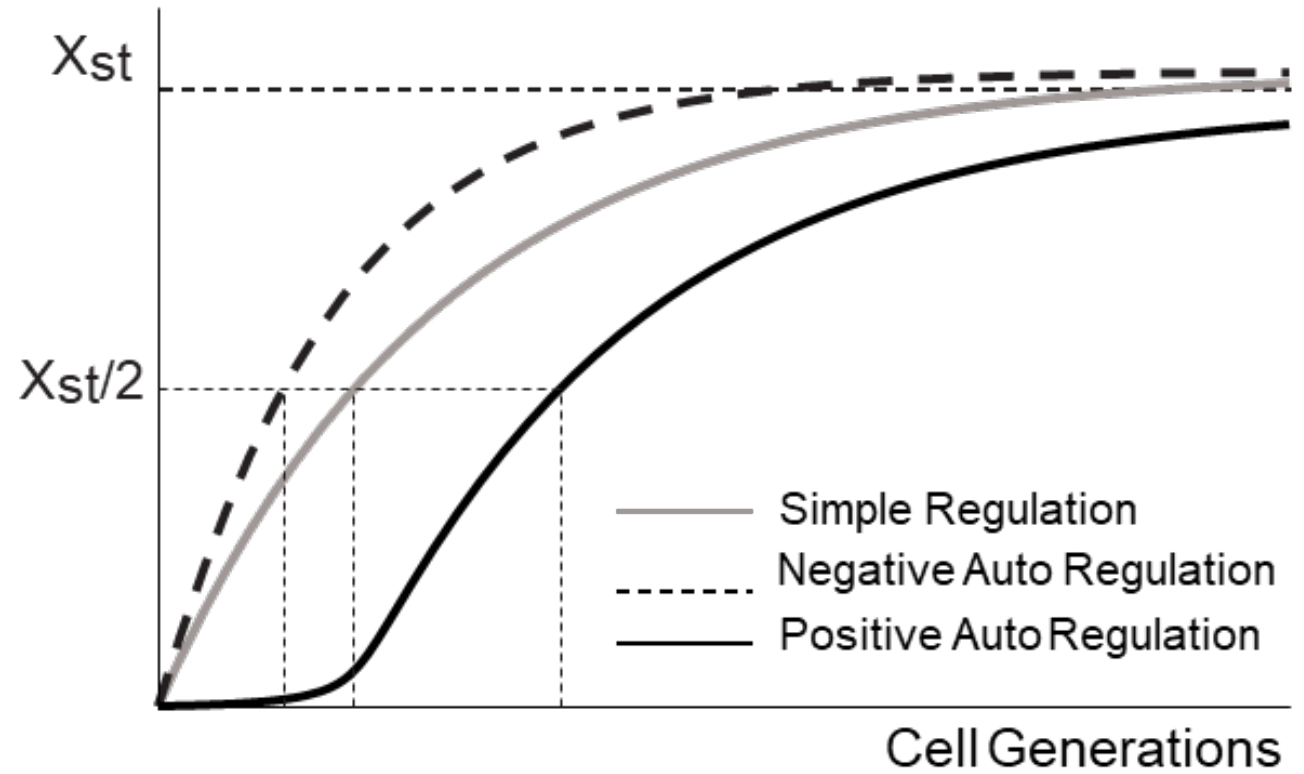
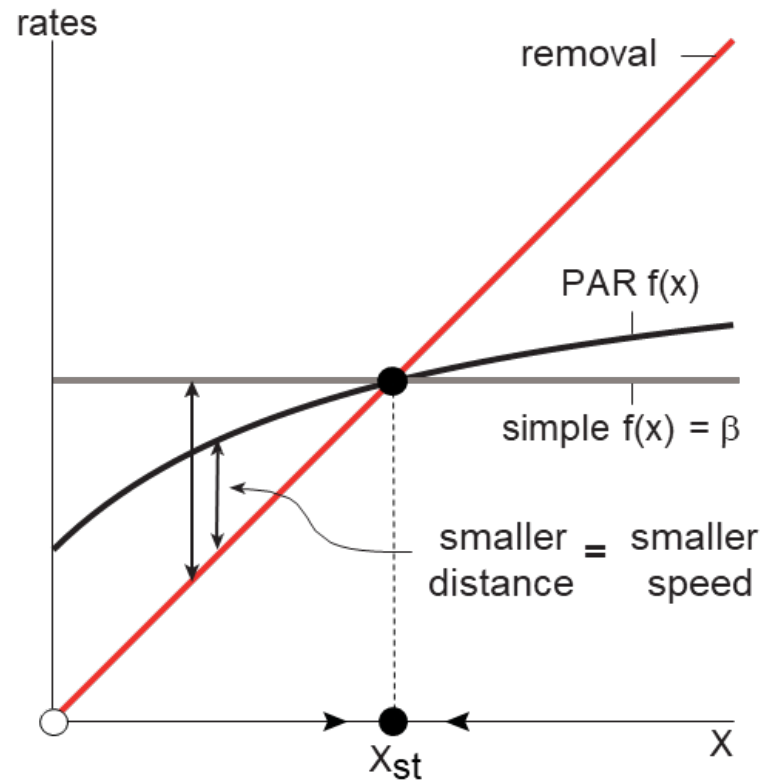
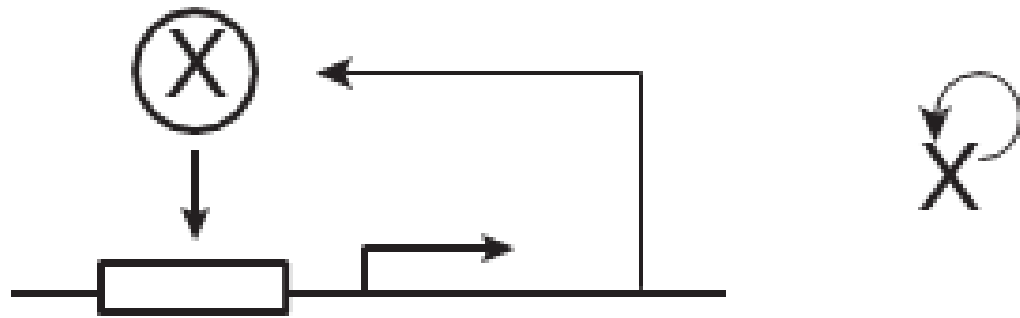
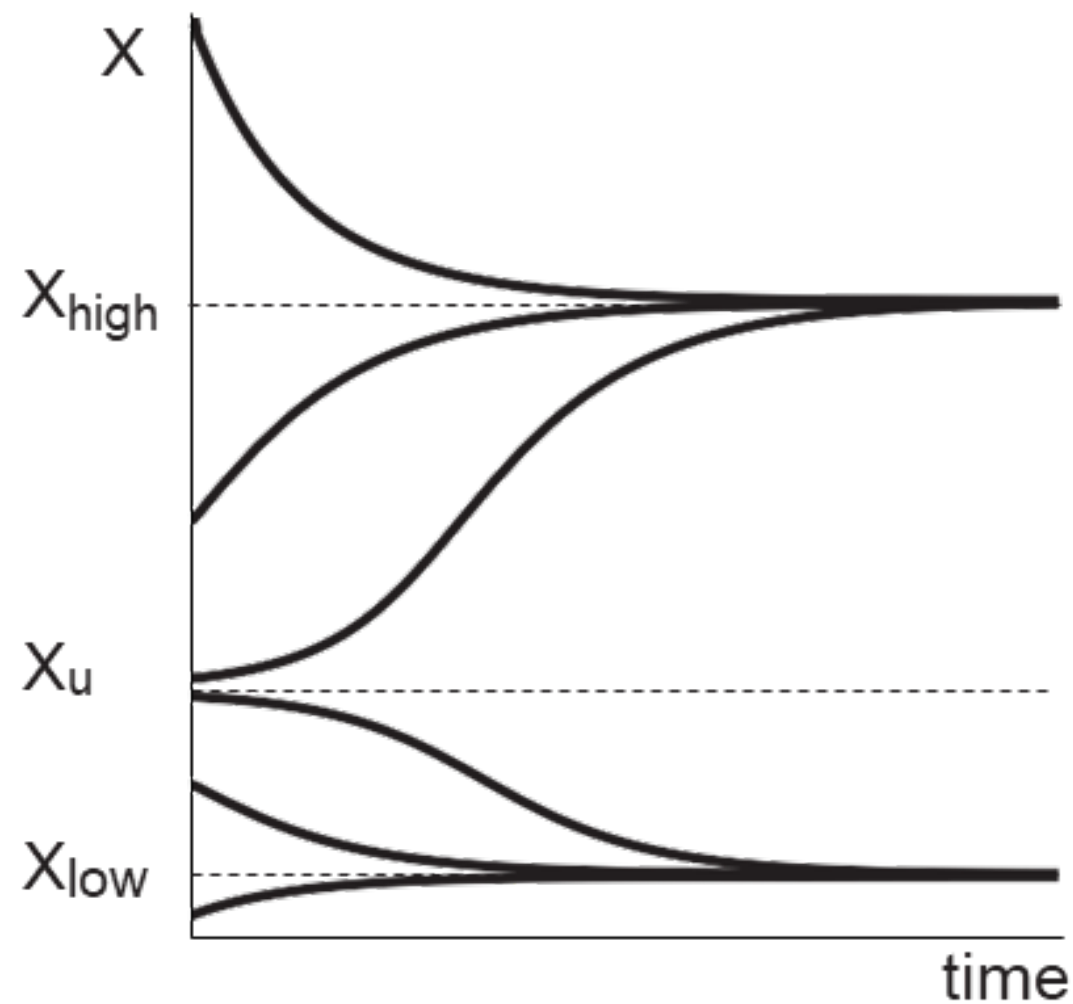
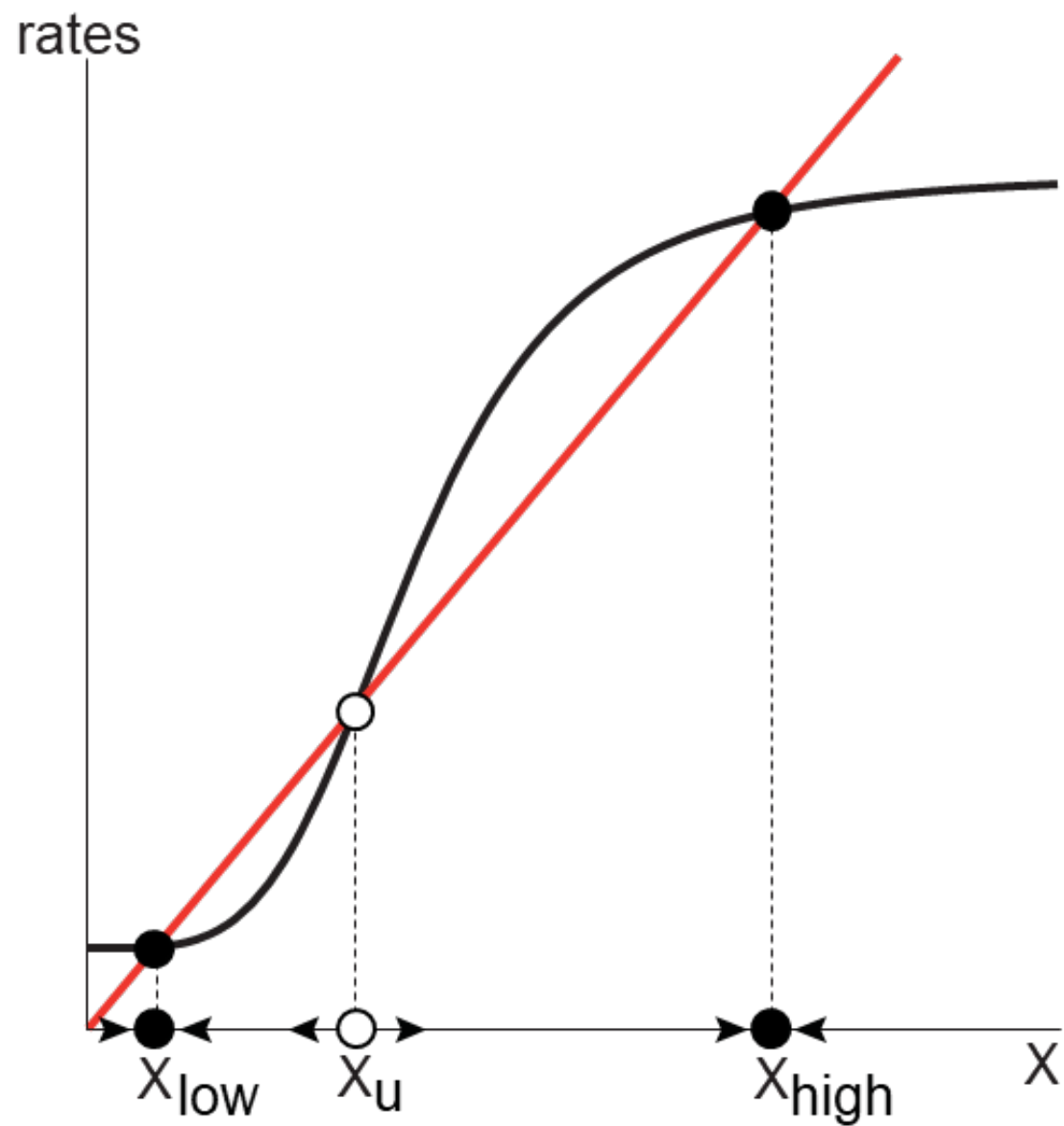


Bistability, Memory and oscillations

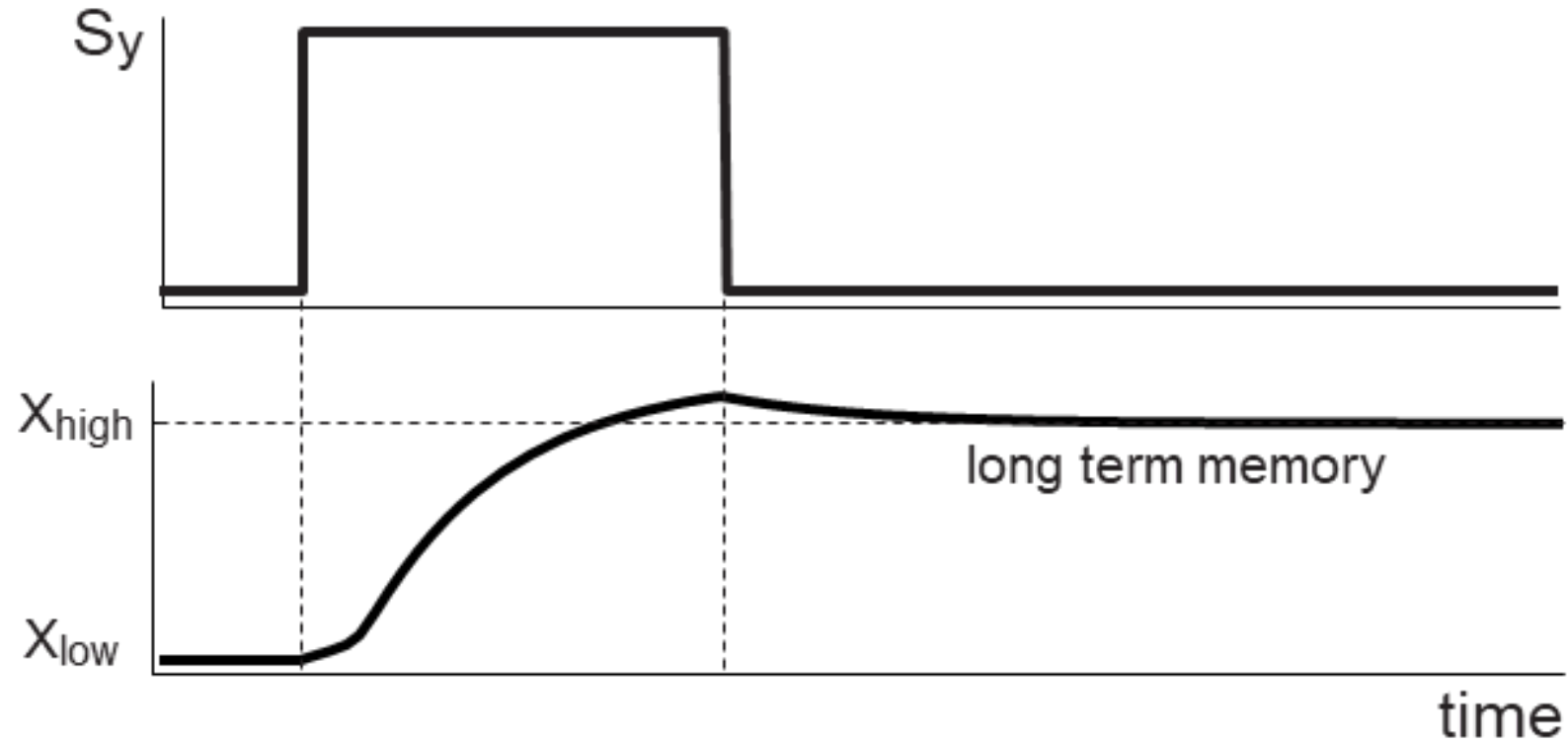
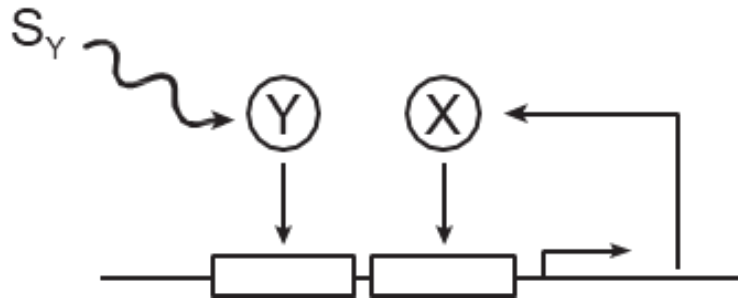
Positive auto-regulation (PAR)



PAR can lead to bistability



This can induce memory!



Double positive feedback loop



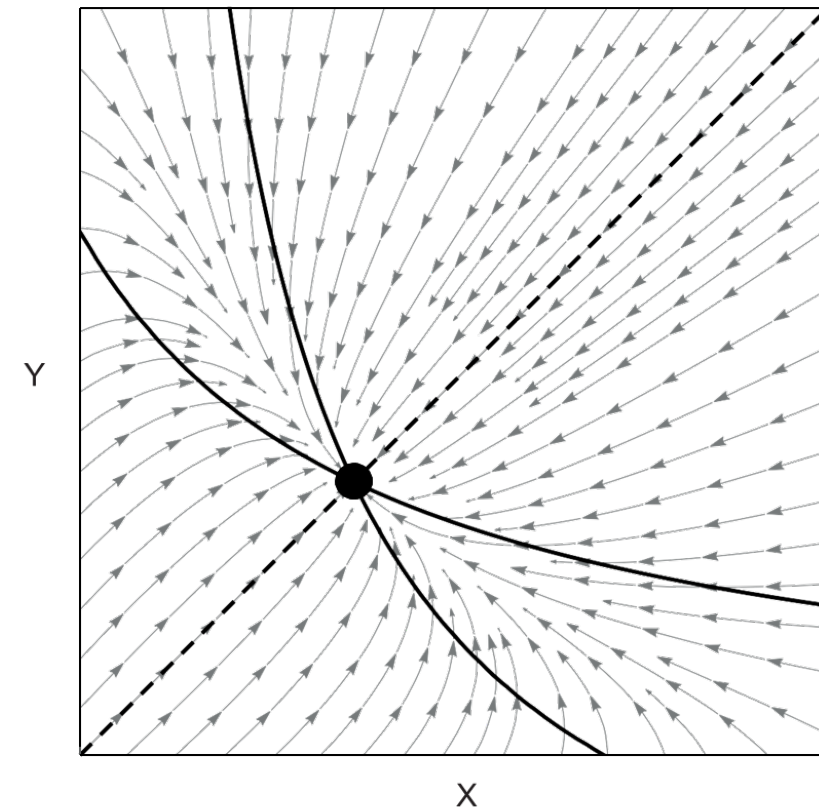
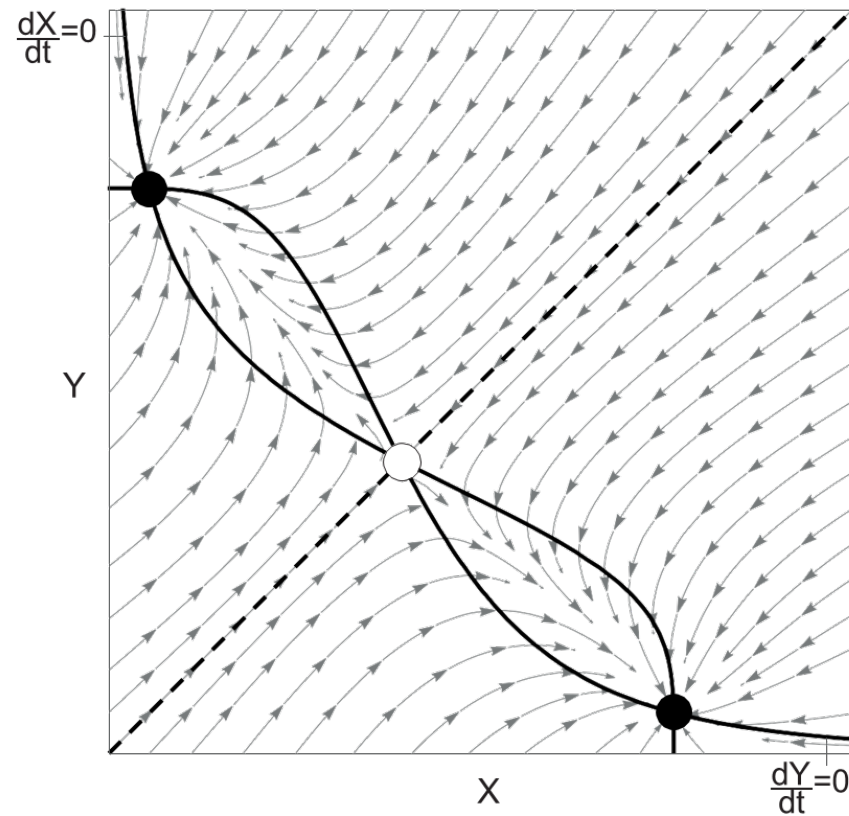
Both ON or OFF

Double negative feedback loop

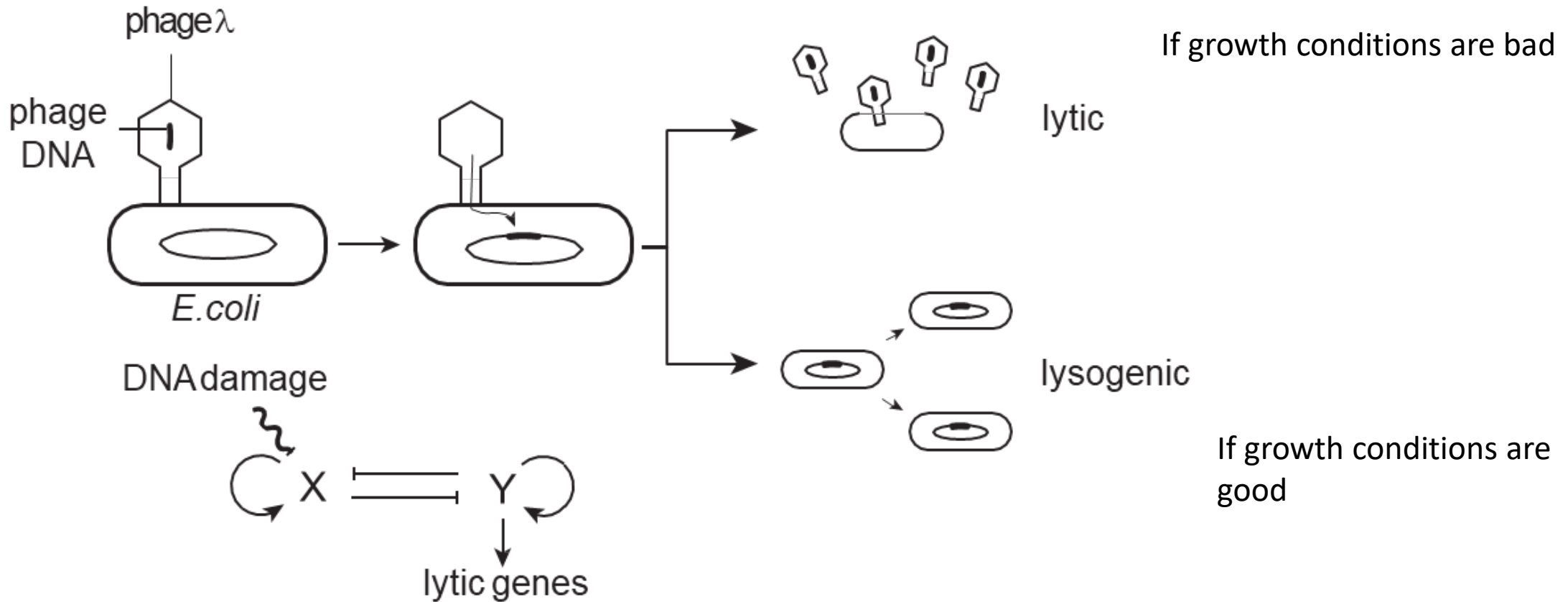


ON and OFF or,
OFF and ON

Toggle Switch



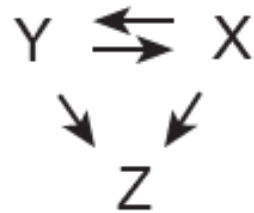
Example switching on of phage in bacteria!



Do we 'contain'
Virus DNA?

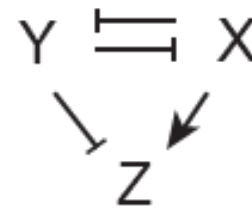
Regulating feedback loops

Double positive
feedback loop

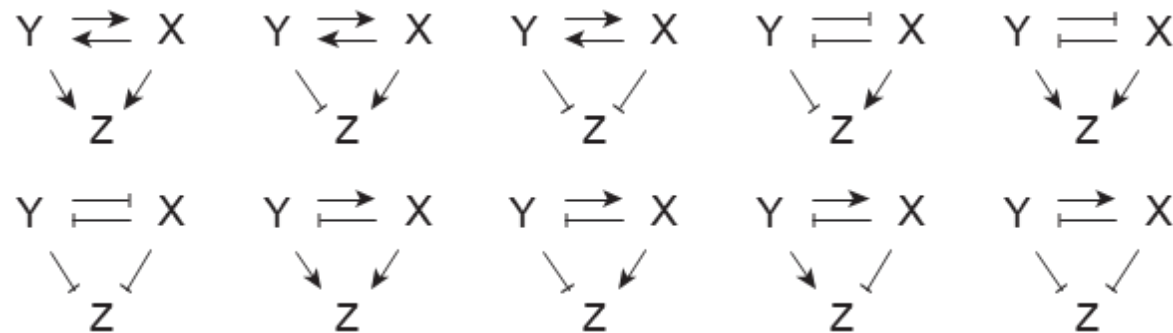


	X	Y	Z
St.St. 1	ON	ON	ON
St.St. 2	OFF	OFF	OFF

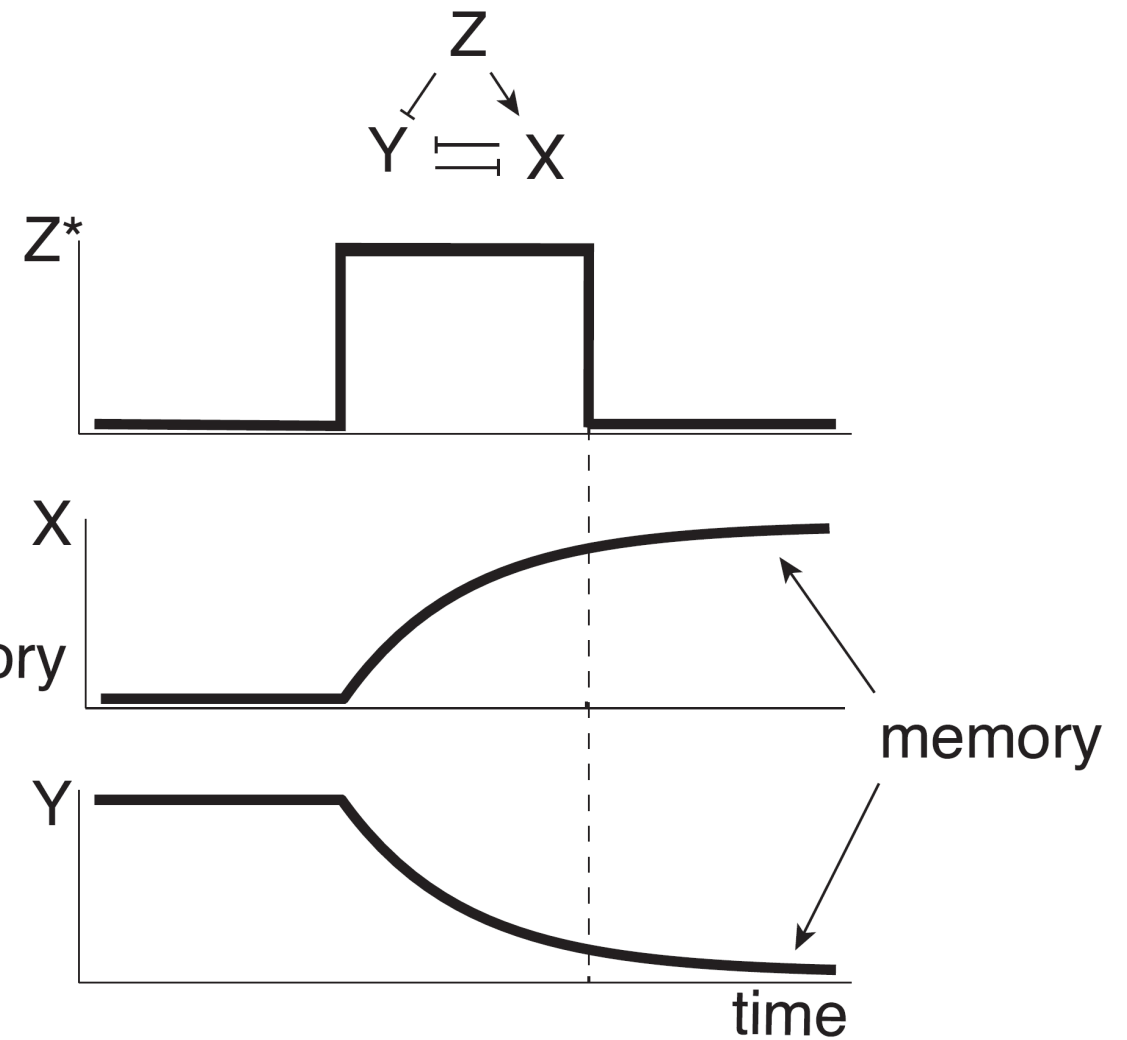
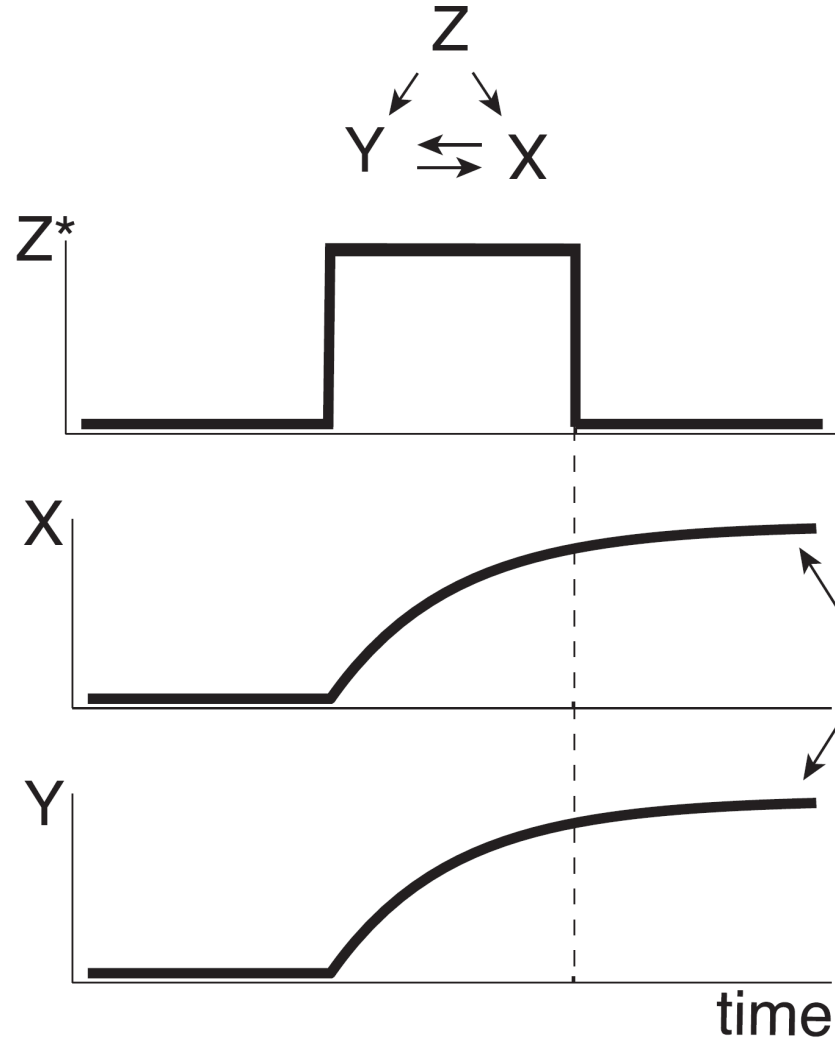
Double negative
feedback loop



	X	Y	Z
St.St. 1	ON	OFF	ON
St.St. 2	OFF	ON	OFF

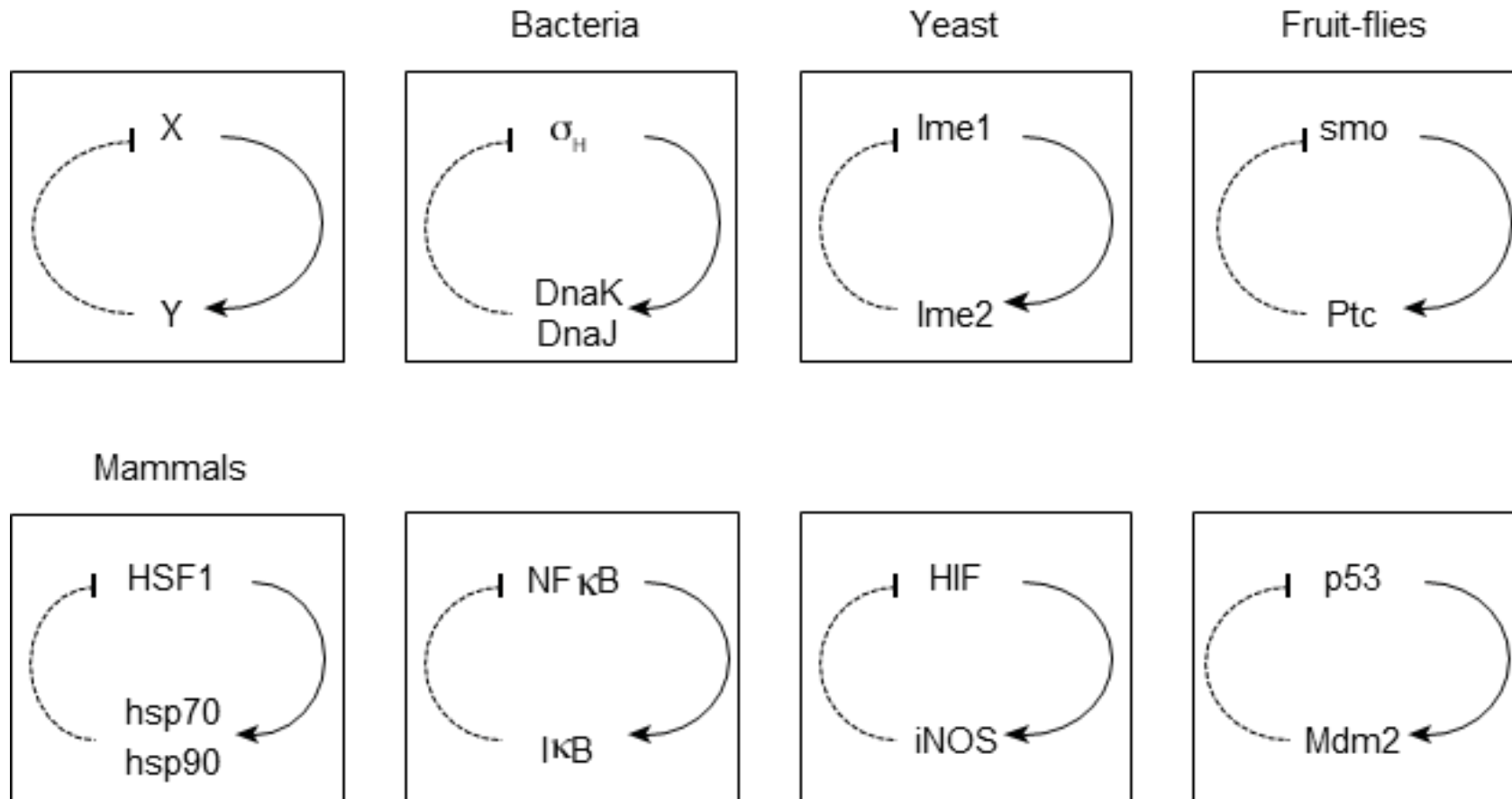


Regulated feedback loops create memory

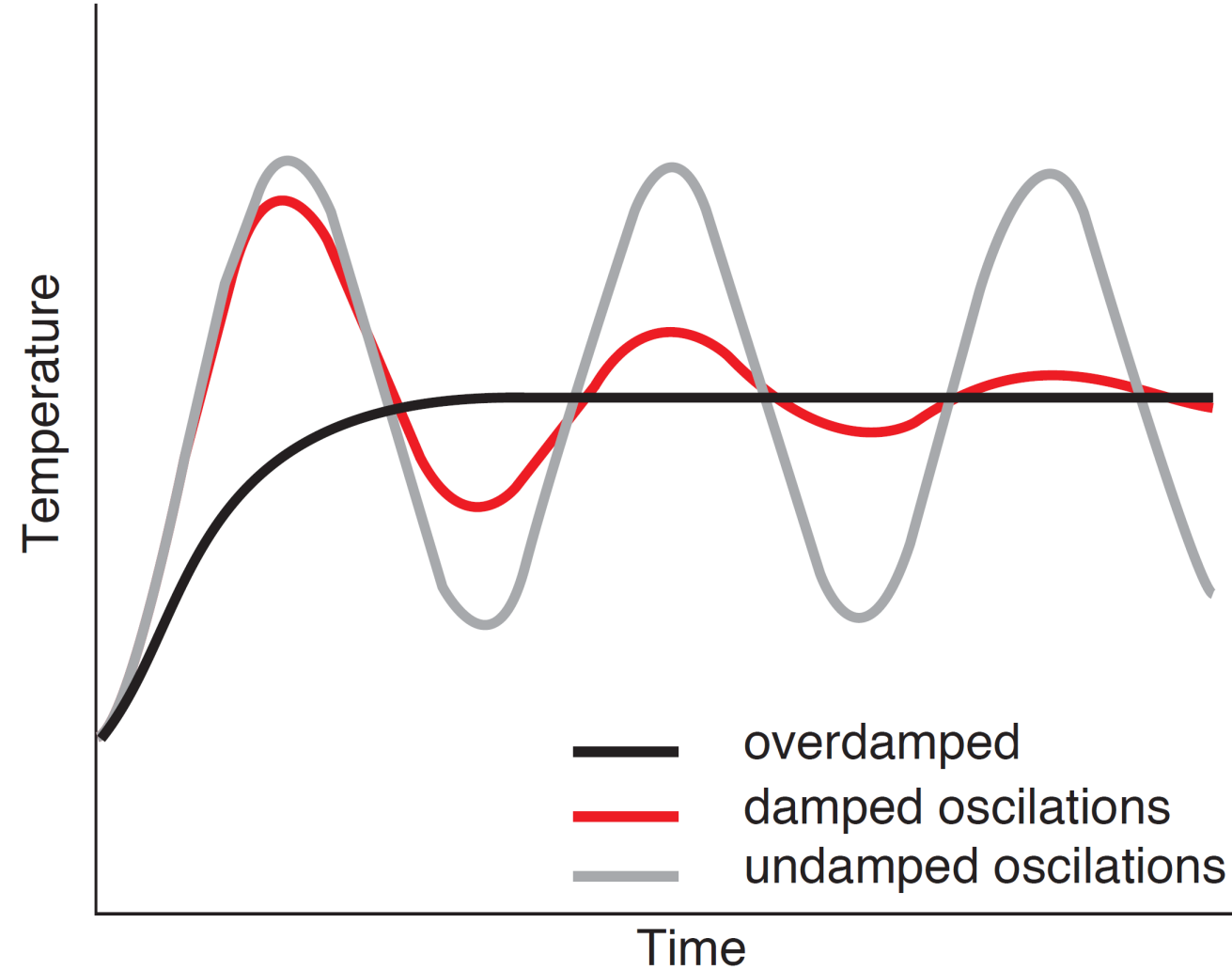
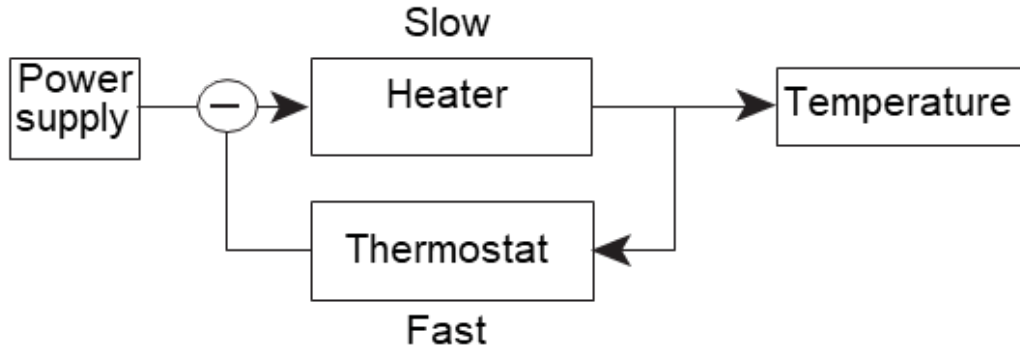


Besides genetic networks: Protein-Protein interaction networks

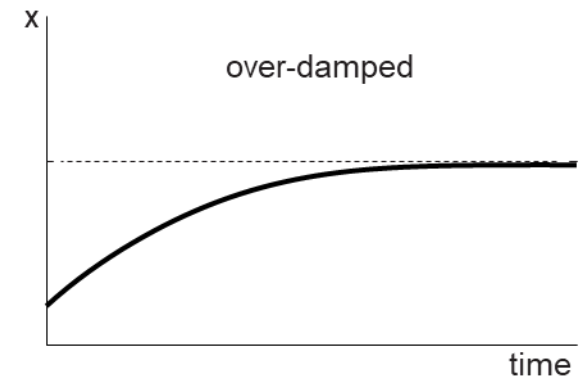
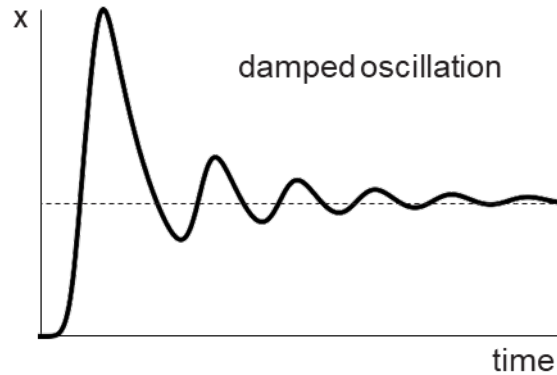
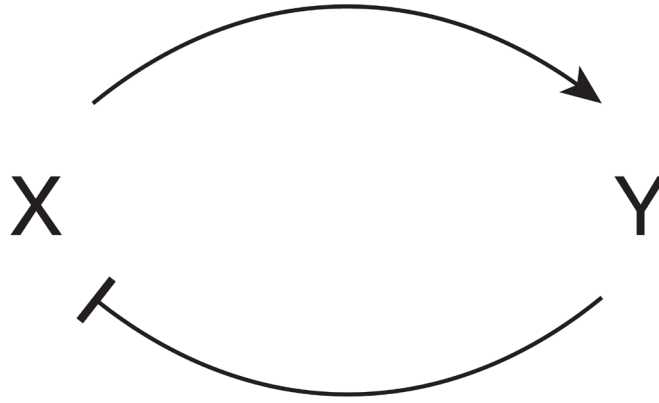
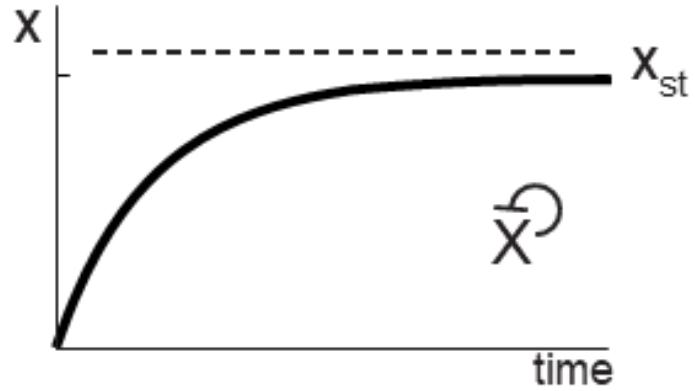
Hybrid negative feedback (one transcription one on protein level)



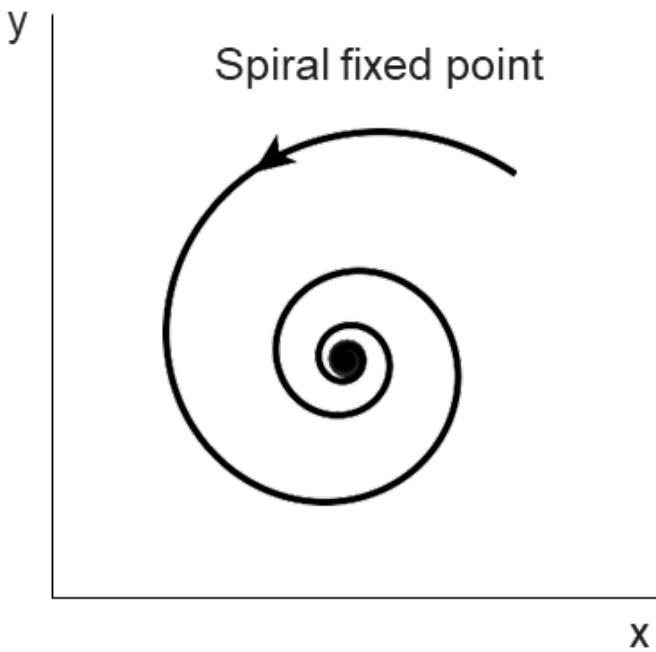
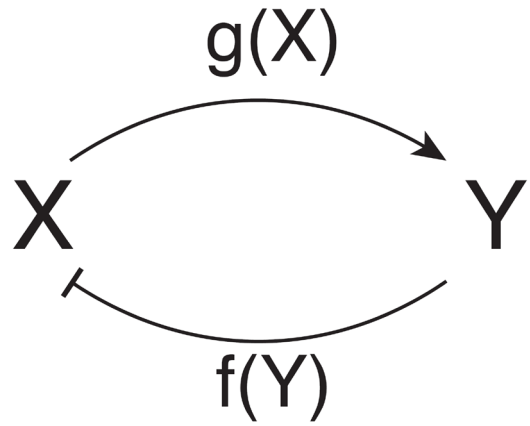
One slow, one fast process



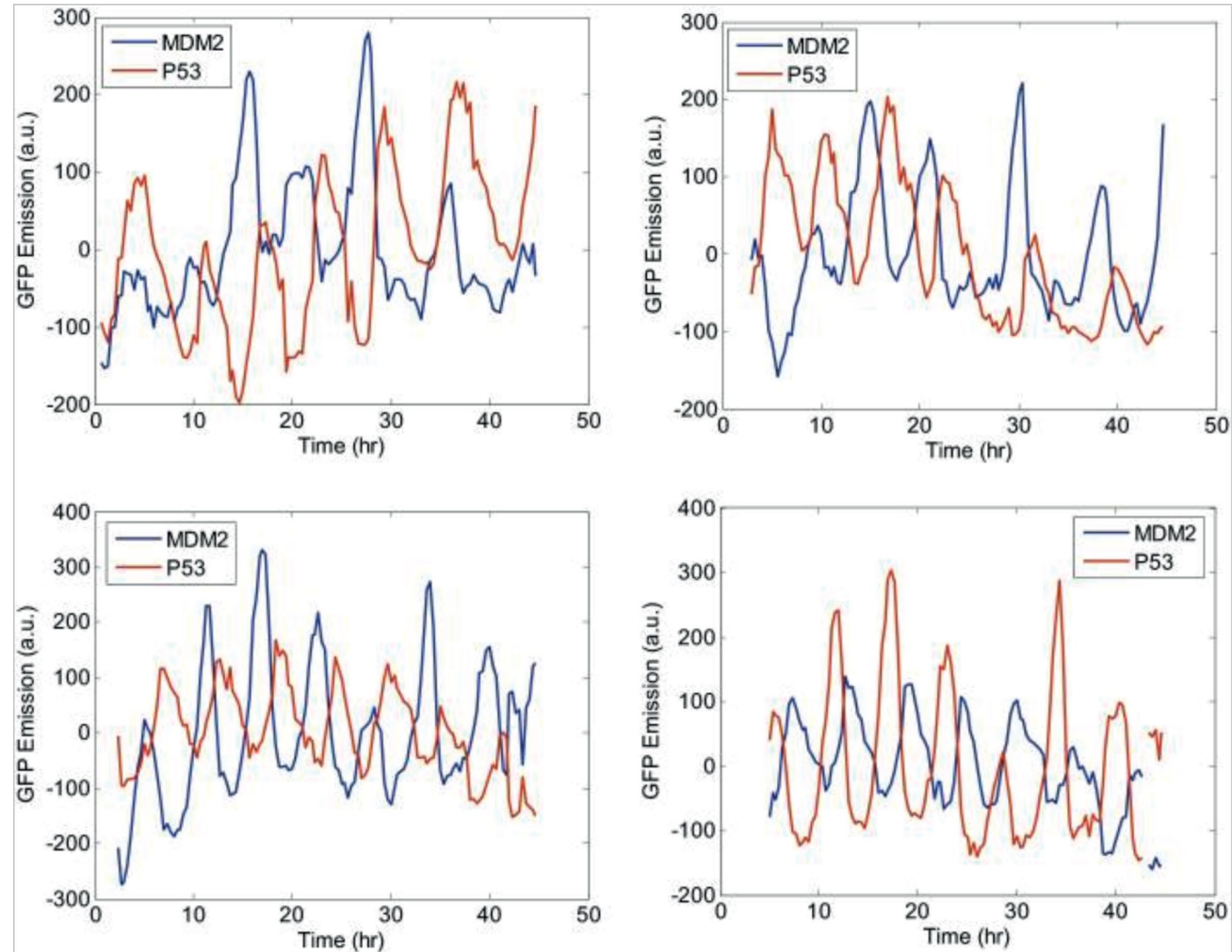
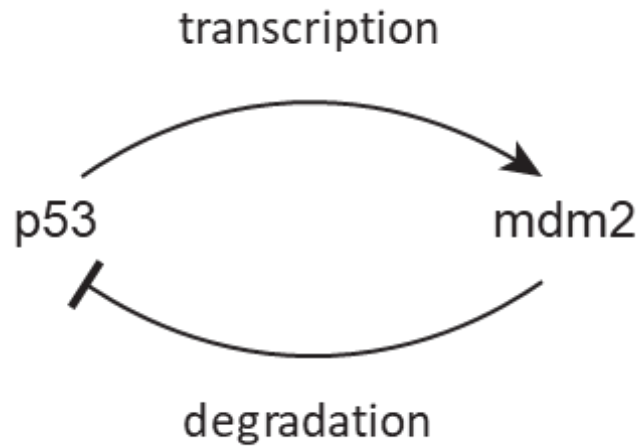
How to build a biological oscillator?



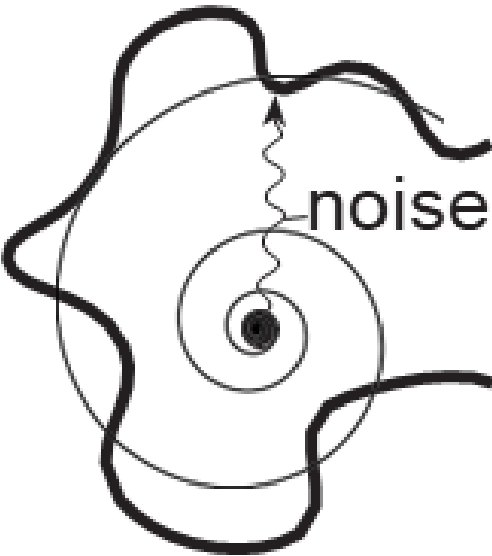
Example: Show that a two component negative feedback shows damped oscillations, if timescale are similar enough and feedback is strong enough



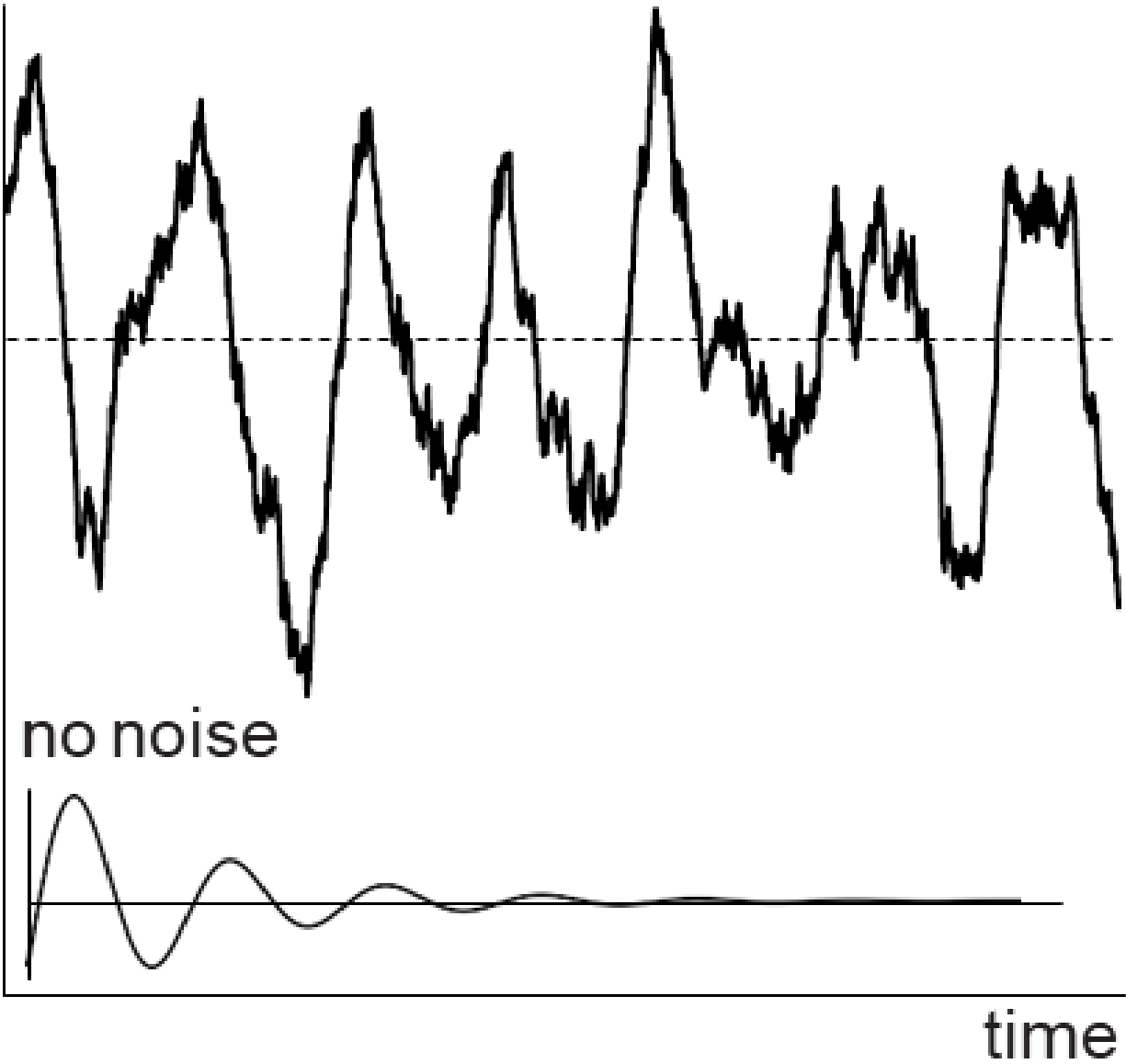
Ok, so these system either show damped oscillations or overdamped oscillation BUT!



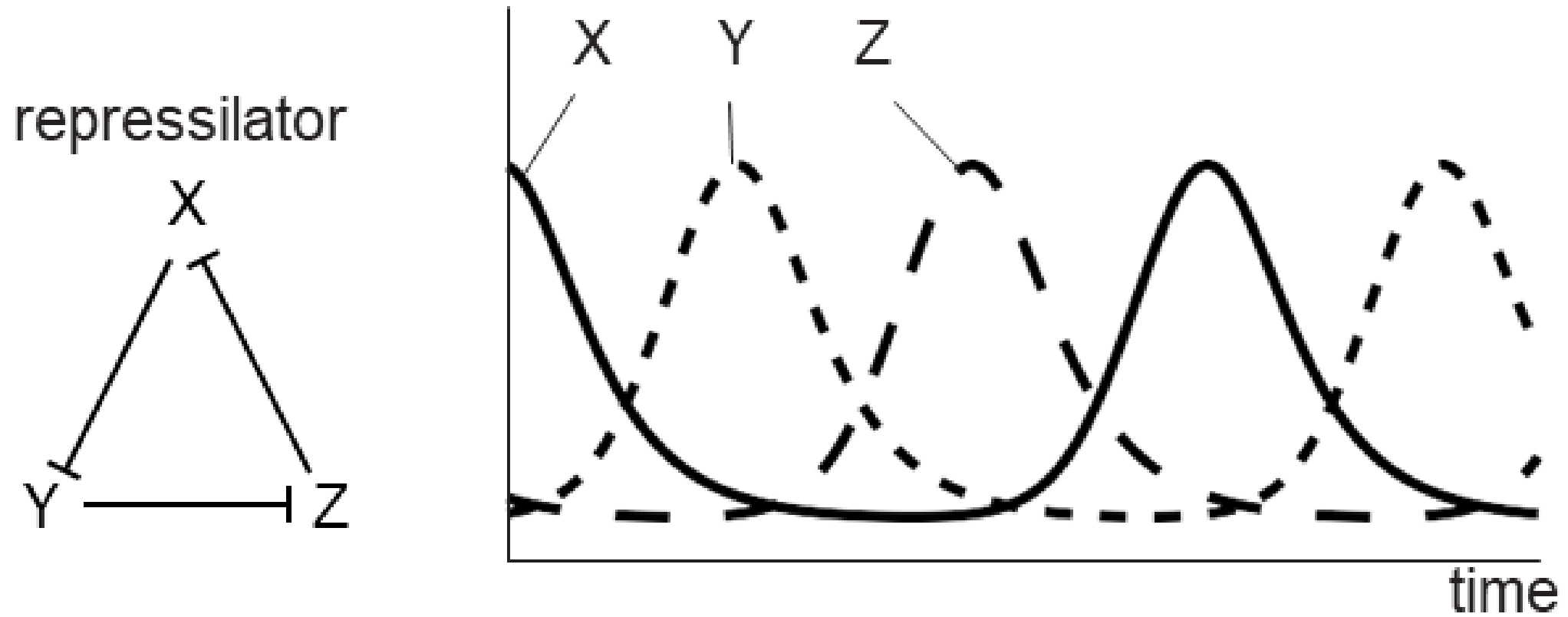
Noise!!!



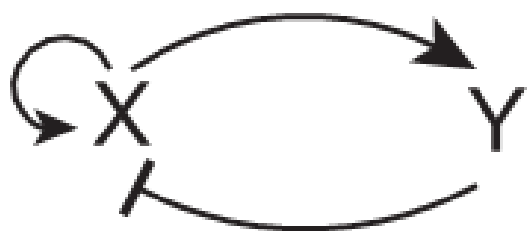
noise induced oscillations



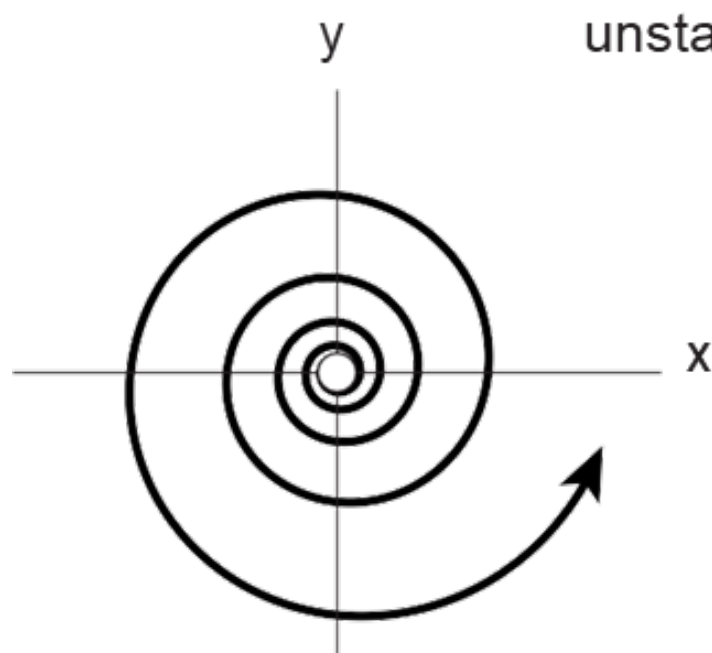
Oscillations without noise in the repressilator



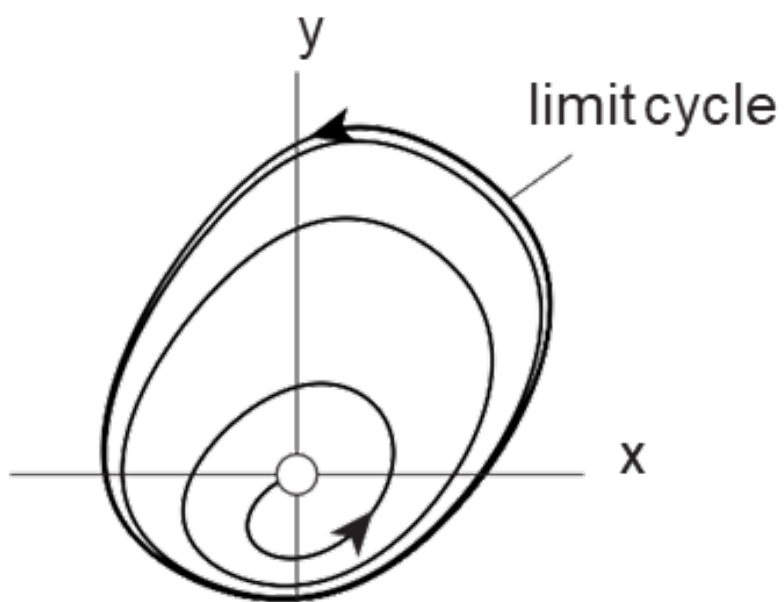
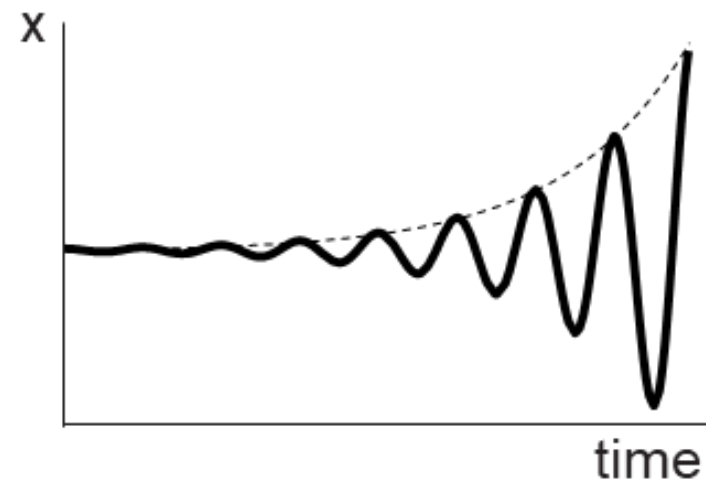
oscillator motif



The positive feedback can make the real part positive -> Unstable



unstable spiral



limitcycle

