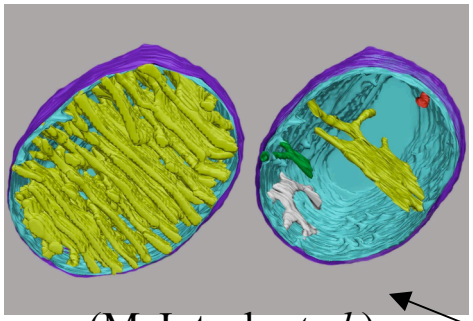
Mechanics of Membrane Structures

Quantitative Models of Biological Function

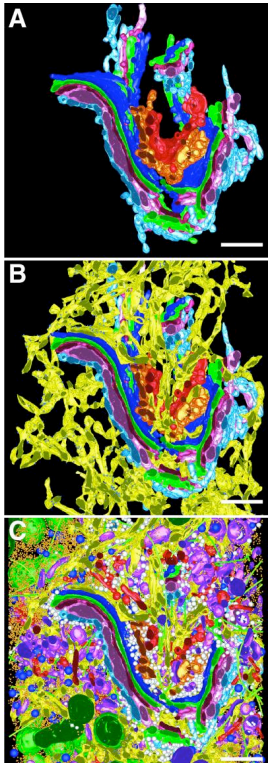
APh/BE161: Physical Biology of the Cell

Eukaryotic Cells: Organelles

(Frey *et al.*)



(McIntosh *et al.*)



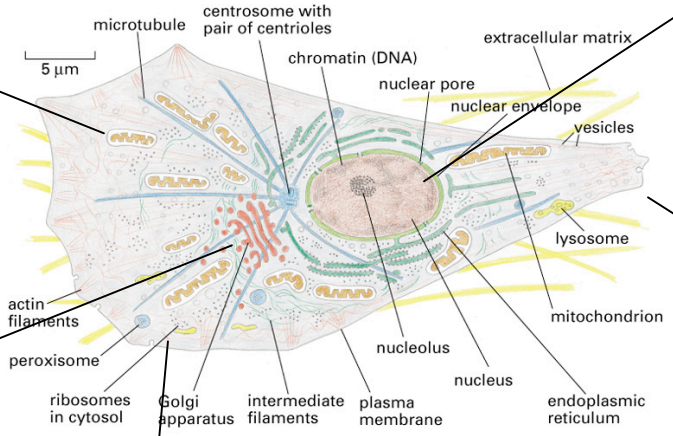
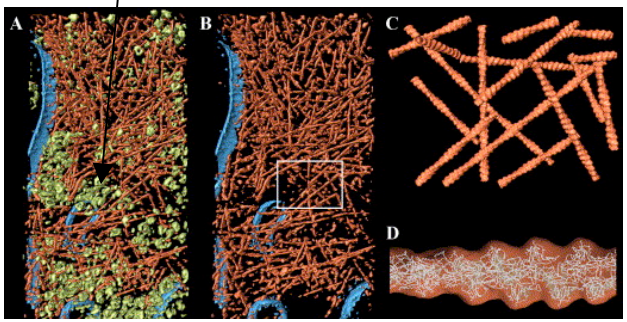
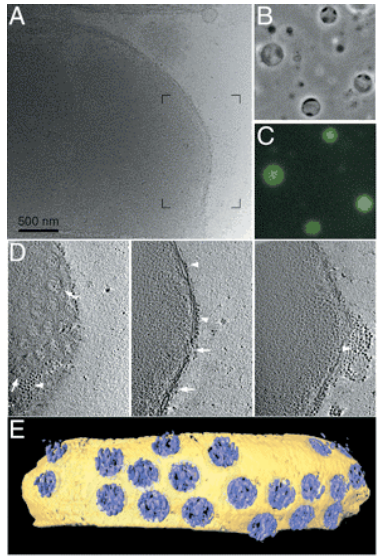
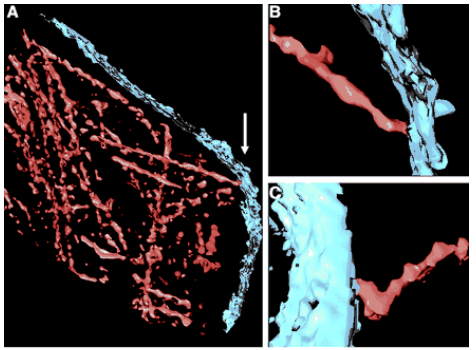


Figure 1–31. Molecular Biology of the Cell, 4th Edition.



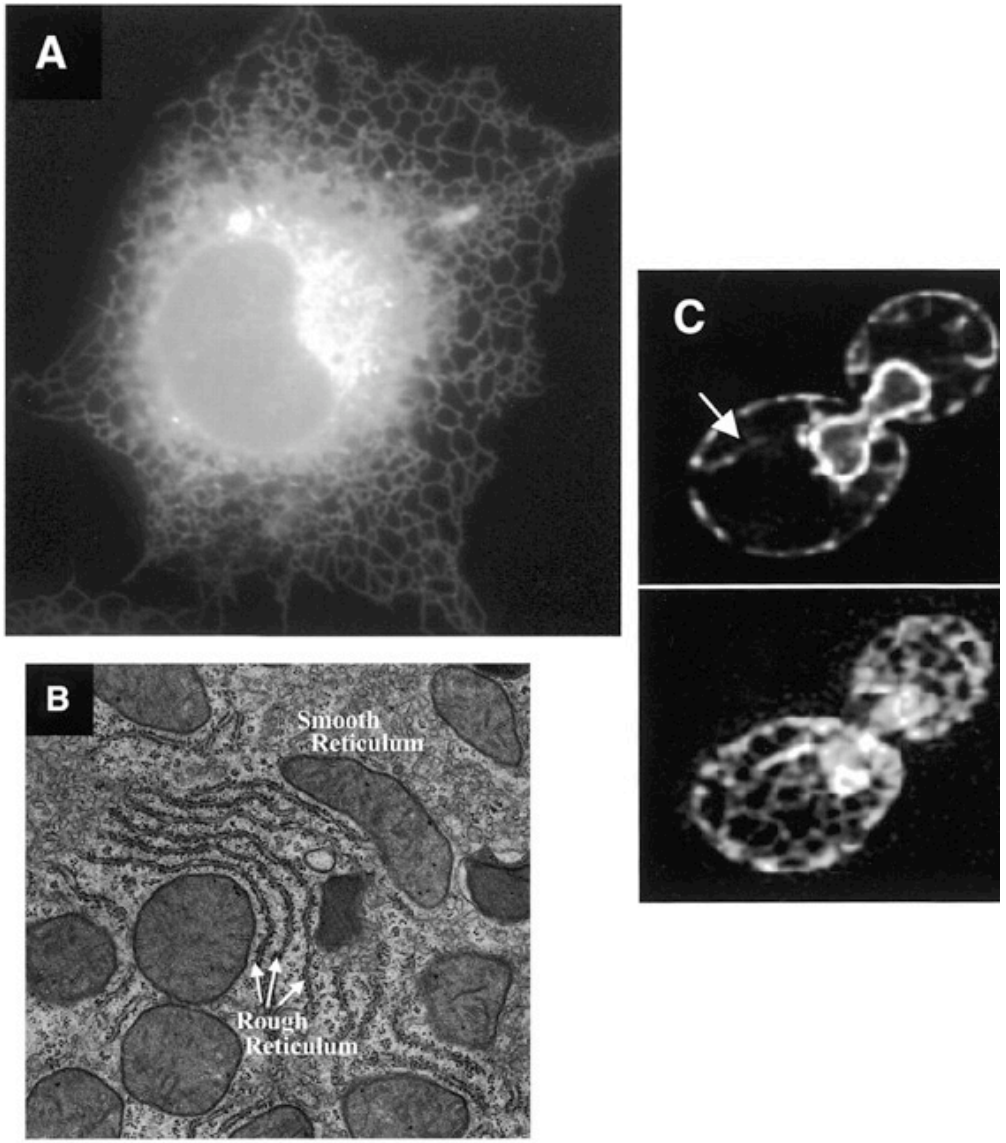


(Medalia *et al.*)



ER Structure

Ultrastructure of the RER, SER and NE. (A) Localization of a GFP–ER fusion protein (GFP-Sec61beta) expressed in a COS cell and visualized by epifluorescence microscopy. The fine ER network is particularly clear in the thin edges of the cell periphery; three-way junctions and polygonal reticulum are easily visualized. (B) An electron micrograph of a liver cell shows RER (rough reticulum) and patches of SER (smooth reticulum) (picture taken from Fawcett, 1966, with copyright permission from the publisher, W.B. Saunders Co.). (C) Localization of GFP–ER fusion protein (GFP-Sec63) expressed in yeast and visualized by fluorescence microscopy outlines the structure of the ER (the upper picture focuses on the middle of the cell, the lower on the top of the cell; taken from Prinz et al., 2001, with copyright permission of the Rockefeller University Press). Several tubules (arrow in top panel) connect the outer NE (top panel) to the peripheral ER (bottom panel).



Voeltz, Rapoport et al

Membrane Tubules Created by Motor Action

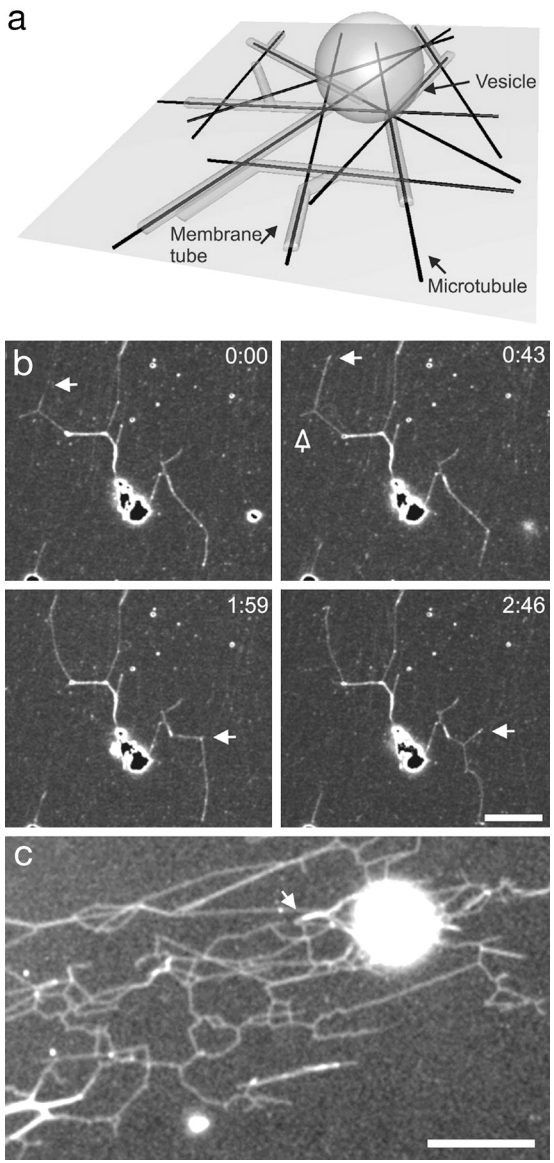
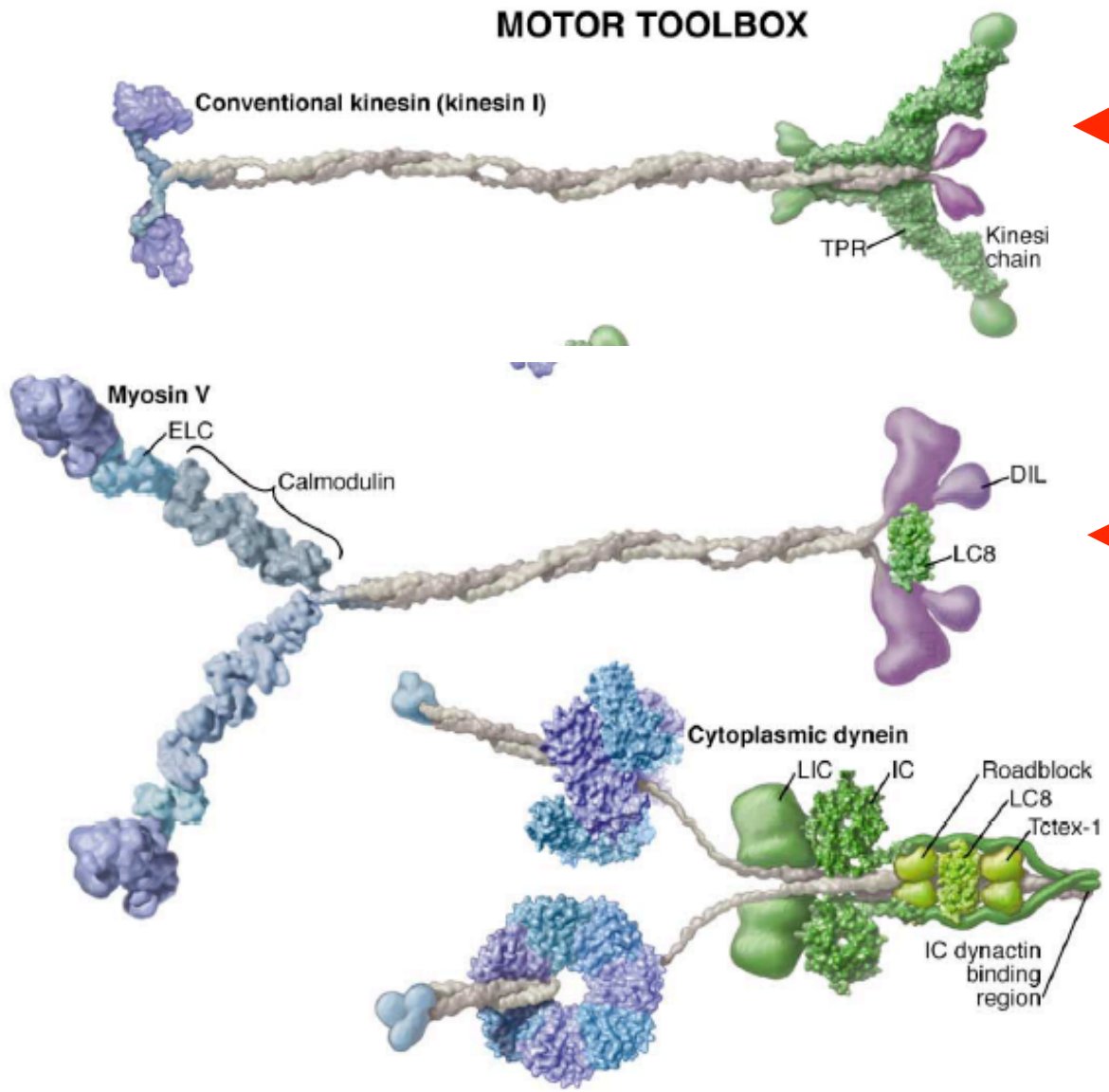


Fig. 1. Overview of the experimental system. (a) Schematic representation of the assay (not to scale). Membrane tubes are formed from a vesicle that lies on top of a random network of MTs attached to the surface. (b) Time sequence of scanning confocal microscopy images of membrane tubes during the early stage of network formation ({approx}10 min after sample preparation). The network is dynamic: existing tubes disappear (open arrow) and new tubes appear and grow (white arrows), giving shape to three-way junctions. The fluorescence is due to fluorescently labeled streptavidin. Neither MTs nor motor proteins are visible. Time is given in minutes and seconds. (Bar, 5 μm.) (c) Fluorescence image of a large network of membrane tubes (with streptolysin). After 2 h, multiple three-way junctions can be observed and multiple membrane tubes are formed alongside each other, as can be seen from a stepwise increase in fluorescence (see arrow). Membranes are stained with BODIPY. (Bar, 10 μm.)

Koster, Dogterom et al.

Translational Motors



Kinesin

Speed: 850 nm/s
ATPase: 44.0 1/s

Myosin V

Speed: 350 nm/s
ATPase: 5.0 1/s

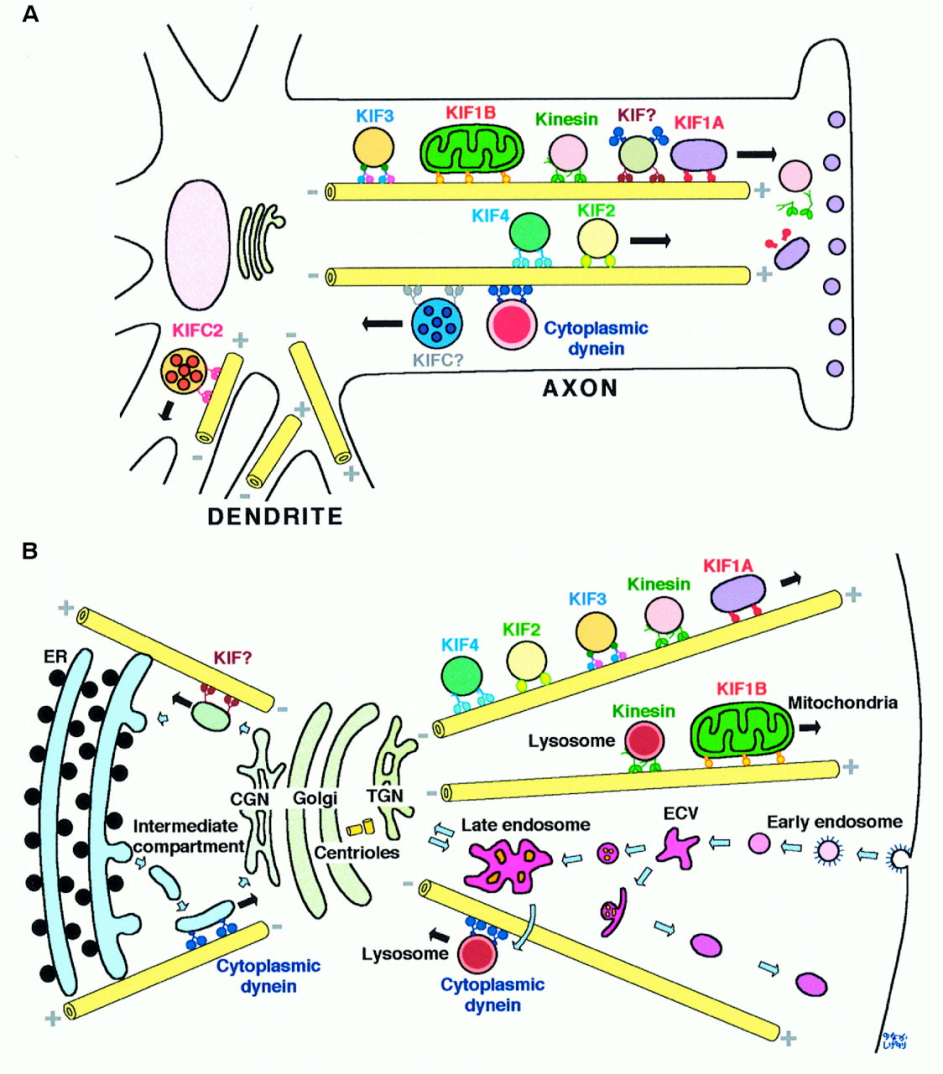
Dynein

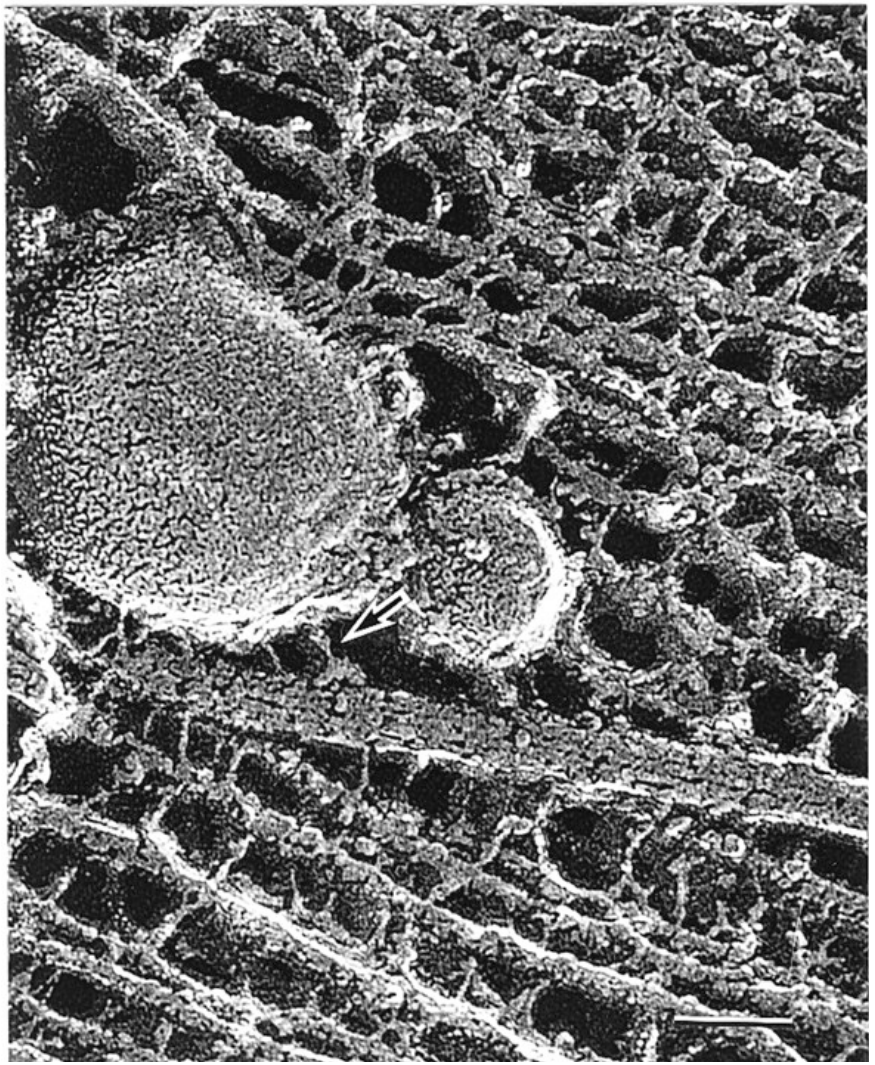
Speed: -1250 nm/s
ATPase: 2.0 1/s

****ALL INVOLVED IN VESICLE TRANSPORT**

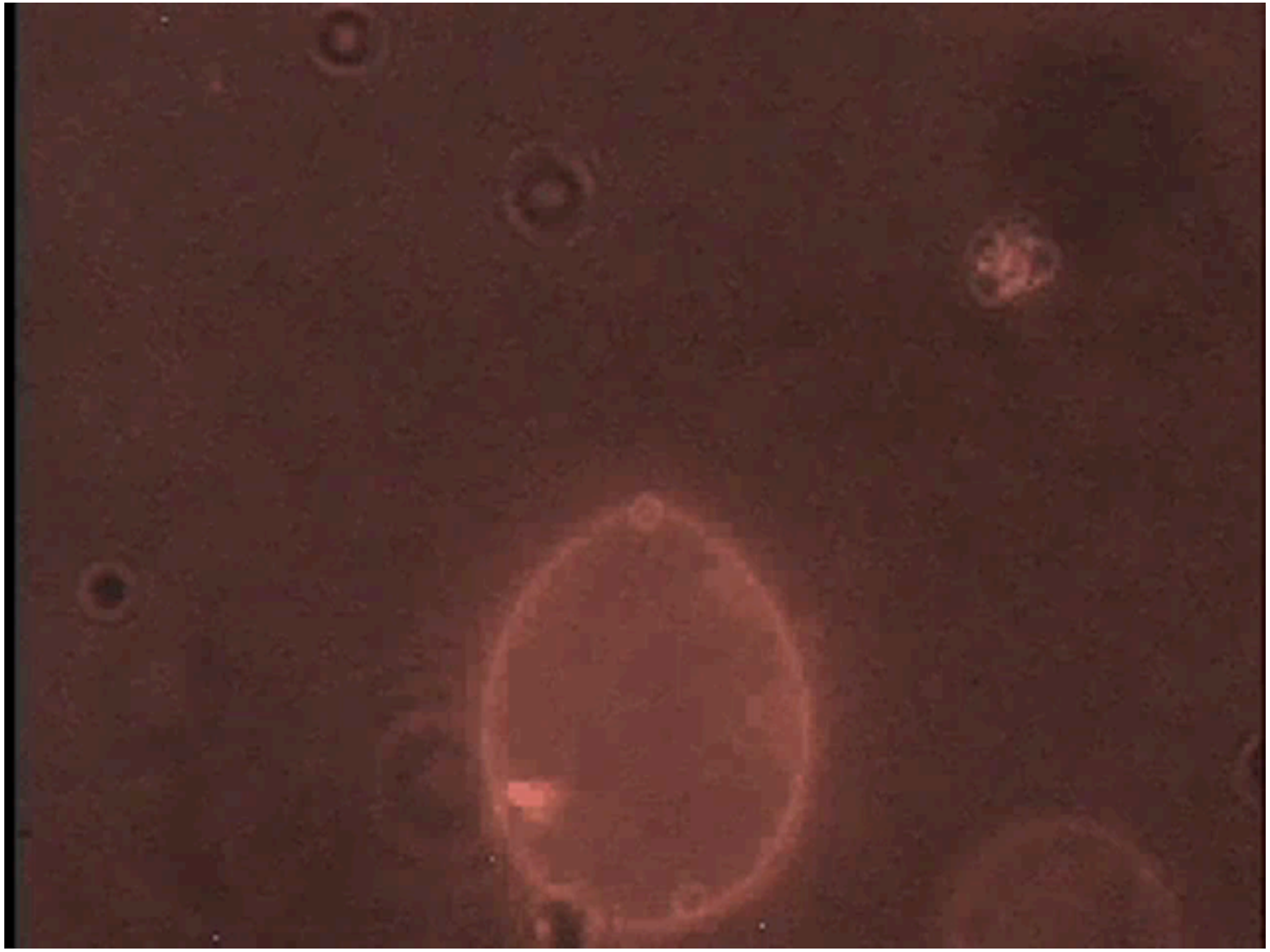
Organellar Transport

(Hirokawa, Science 1998)





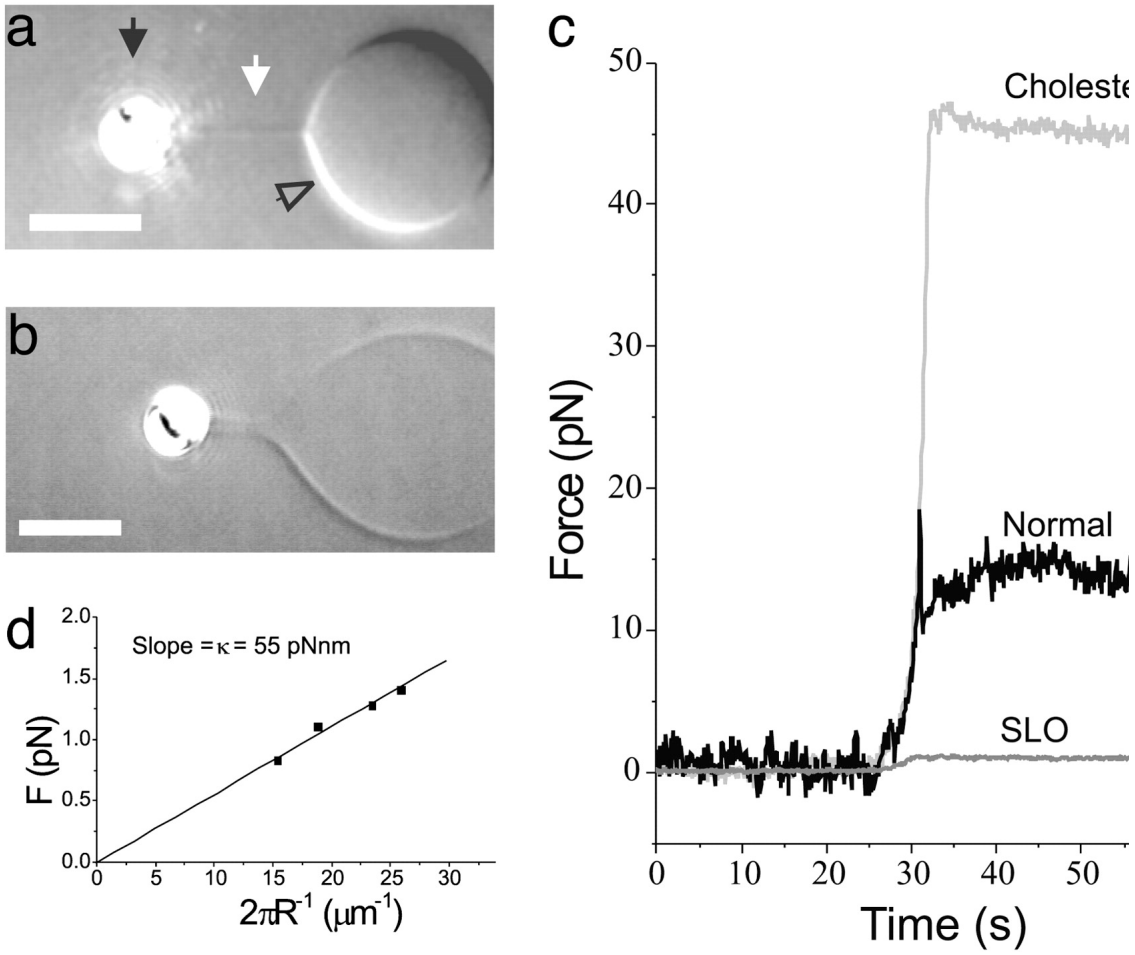
Optical Trapping and Tubule Formation



Heun Jin Lee, Eric Peterson, Paul Wiggins

Quantitative Dissection of the Mechanics of Tube Formation

Fig. 3. Force measurement of tube formation. (a) Video-enhanced differential interference contrast image of a normal vesicle (open arrow) from which a tube (white arrow) is pulled with a bead (black arrow) held in optical tweezers. The contrast has been enhanced to make the tube visible. (Bar, 5 µm.) (b) Tube formed from a vesicle with SLO and cholesterol. Note that the diameter of the tube is {approx}800 nm. This is larger than the tube in a because of a lower membrane tension. (Bar, 5 µm.) (c) Examples of the tube formation forces for the different vesicles studied. After pulling a tube with the optical tweezers (around t = 30 s), the bead is held at a fixed position for several tens of seconds. The curves for the normal and SLO vesicles correspond to the images in a and b.(d) Tube force dependence on the radius for the SLO vesicle shown in b. Stepwise elongation of the tube results in an increased tension, which results in a smaller tube radius. The slope of the curve reveals the bending rigidity of the membrane.



Koster, Dogterom et al.