

# Mechanical basis for organelle movement in cells

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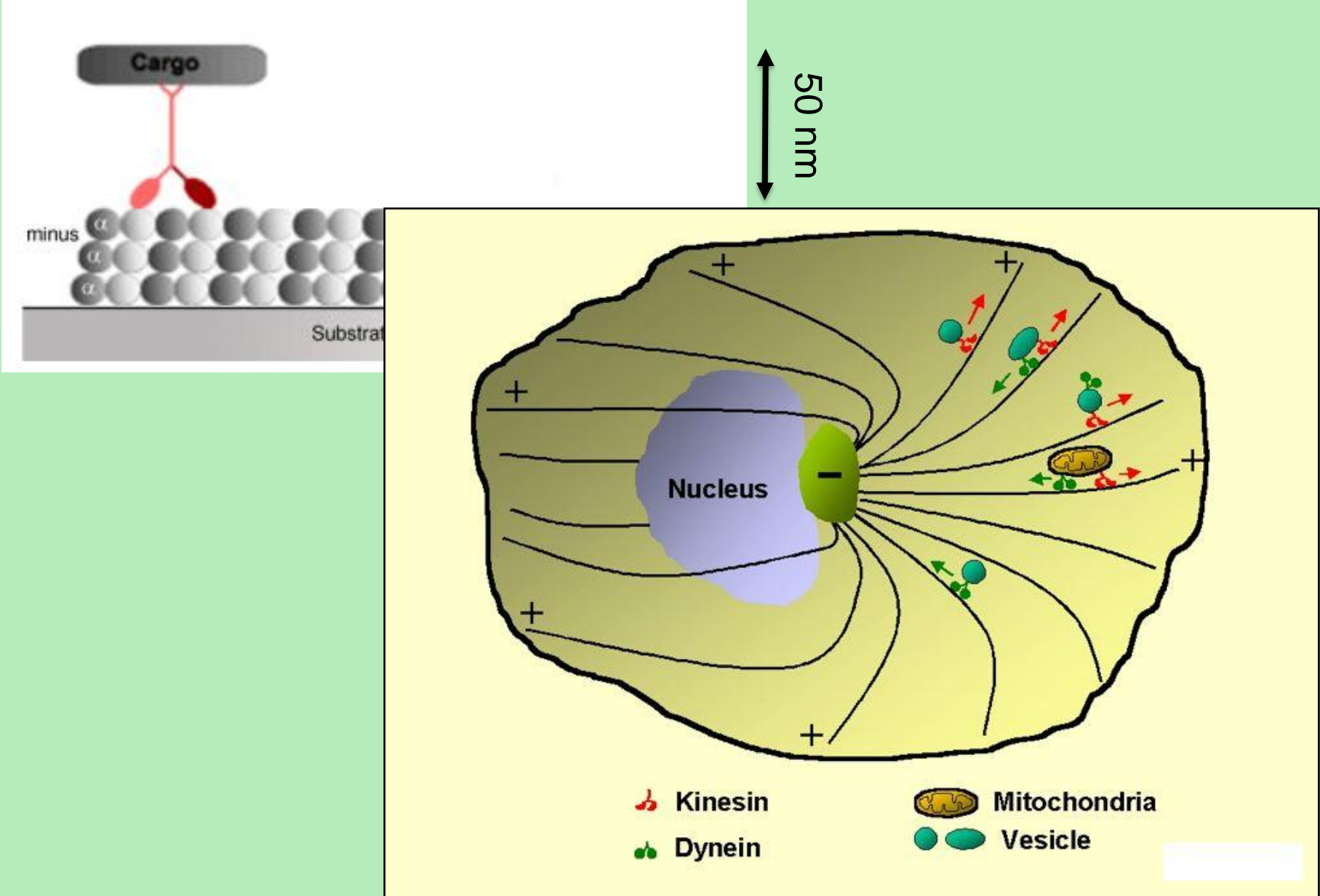
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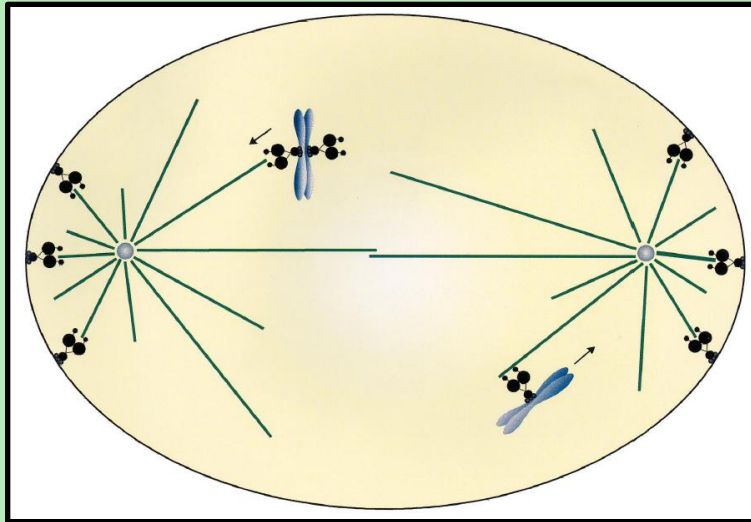
Transport and Biogenesis of Lipid Droplets  
in Mammalian Liver

# Cytoskeletal Motors

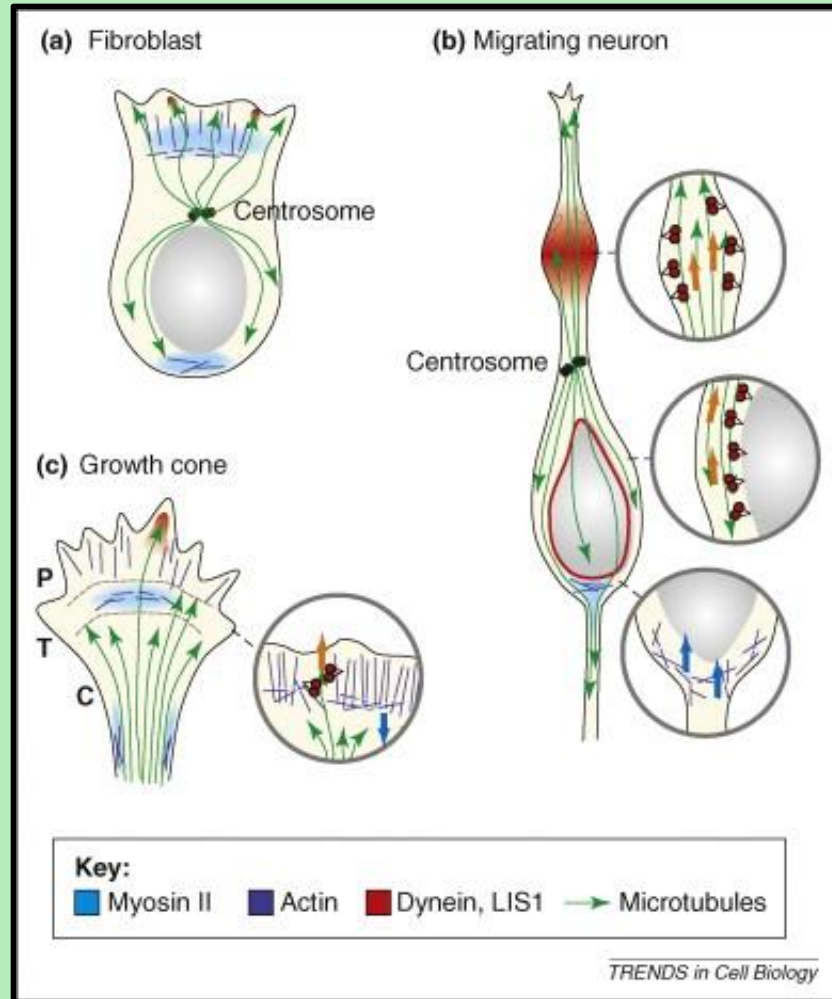
<http://www.imb-jena.de/~kboehm/>



# Many cellular processes use Multiple Motors



*Vallee et al, 2000*



*Vallee et al, 2009*

Nuclear transport in Muscle Fibers, MTOC reorientation in Immune cells, Beating of flagella, Maintenance of Golgi structure,

# Core properties of Motors important for collective force generation ?

Soppina et .al. *PNAS* (2009)

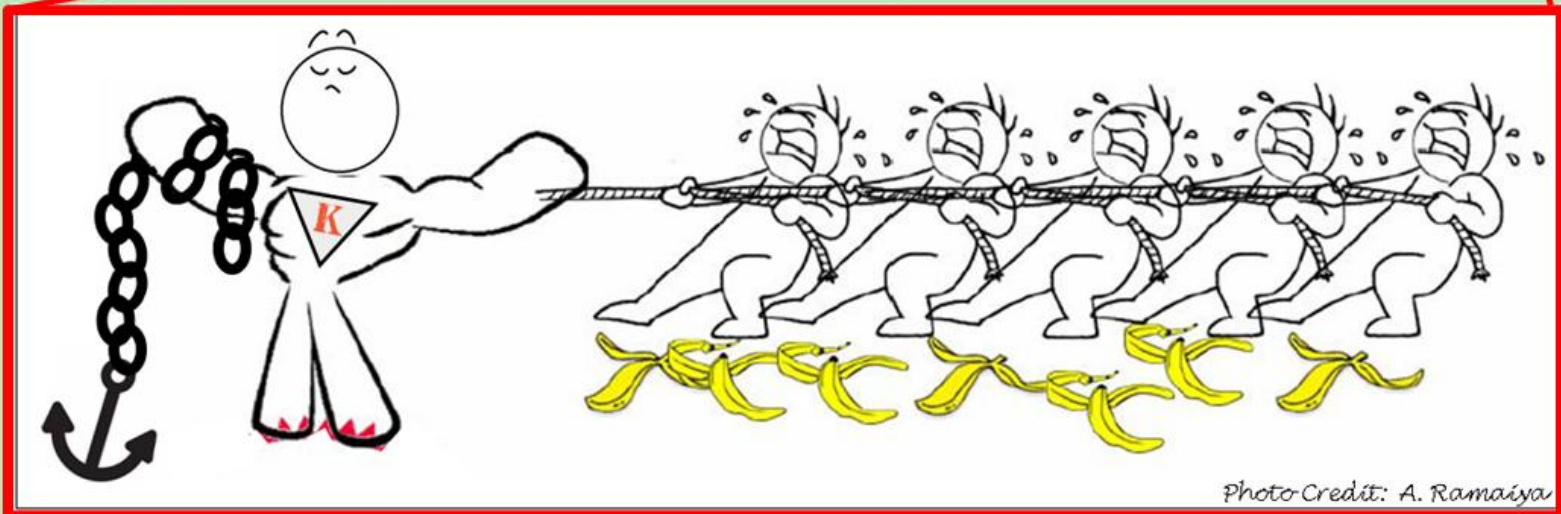
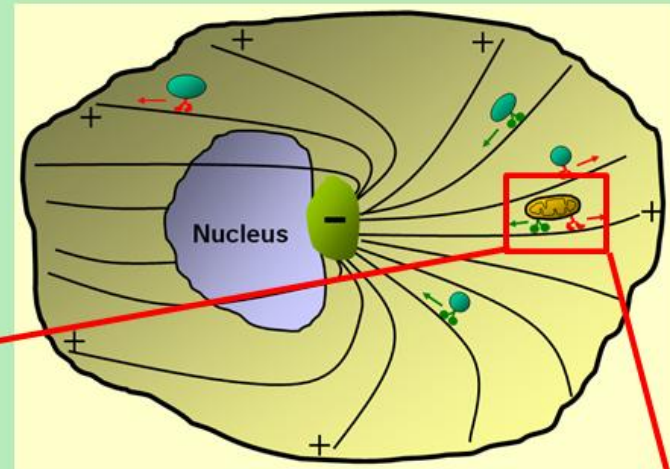
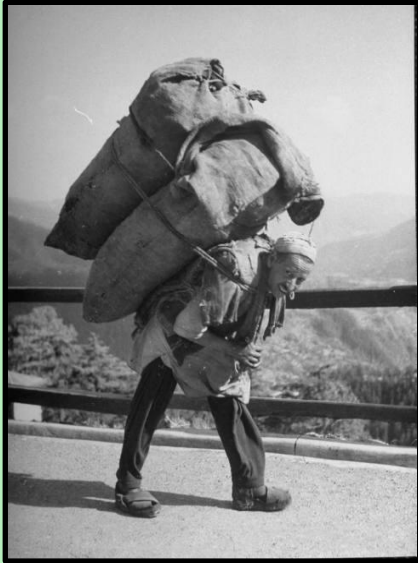


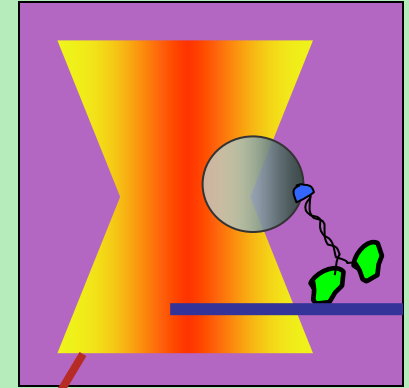
Photo Credit: A. Ramaiya

# Optical trapping

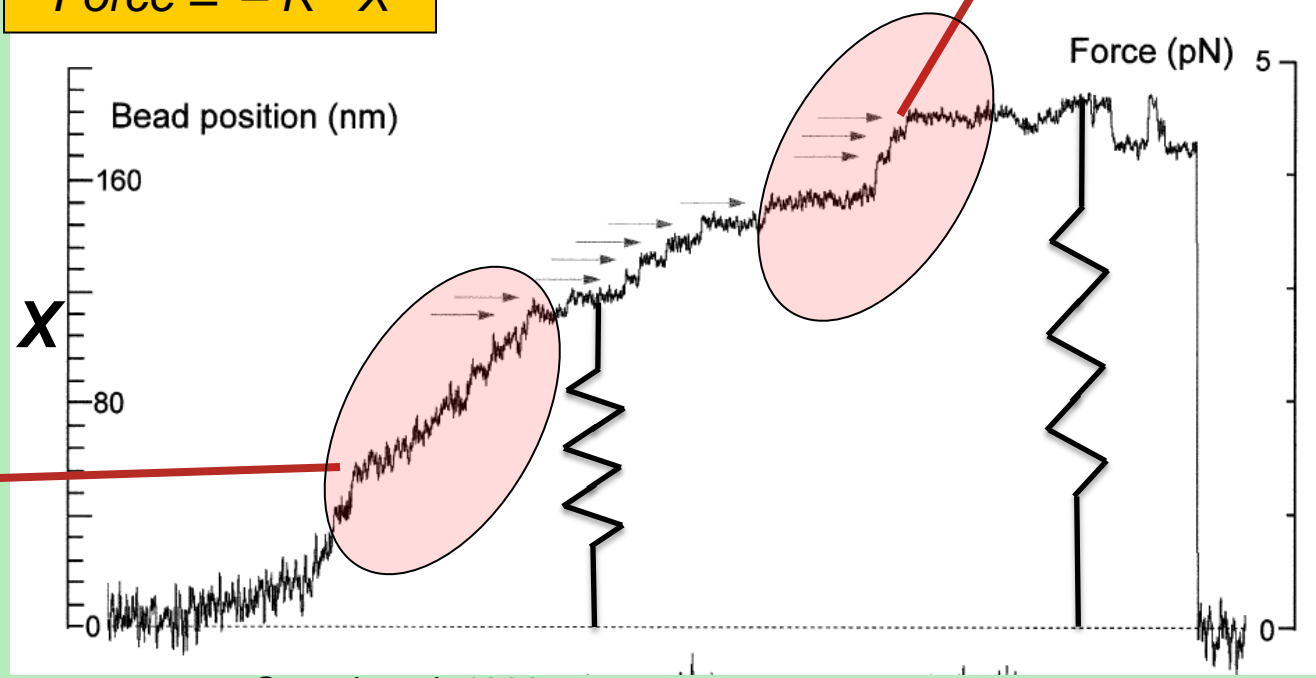
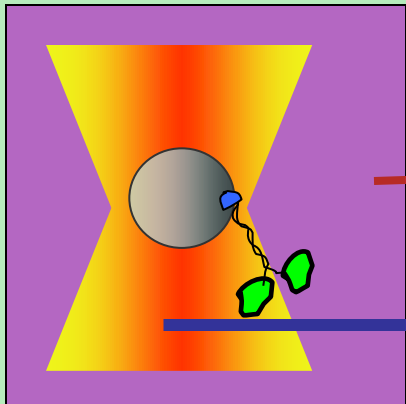


5 microns

$X$



$$\text{Force} = -K \cdot X$$

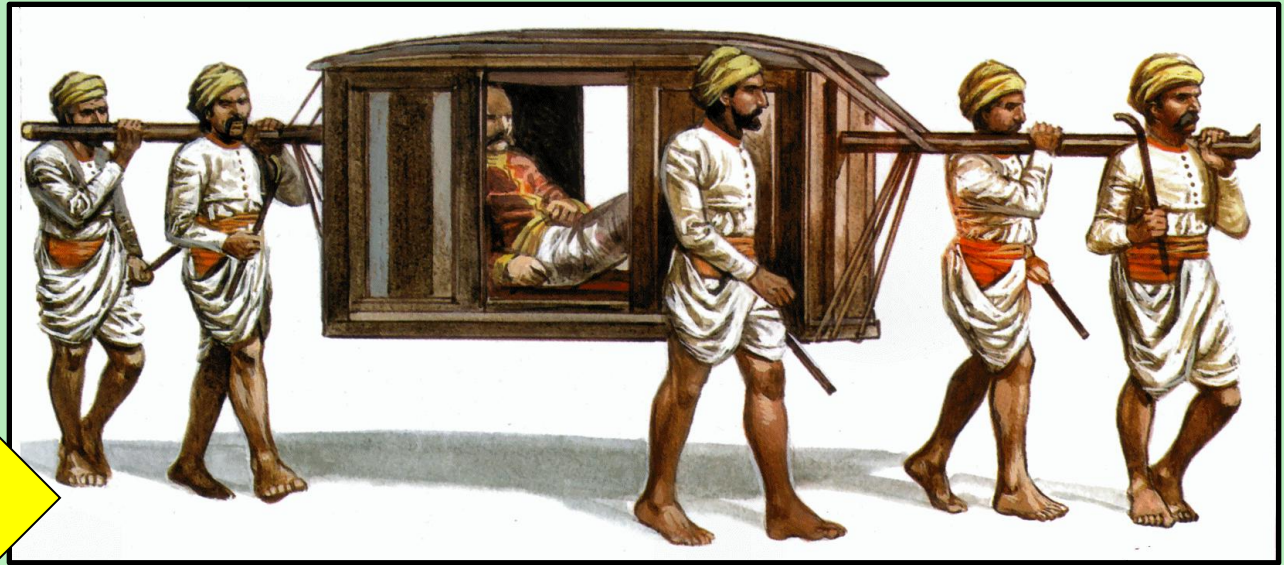


Crevel et al, 1999





??



To understand Teamwork ...

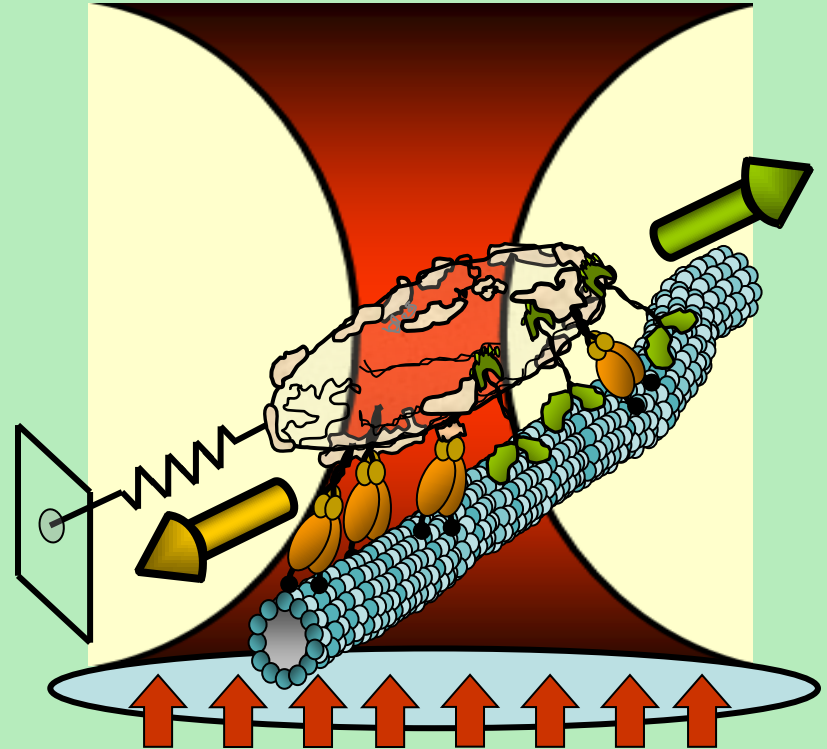
How many in a team ?

Single Motor properties

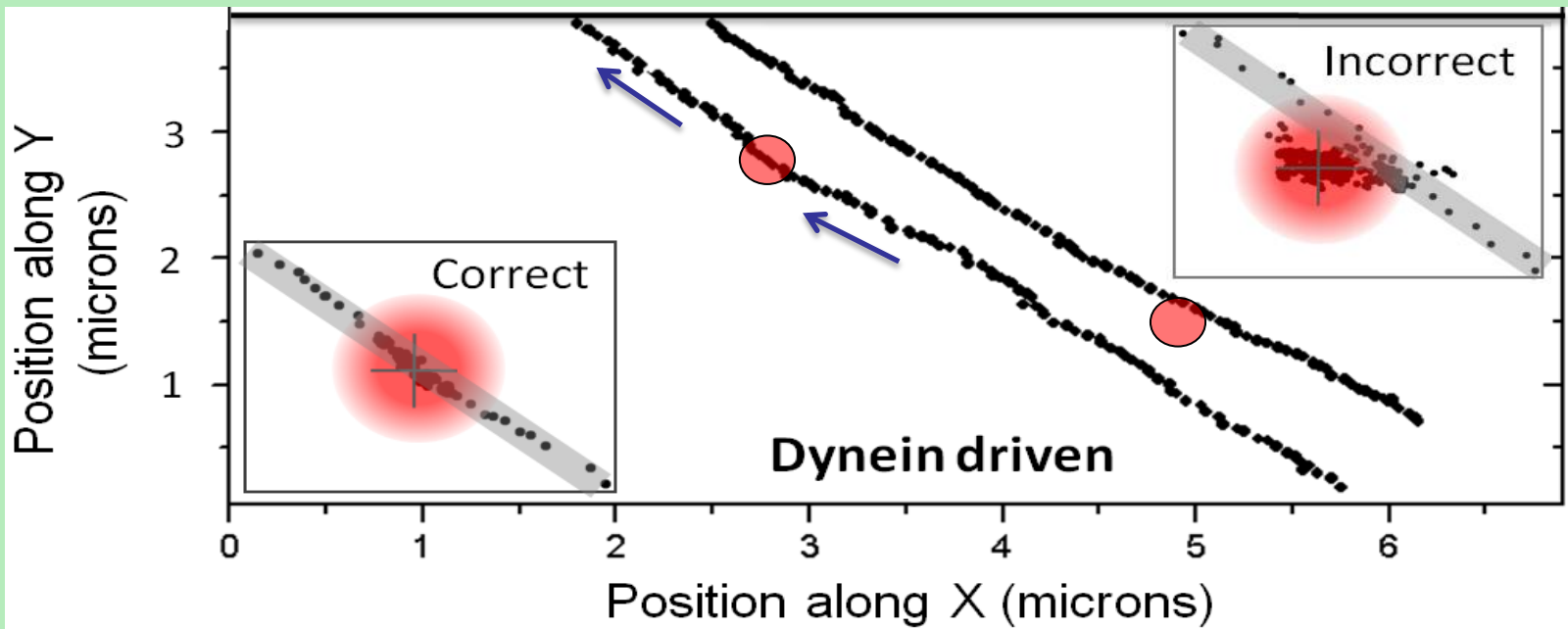
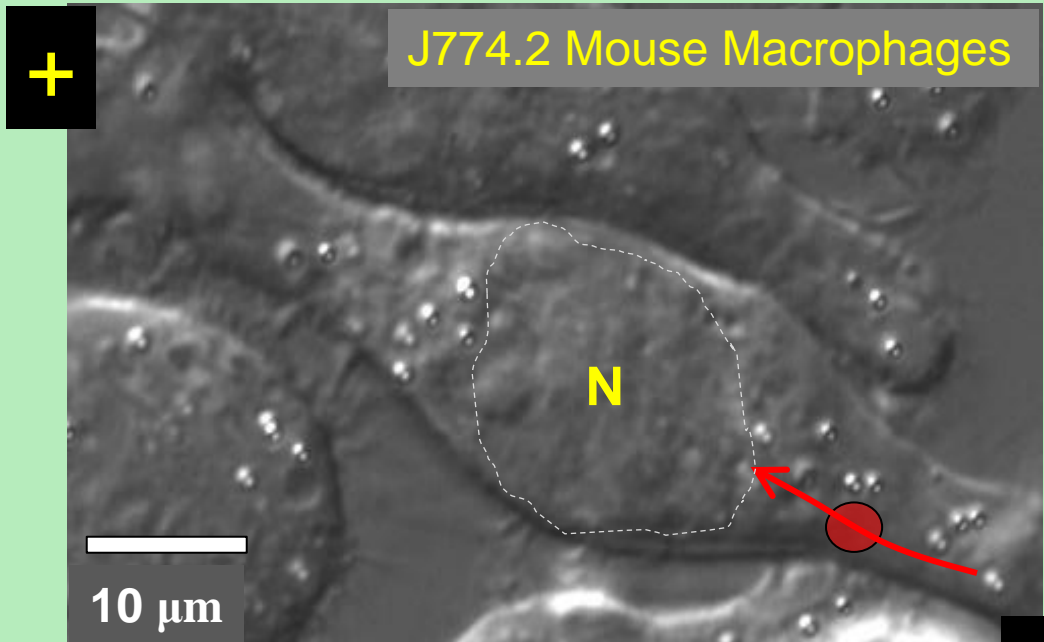
→ Strength ?

→ Tenacity ?

→ Force-Velocity Relation ?

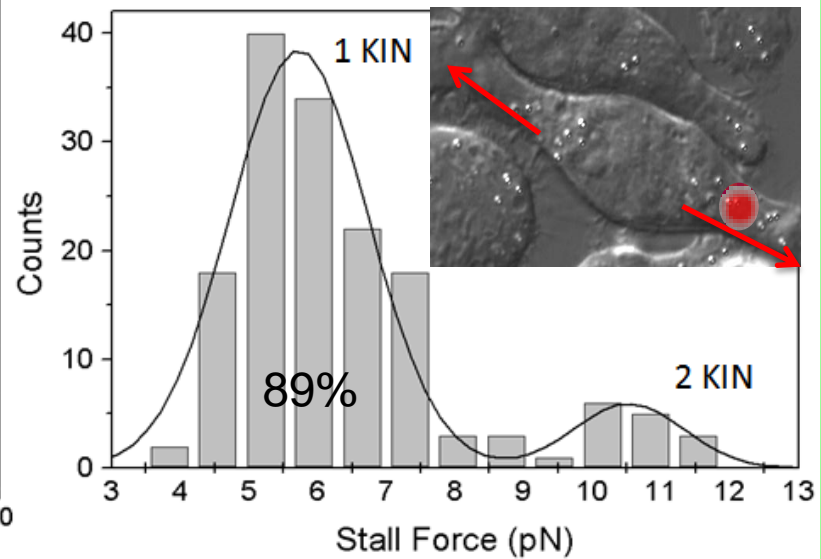
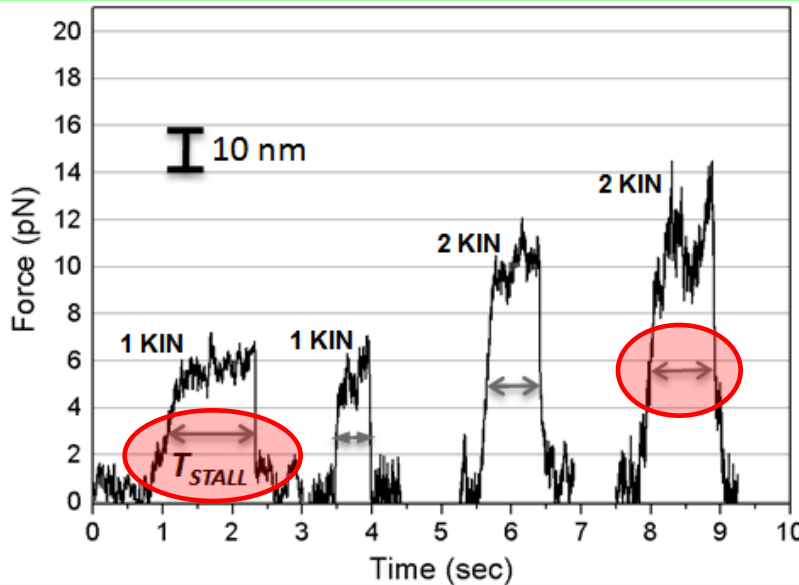


# Latex Bead Phagosomes

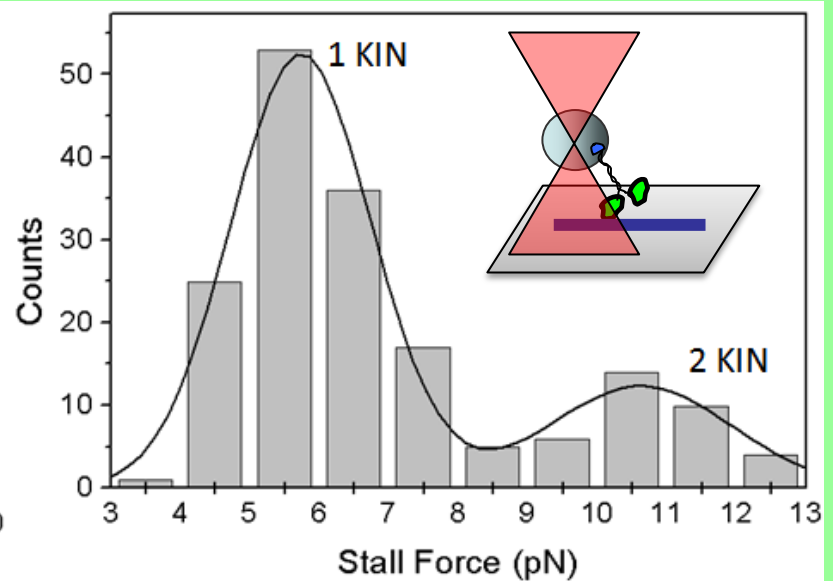
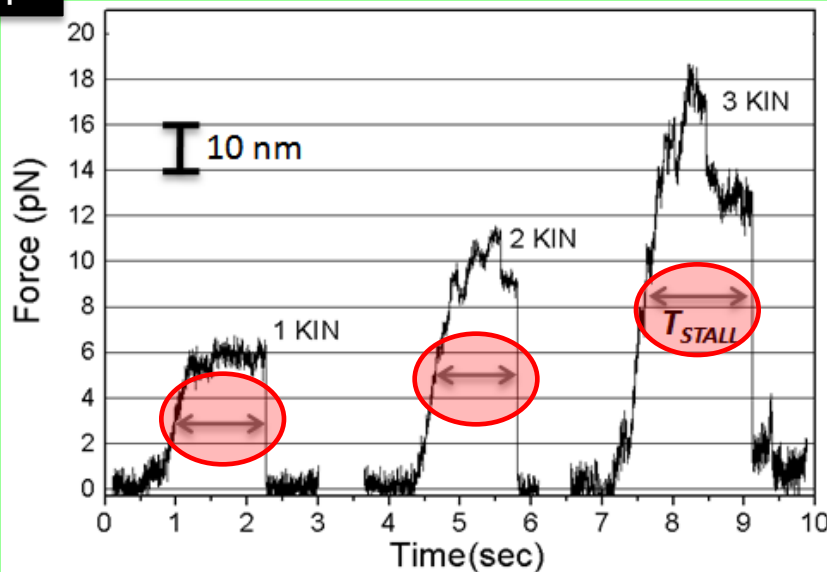


# Kinesin does *not* work well in a team ...

$5.8 \pm 1.0$  pN

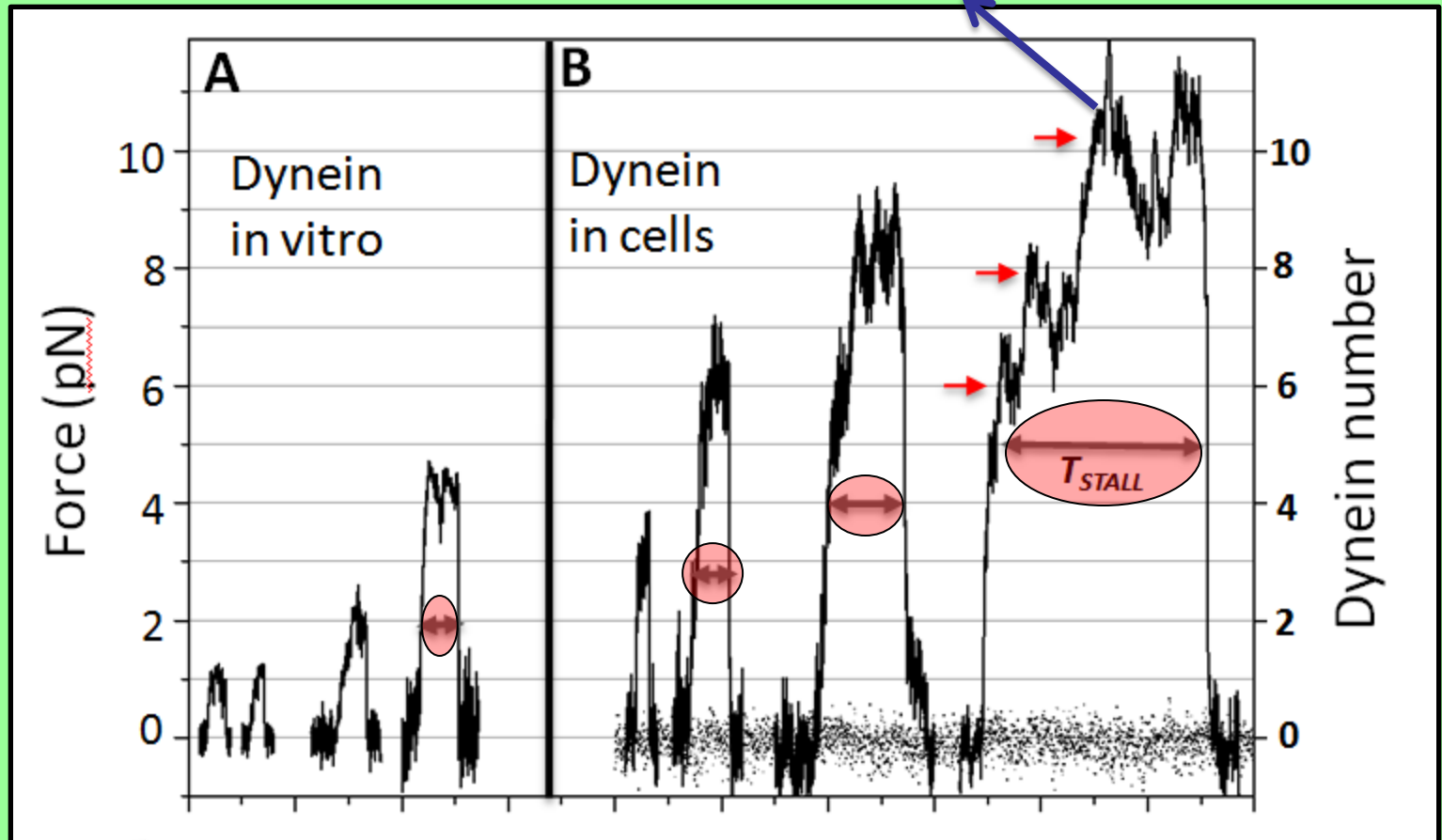
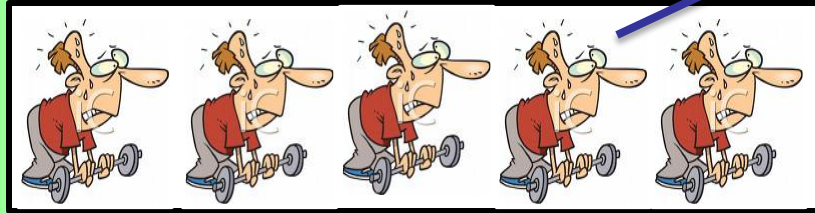
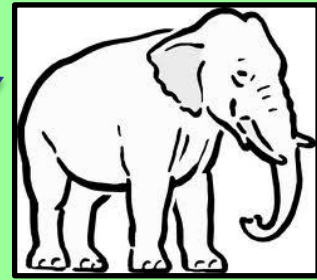


$5.7 \pm 1.0$  pN



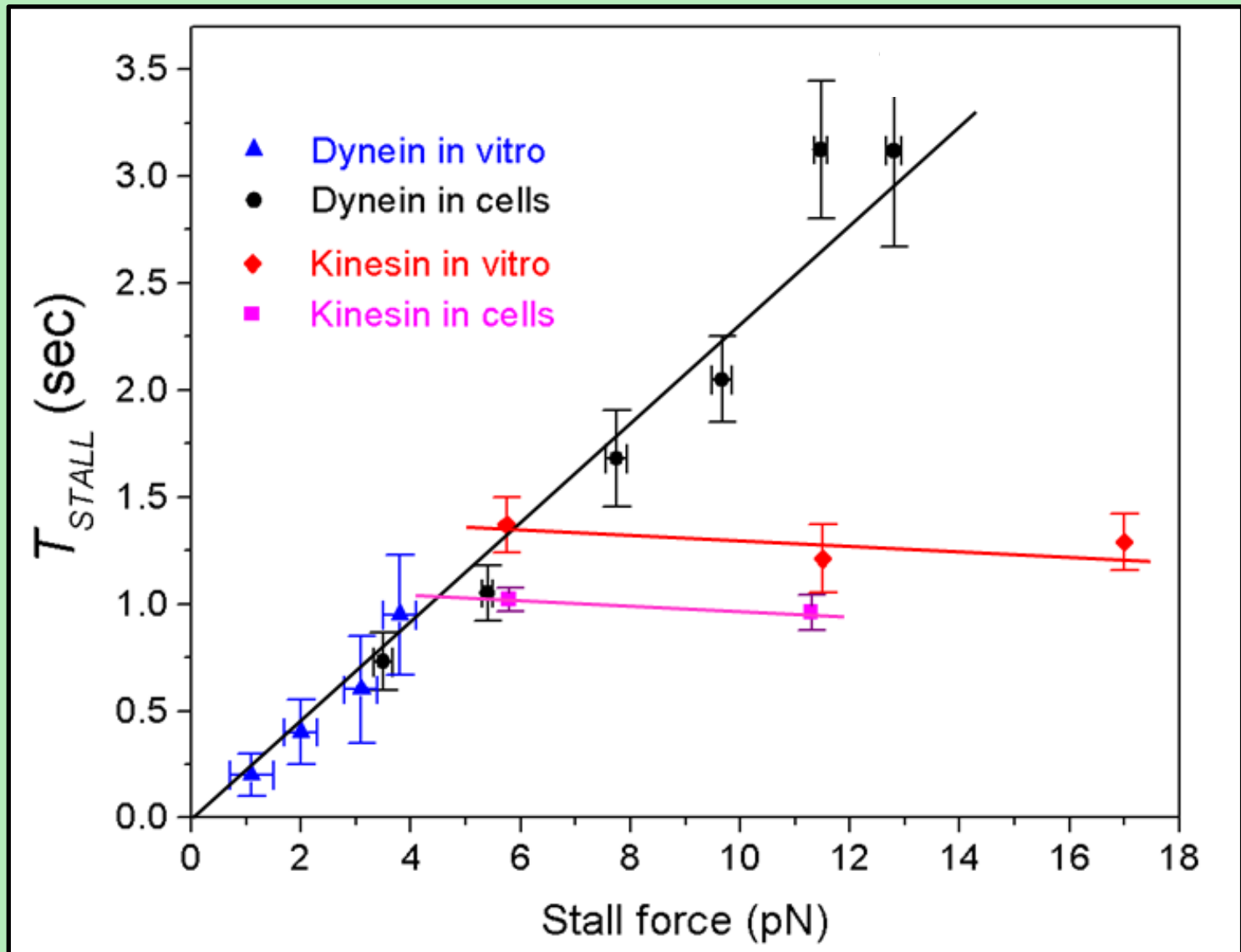


But, Dynein is a Team-player !!

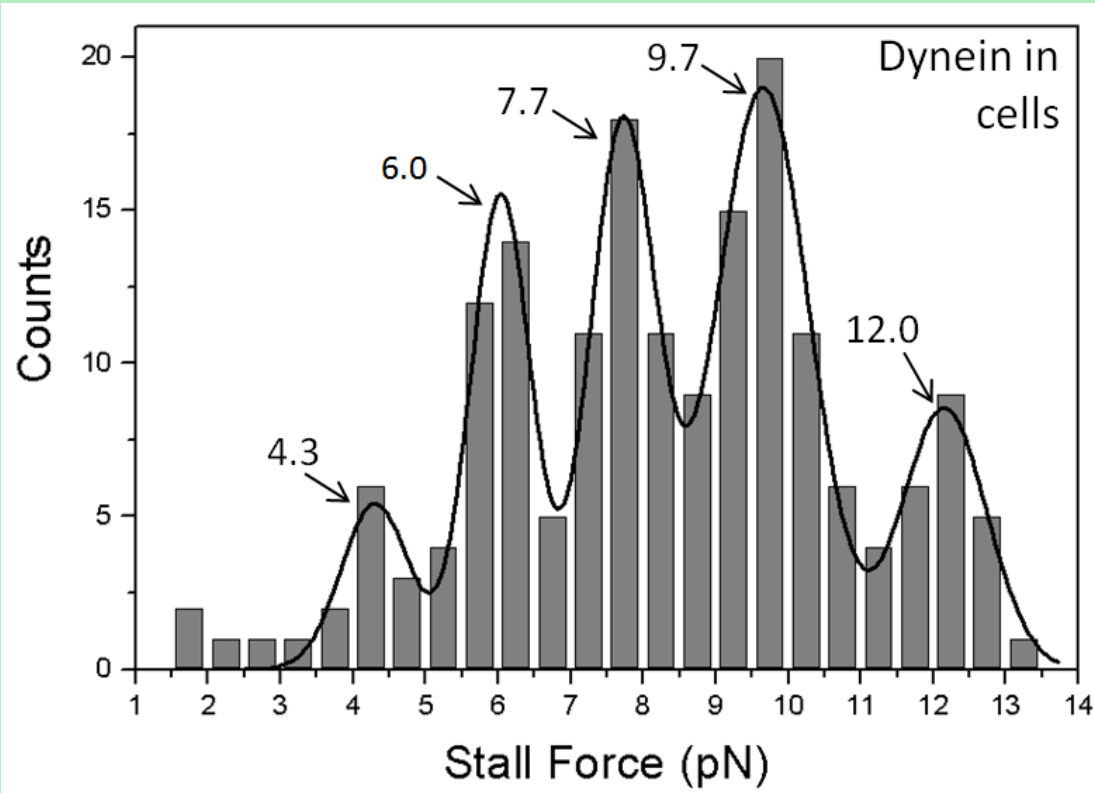


Force and tenacity scale as  $N$  in an  $N$ -dynein team  
No such advantage for kinesin ...

TENACITY



# How many dyneins are active ?

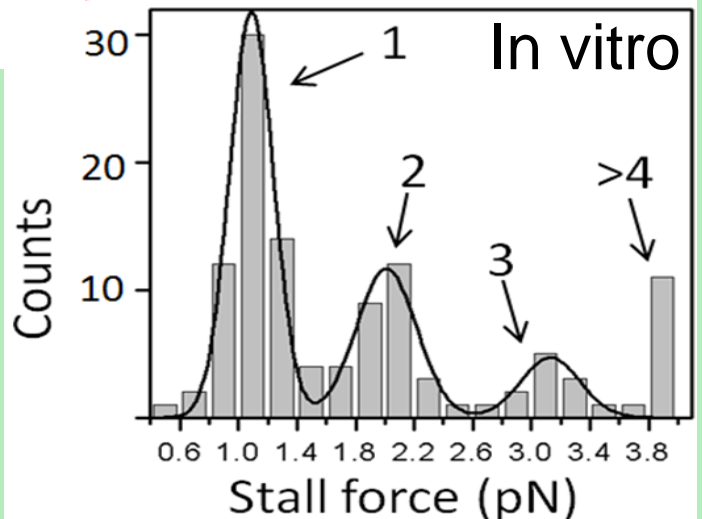


Dynein >> Kinesin

20-fold excess

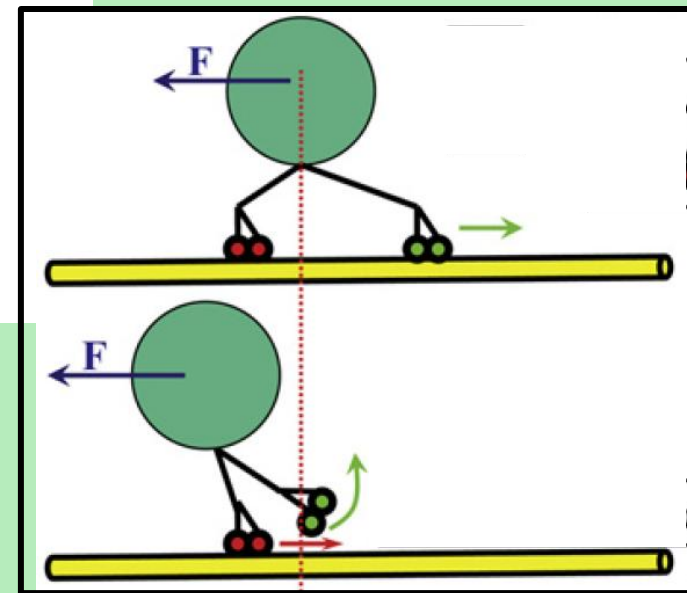
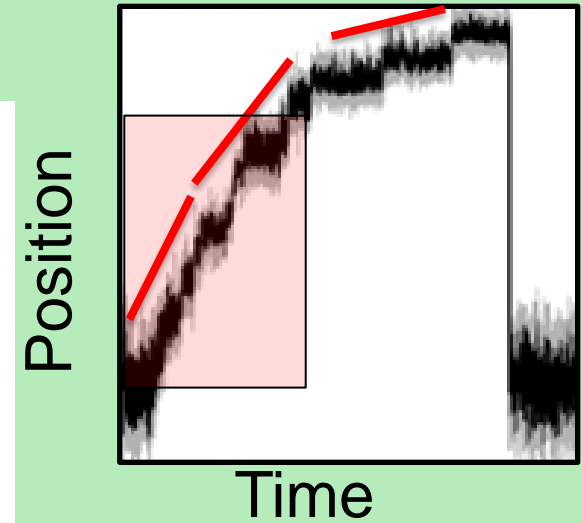
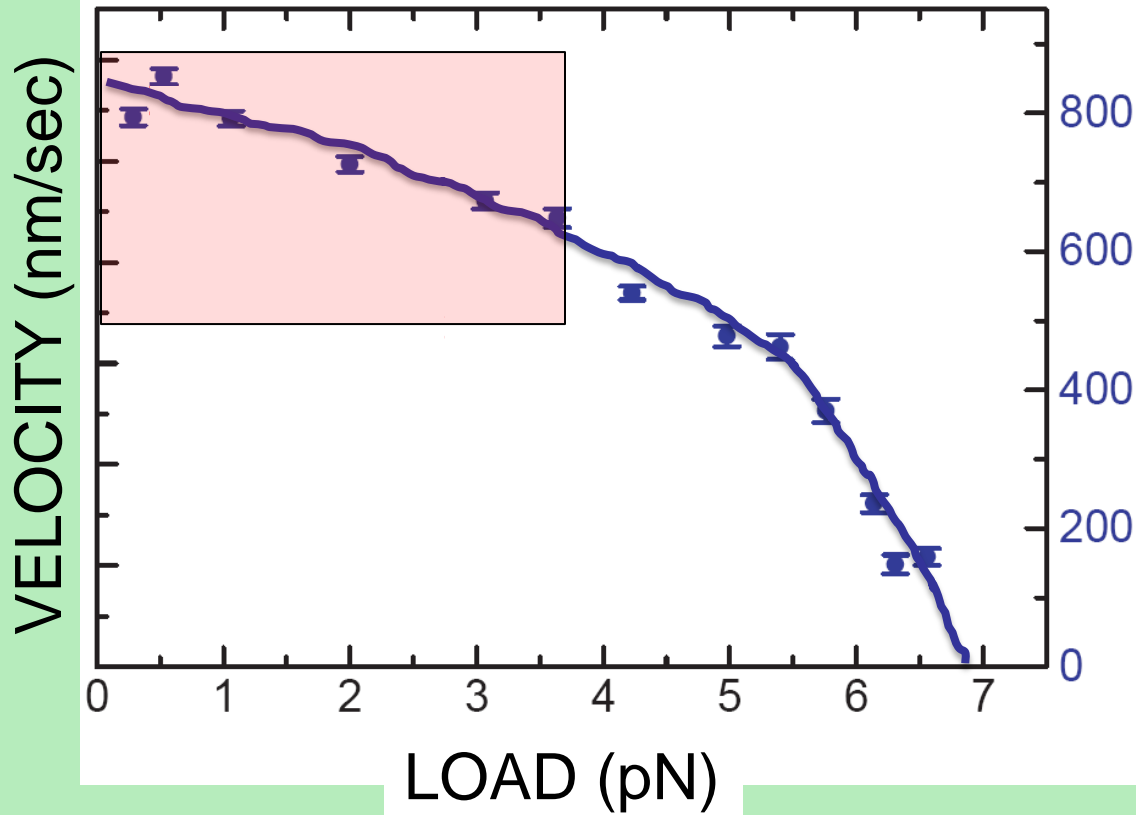
Verified biochemically

**DYNEINS PAIRED UP ??**



# Kinesin's response to Load ...

F-V curve

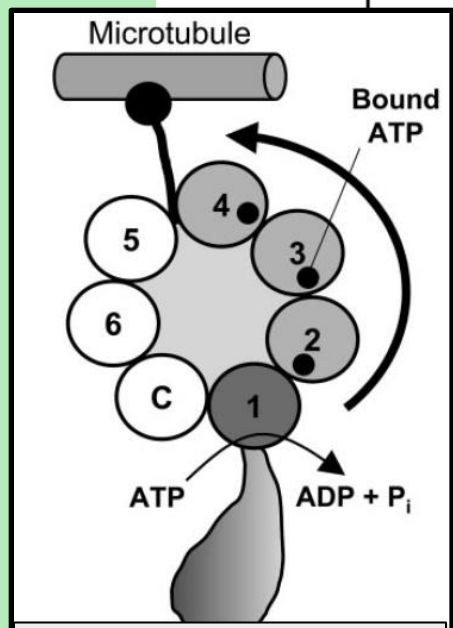
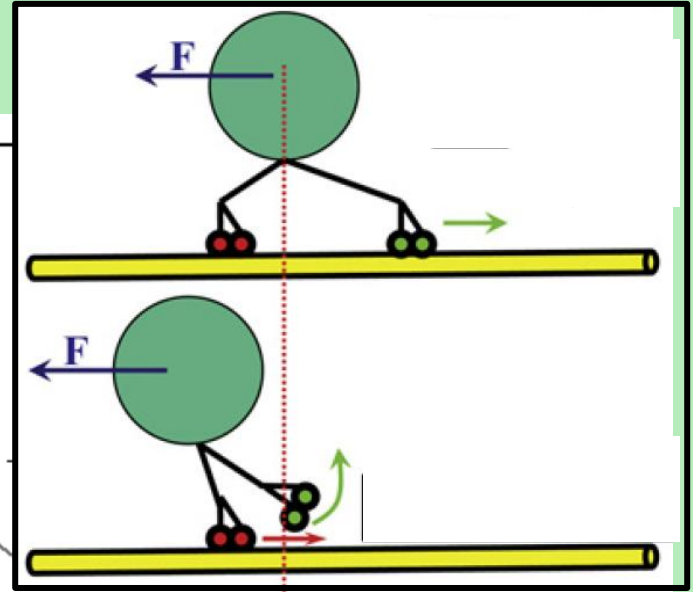
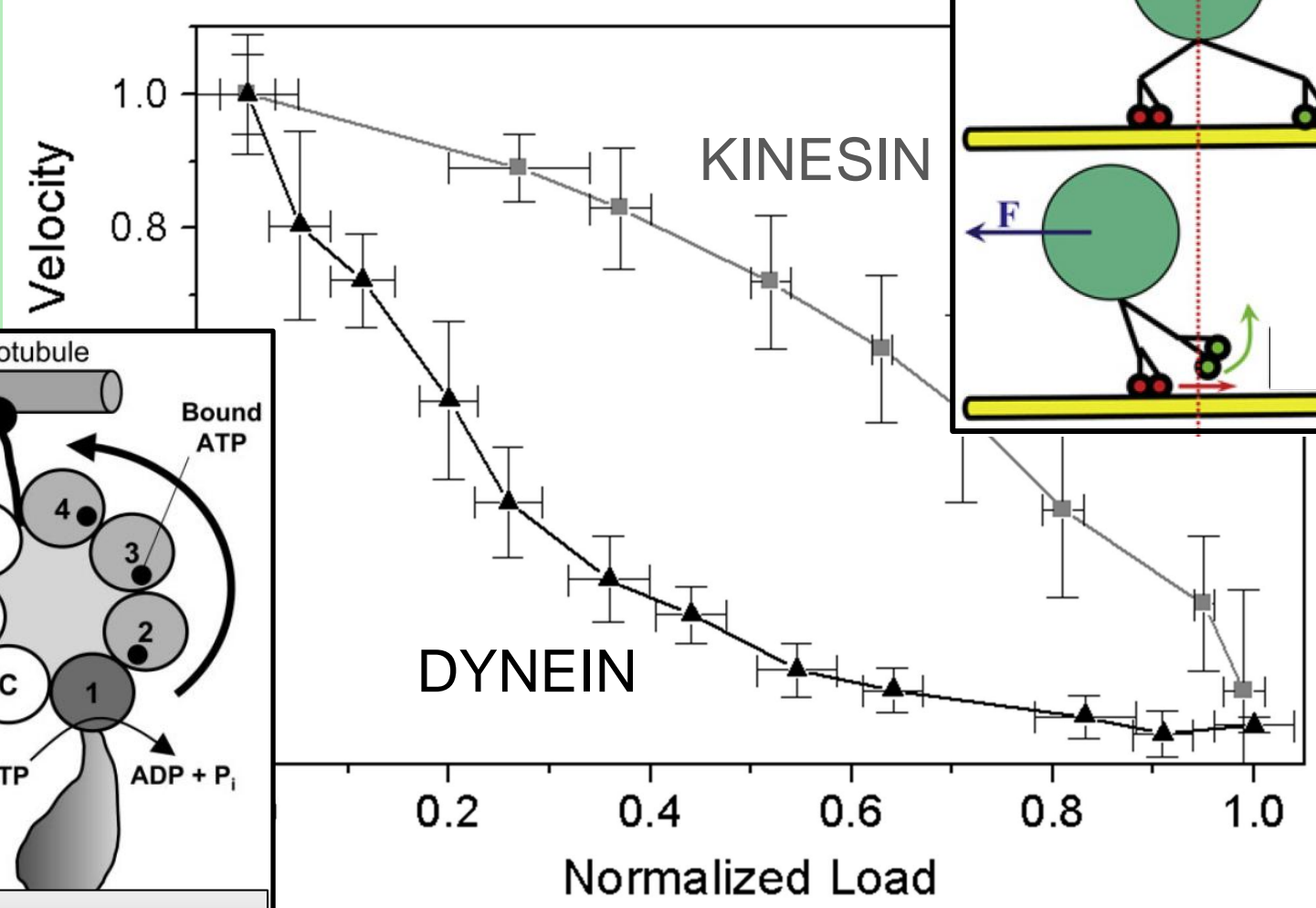


*Visscher et al, Nature 1999*

*Jamison et al 2010*  
*Driver et al 2011*  
*Kunwar et al 2008*

# Mechanism for Dynein's improved collective Function ?

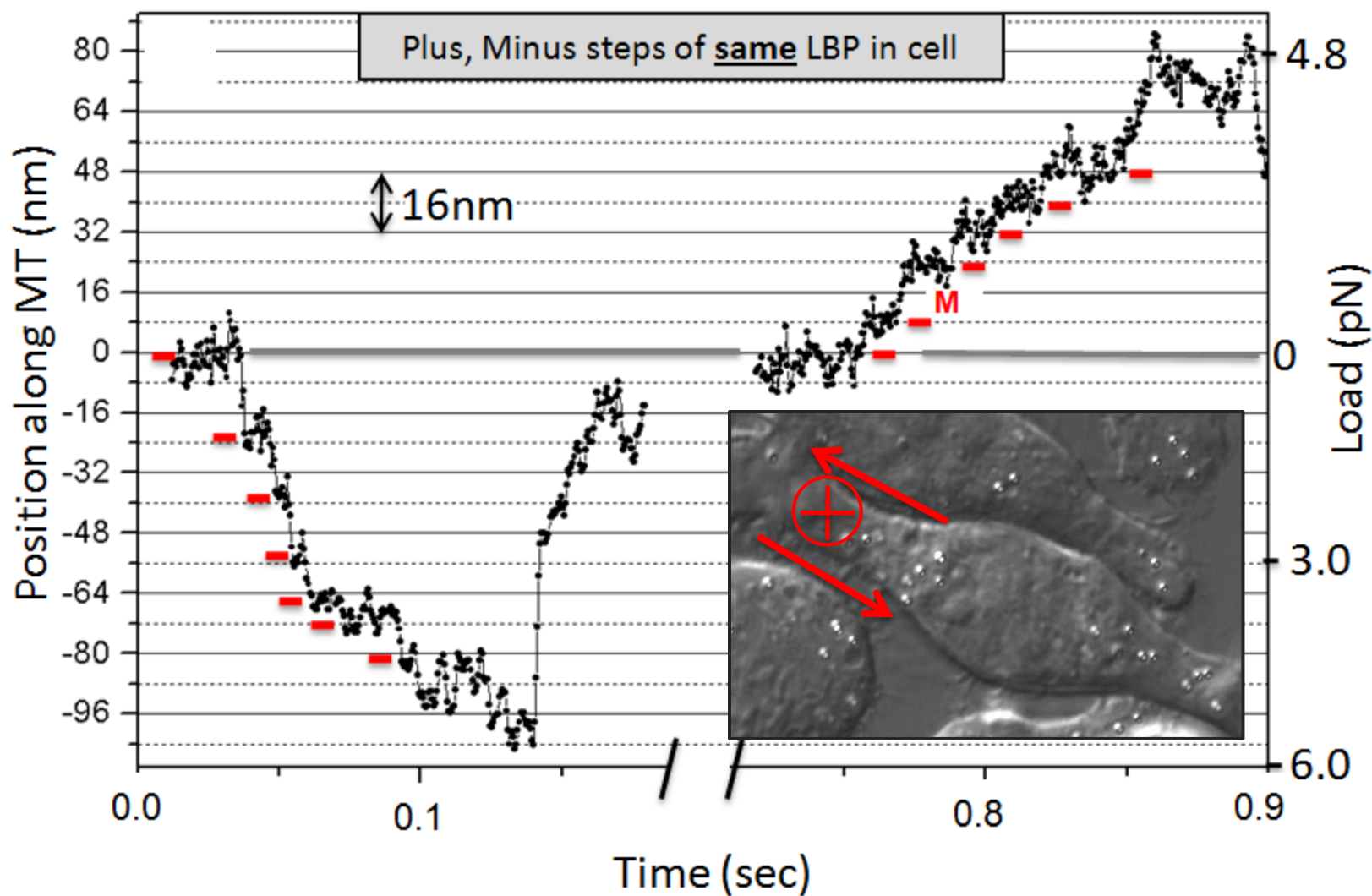
## MEASURED F-V CURVES



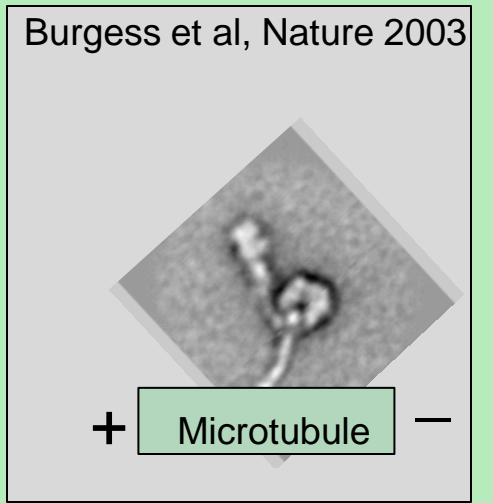
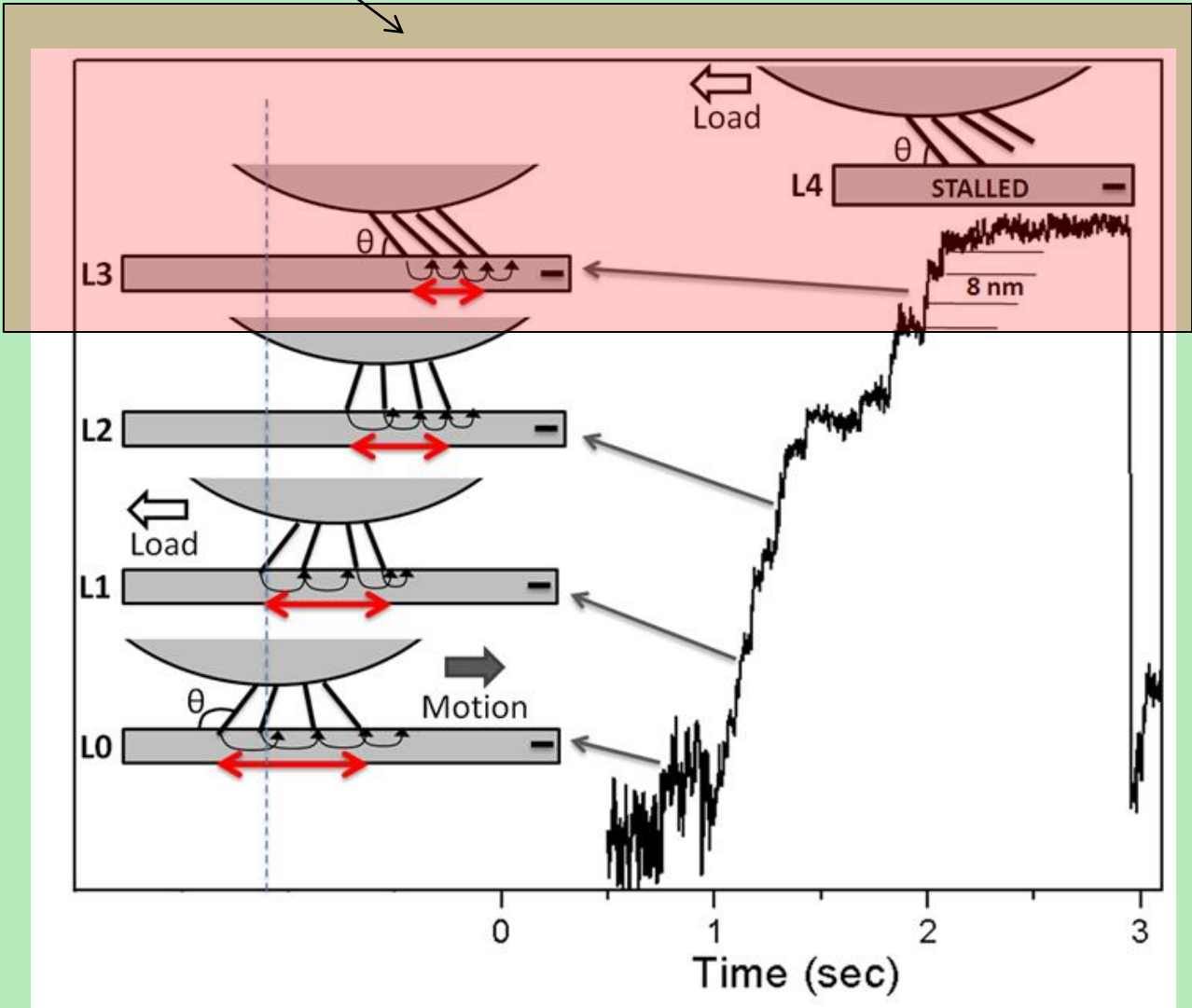
Dynein as a Gear  
*Mallik et al,*  
*Nature 2004*



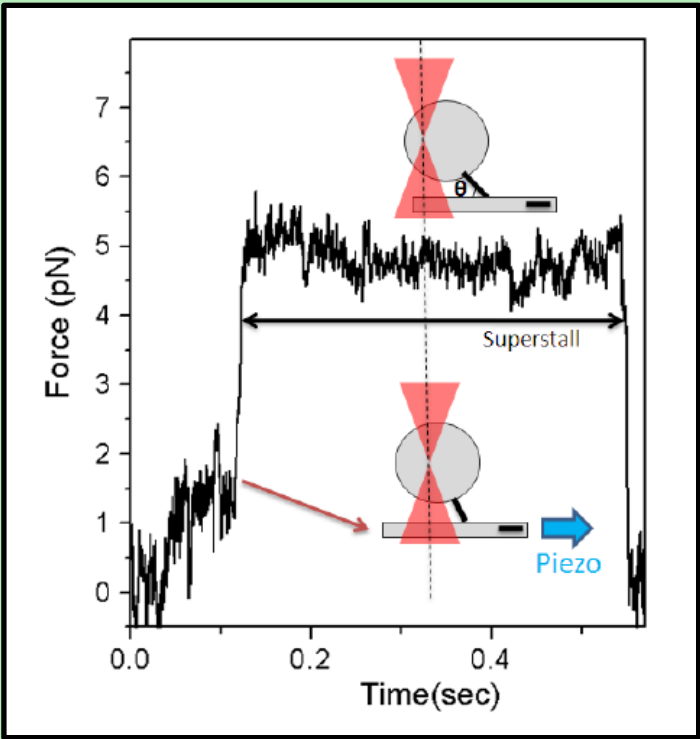
# LOAD-DEPENDENT STEP SIZE INSIDE CELLS



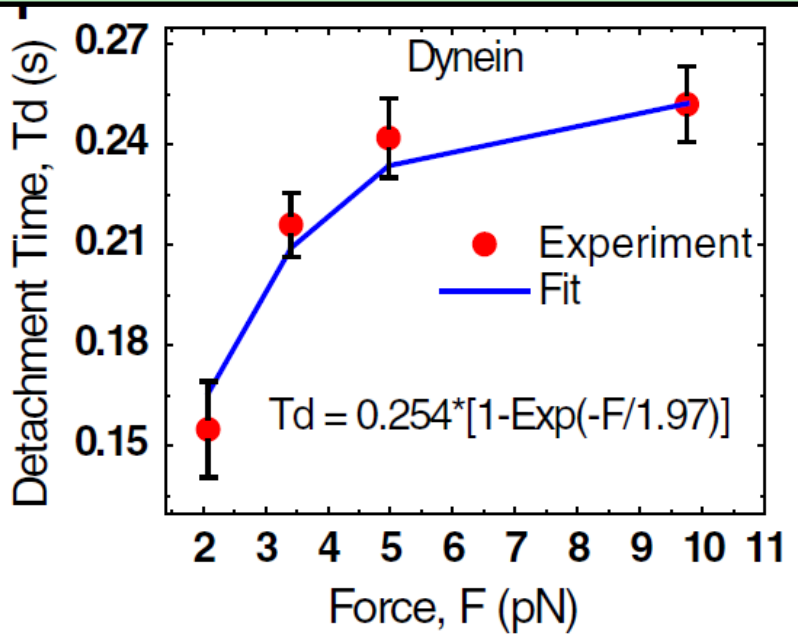
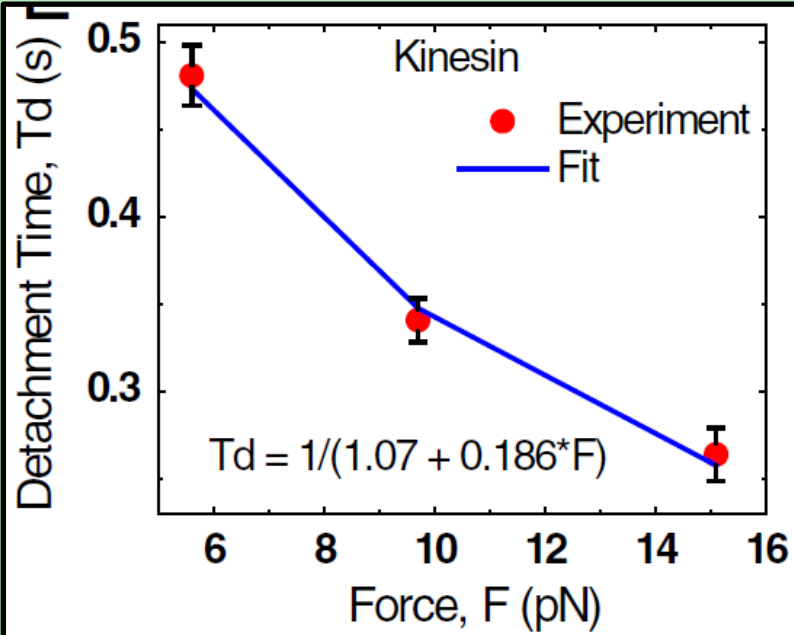
# What happens at high load ?



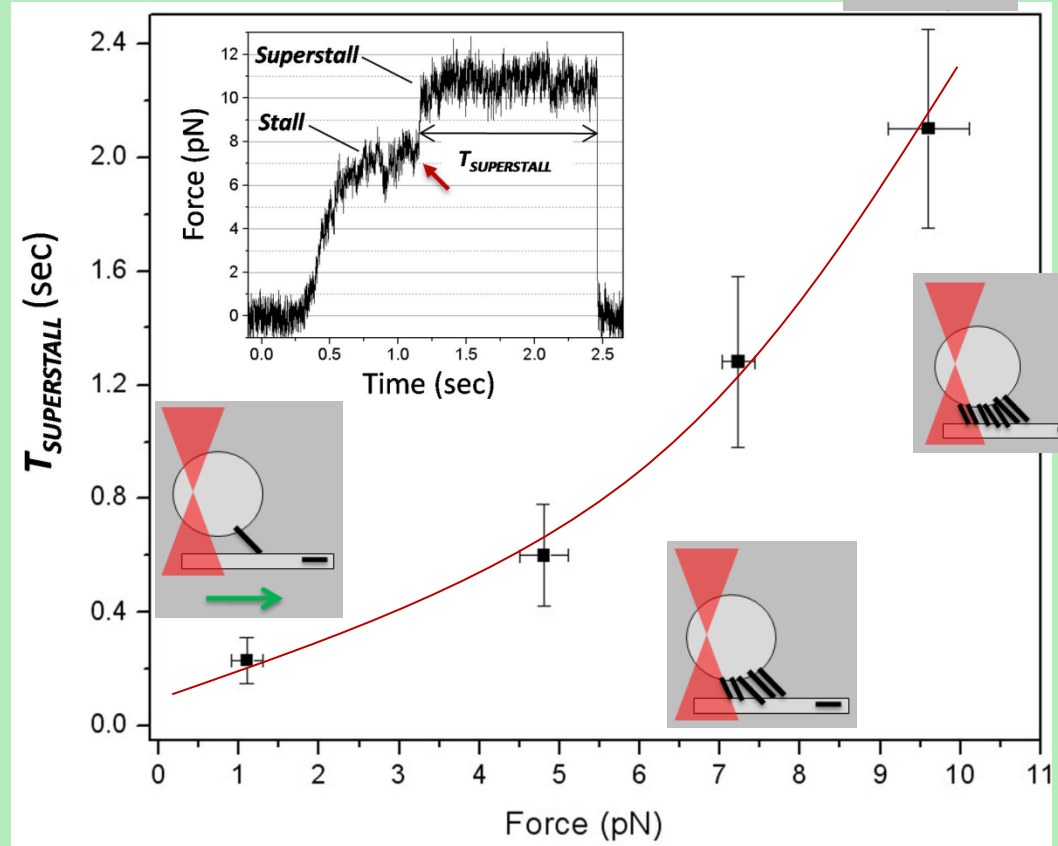
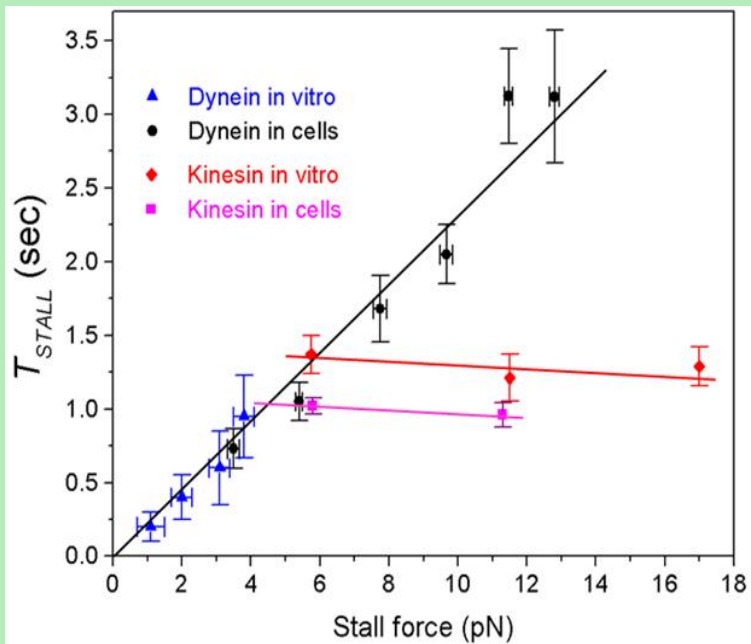
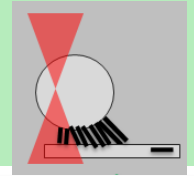
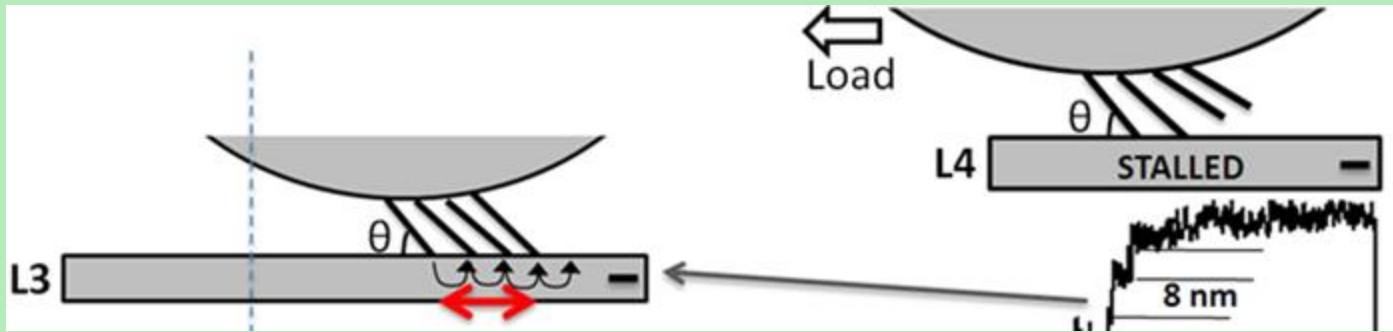
# Dynein travels with a Hook ?



*Kunwar et al, PNAS 2011*



# Activate the Catch-bond artificially...



Arpan  
Rai



Rai *et al*  
Cell 2013, 152:172-182.

- Roles are reversed between Single and Collective behaviour
- Dyneins appears molecularly adapted to generate large collective forces → Gear, Catch-bond
- Possible to tune forces, and therefore processes with Dynein. Not possible with Kinesin.
- Model system for Quantitative Force measurement in Cells
- Optical trapping techniques for intracellular force measurements. Caveats.



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