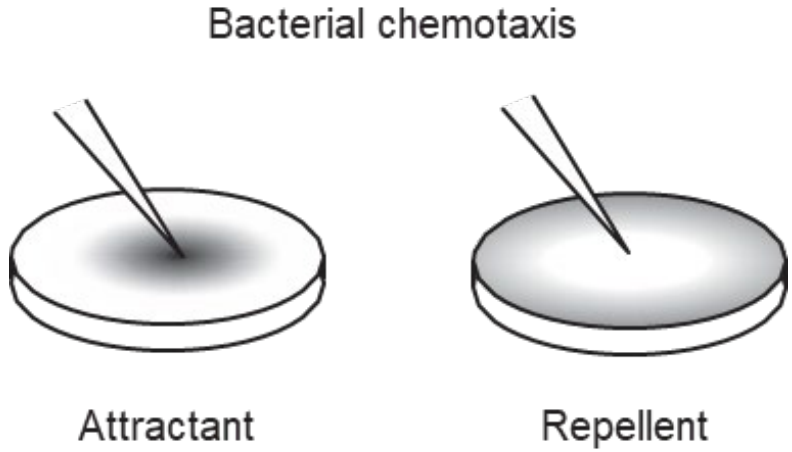
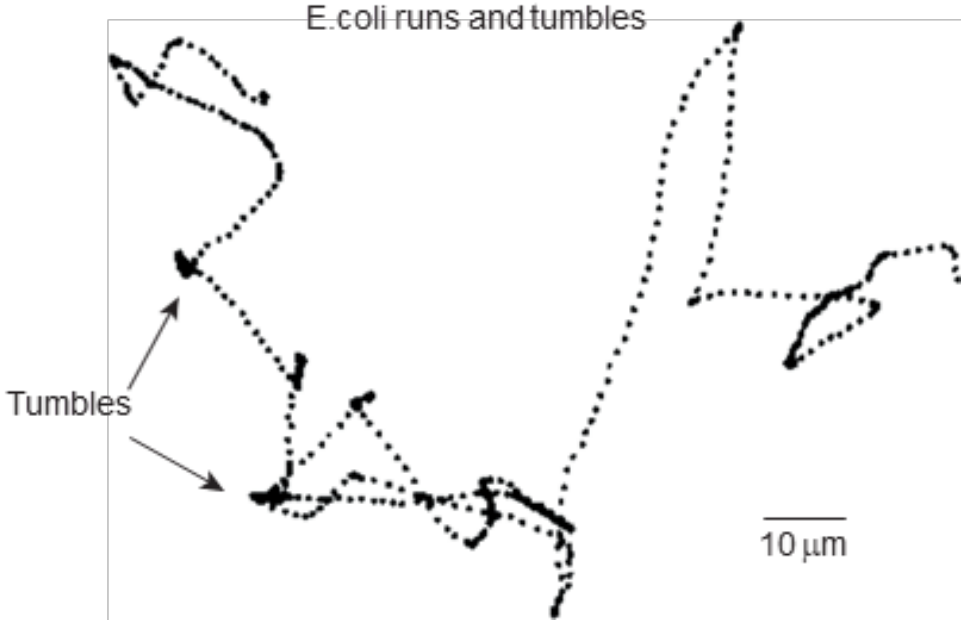
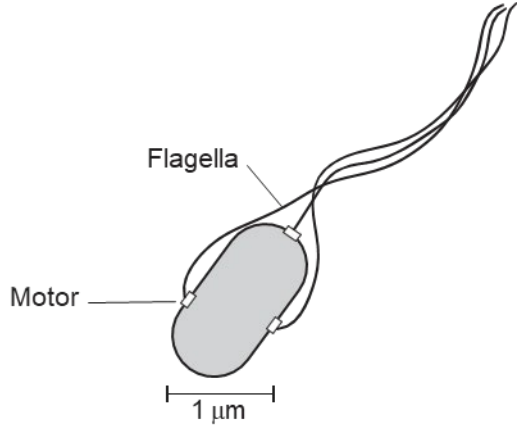
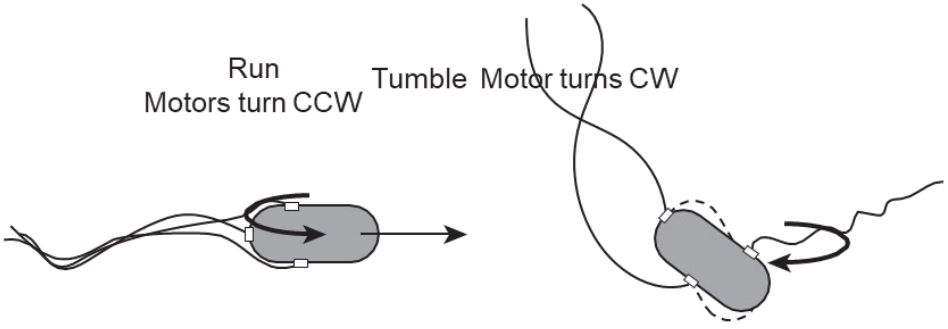
Robustness in bacterial chemotaxis

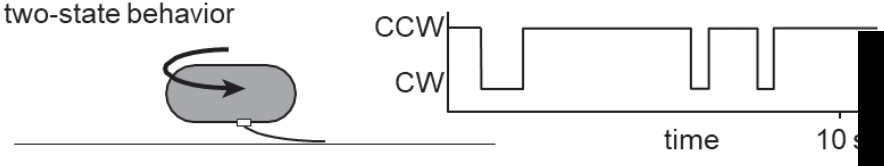



E.coli runs and tumbles
Tumbles
10 μm

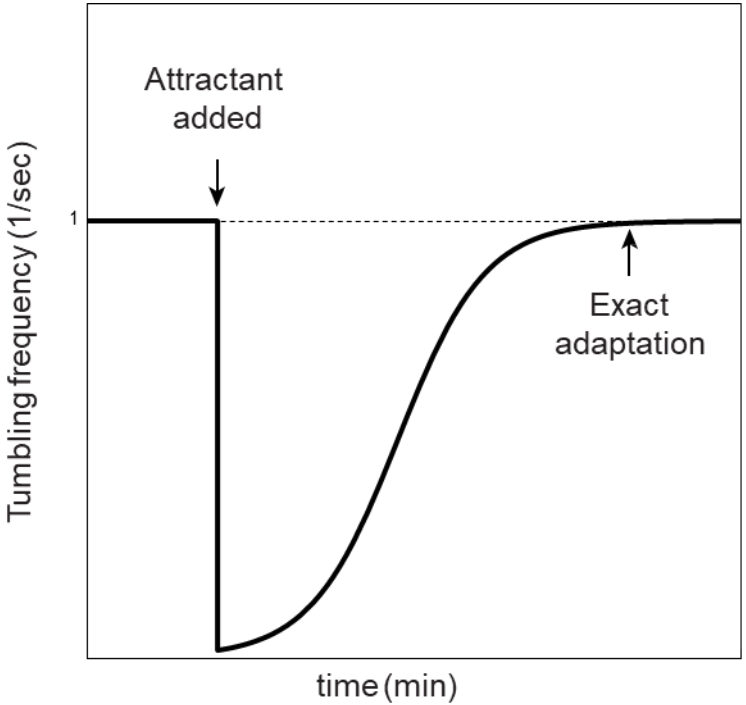

Flagella
Motor
1 μm

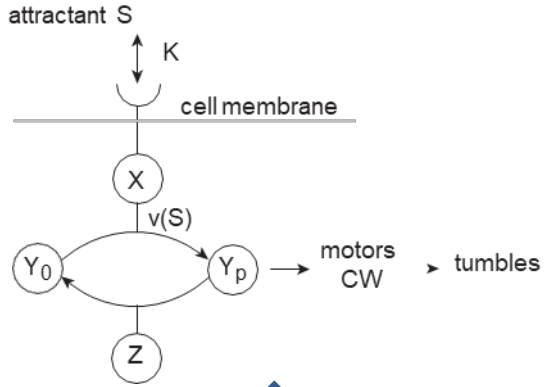


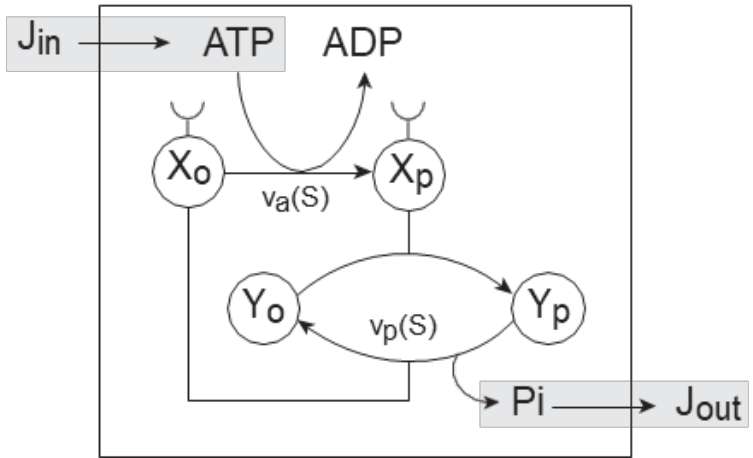
When tethered to a surface the entire cell rotates, and individual motors show two-state behavior

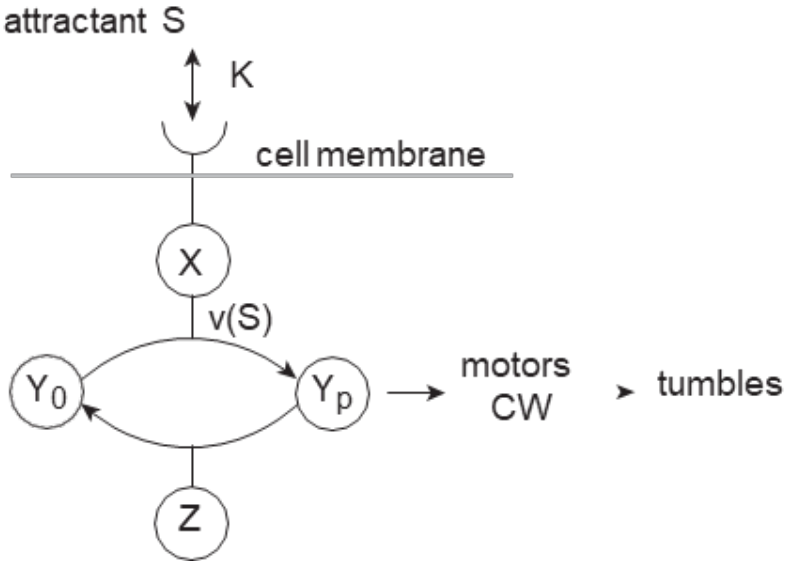


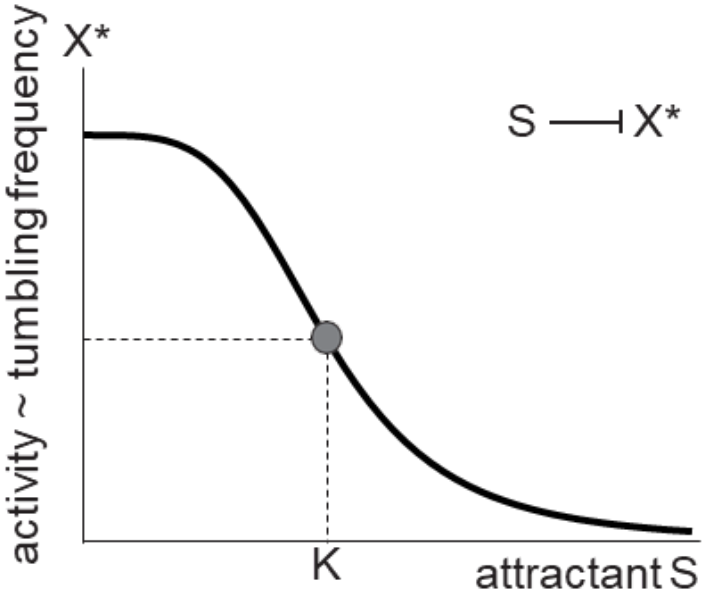
Sensory adaptation and exact adaptation



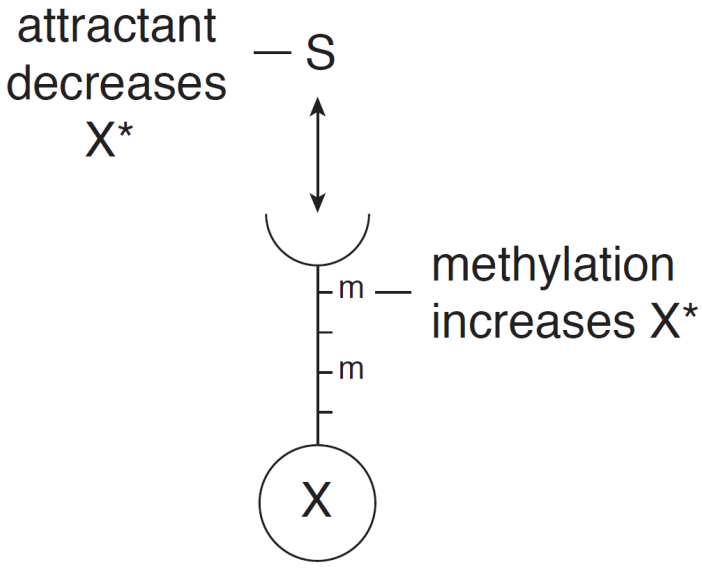


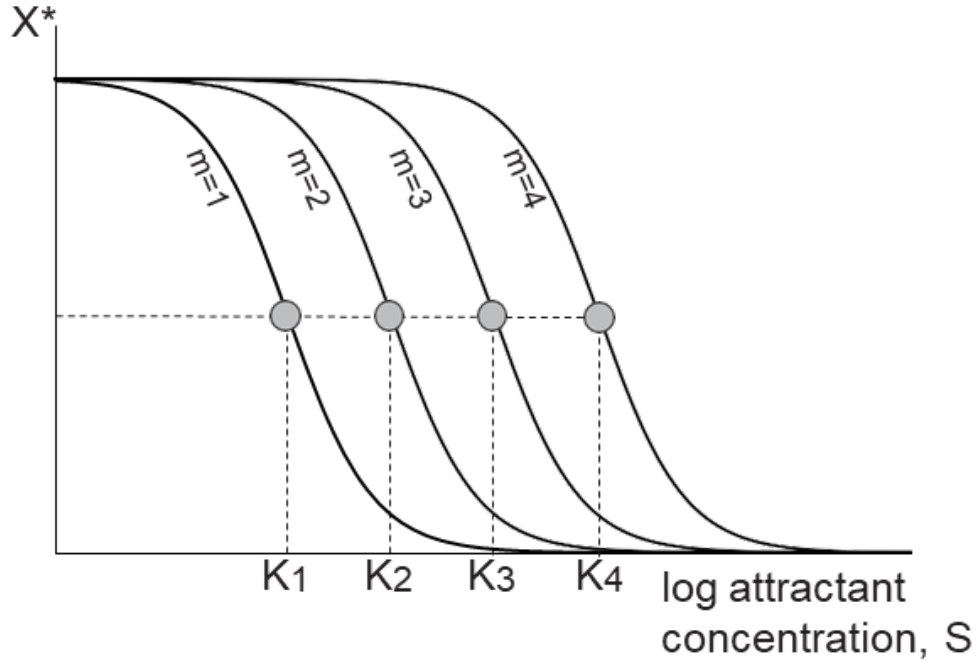



attractant S
K
cell membrane
X
v(S)
Y0
Yp
motors
CW
tumbles
Z

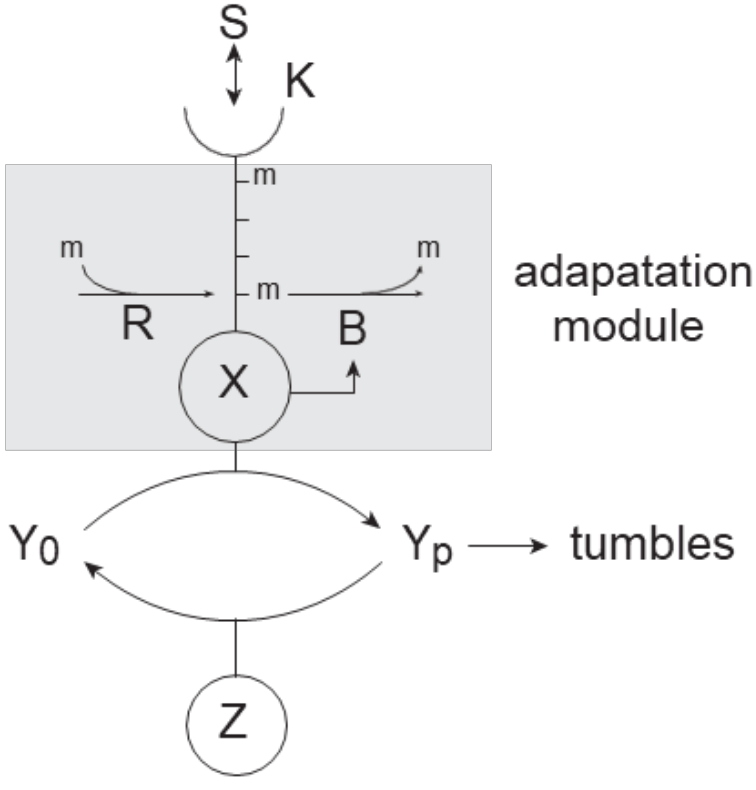

X*
S ⊣ X*
activity ~ tumbling frequency
K
attractant S

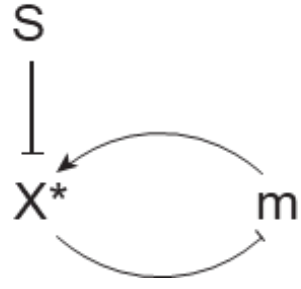
The magic comes from methylation… it increases the effect of X*





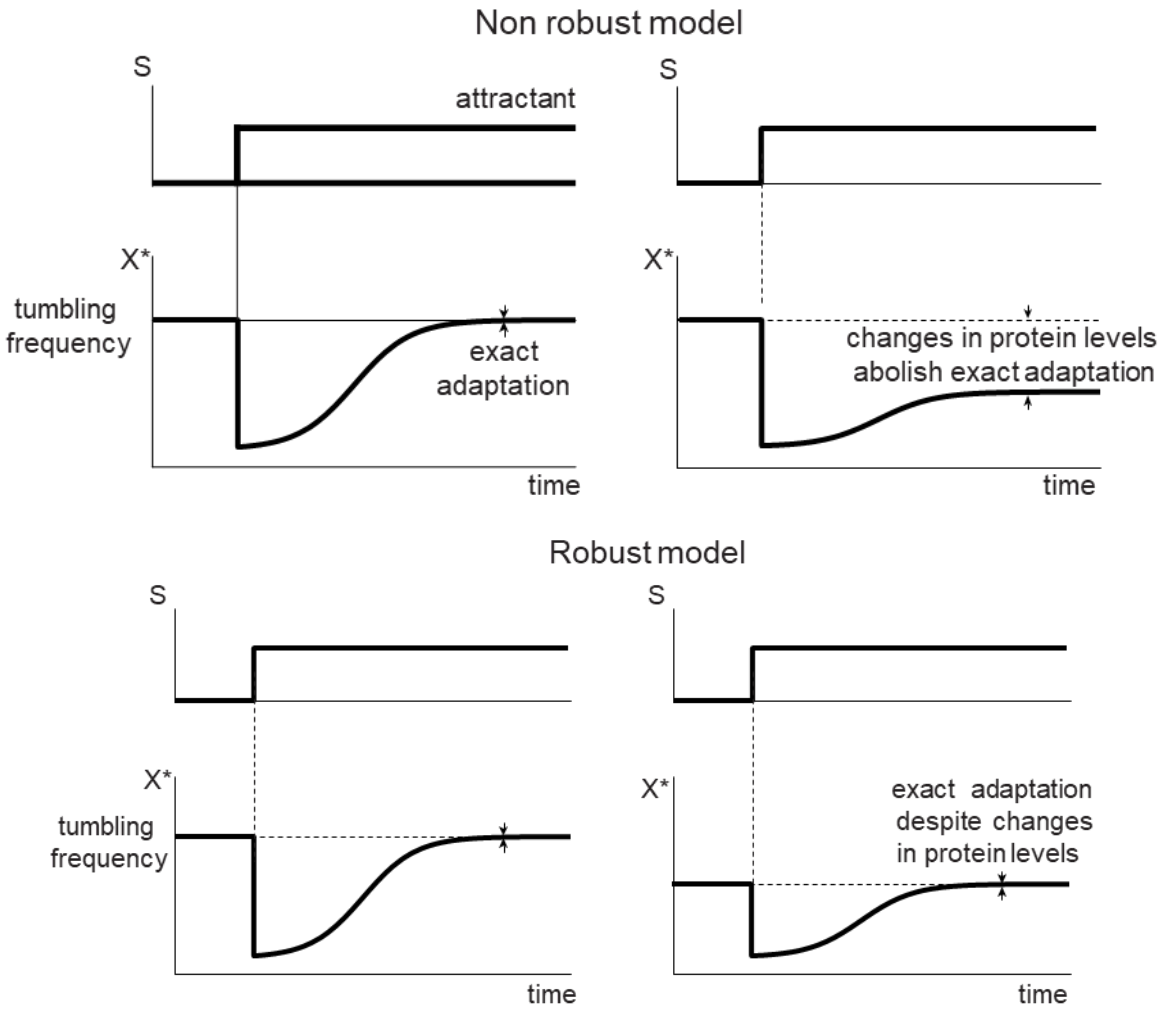
Methylation controlled by CheR and CheB



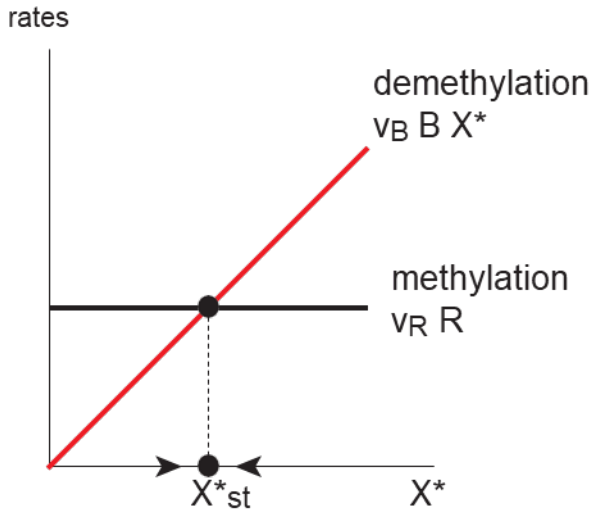


Negative feedback loop!

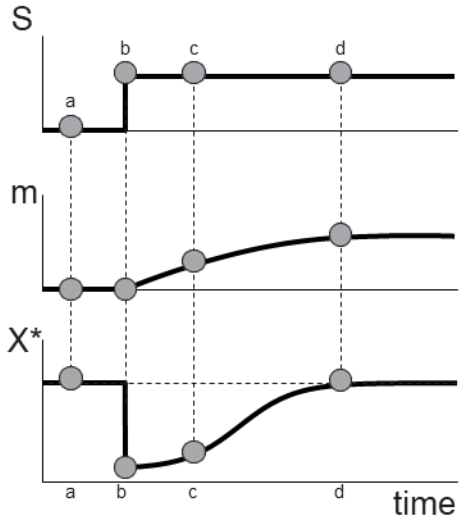
The Barkai-Leibler model of exact adaptation

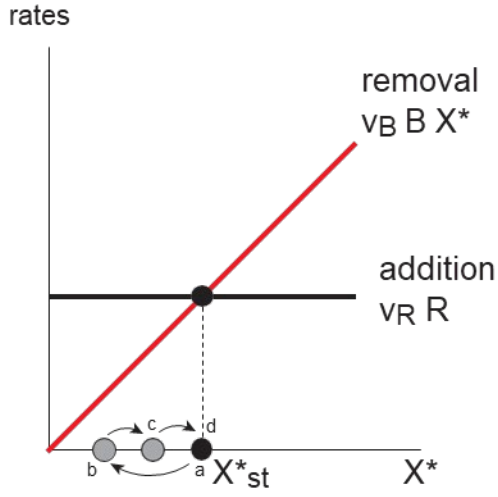


Simple feedback to reach steady state X*

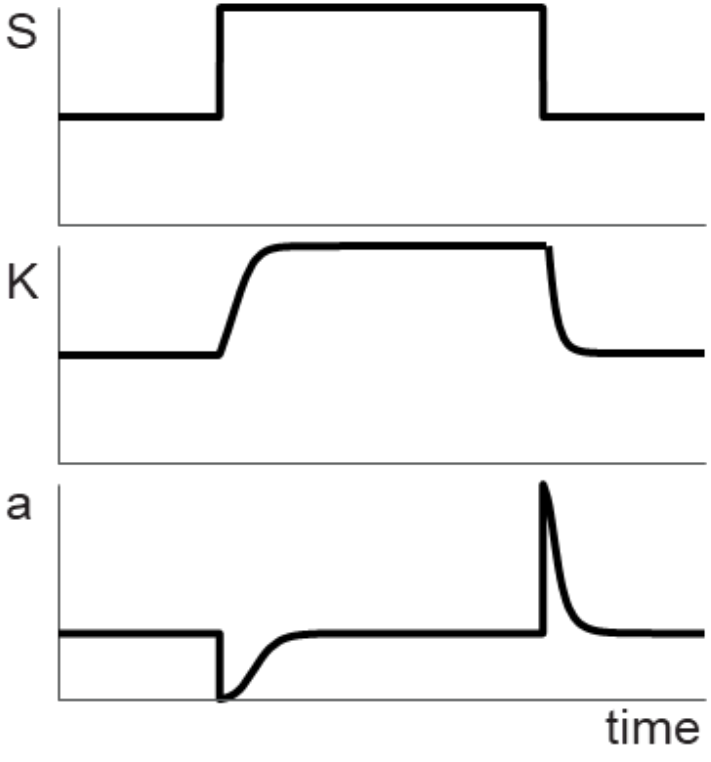


The Barkai-Leibler model nicely explains the adaptation as slow process

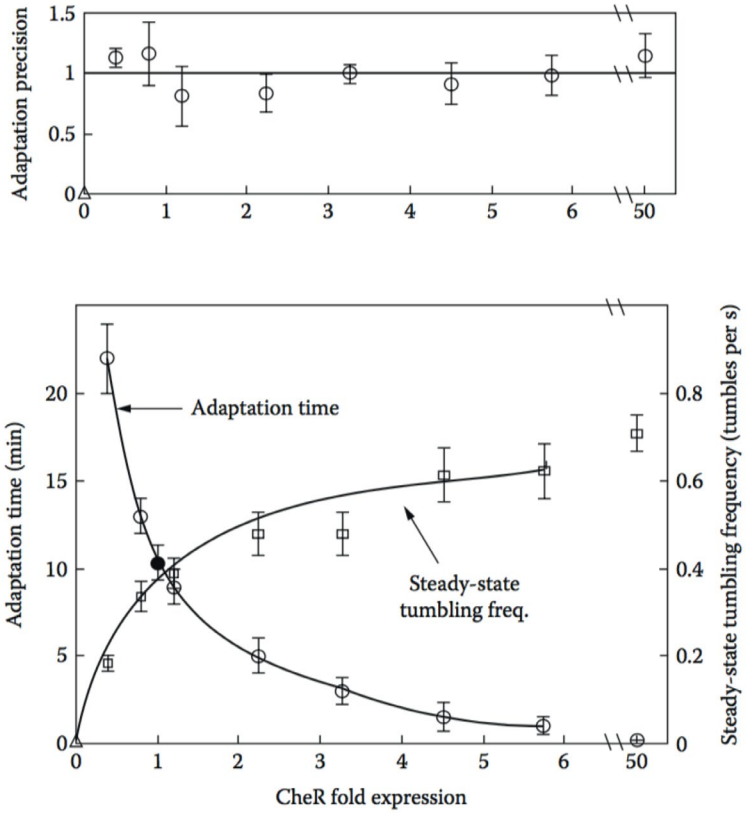




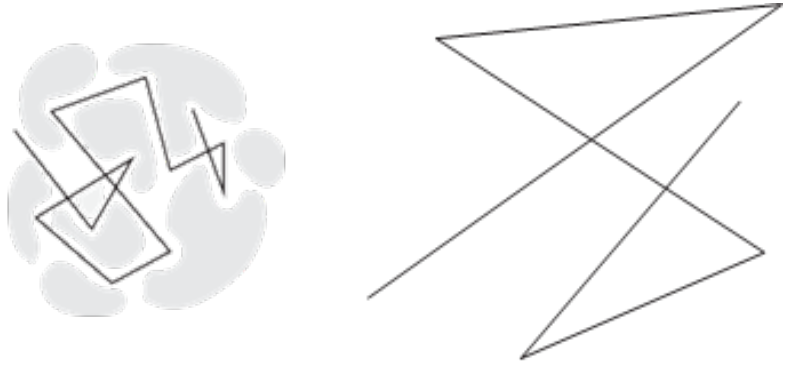
Robust Adaptation and Integral Feedback



Exact adaptation is robust, whereas Steady State Activity and adaptation time are fine tuned



Why individuality is usefull!



rapid progress
in dense obstacles

rapid progress
in free liquid