Final PS due next Tuesday (12/12/06)
Before 3PM in class, or Rm. 13-2042

As with other PSs
 collaborations are also allowed for Final PS
 (indicate collaboration)

Goshima et al. Length control of the metaphase spindle

What determines the length of the spindle?
Three forces:

Force I: Sliding force forcing centrosomes apart

Force II: Kinetochore pulls centrosome inwards

Force III: Restoring spring forces tries to keep spindle length at $S_0$. 

\[
\frac{dS}{dt} = 2(V_{sliding} - V_{depol}) \\
\frac{dL}{dt} = 2(V_{poly} - V_{sliding}) \\
\frac{dS}{dt} = \frac{1}{\mu} 2(F_{sliding} - F_{kt} - F_{tension})
\]

\[
F_{sliding} = \alpha L \left(1 - \frac{V_{sliding}}{V_{sliding, max}}\right)
\]

\[
F_{tension} = \beta (S - S_o)
\]

\[
F_{kt} = F_{kt,0}
\]

**Problem:**

Depolymerization rate depends on \(F_{sliding}\)

Probability to find minus end of MT a distance \(x\) away from centrosome:

\[
P(x) \sim \exp\left( -\left(\frac{F_{sliding}}{N}\right)x \right)
\]

Probability to find it within a distance \(\delta\):

\[
P(x < \delta) = 1 - \exp\left( -\left(\frac{F_{sliding}}{N}\delta\right) \right)
\]
Therefore, $V_{\text{depoly}}$ is not constant:

$$V_{\text{depoly}} = V_{\text{depoly},0} + V_{\text{depoly, max}} \exp\left(\frac{(F_{\text{sliding}} / N) \delta}{k_B T}\right)$$

Now this systems of equations has a steady-state.

**B**

![Graphs and images](image)

**Developmental Systems Biology**

'Building an organism starting from a single cell'

Introducing: *Drosophila melanogaster* (or the fruitfly)

Great book: ‘The making of the fly’ by Peter Lawrence
The major advantage of Drosophila:
each stripe in the embryo corresponds to certain body parts in adult fly.

zygote (contains DNA from father and mother, **zygotic effects**)
egg (contains maternal components, **maternal effects**, only determined by mother, RNA, proteins)

early development

MOVIE !
http://flymove.uni-muenster.de

nuclei form plasma membrane
Pioneering experiments by Klaus Sander (1958) on leaf-hoppers

ligation and transplantation experiments indicate the presence of morphogens created/destroyed at the poles of the embryo

First morphogen: bicoid (true maternal)
transplantation of bicoid can rescue cells
head fold shift to right for increasing number of gene copies in mother
radioactive labeled RNA reveals localization at pole
interpreting the bicoid gradient (created by maternal effects) by zygotic effect (gene expression by embryo itself)

hunchback is a zygotic effect!

hunchback reads the bicoid gradient

a lot of zygotic gene controls formation of stripes

recent experimental paper explores relation between bicoid and hunchback quantitatively:
only gene that makes hb more noisy is Staufen