Physics of protein thermometry

Michael Vennettilli, Soutick Saha, Ushasi Roy, Andrew Mugler

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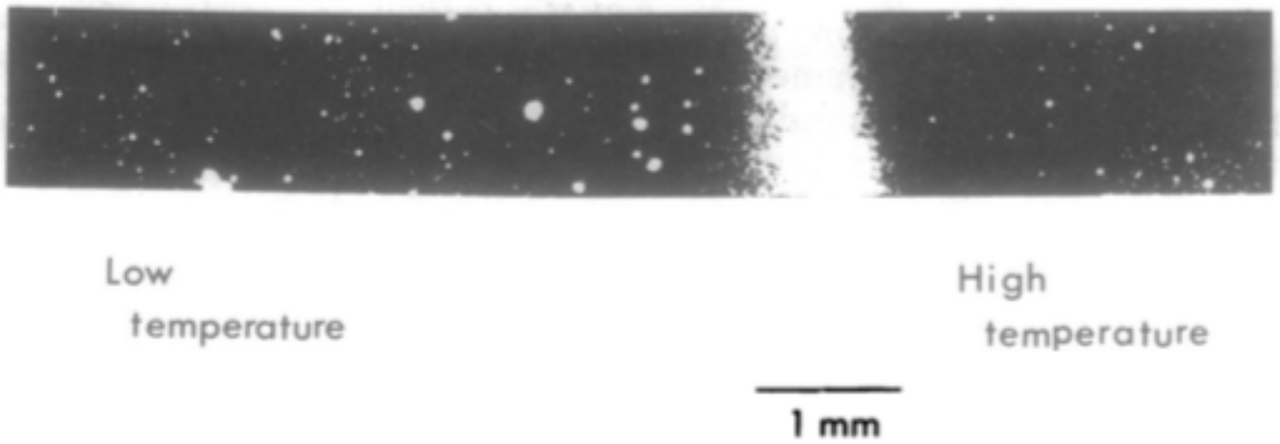
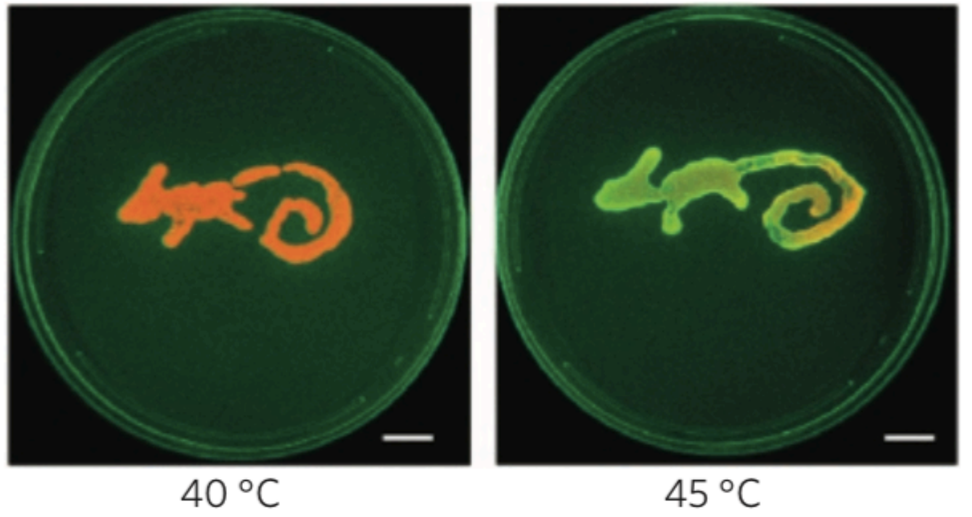
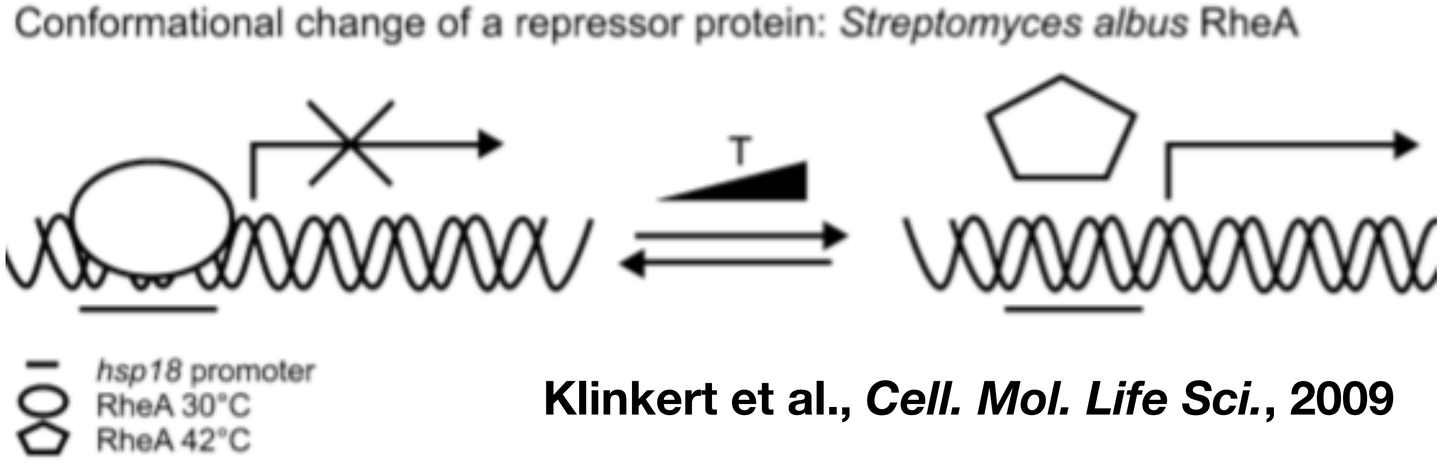
Motivation



Maeda et al., *J. Bacteriol.*, 1976

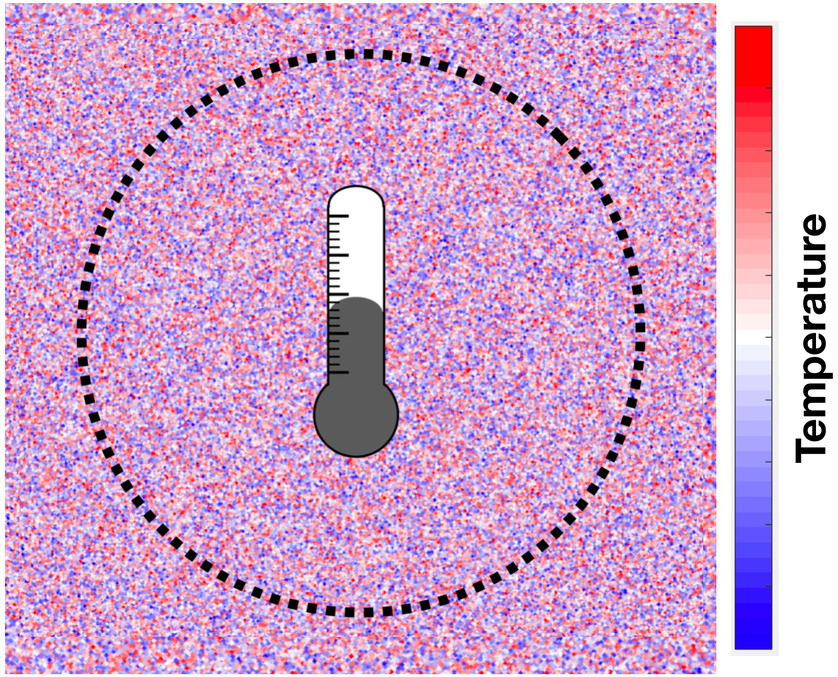


Piraner et al., *Nat. Chem. Biol.*, 2017



Klinkert et al., *Cell. Mol. Life Sci.*, 2009

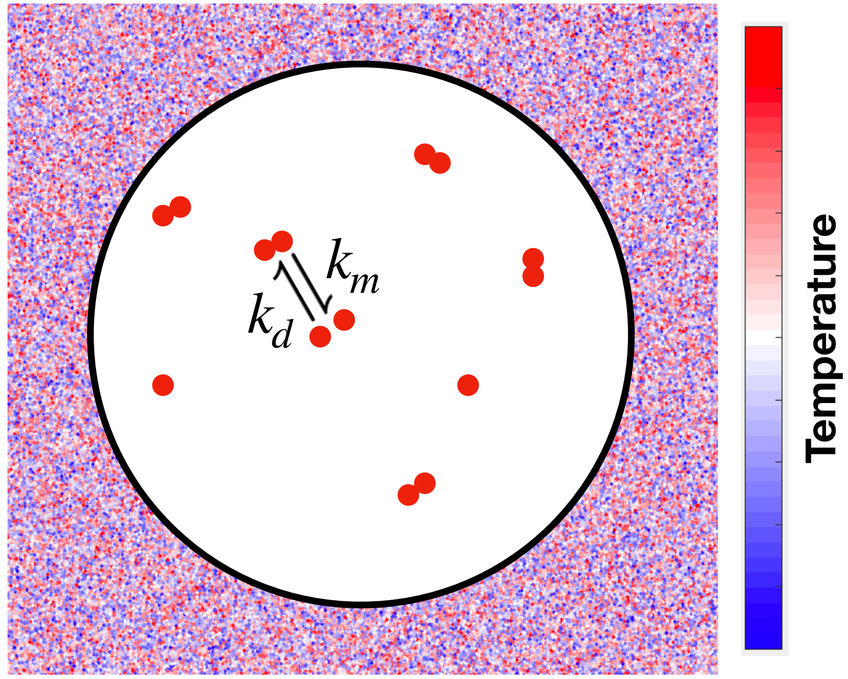
Perfect Instrument

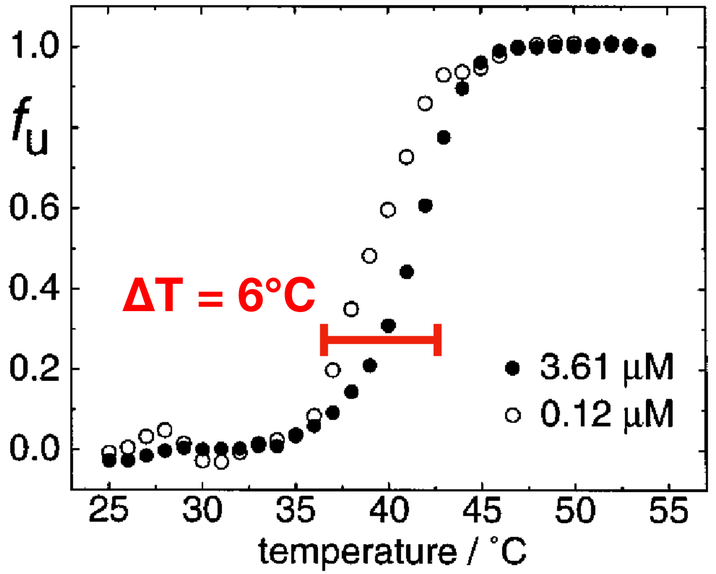


$$\frac{\sigma(\hat{T})}{\overline{T}} \sim \begin{cases} \sqrt{\dfrac{k_B}{C}}, & \tau \to 0 \\ \sqrt{\dfrac{4k_B\tau_D}{5C\tau}}, & \tau \gg \tau_D, \end{cases}$$

Instantaneous: 10^{-6}, after one minute: 10^{-10}

Fixed pool





Hurme et al., *Cell*, 1997

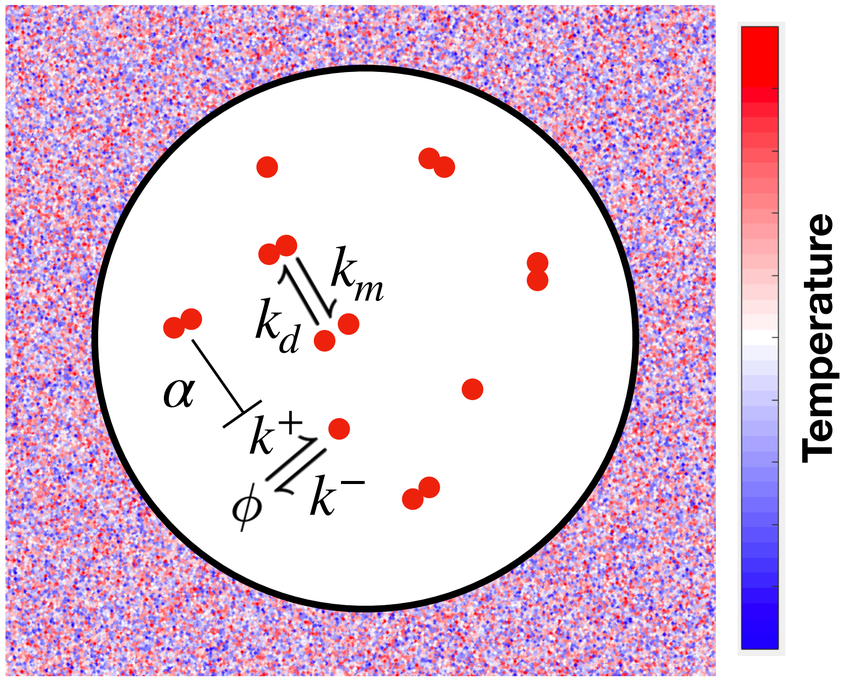
$$\frac{\sigma(\hat{T})}{\Delta T} = f'(T_M)\frac{\sigma(\hat{m}_\tau)}{dm^*/dT}$$

- **Short-Time Limit: Binomial-like noise.**
- **Long-Time Limit: decays like**

$$\sqrt{\sigma^2(m)\tau_c/\tau}$$

Instantaneous: 1.4%, after one minute: 0.1%

Production-degradation with feedback

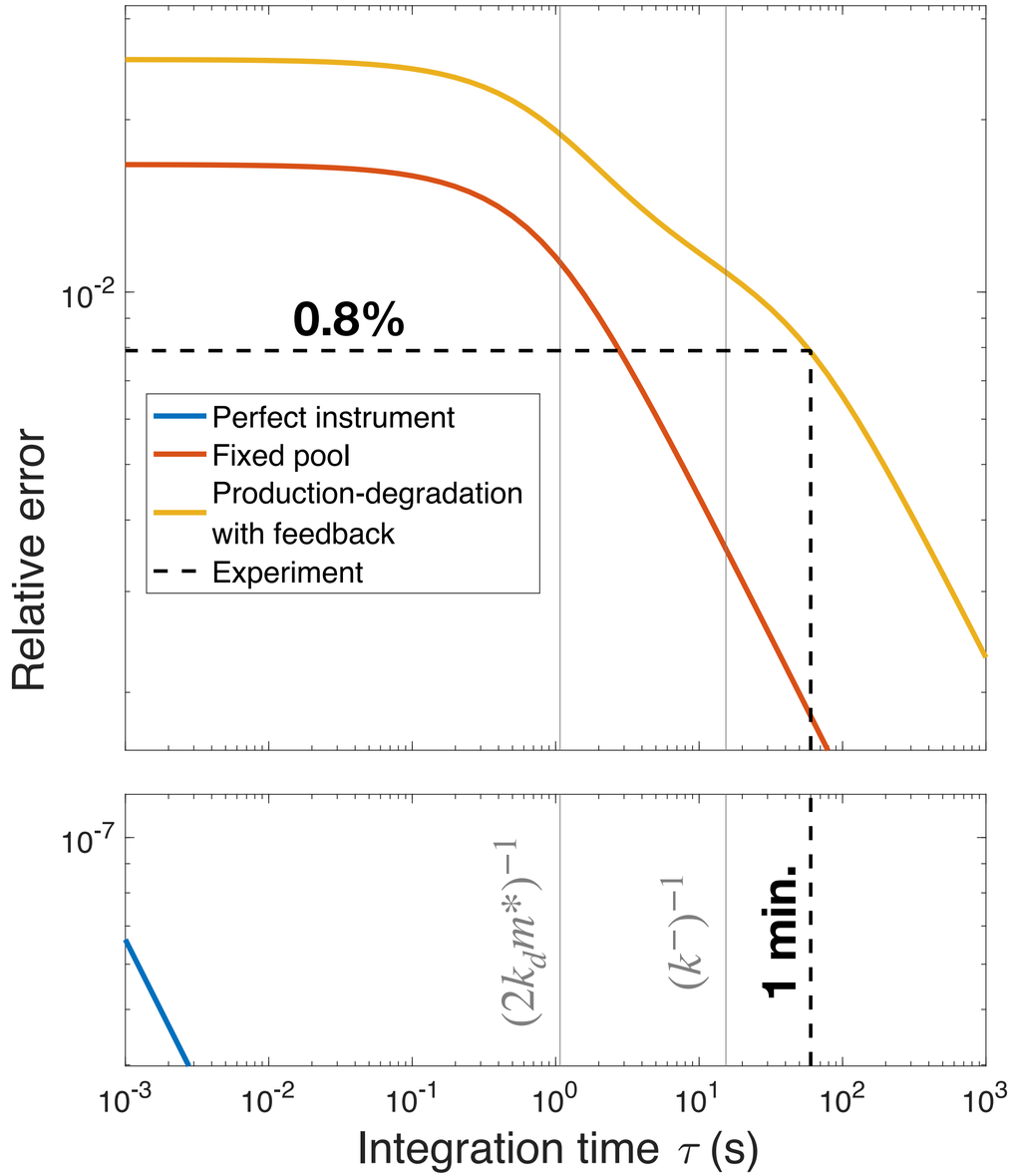


$$\frac{\sigma(\hat{T})}{\Delta T} = f'(T_M)\frac{\sigma(\hat{m}_\tau)}{dm^*/dT}$$

- **Variance is always larger than the fixed pool.**
- **Feedback reduces the variance and makes the derivative more sensitive.**

Instantaneous: 2.5%, after one minute: 0.8%

Summary


0.8%
Perfect instrument
Fixed pool
Production-degradation with feedback
Experiment
Relative error
10^{-2}
10^{-7}
$(2k_d m^*)^{-1}$
$(k^-)^{-1}$
1 min.
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Integration time τ (s)