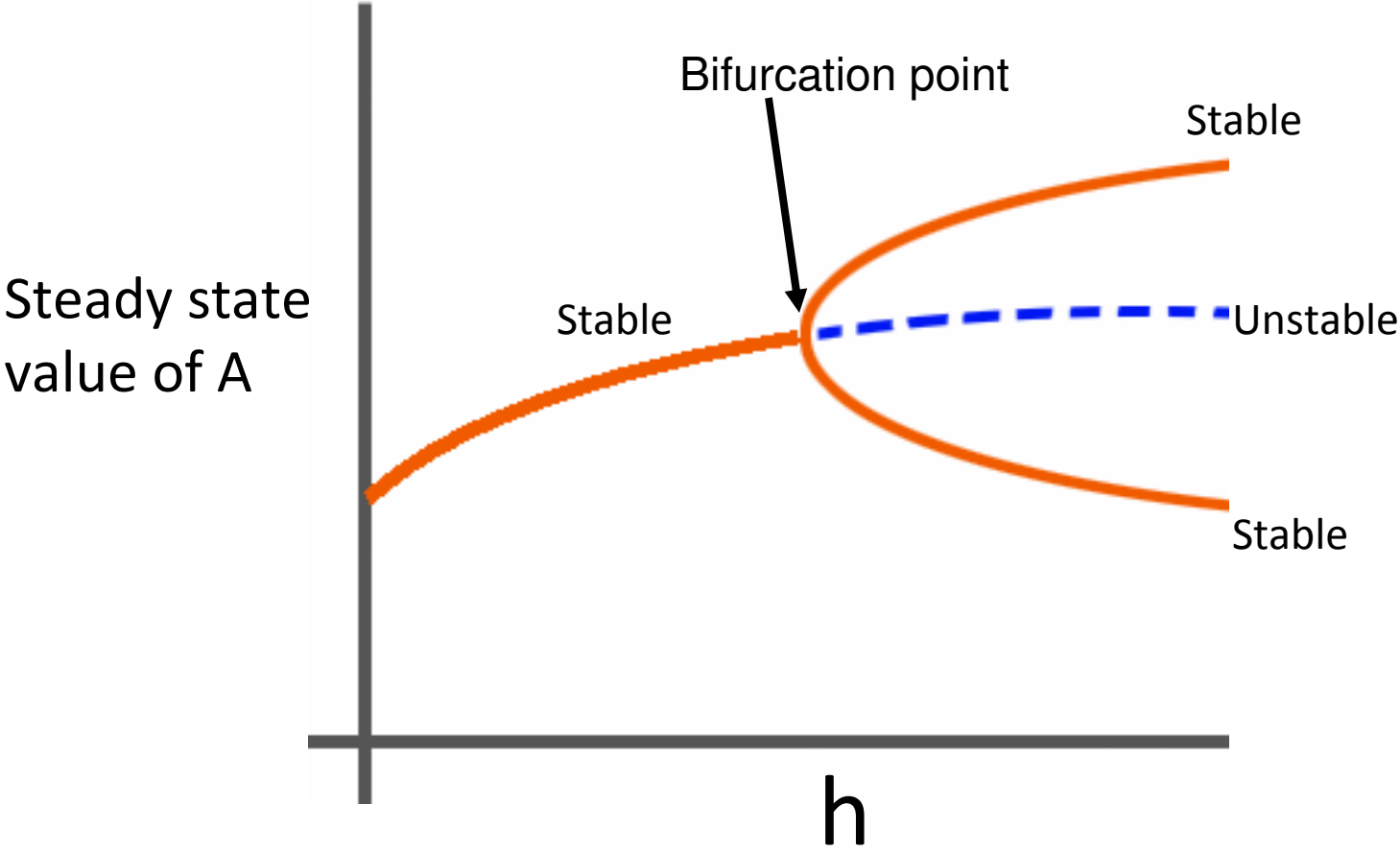
PPlane

<http://math.rice.edu/~dfield/dfpp.html>

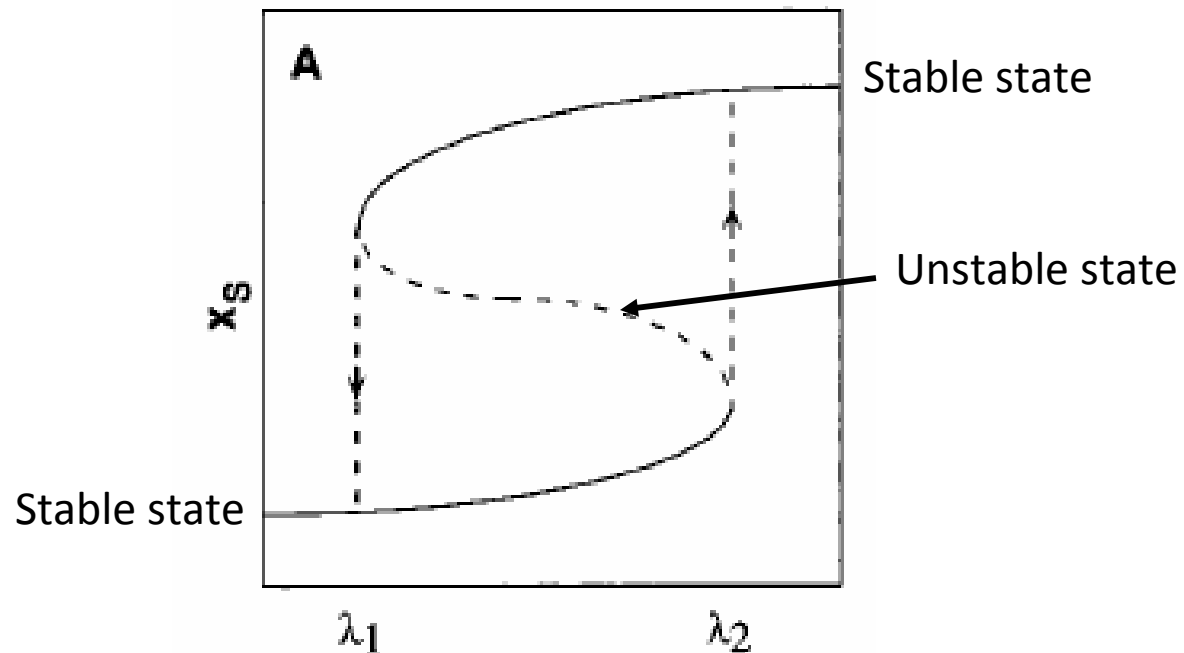
# Stable points



# Bifurcation Diagram



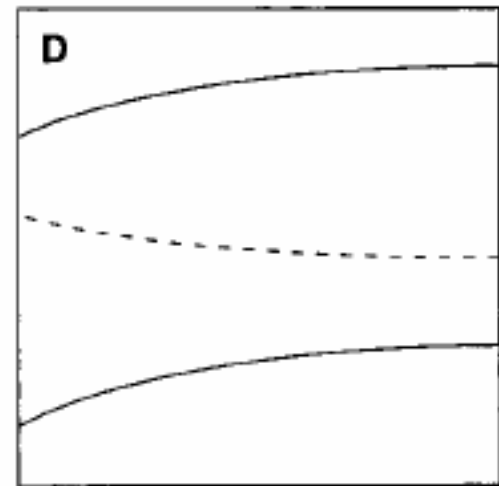
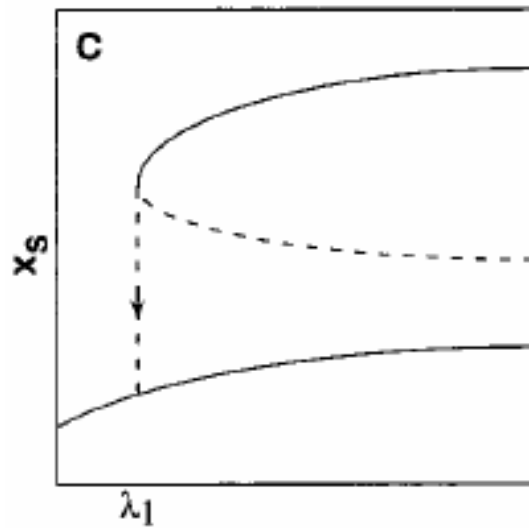
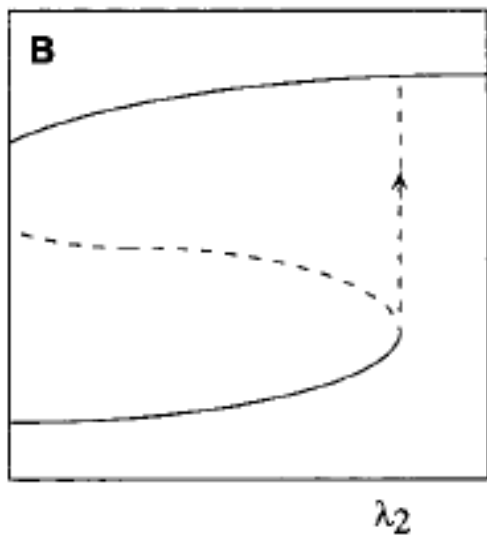
# Bistability with Hysteresis



One of the parameters in the model

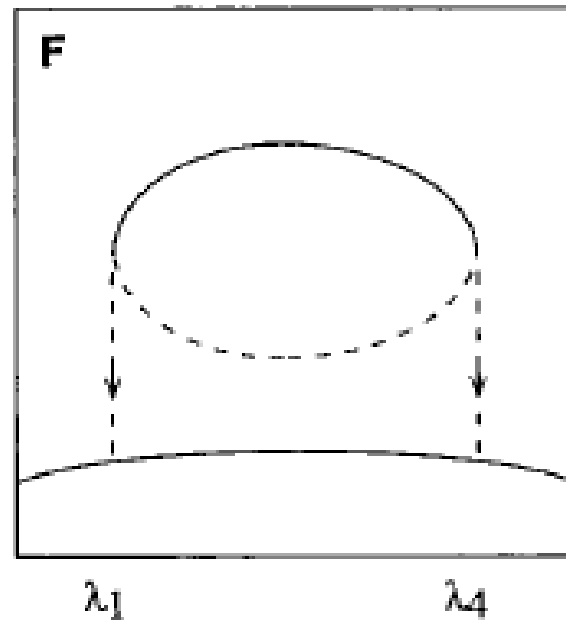
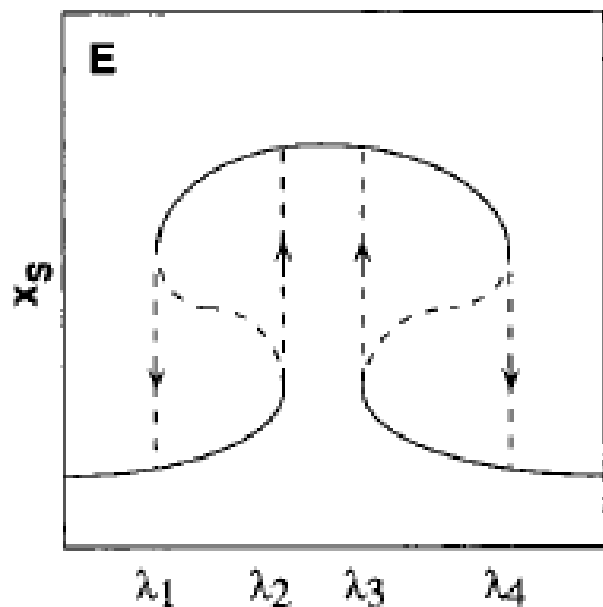
Gianluca M. Guidi, and Albert Goldbeter. Bistability without Histeresis in Chemical Reaction Systems: A Theoretical Analysis of Irreversible Transitions between Multiple Steady States. *Journal of Physical Chemistry* (1997), 101 (49).

# Bistability with Irreversibility



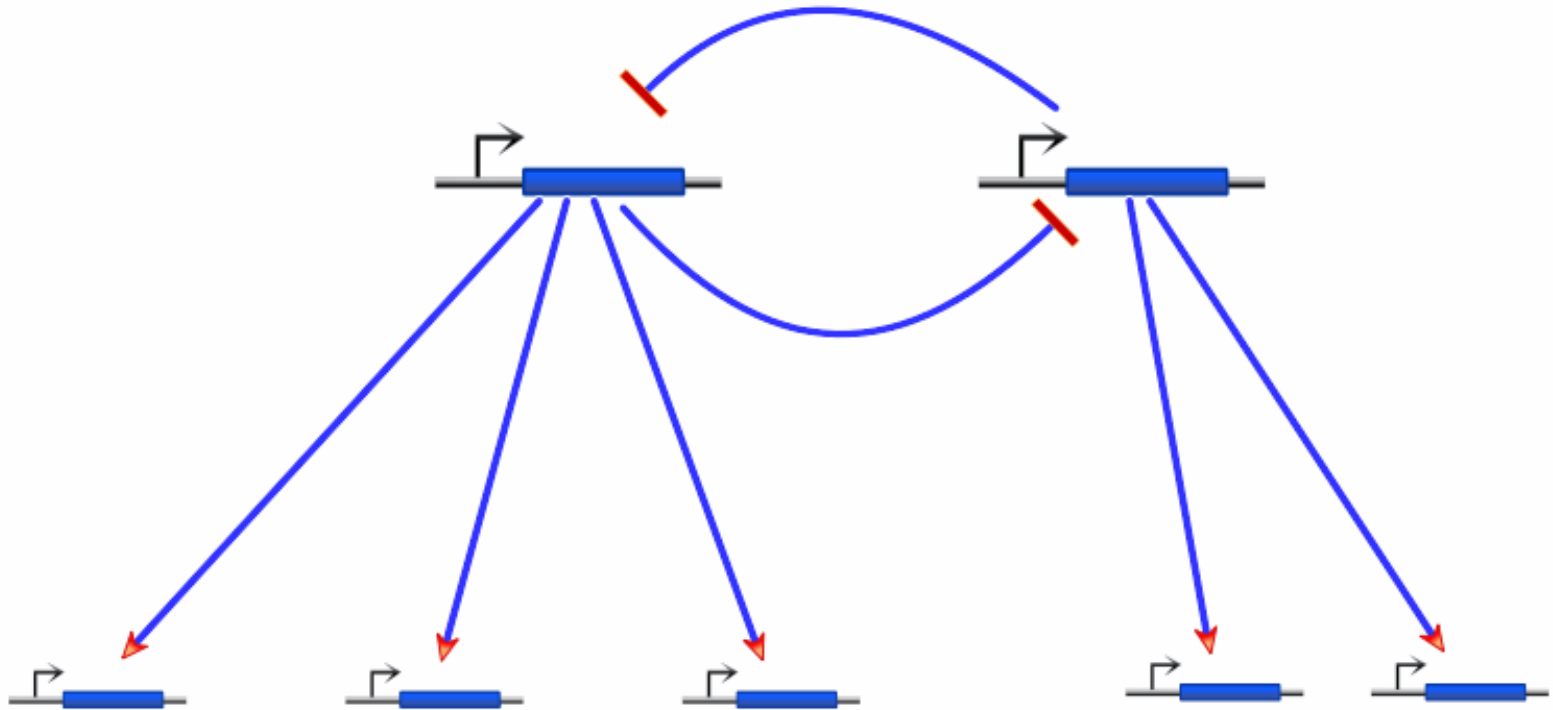
Gianluca M. Guidi, and Albert Goldbeter. Bistability without Hysteresis in Chemical Reaction Systems: A Theoretical Analysis of Irreversible Transitions between Multiple Steady States. *Journal of Physical Chemistry* (1997), 101 (49).

# More Hysteresis and Irreversibility



Gianluca M. Guidi, and Albert Goldbeter. Bistability without Histeresis in Chemical Reaction Systems: A Theoretical Analysis of Irreversible Transitions between Multiple Steady States. *Journal of Physical Chemistry* (1997), 101 (49).

# Network structures involving toggle switches



Can you guess where this is useful?