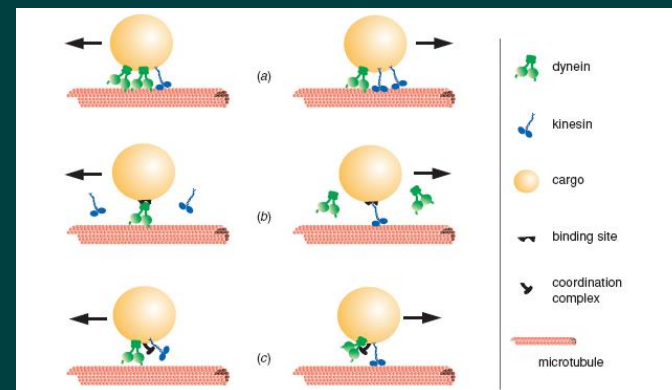
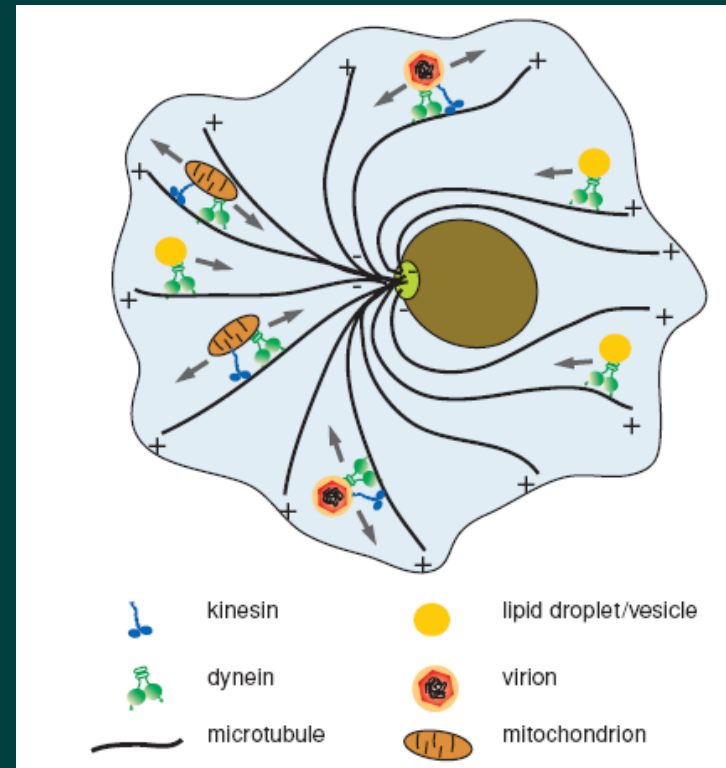
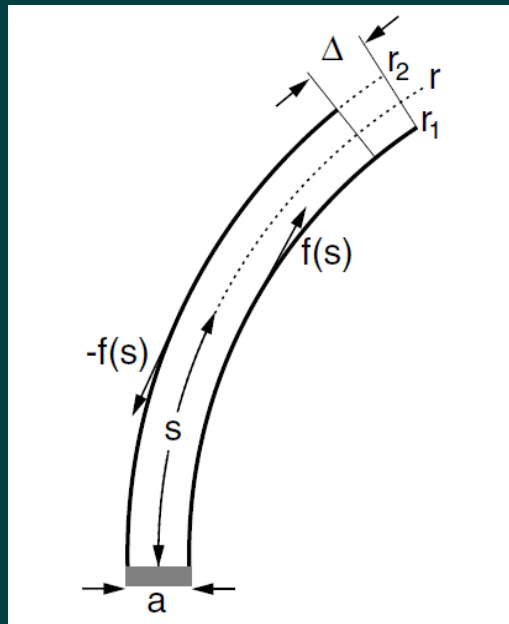
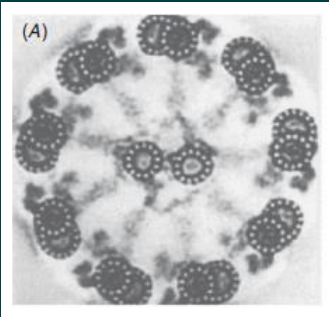


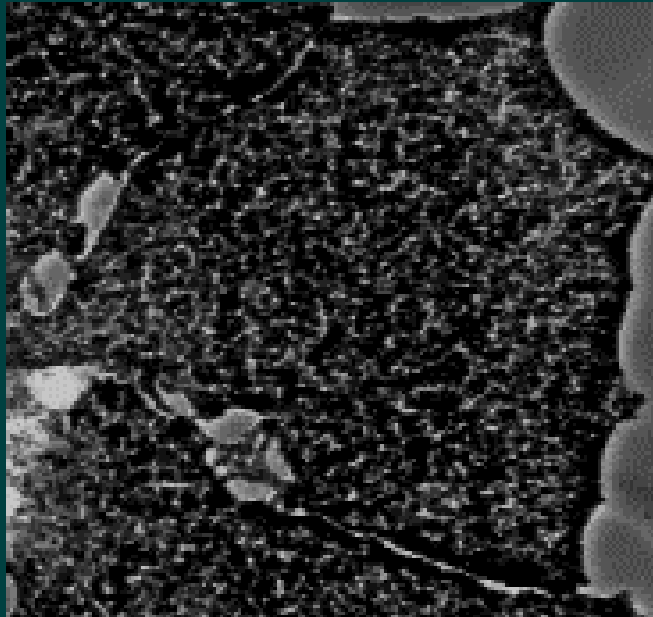
last time:
functions of microtubule motors: cilia and flagella beating, intracellular transport



Camalet and Julicher, 2000

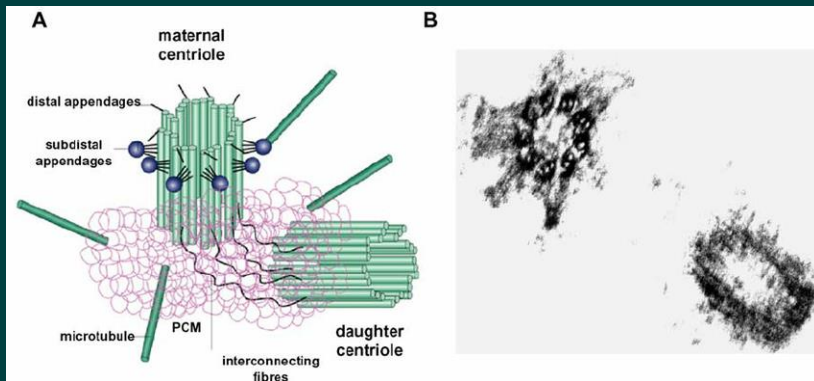
Gross, 2004

self-centering by microtubules and motors



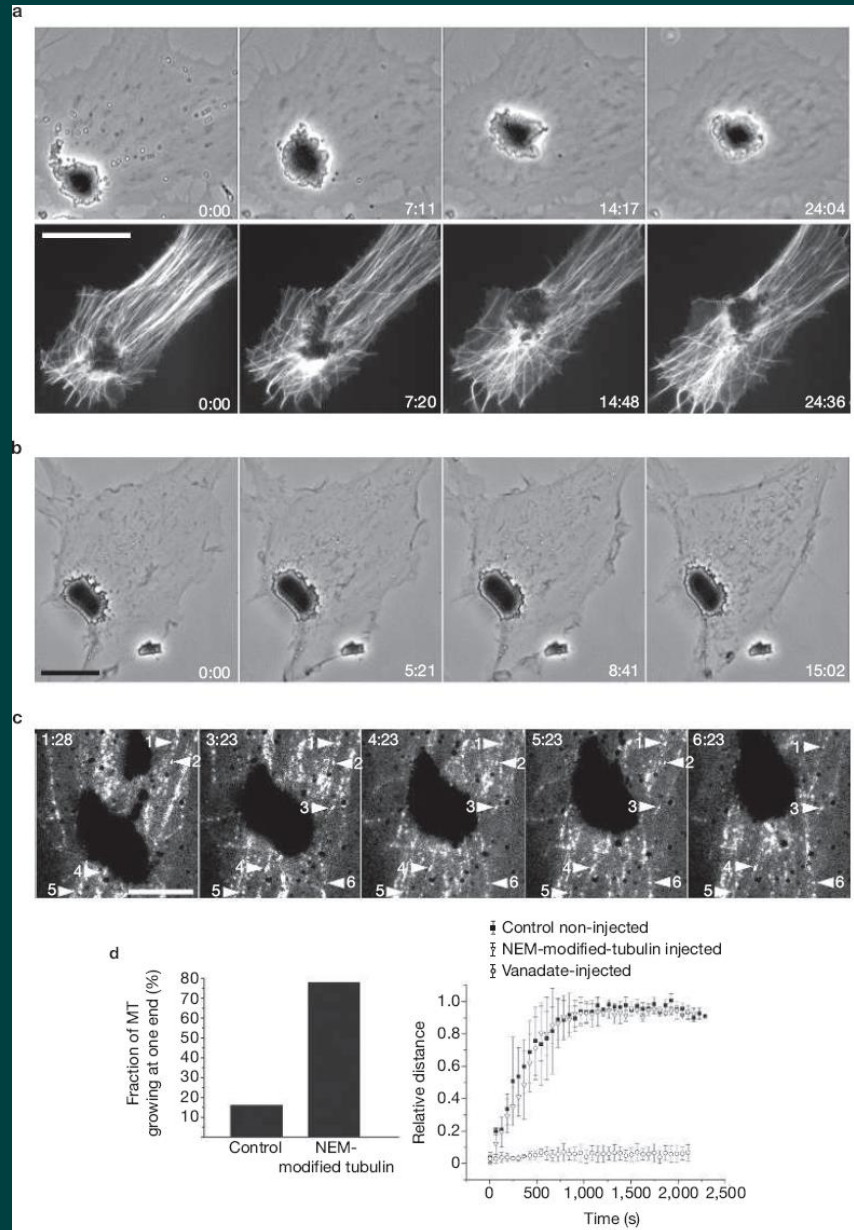
2 processes: 1) formation of a radial array
2) centering

often radial array is
established by centrosome
(γ -tubulin, centrin, ninein)



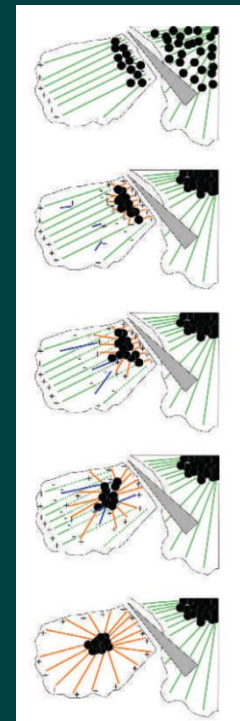
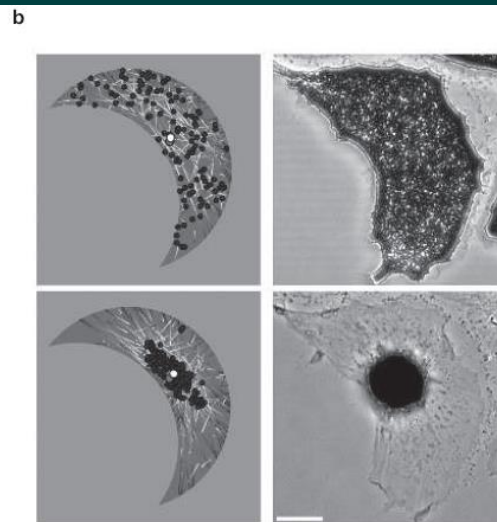
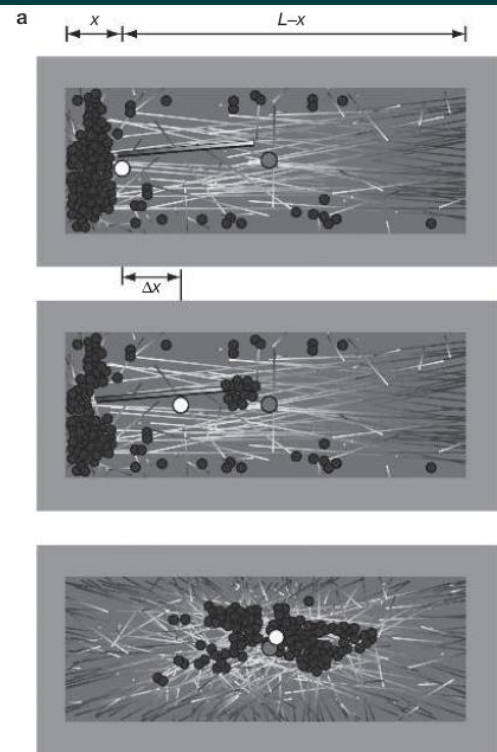
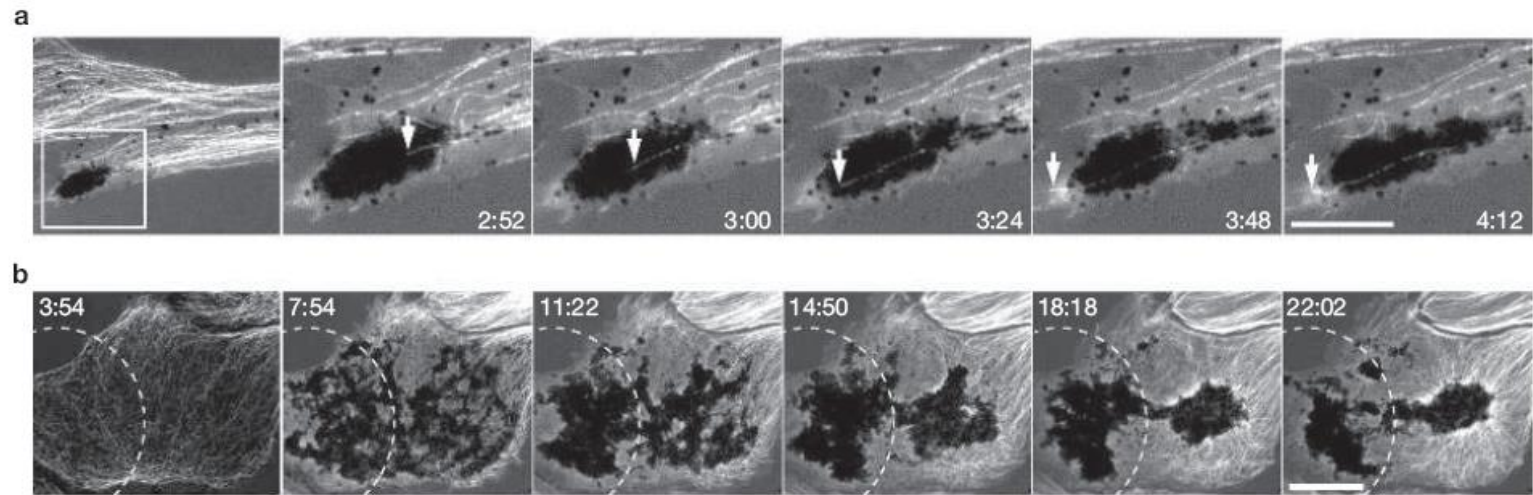
without centrosome - by motors

Mechanism of self-centering of the microtubule array: microtubule dynamics and transport along newly nucleated microtubules



Malikov et al., NCB, 2005

Movement along Mt nucleated in the cytoplasm



Centering by pushing

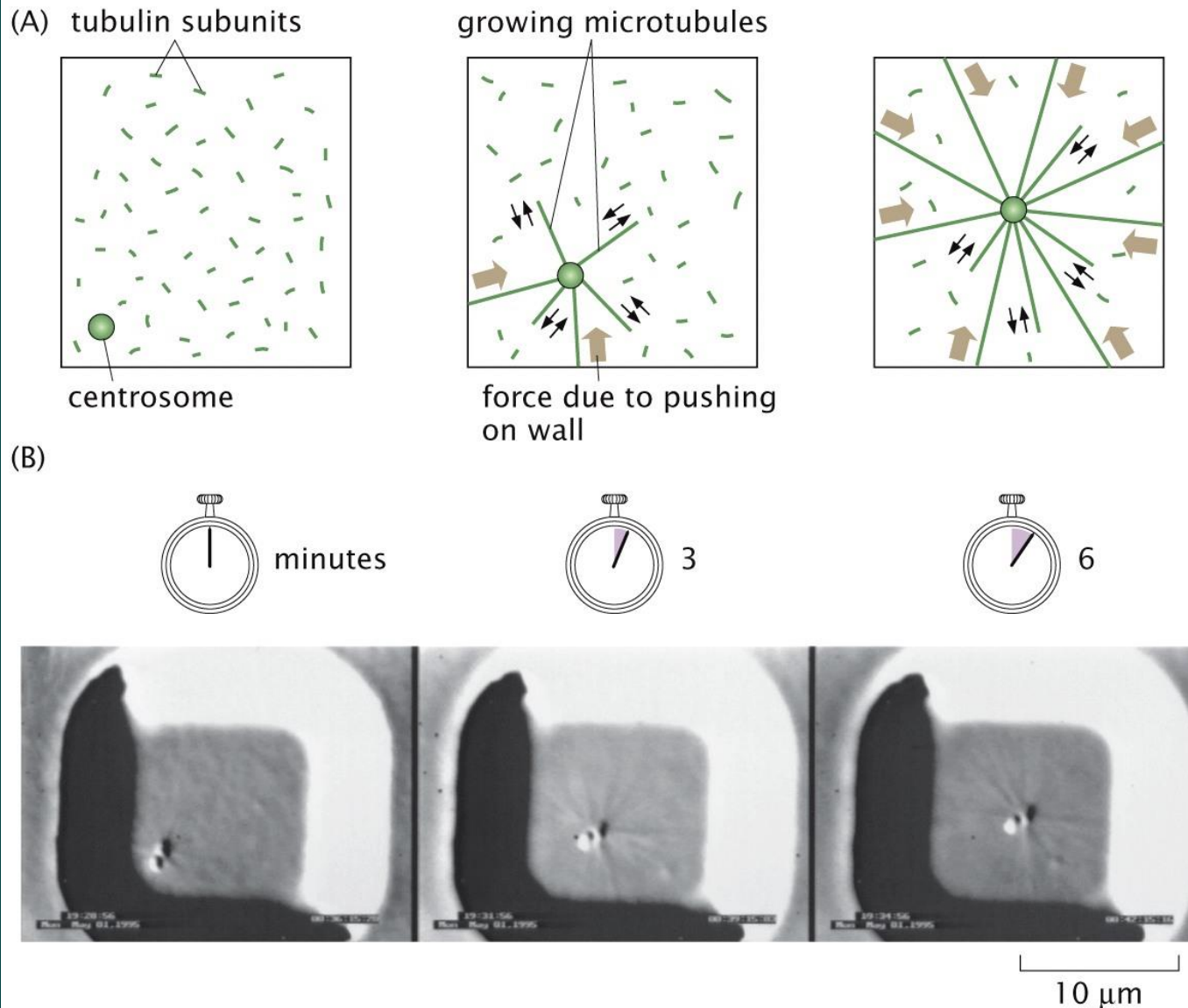
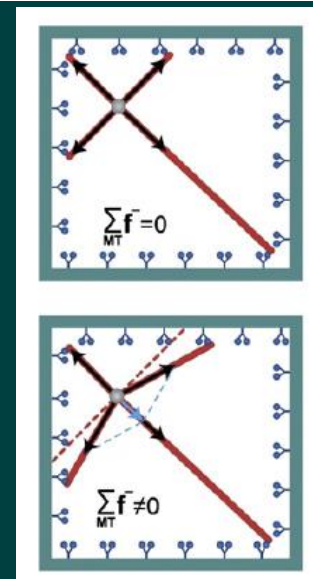
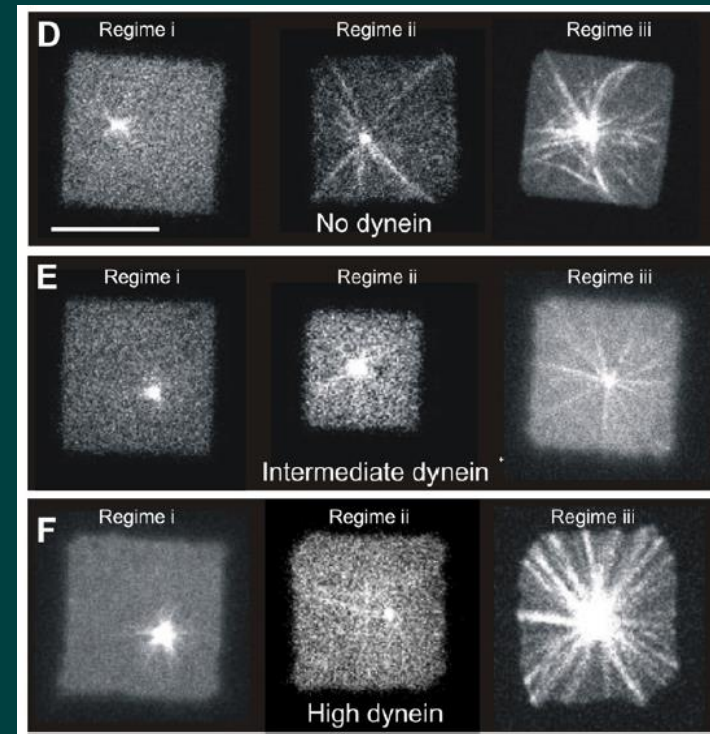
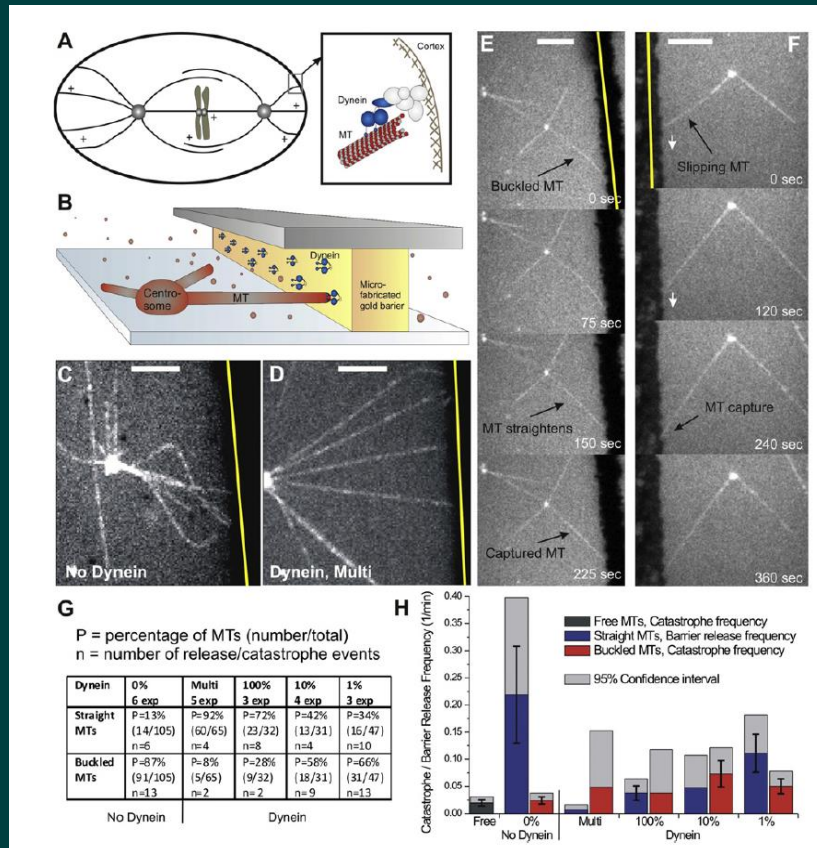


Figure 16.51 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Centering by pulling



Laan et al., 2012

cell division



Video Enhanced DIC Microscopy
of Mitosis in Newt Lung Cells
(*Taricha granulosa*)

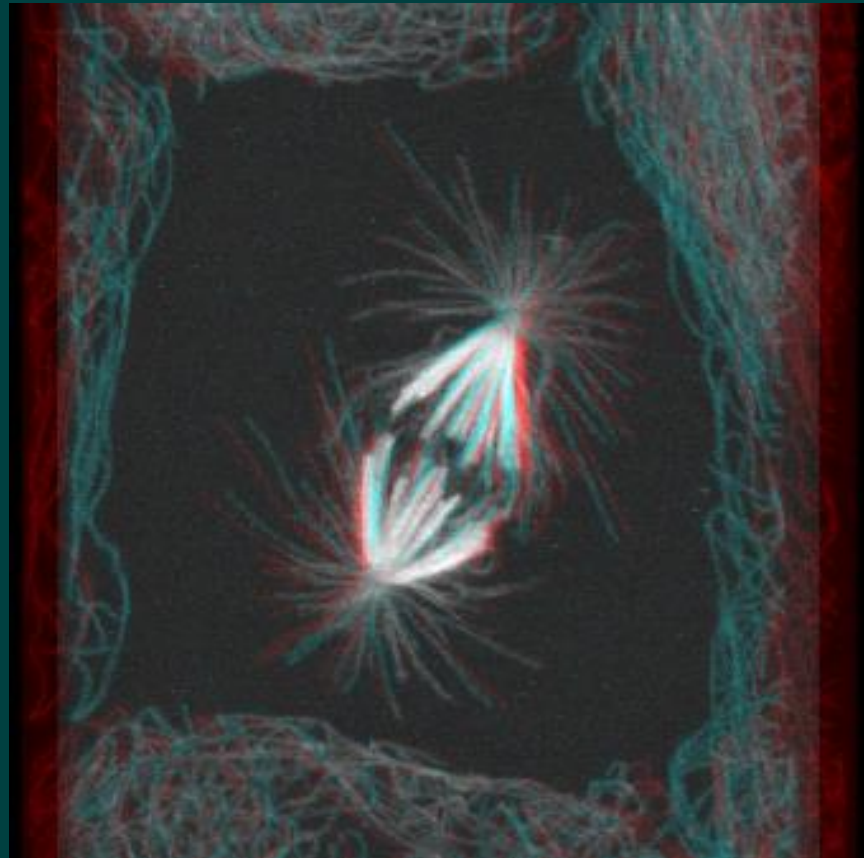
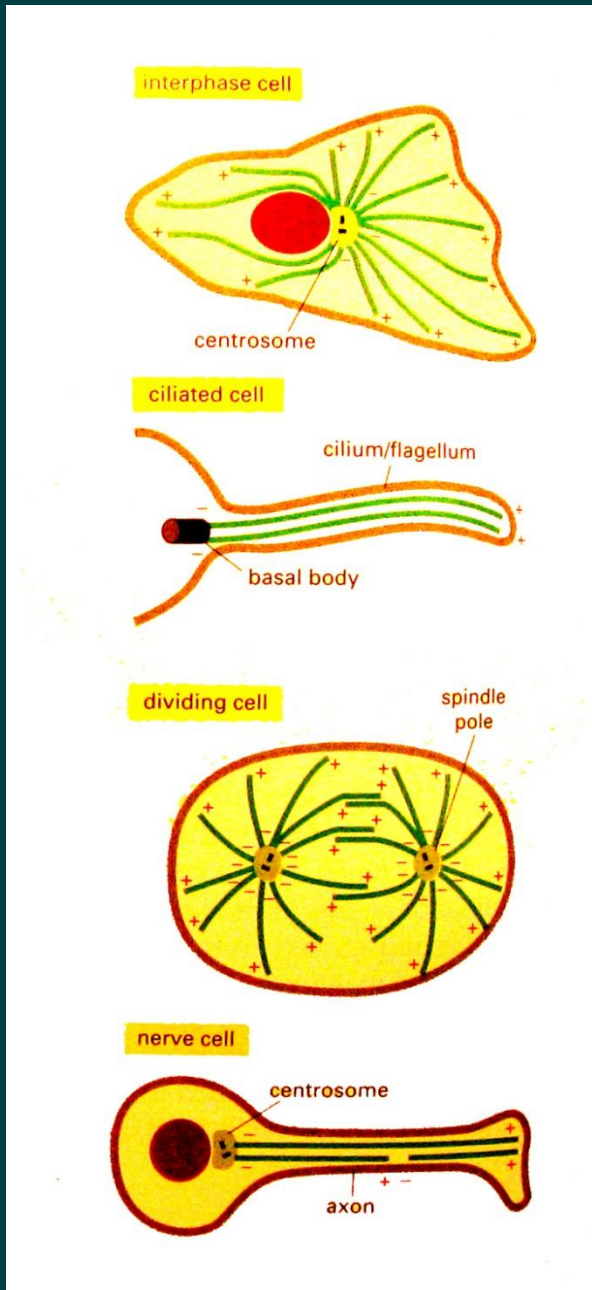
Victoria Skeen,
Robert Skibbens, and
E. D. Salmon

University of North Carolina at Chapel Hill
(see Skibbens et al., 1993, J. Cell Biol.
122:859-875)

Frame Time = HR:MIN:SEC

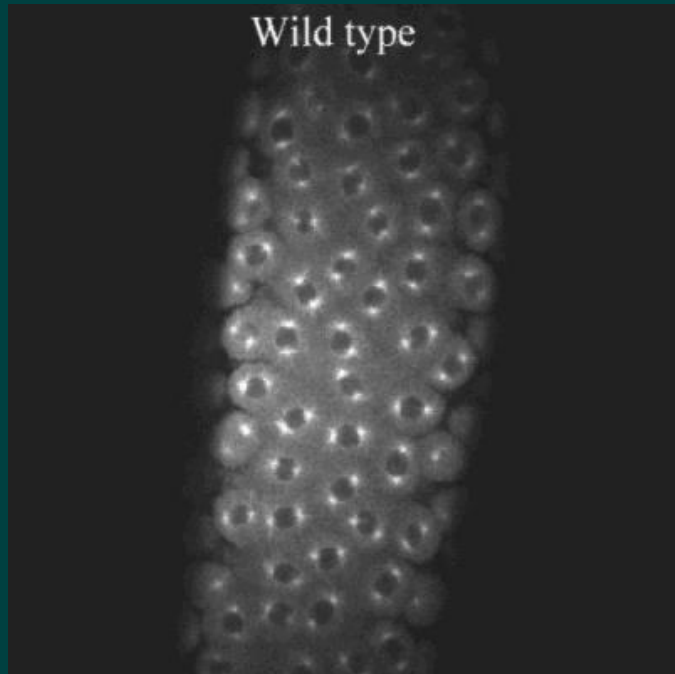
Salmon lab. web site

Microtubules organization in cell division: mitotic spindle

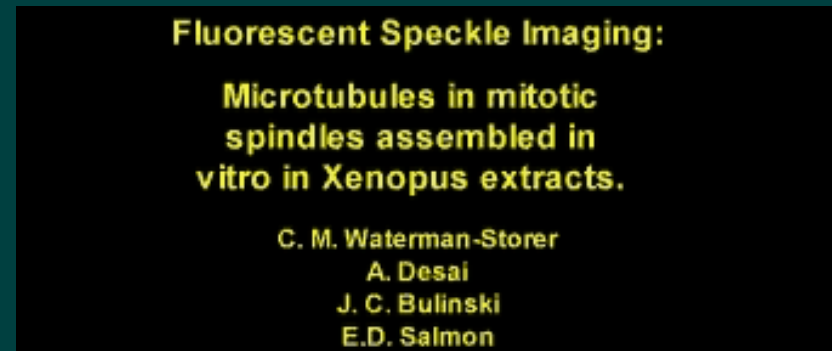
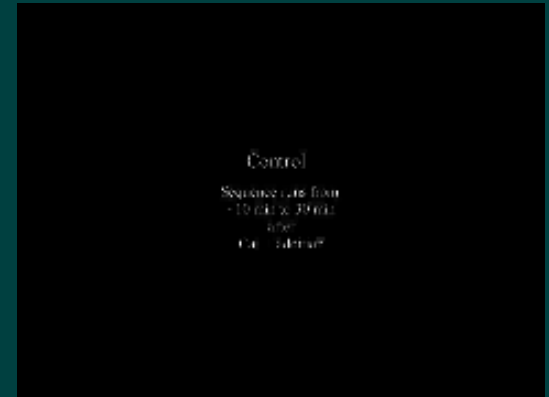


Salmon lab. web site

examples of spindle dynamics

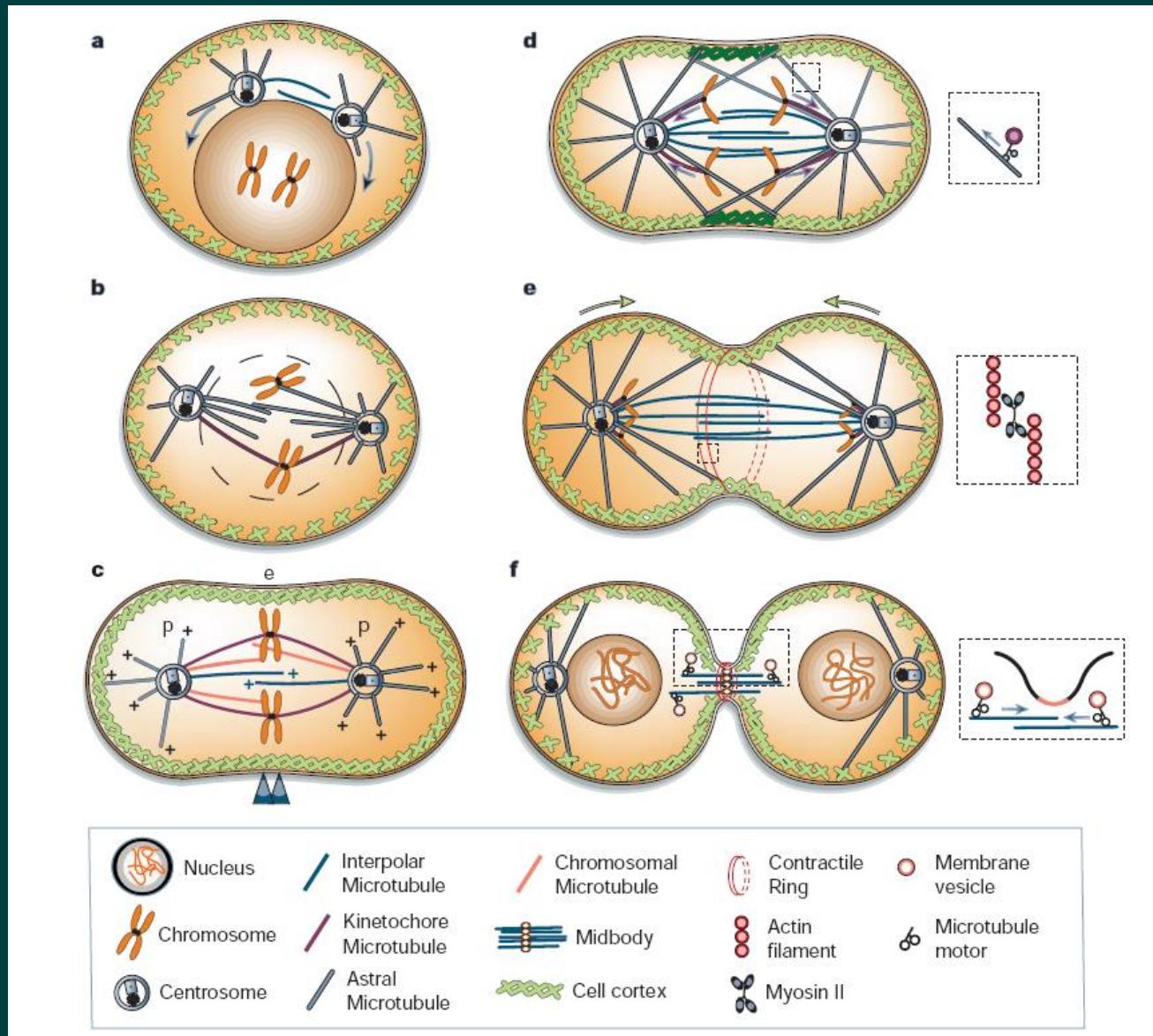


Drosophila embryo
Sharp et al.,
Mol. Biol. Cell, 2000

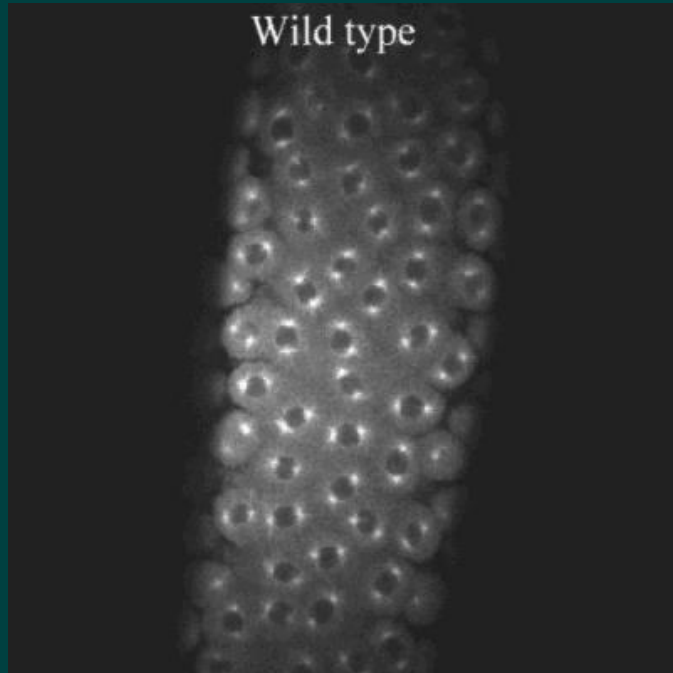


Xenopus egg extract

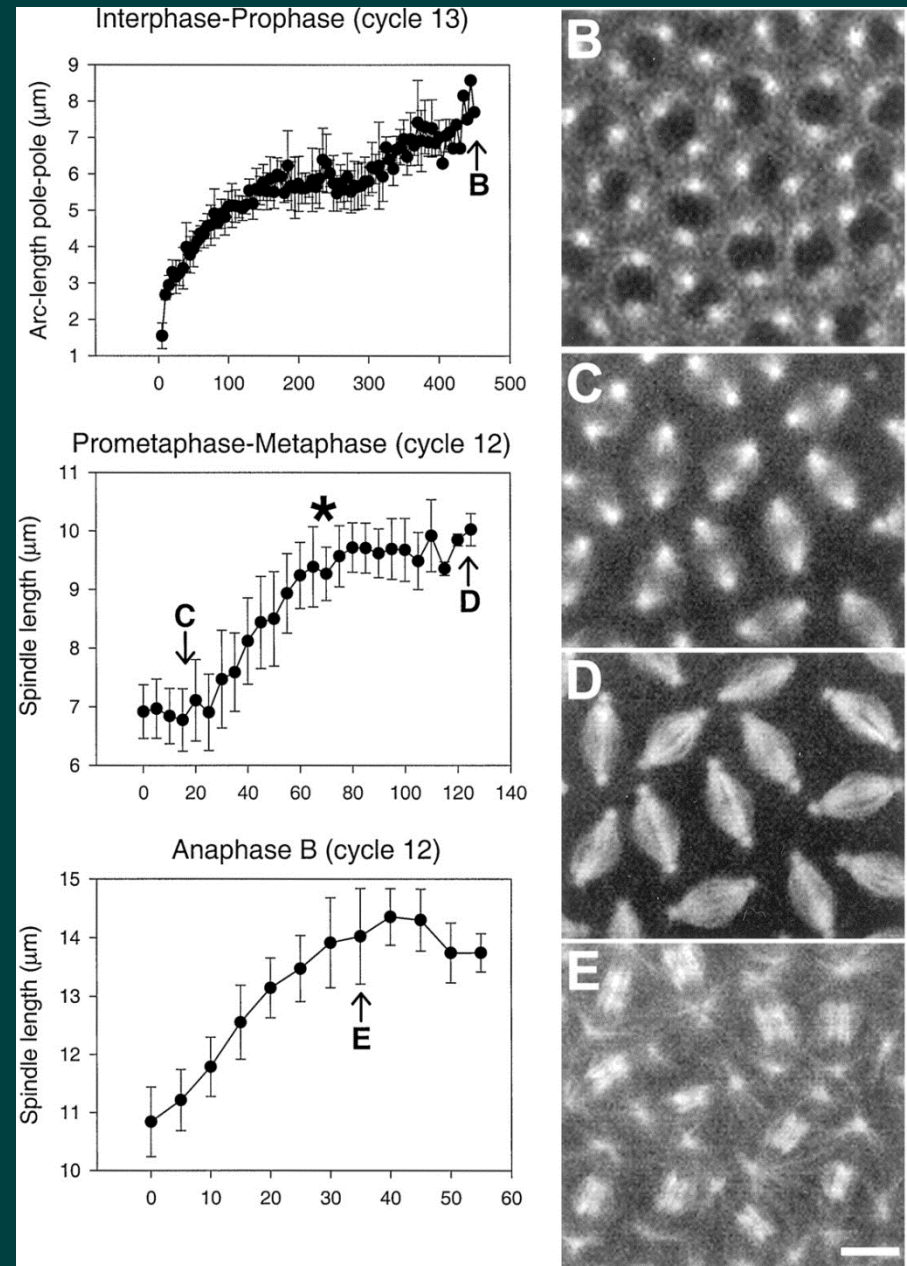
Phases of cell division



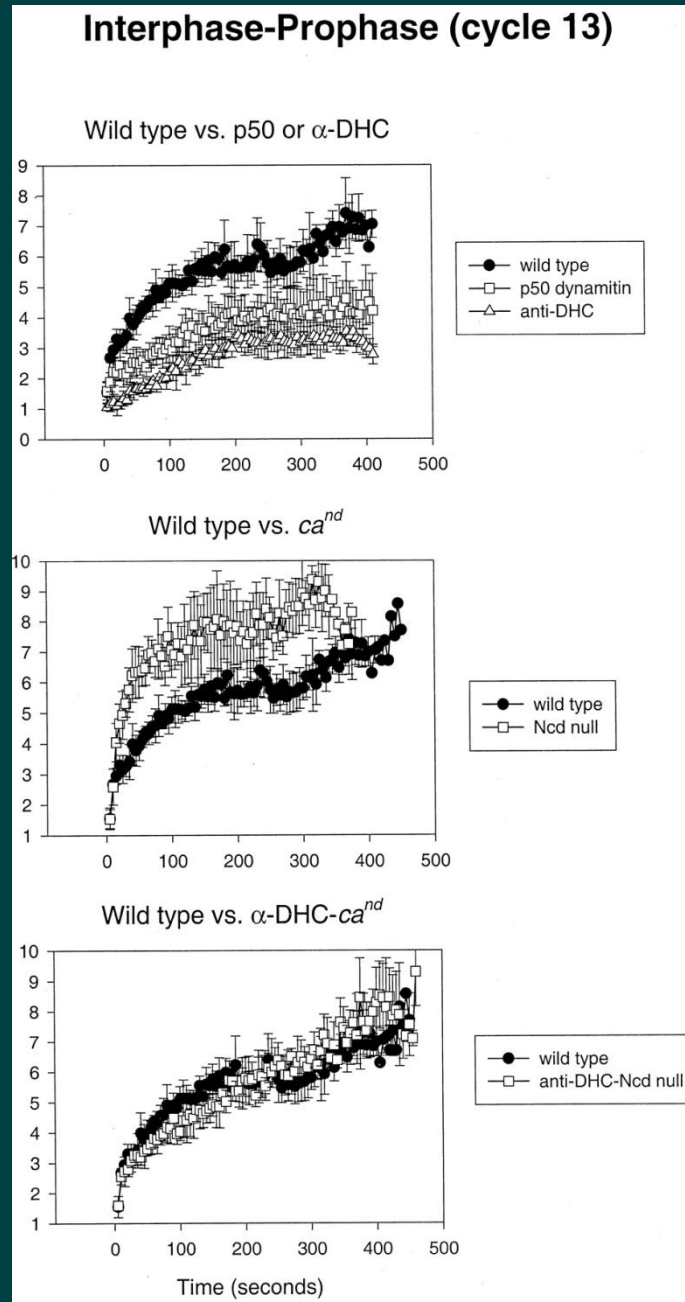
Multiple motors in pindle pole separation during mitosis



Sharp et al., Mol. Biol. Cell, 2000

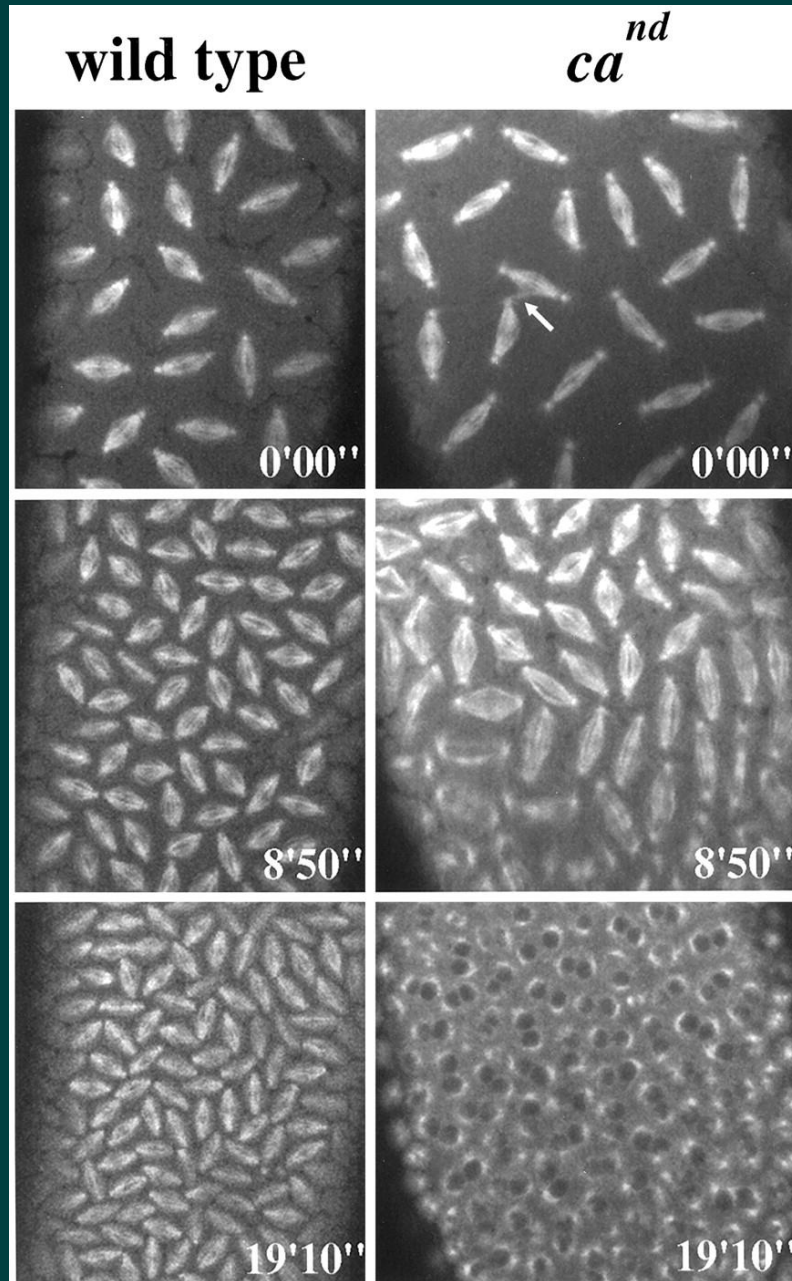


Balance of two – end directed motors: dynein and NCD



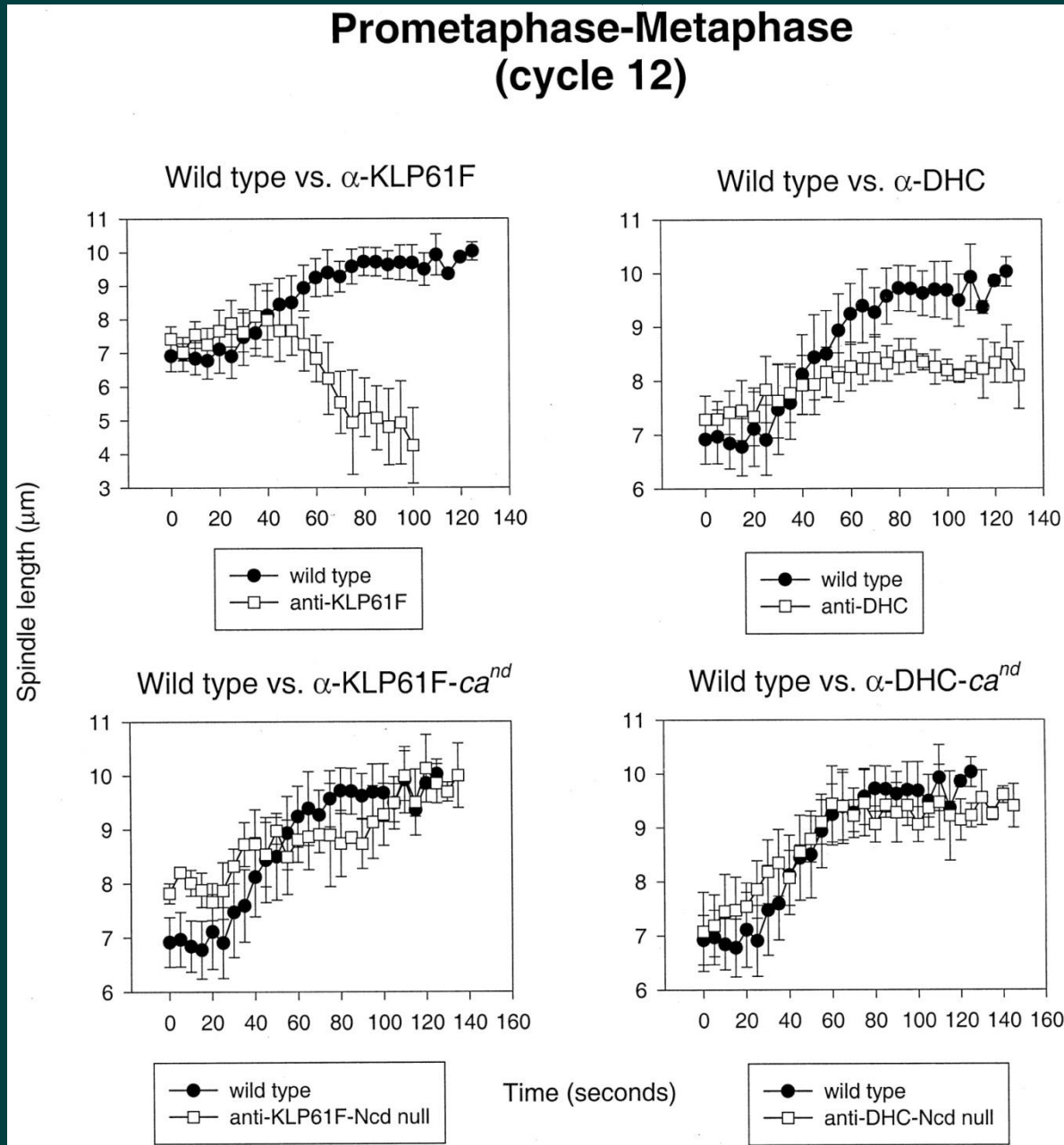
Sharp et al., Mol. Biol. Cell, 2000

without NCD it's faster



Sharp et al., Mol. Biol. Cell, 2000

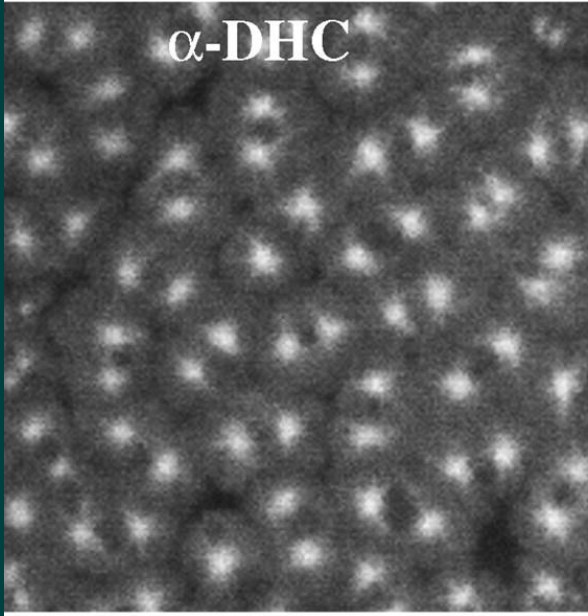
Balance of three motors: dynein and NCD (-end), and KLP61F (+end)



Sharp et al.,
Mol. Biol. Cell, 2000

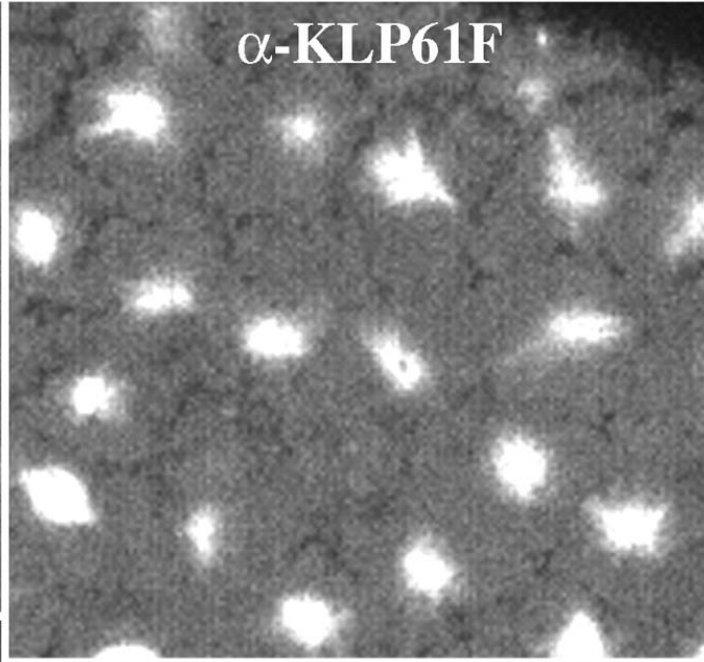
Inter-Pro

α -DHC

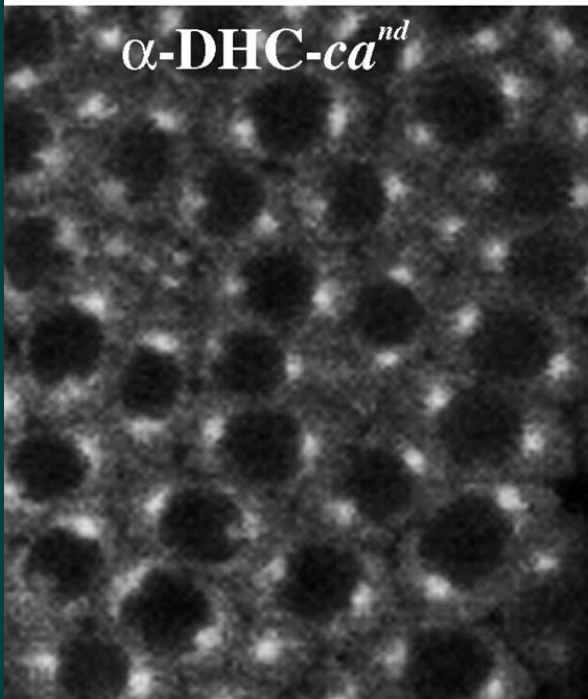


Promet-Met

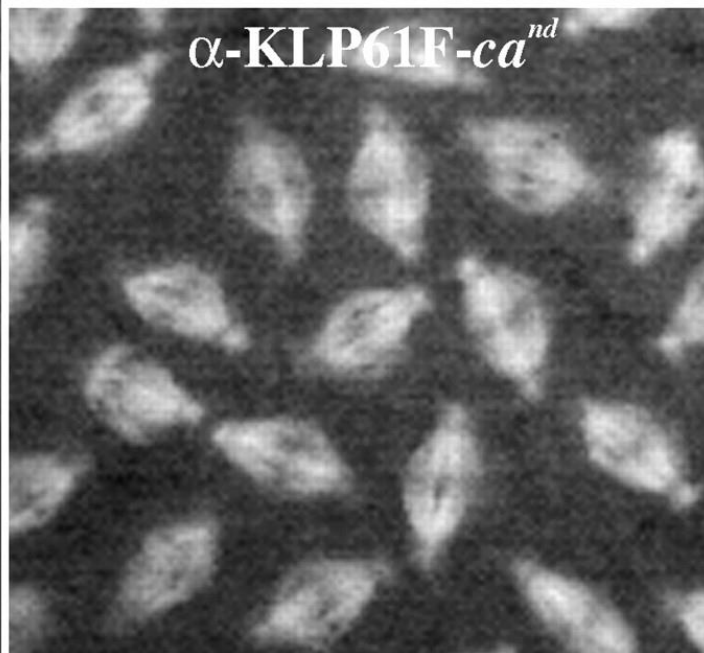
α -KLP61F



α -DHC-*ca*nd

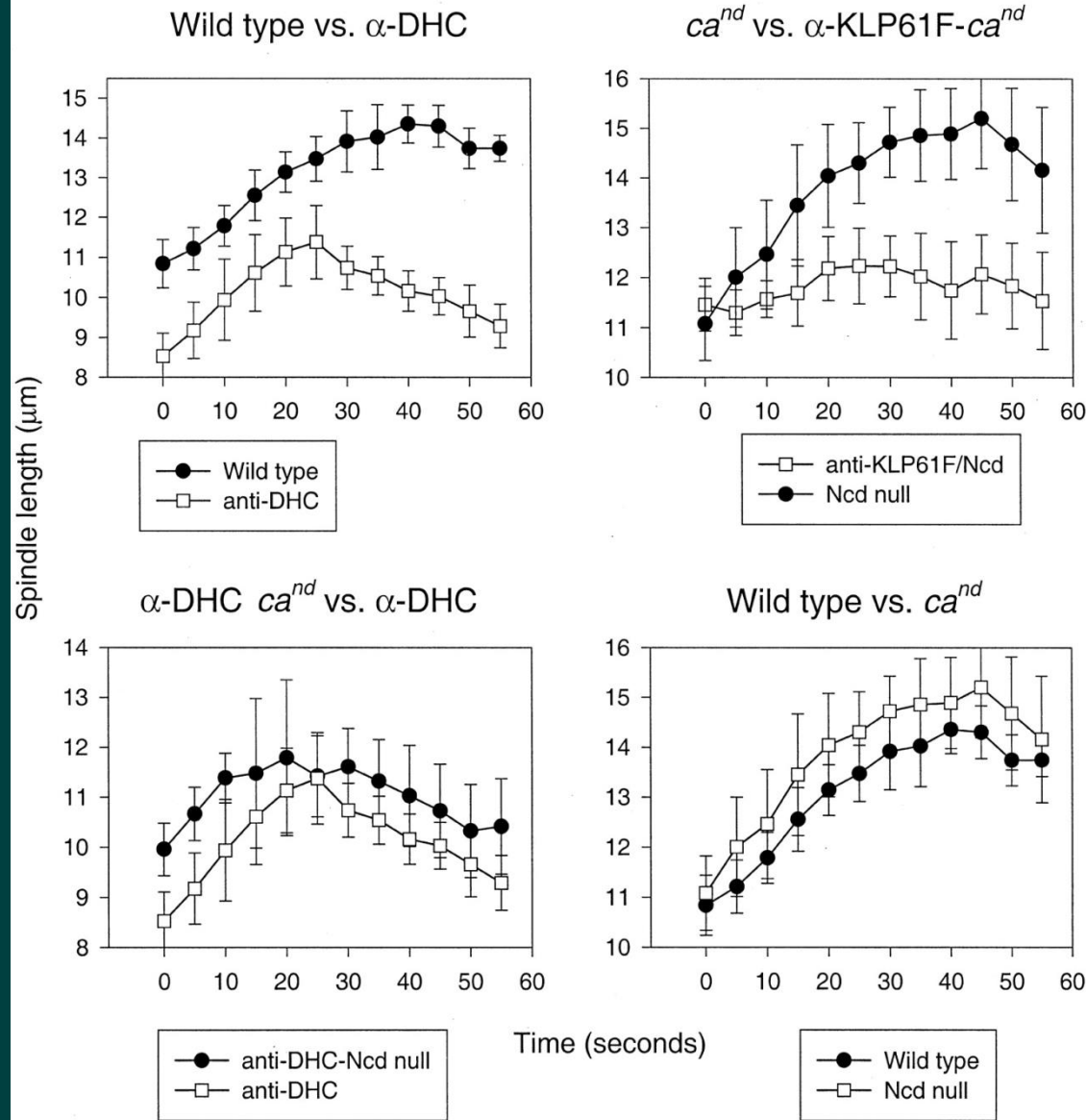


α -KLP61F-*ca*nd

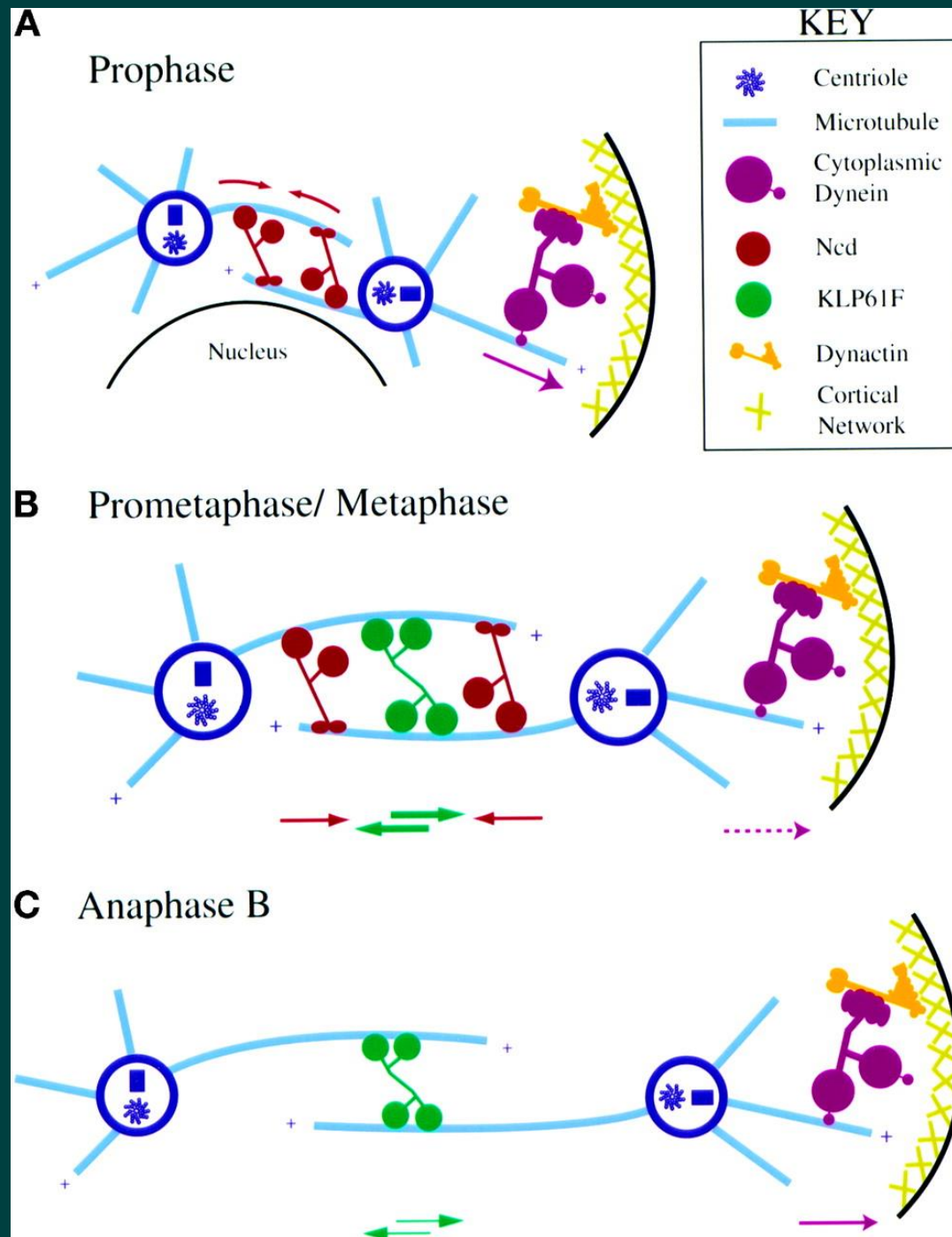


How many motors are working in anaphase?

Anaphase B (cycle 12)



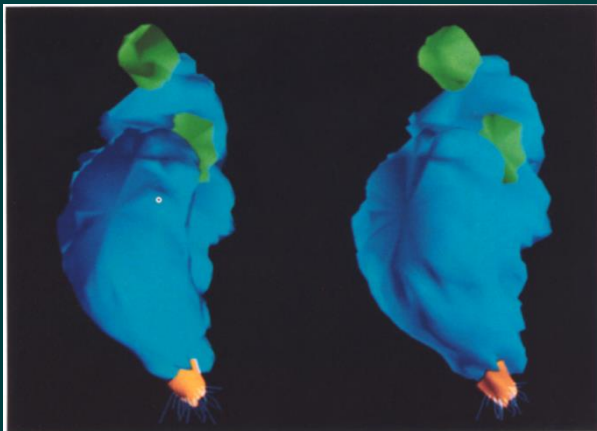
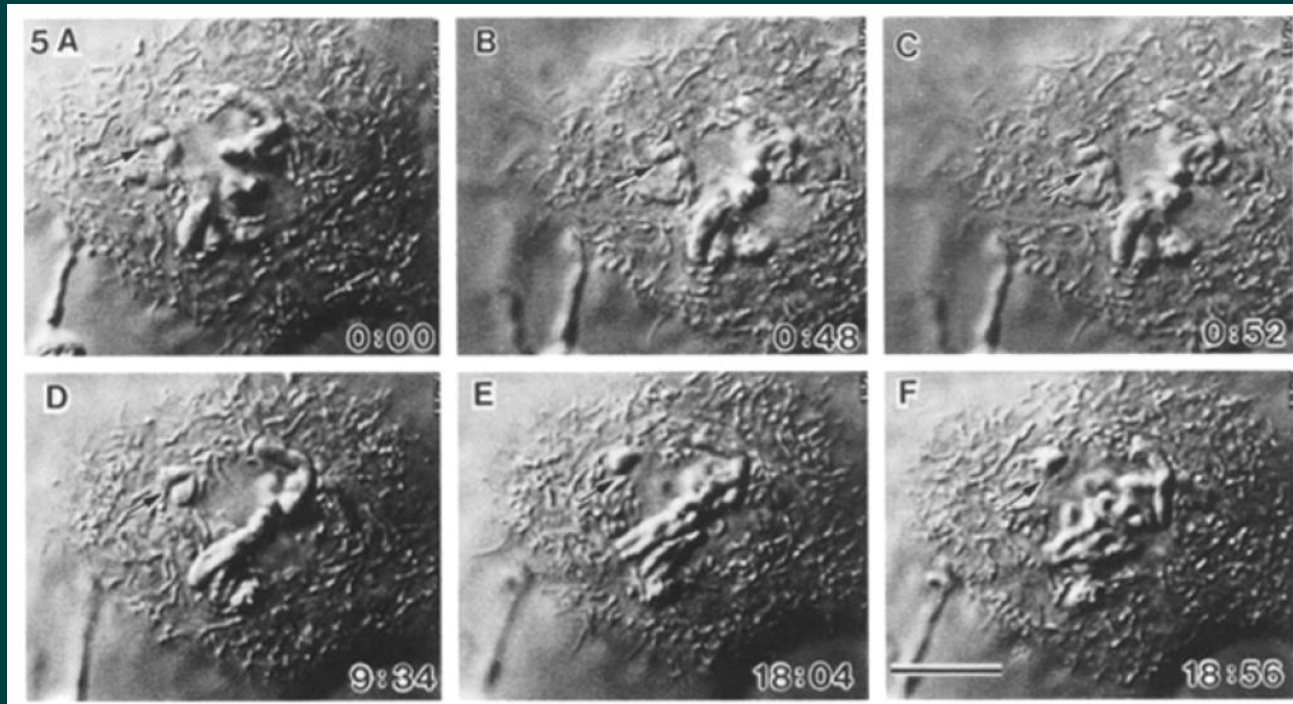
Sharp et al.,
Mol. Biol. Cell, 2000



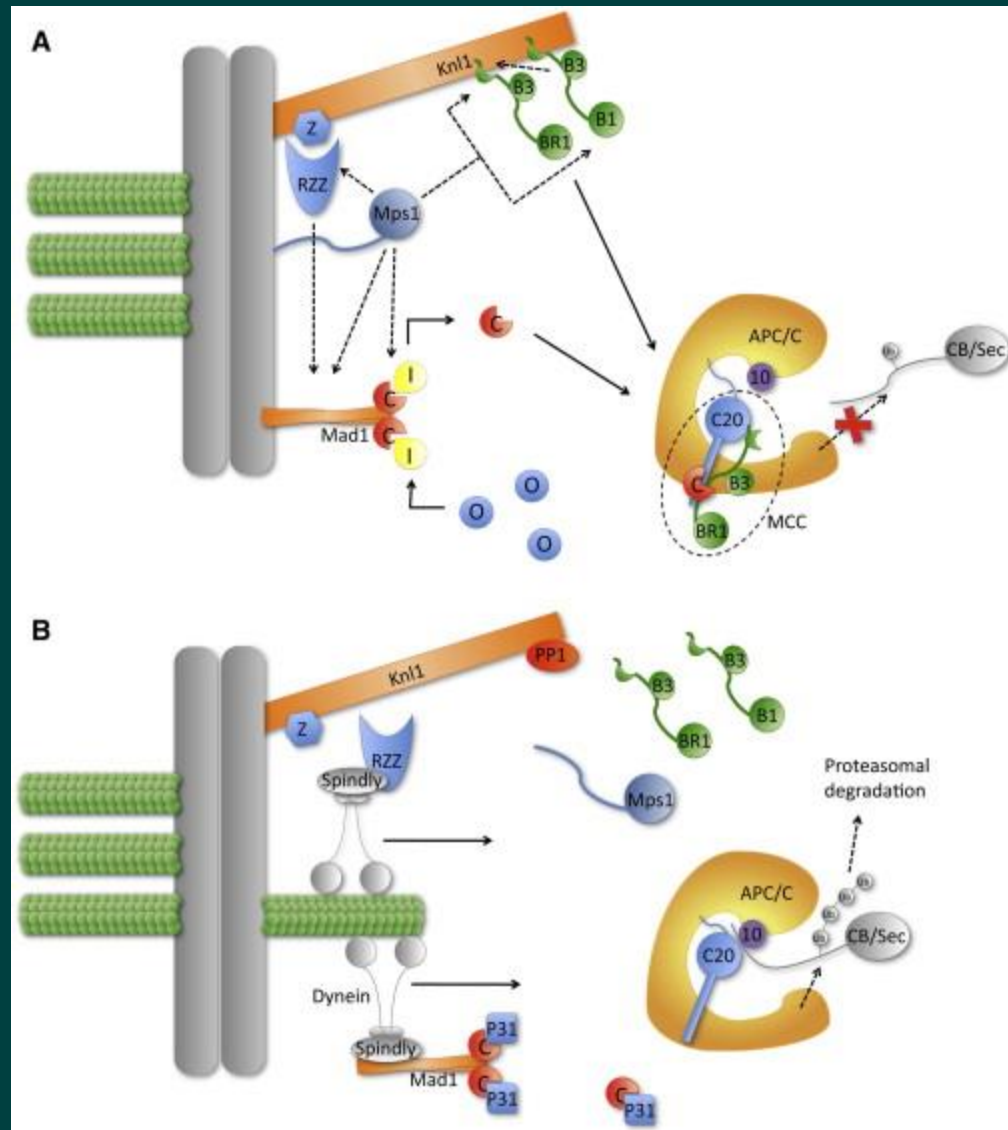
Sharp et al.,
Mol. Biol. Cell, 2000

Mitotic checkpoint: wait until all chromosomes are attached (in a proper fashion)

Anaphase starts after unattached kinetochore is destroyed by laser



Mitotic checkpoint complex



Vleugel et al.,
Dev. Cell, 2012