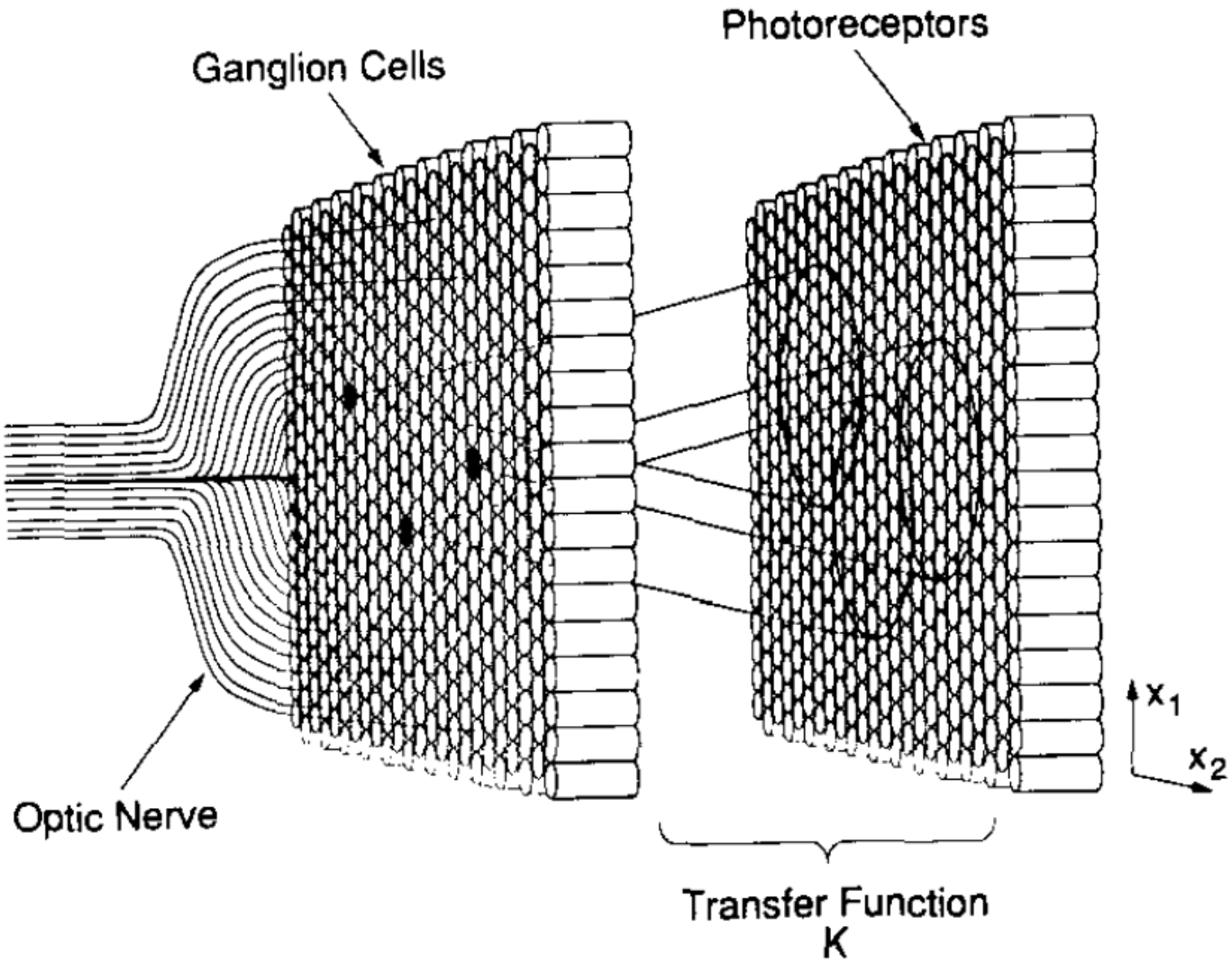
Lecture 13

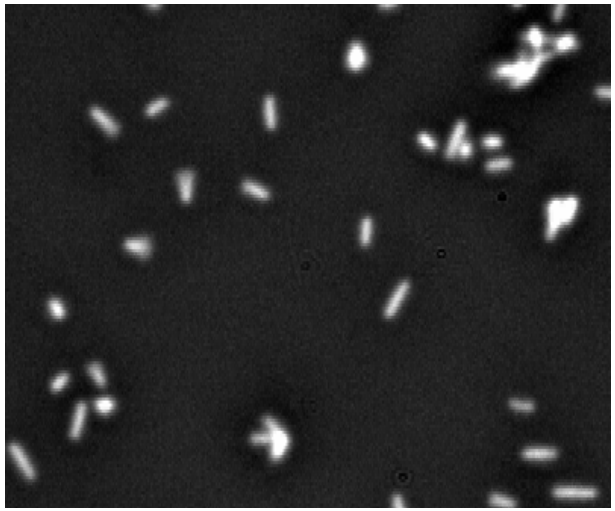
Short caveat on using information arguments seen in Lectures 11 and 12 to other biological black box processors: the example of bacterial chemotaxis

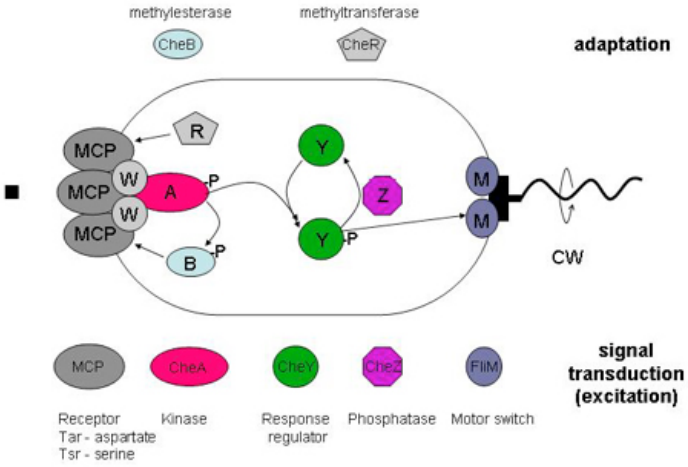
The retina as a black box processor



Bacterial chemotaxis response

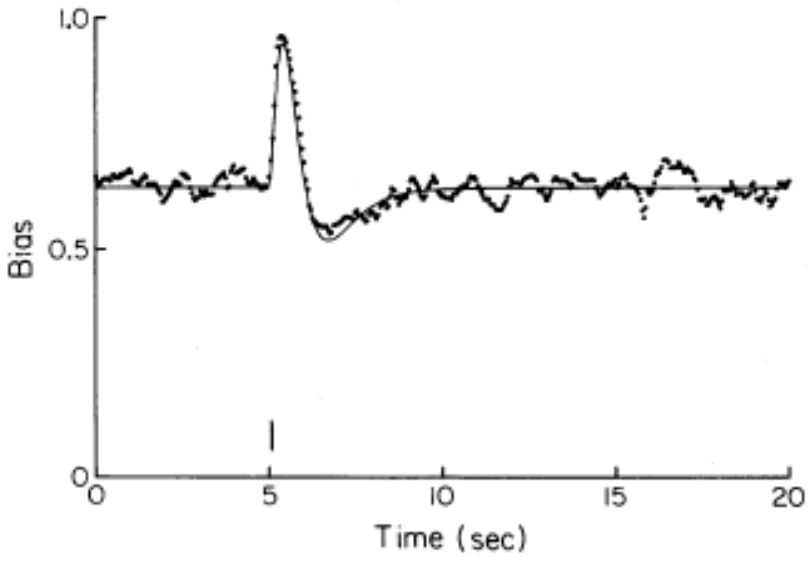
Tethering assay





Response I(t) to a short pulse stimulus

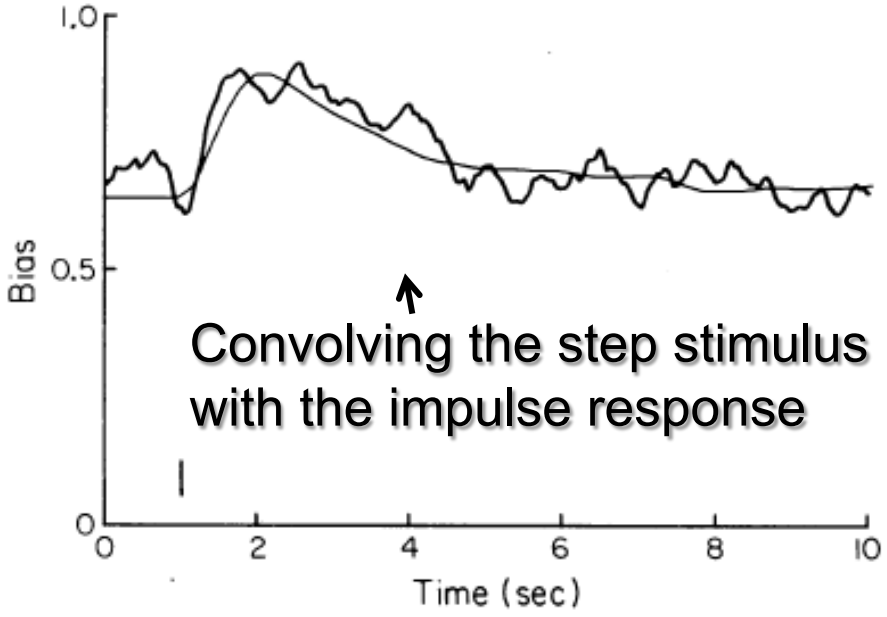
(Segall et al, PNAS 1986; Paster & Ryu, PNAS 2008 for thermal pulses)



Response to signals of moderate intensity is built from the impulse response

Running to tumbling rate

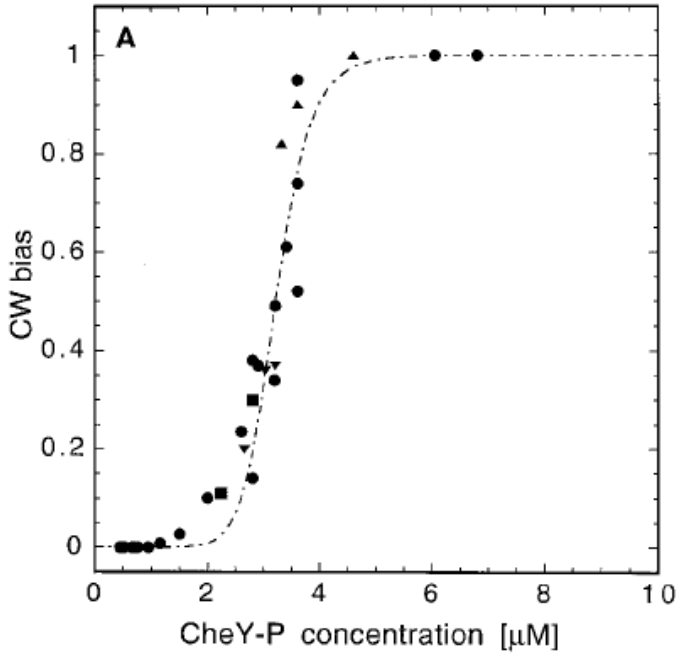
$$= \frac{1}{\tau_r}\left[1 - \int^{t} I(t-s)c(s)\,ds\right]$$



Adaptation to the background level: the rate after the step goes back to its initial value

$$\int_0^{\infty} I(t)\,dt = 0$$

Standard dynamic-range argument for adaptation



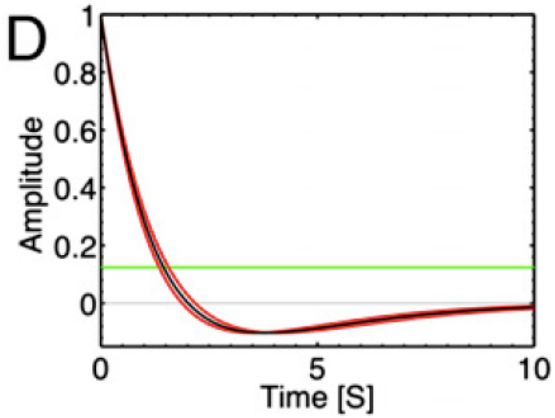
Bacterial motor response curve
(Cluzel, Surette & Leibler, Nature 2000)

Drifting from the inflection point reduces sensitivity and **eventually** leads to the plateaux.

Recently shown (HC Berg and colls., Nature & PNAS 2012), though, that the motor shifts its range by regulating the number of FliM components.

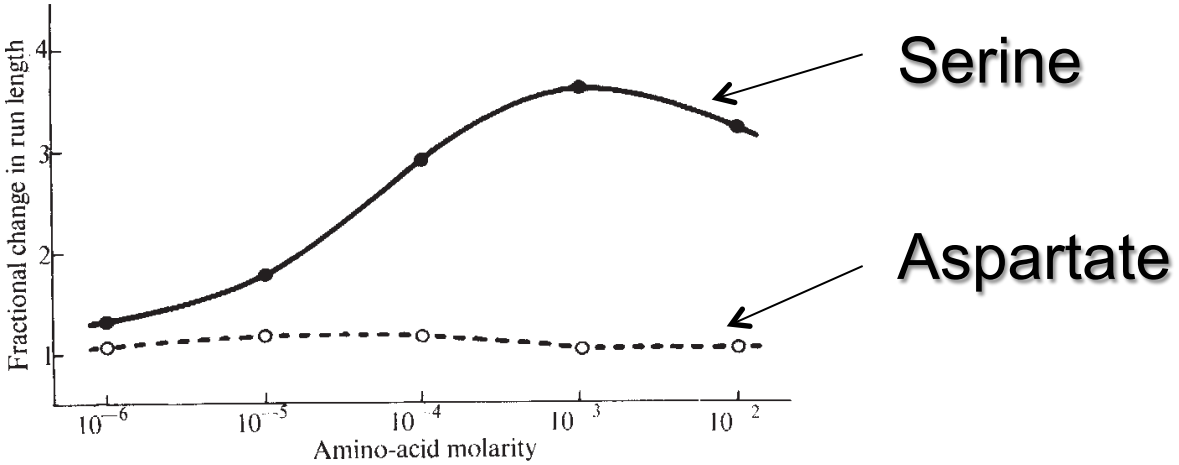
Perfect *vs* non-perfect adaptation

The same *E. coli* bacterium is not perfectly adapted in its response to serine, which goes through the same pathway but binds a different receptor.

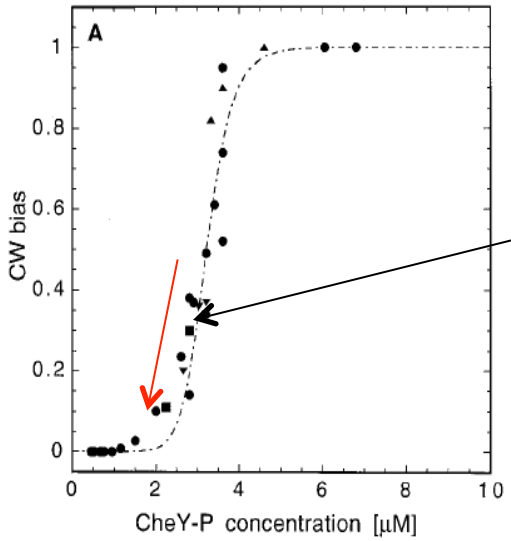


Chemoattractant serine

Running time *vs* concentration

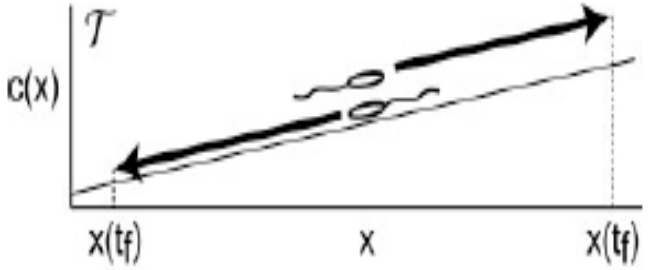


E. coli function is to sense **and** to run



A negative lobe in the response reduces the current (de Gennes, 2004)

Decreasing CheY-p: the running time τ increases and sensitivity reduces. **Yet,** the mean drift increases with τ.The balance between these competing factors depends **on numbers**…



$$\bar{v} = u(\tau_+ - \tau_-)/2\tau \approx gu^2\tau^2 \int_0^\infty e^{-t}\,dt \int_0^t dsK(\tau(t-s))s$$

$$\bar{v} = \chi\nabla c \qquad \sigma = \frac{6D\tau + 2}{3\tau} \qquad \chi = \frac{2D_0}{3\sigma\tau}\int_0^\infty e^{-\sigma t}K(t)dt \qquad D_0 = \frac{u^2}{3\sigma}$$

(Celani & MV, PNAS '10)

Can tell you much more and discuss ongoing works but main message is:

E. coli chemotaxis is an integrated system, where acquisition and transfer of information on the environmental gradients is directly coupled to decision, viz. swimming. Information is clearly needed to navigate effectively but it's not all…