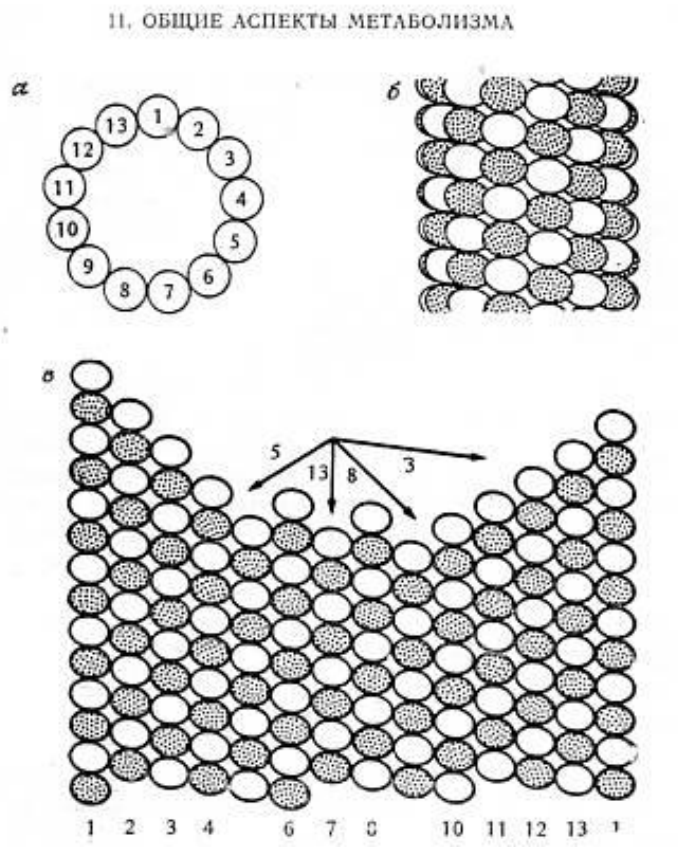
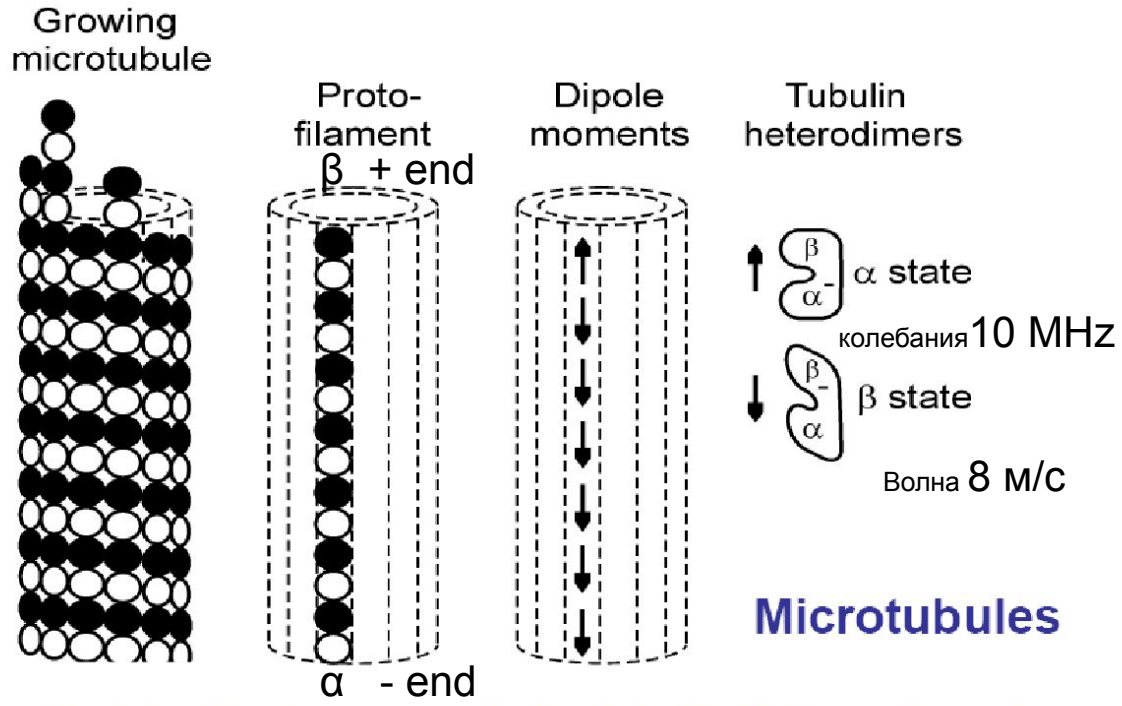




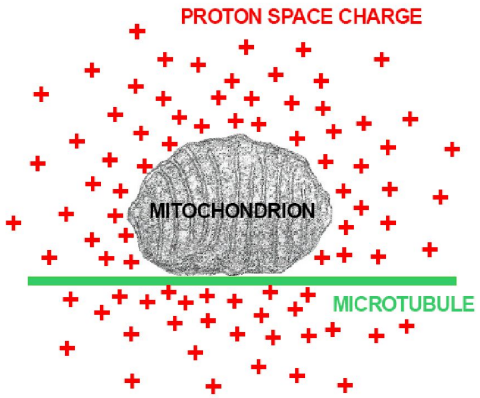
The electric dipole moment of a tubulin heterodimer is greater than 1000 Debye (10^{-26} Cm)

ПЛОТНОСТЬ ЭНЕРГИИ (МОЩНОСТИ), ЗАПАСЕННОЙ В МИКРОТРУБОЧКЕ В РЕЗУЛЬТАТЕ ГИДРОЛИЗА GTP: ~ 100 eV/c/10 мкм = 10^{-17} вт/10 мкм

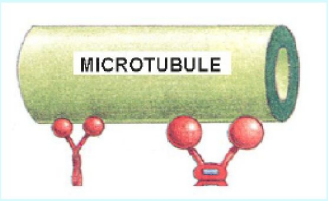
ЭНЕРГИЗАЦИЯ МИКРОТРУБОЧЕК

Источники энергии для мт:

1. За счет расщепления GTP: 0,074 eV / молекулу GTP,
Или 10^{-14} W/см длины мт;
2. За счет расщепления ATP моторными белками:
≈ 4 x 10^{-17} W
3. Поступление энергии от митохондрий: ≈ 10^{-16} – 10^{-14} W на мт.



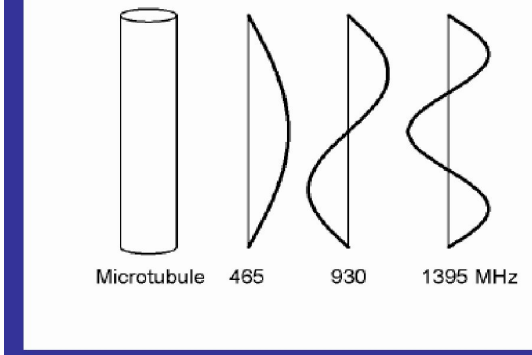
Activity of motor proteins



Motor proteins
moving along microtubules

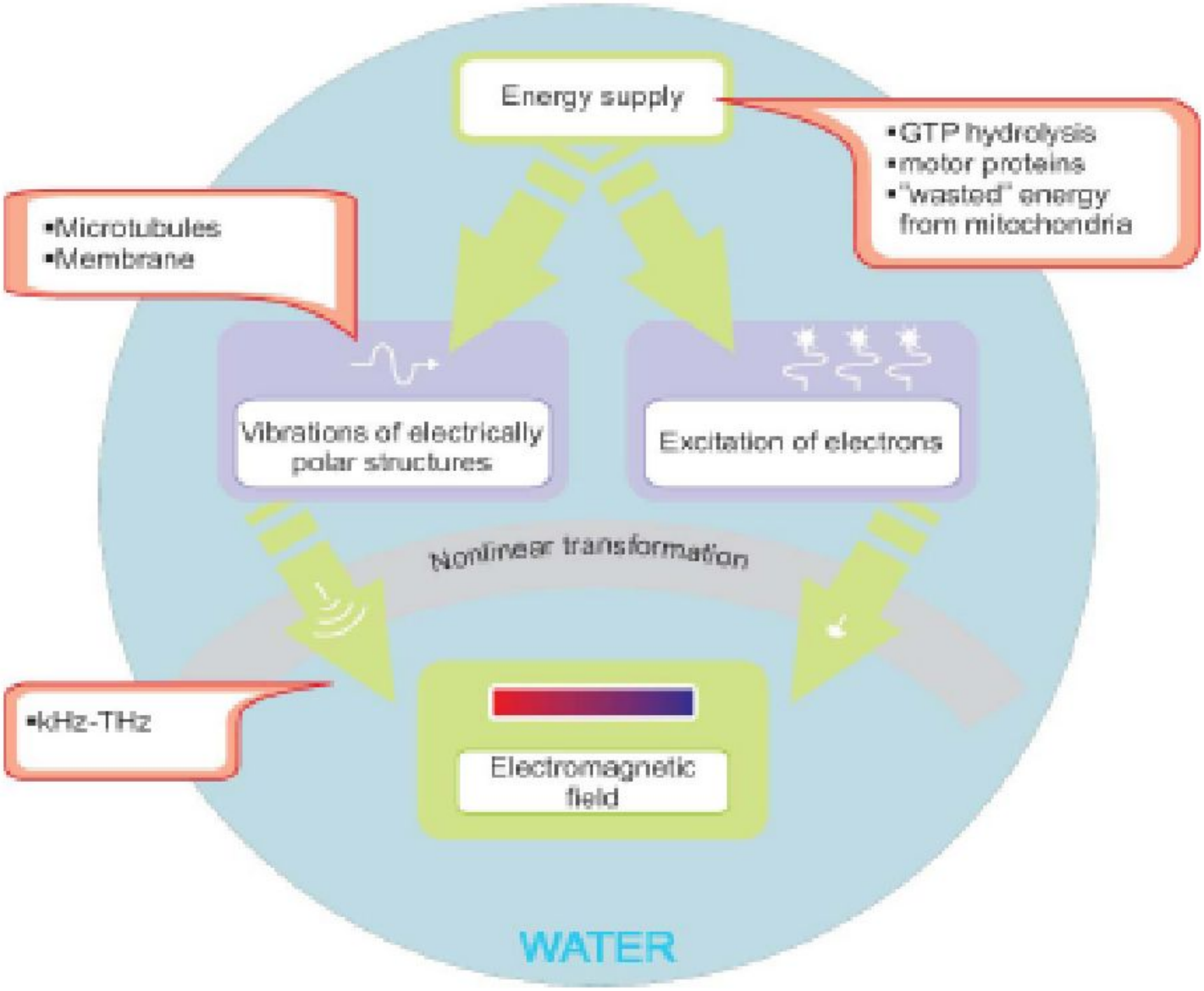
Pelling A.E. et al.
Local Nanomechanical Motion of the Cell Wall of *Saccharomyces cerevisiae*
Science 305, 2004,1147-1150

Concerted motor protein action supplies energy to vibration states (activation energy 58 kJ/mole). Metabolically driven nanomechanical process of vibrations.

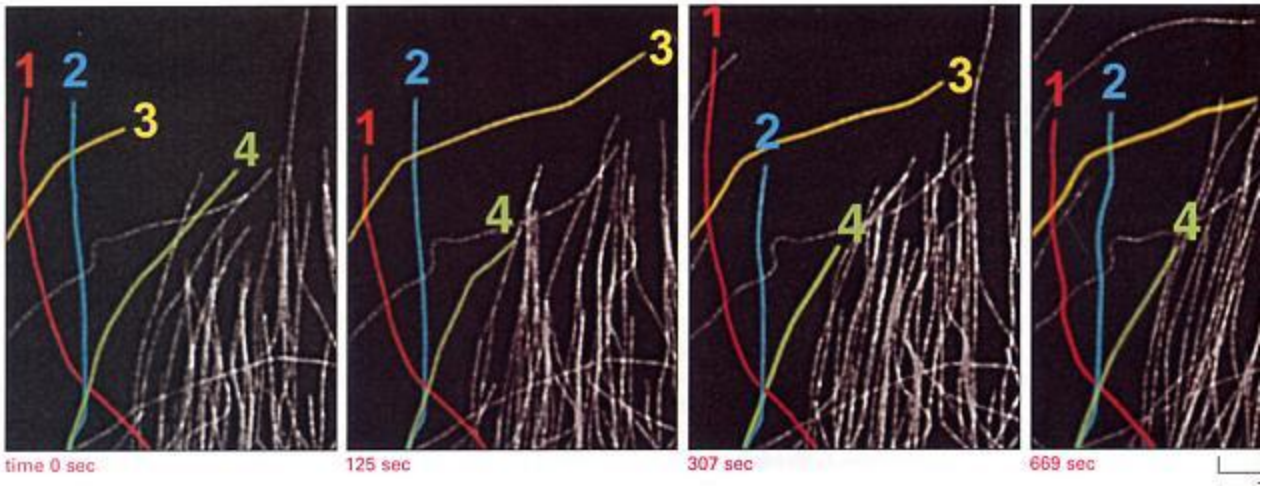


A schematic picture of longitudinal elastic resonant oscillations in a microtubule at the frequencies 465, 930, and 1395 MHz.

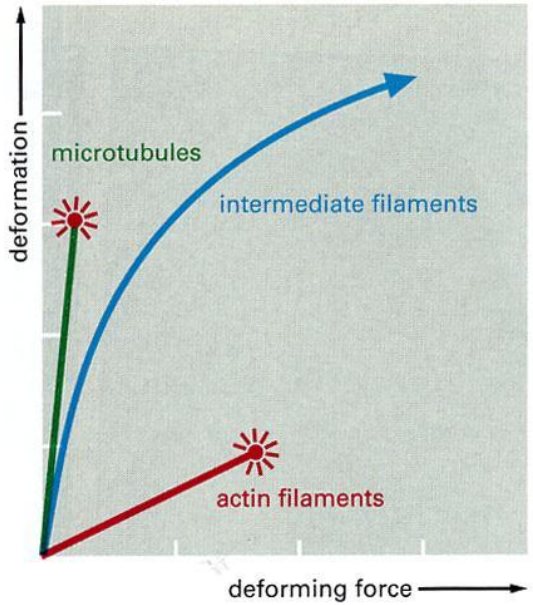
Physical mechanism of generation of cellular EM field



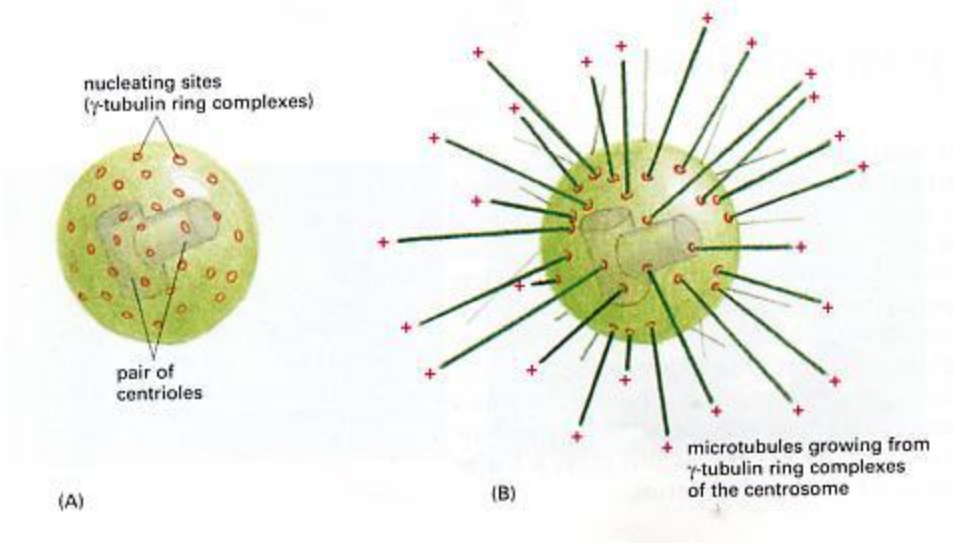
Реология и динамическая нестабильность микротрубочек



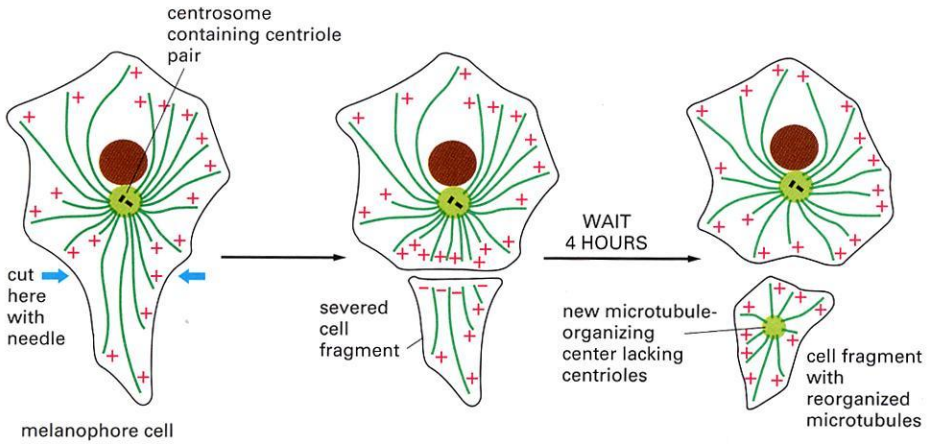
Микротрубочки сильно деформируются малыми силами

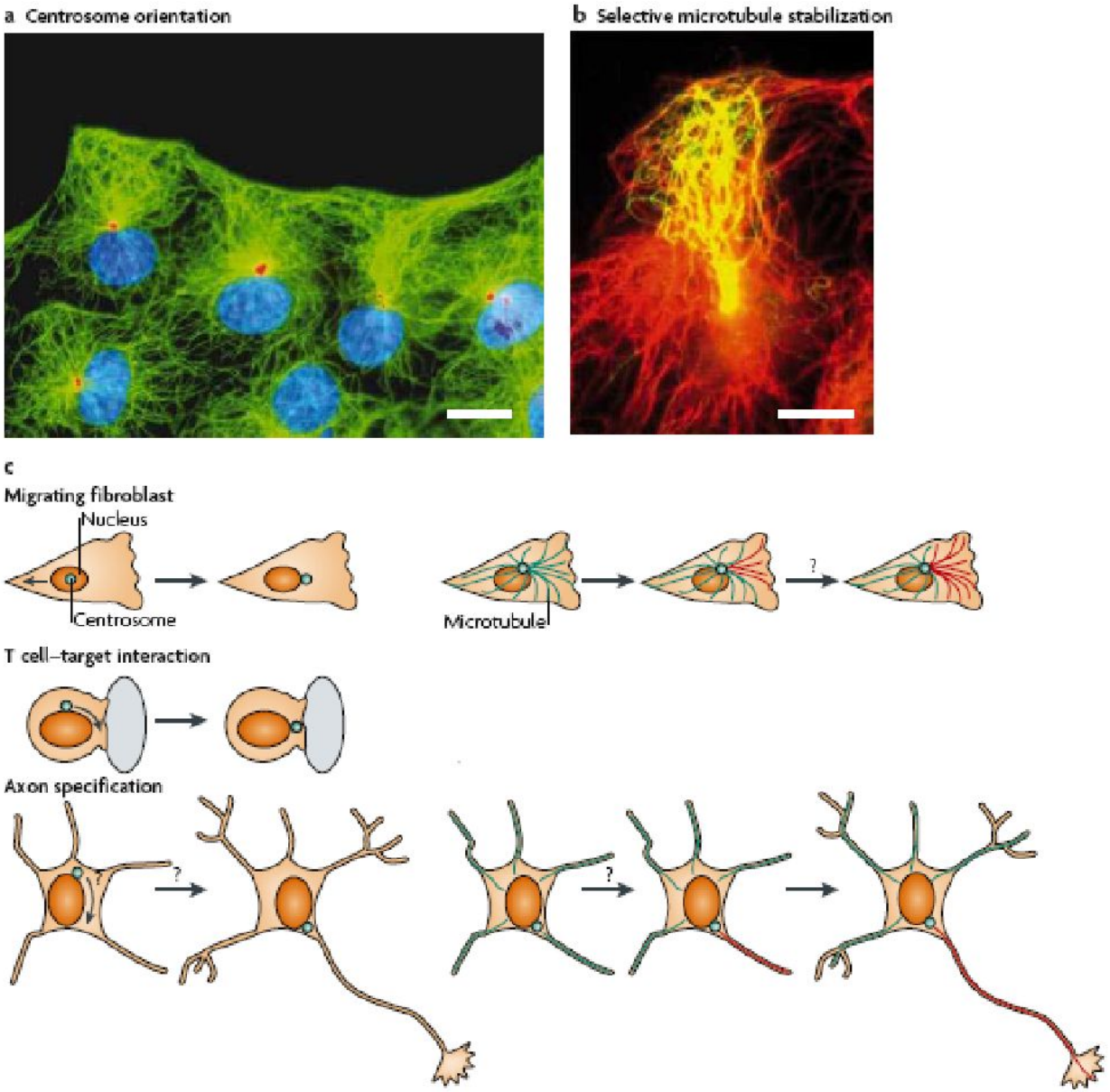


ЦЕНТРЫ ОБРАЗОВАНИЯ МИКРОТРУБОЧЕК

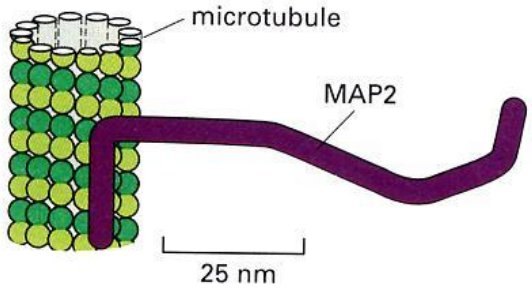


~ 20 микротрубочек / мин

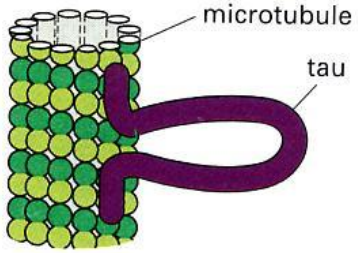



a Centrosome orientation
b Selective microtubule stabilization
c
Migrating fibroblast
Nucleus
Centrosome
Microtubule
?
T cell–target interaction
Axon specification
?
?

БЕЛКИ, СВЯЗАННЫЕ С МИКРОТРУБОЧКАМИ



Рыхлая упаковка



плотная упаковка

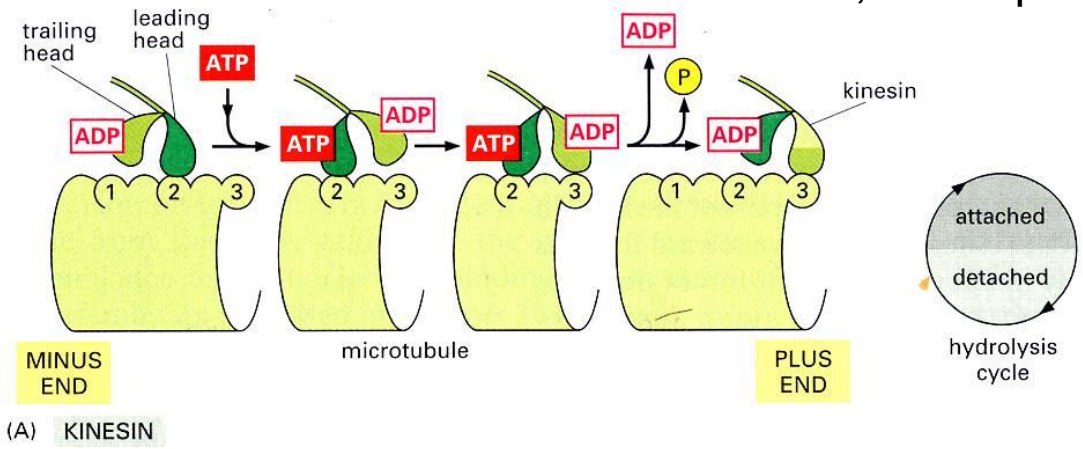
Катастрофин к + концу

Severing proteins (катанин) к « - » концу

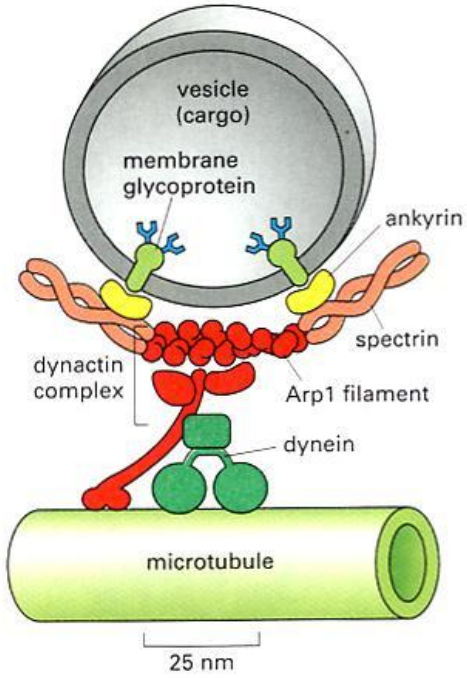
ДВИЖЕНИЕ КИНЕЗИНА И ДИНЕИНА ПО МИКРОТРУБОЧКЕ

ОБЩЕПРИНЯТАЯ МОДЕЛЬ

0,02 – 2 μm/s



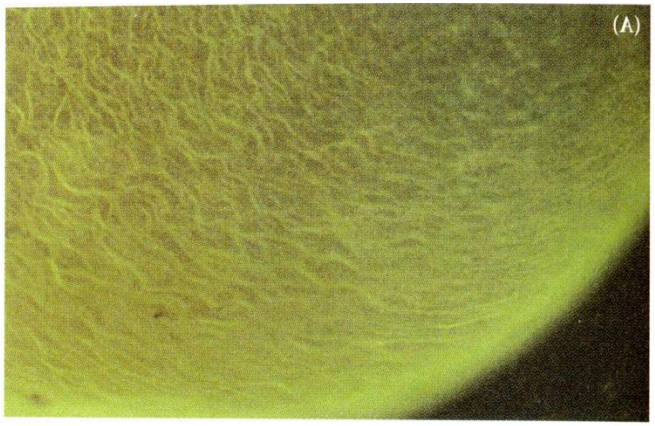
(A) KINESIN

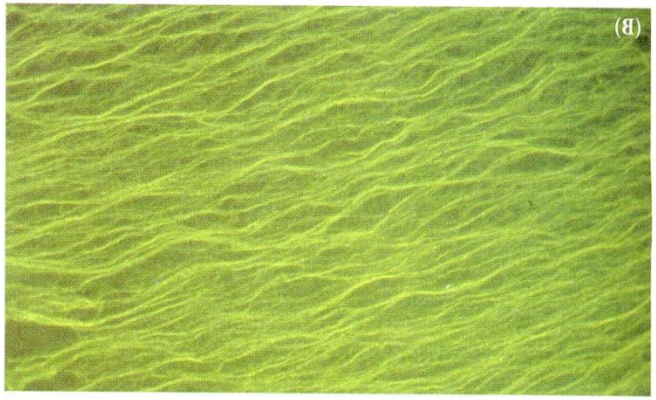


ПО POLLACK

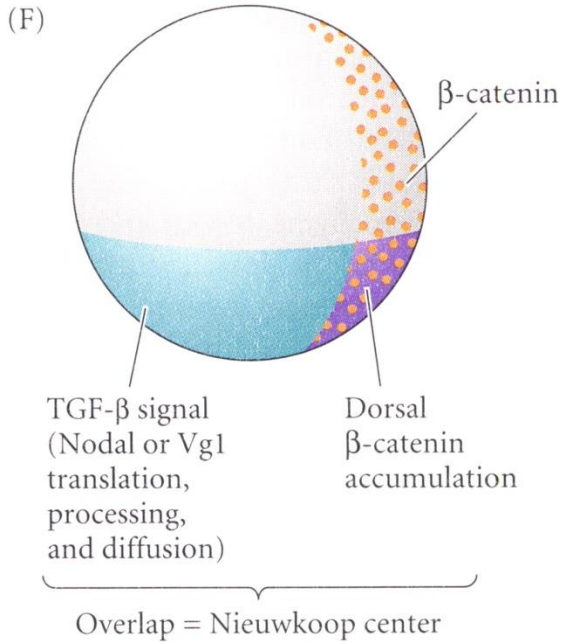
Figure 12.9. Mechanism of kinesin advance along the microtubule.

НАКОПЛЕНИЕ β-КАТЕНИНА В КЛЕТОЧНЫХ ЯДРАХ ДОРСАЛЬНОЙ СТОРОНЫ ЯЙЦЕКЛЕТКИ АМФИБИЙ В ХОДЕ ПОВОРОТА ОПЛОДОТВОРЕНИЯ

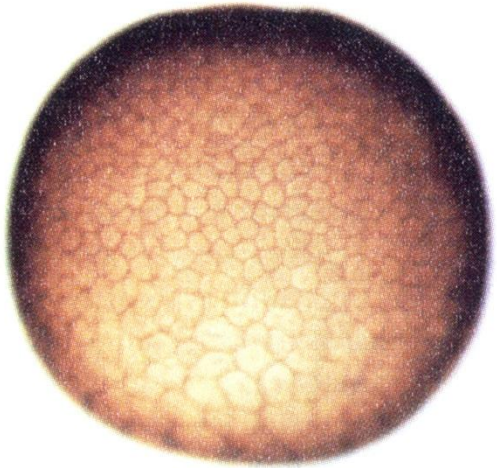




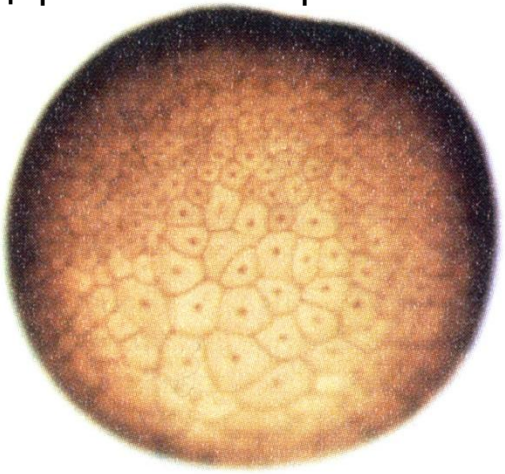
микротрубочки



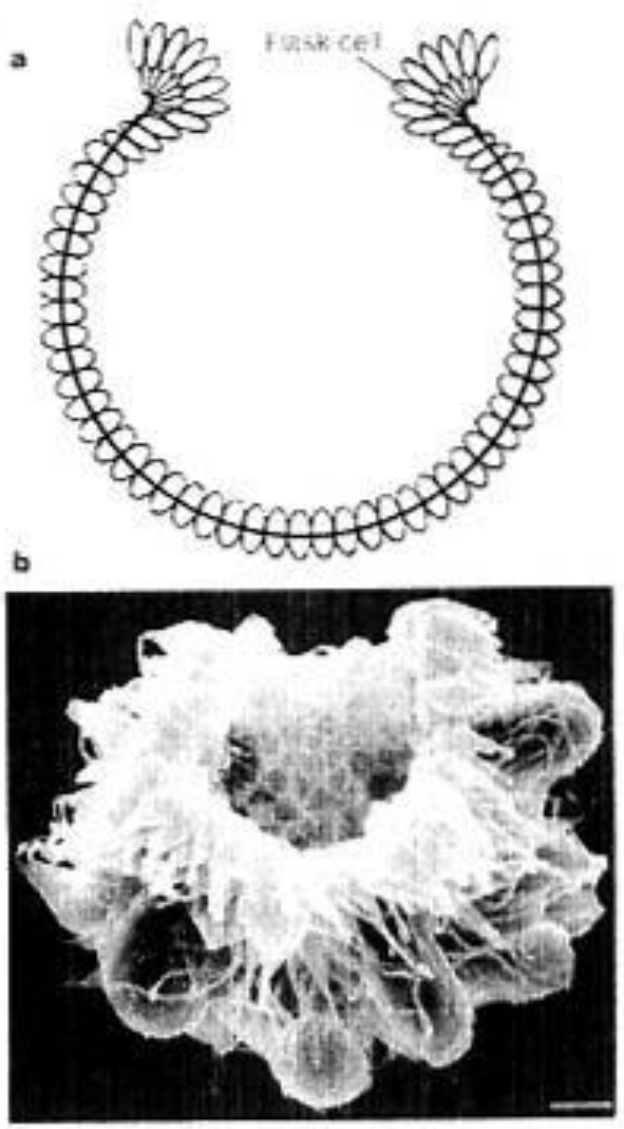
Вентральная сторона

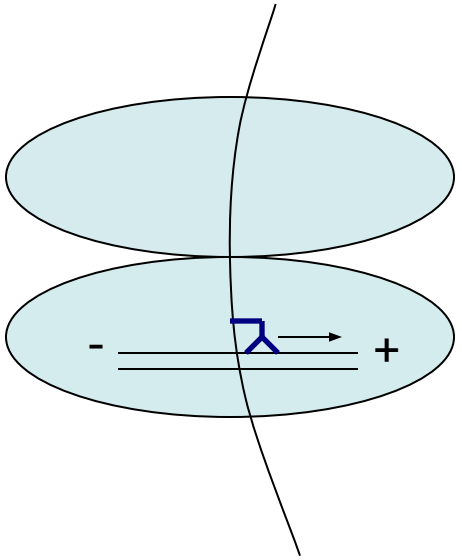


Дорсальная сторона

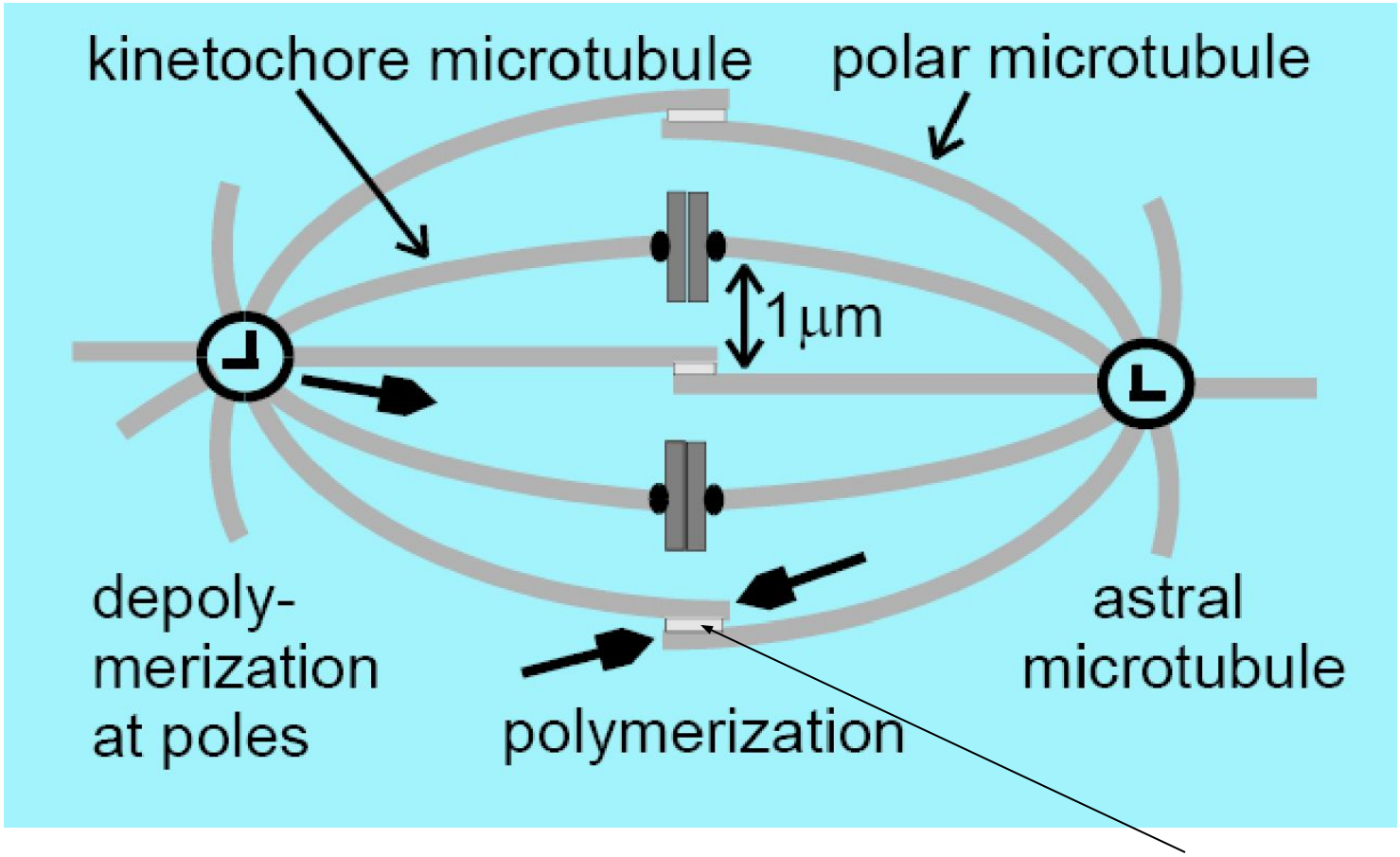


Участие кинезина INV D в экскурвации вольвокса



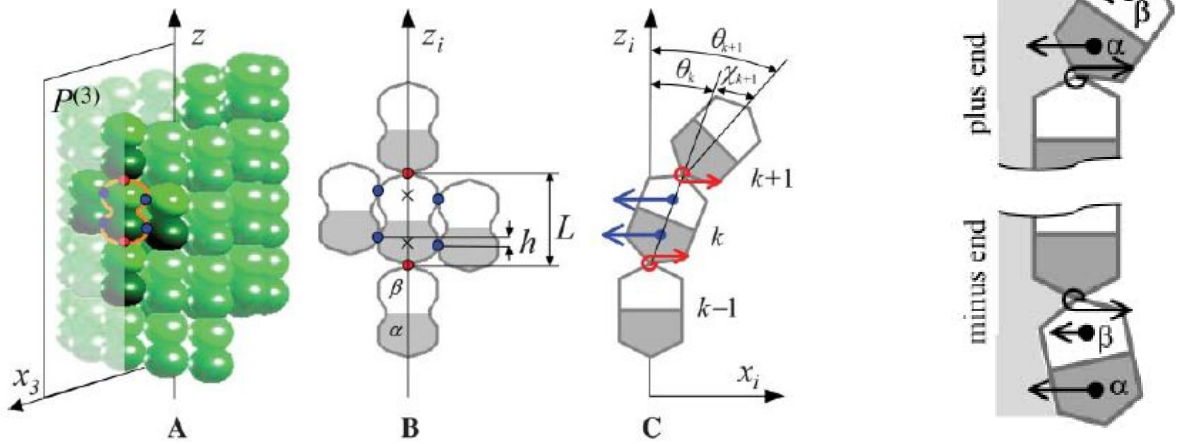


МИКРОТРУБОЧКИ МИТОТИЧЕСКОГО ВЕРЕТЕНА



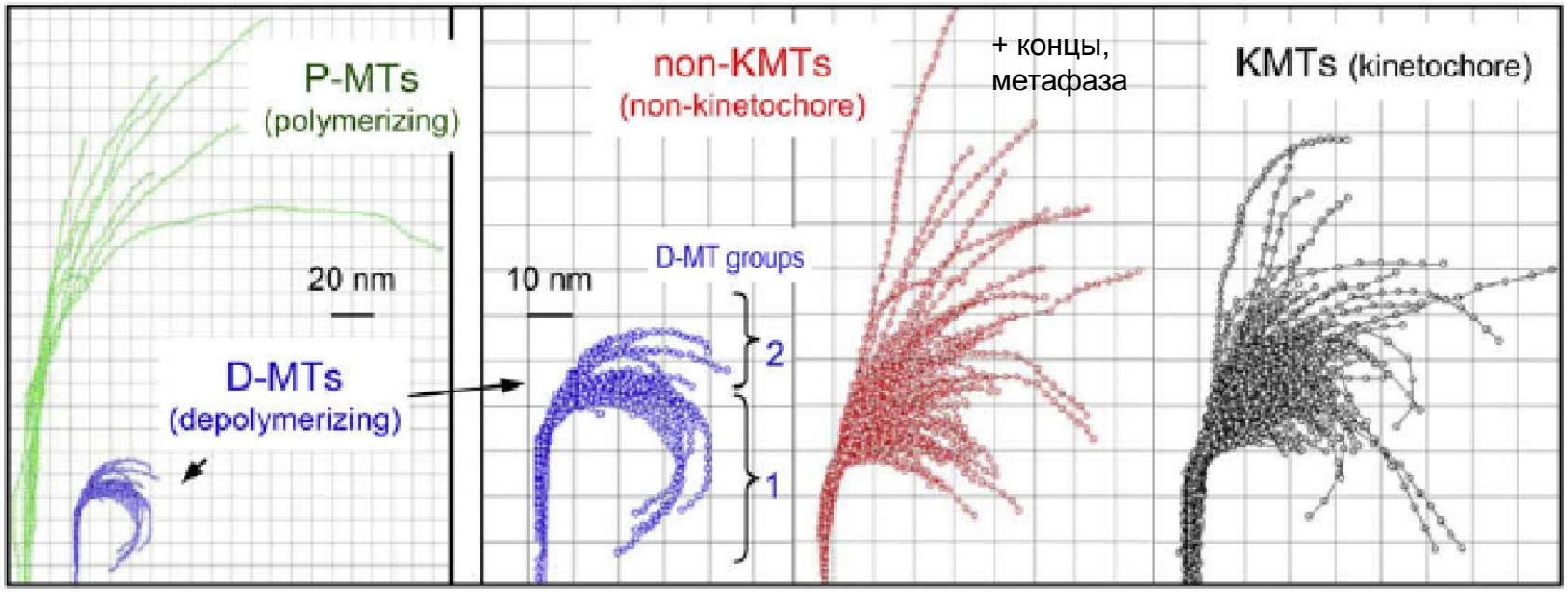
7 семейств кинезинов, в частности биполярный тетрамерный кинезин N

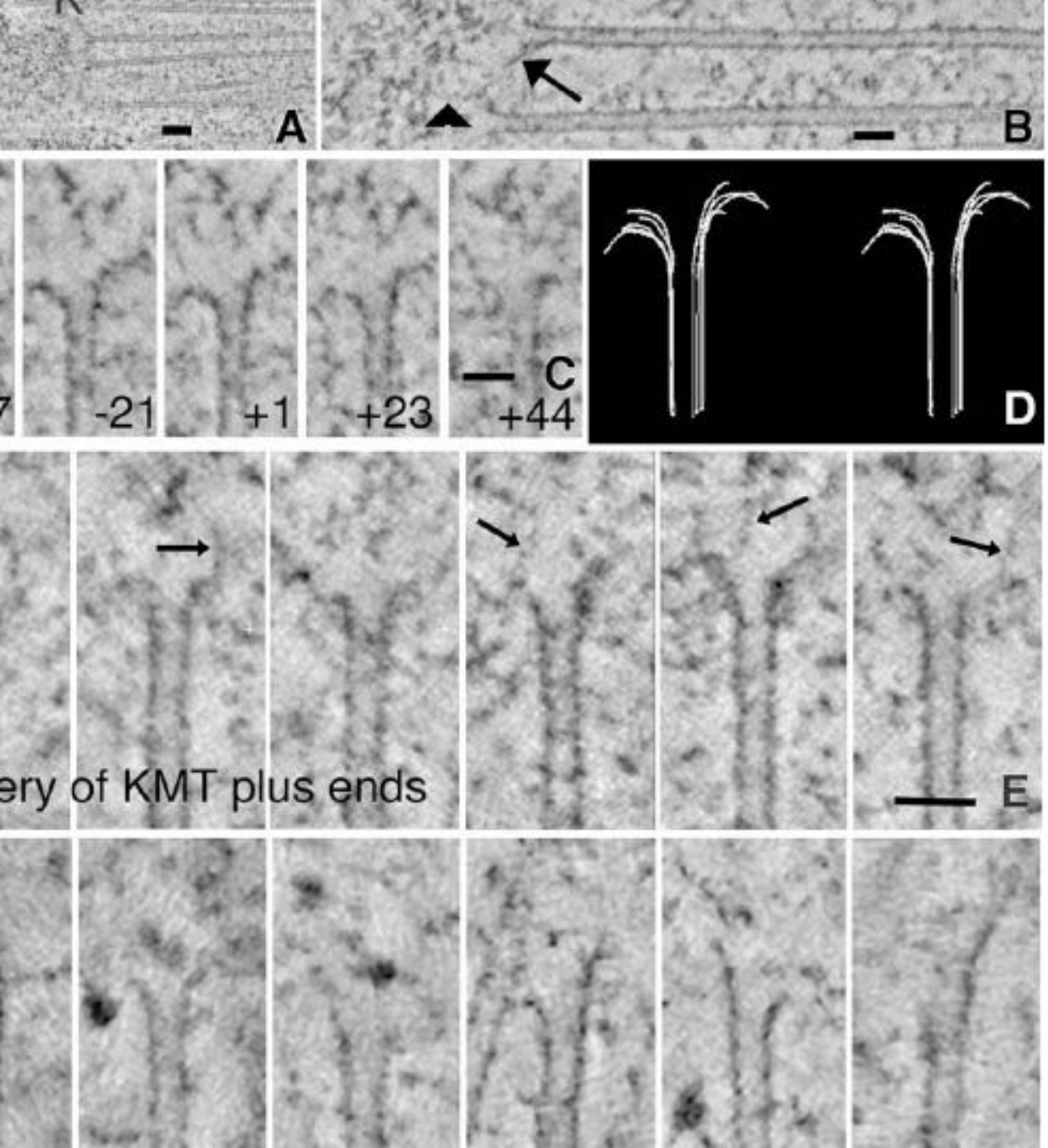
ИЗГИБЫ ПРОТОФИЛАМЕНТ МИКРОТРУБОЧЕК



Тубулин in vitro

Случайная выборка из метафазных и анафазных МТ





(A) Average of 15 consecutive tomograp
total thickness ~30 nm, analogous to
tional thin section. Chromosome (C) a
chore (K) show characteristic staining.
identified as KMTs when they ended i
near a chromosome. Bar = 0.1 μm.

(B) KMTs from the same cell but seen i
slice cut parallel to their axes with th
feature of IMOD. Arrow identifies a be
arrowhead indicates a fibril that runs fr
the chromatin. Bar = 0.05 μm.

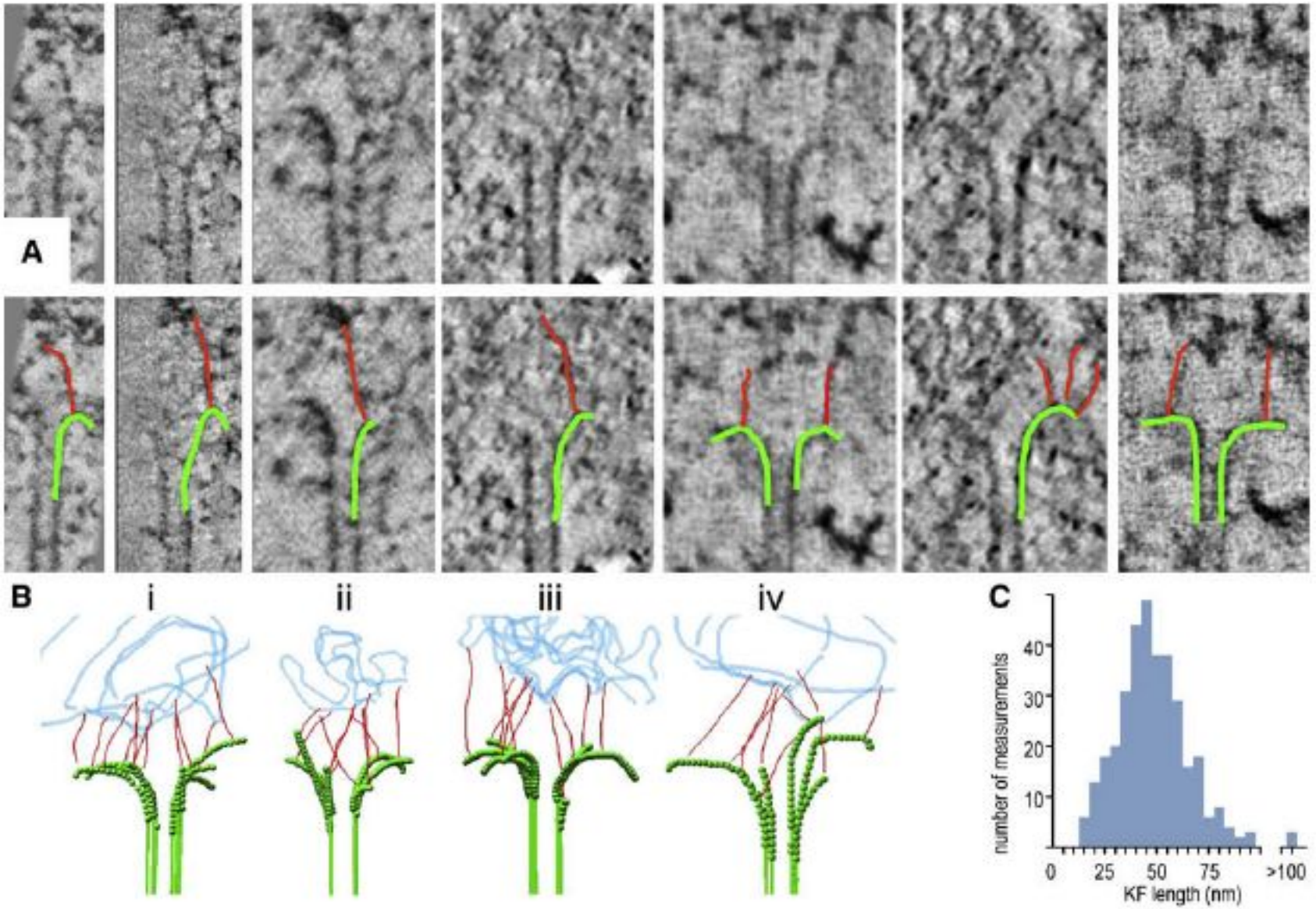
(C) Multiple image planes that contain th
but are oriented at the angles stated rela
plane of section; PFs in each view diffe
and extent of flare. Bar = 0.05 μm.

(D) Stereo pair of a 3D model of all the P
on the MT shown in Figure 1C. Use
viewing.

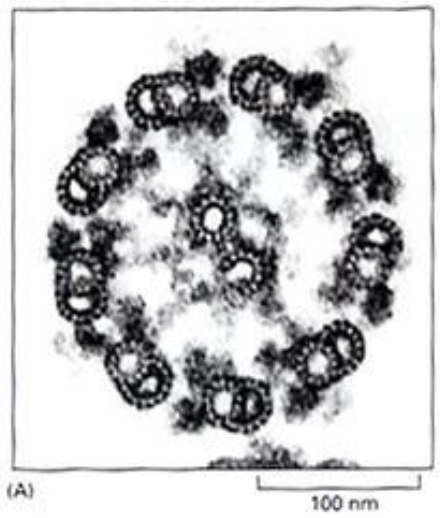
(E) Gallery of different KMT ends from
cell. PF flare is variable; fibrillar material
ated with some PFs (arrows). Bar = 0.0

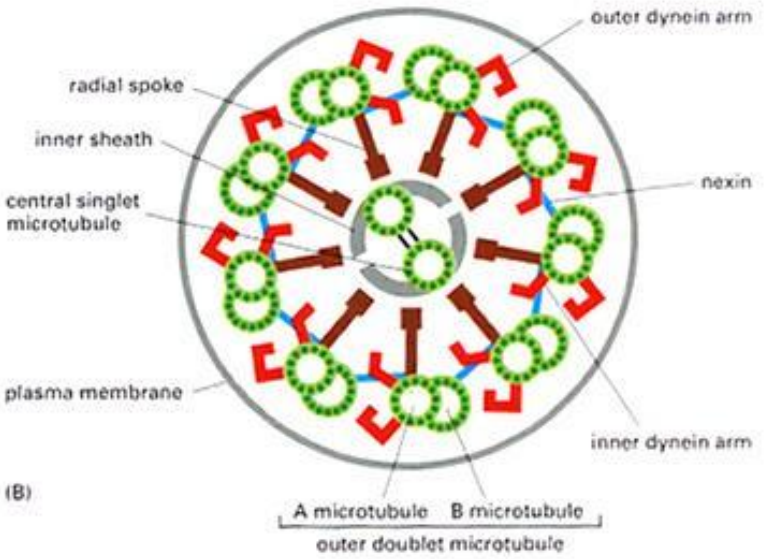
(F) Gallery of non-KMT ends from the po
of a metaphase spindle; no chromos
near. Some MT ends are flared, others
are not seen. Bar = 0.05 μm.

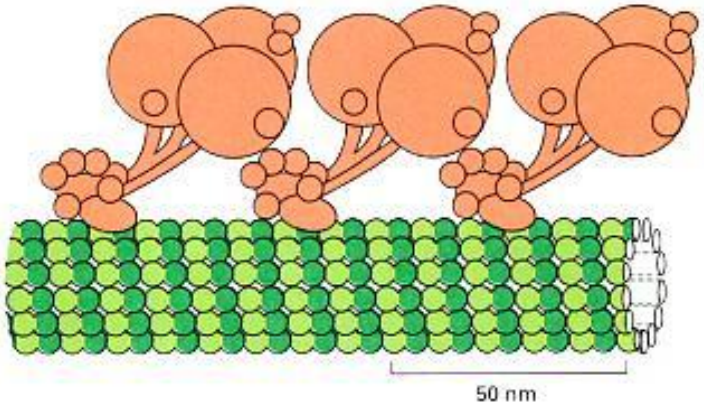
depolymerizing when their leng
on average, constant? Is KMT
a simple reflection of dynamic s
in vitro, or do other factors a

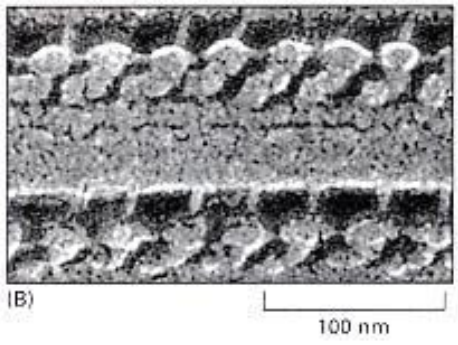

A
B
i
ii
iii
iv
C
number of measurements
40
30
20
10
0
25
50
75
>100
KF length (nm)

СТРУКТУРА РЕСНИЧЕК

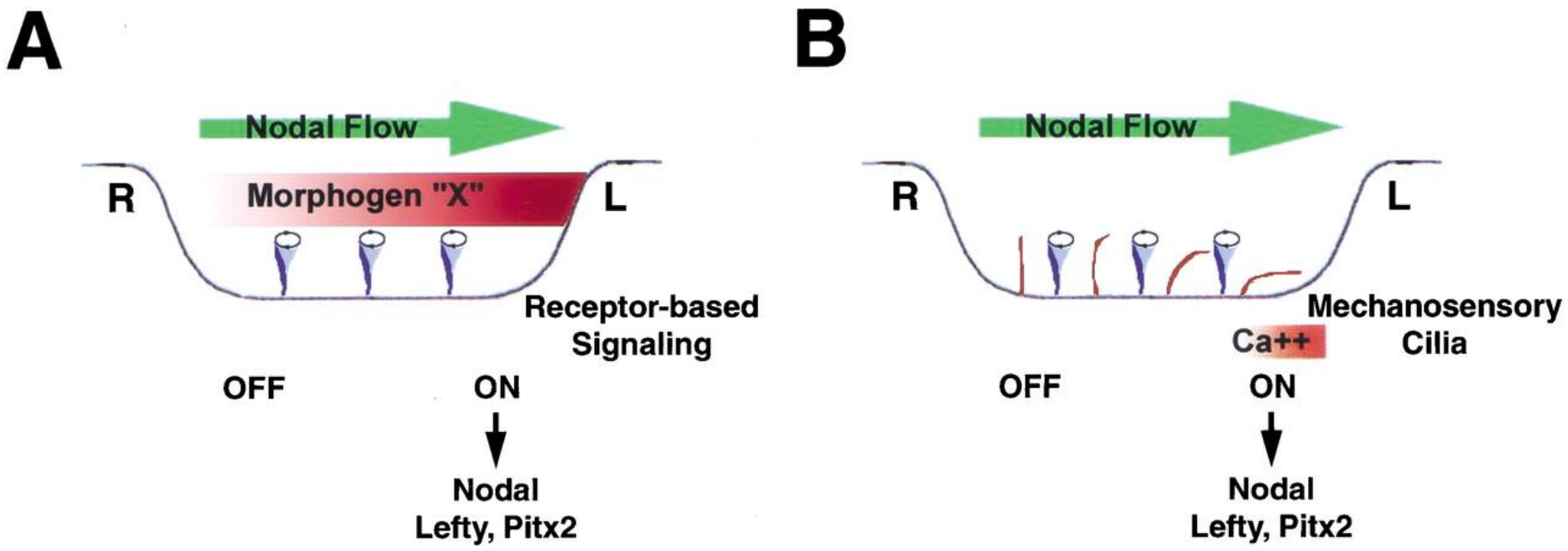


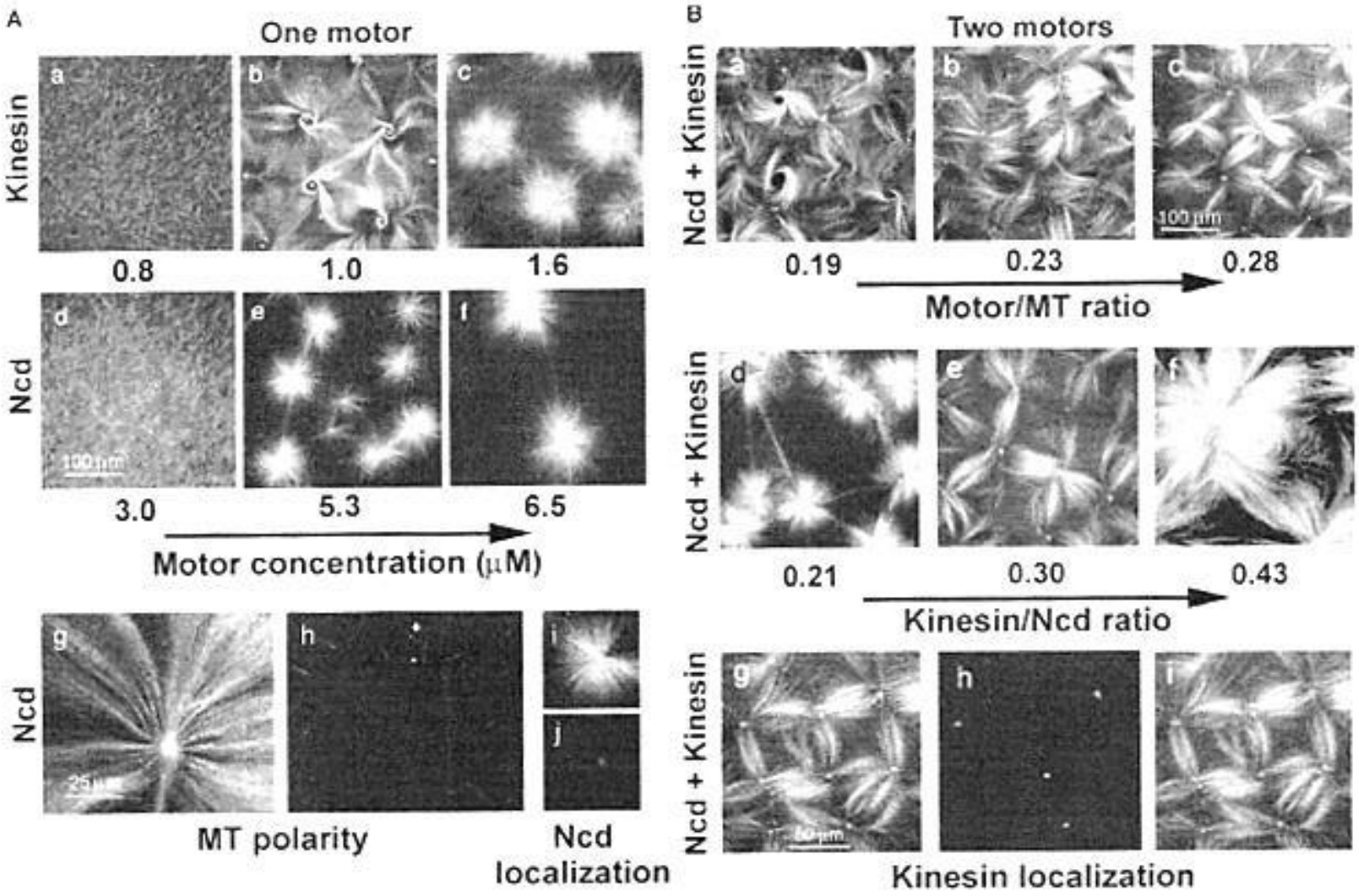






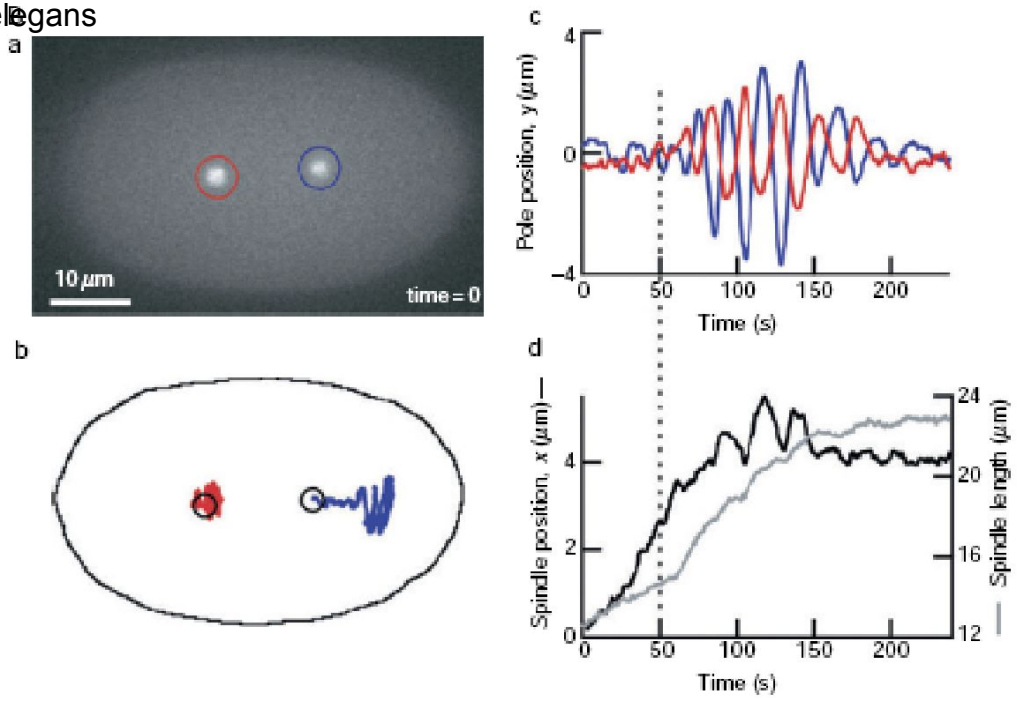
РОЛЬ РЕСНИЧЕК В ФОРМИРОВАНИИ ЛЕВО-ПРАВОЙ ДИССИММЕТРИИ




A
One motor
Kinesin
a
b
c
0.8
1.0
1.6
Ncd
d
e
f
100 μm
3.0
5.3
6.5
Motor concentration (μM)
Ncd
g
h
i
j
25 μm
MT polarity
Ncd localization
B
Two motors
Ncd + Kinesin
a
b
c
100 μm
0.19
0.23
0.28
Motor/MT ratio
Ncd + Kinesin
d
e
f
0.21
0.30
0.43
Kinesin/Ncd ratio
Ncd + Kinesin
g
h
i
50 μm
Kinesin localization

КОЛЕБАНИЯ, ПОТОКИ И ВИХРИ МИКРОТРУБОЧЕК, СВЯЗАННЫХ С МОТОРАМИ

Колебания митотического веретена при первом делении дробления C.elegans



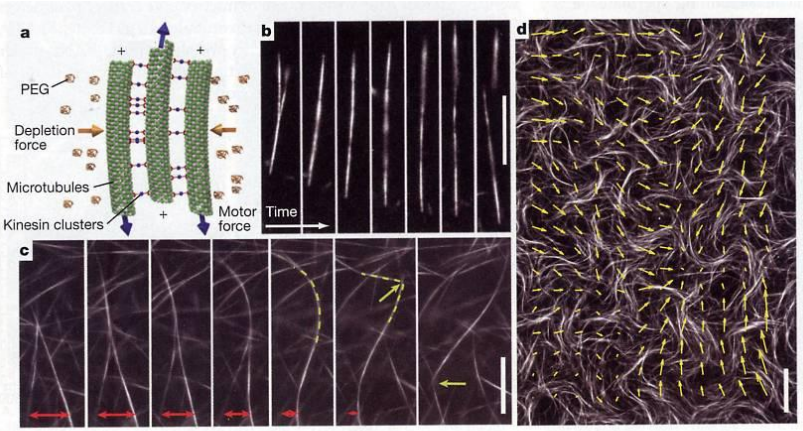


Figure 1 | Active microtubule networks exhibit internally generated flows. **a**, Schematic illustration of an extensile microtubule–kinesin bundle, the basic building block used for the assembly of active matter. Kinesin clusters exert inter-filament sliding forces, whereas depleting PEG polymers induce microtubule bundling. **b**, Two microtubule bundles merge and the resultant bundle immediately extends, eventually falling apart. Time interval, 5 s; scale bar, 15 μm. **c**, In a percolating microtubule network, bundles constantly merge (red arrows), extend, buckle (green dashed lines), fracture, and self-heal to produce a robust and highly dynamic steady state. Time interval, 11.5 s; scale bar, 15 μm. **d**, An active microtubule network viewed on a large scale. Arrows indicate local bundle velocity direction. Scale bar, 80 μm.

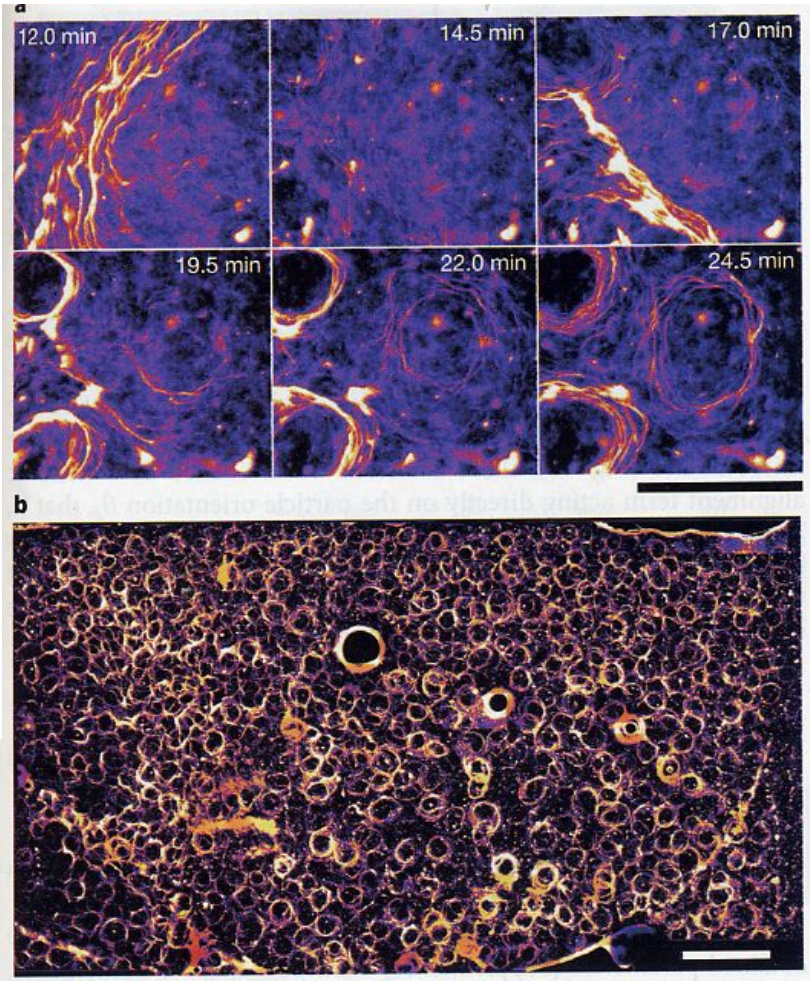
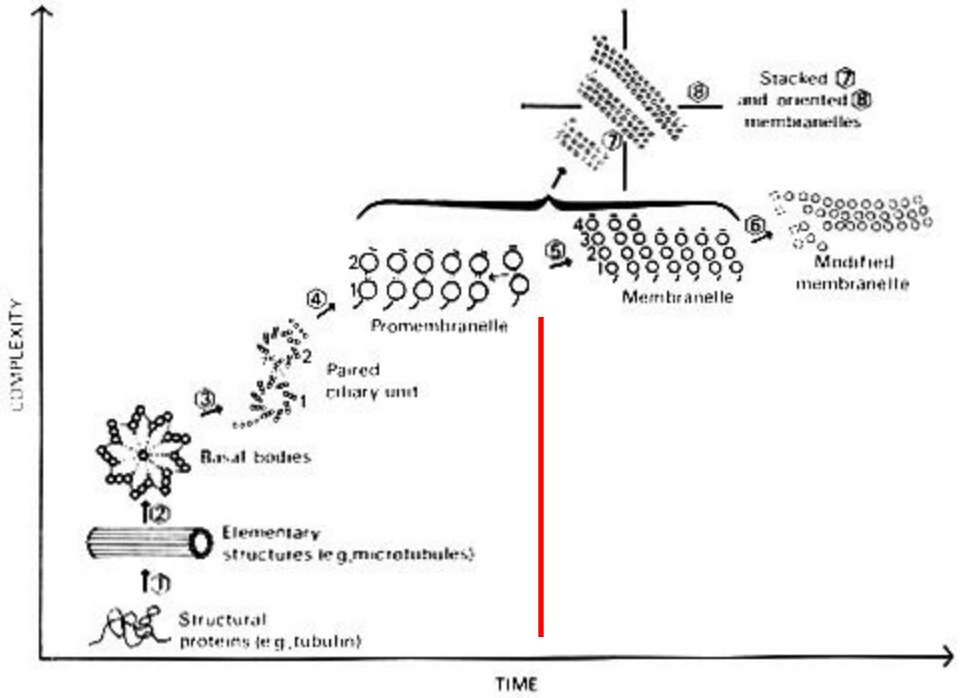
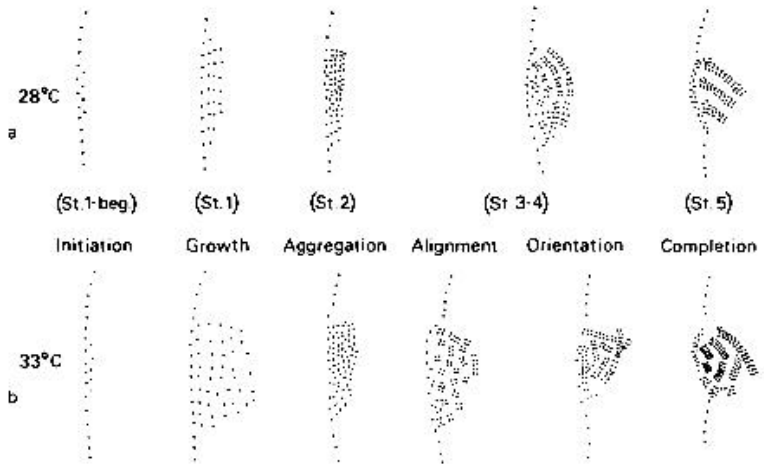


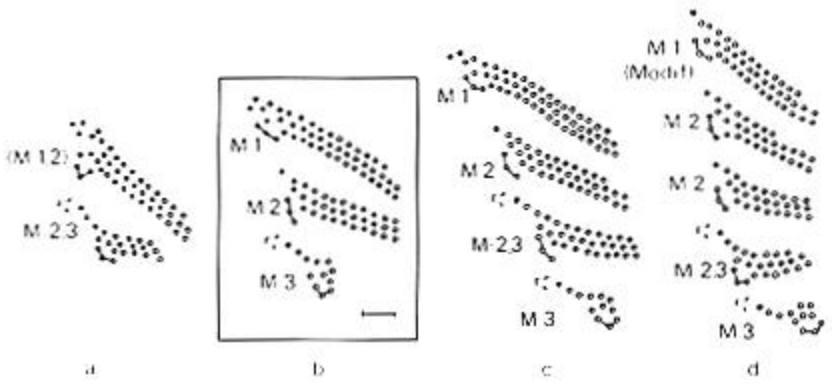
Figure 1 | Emergence of vortices of microtubules. False-colour images. **a**, Formation process of vortex pattern: 0 min corresponds to the time of injection of ATP. Streams appeared around 5 min after this injection. At 12 min, streams started to meander. Vortices started to appear around 17 min, when meandering streams contacted one another. Once vortices had formed, they grew steadily (22 min). Scale bar, 500 μm. **b**, Large-scale lattice of vortices. Vortices can be observed everywhere on the surface of the flow cell. Three air bubbles in the flow cell can be seen distinctively owing to their greater size and thicker edges. Scale bar, 2 mm.

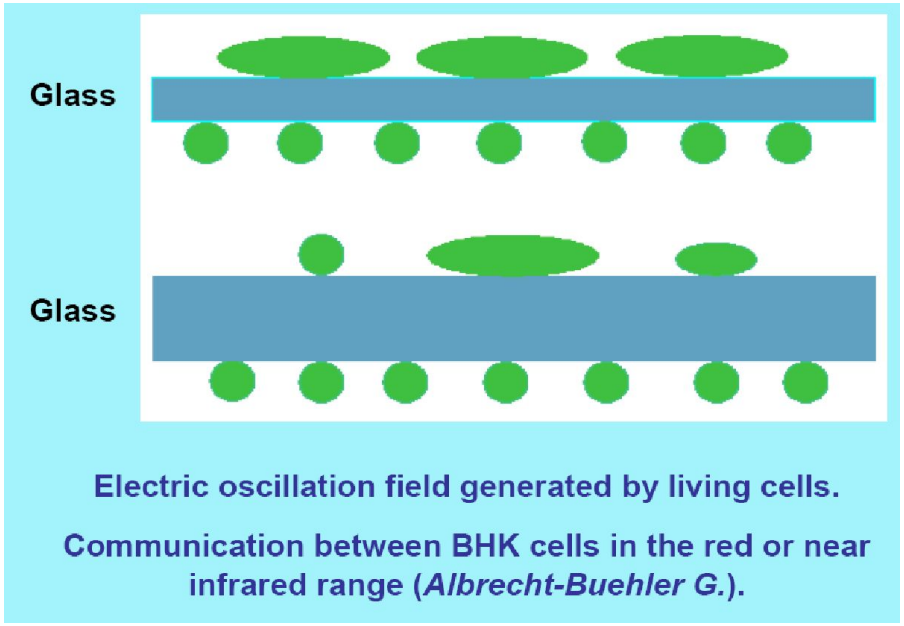
БАРЬЕР ФРАНКЕЛЯ: ПЕРЕХОД ОТ МОЛЕКУЛЯРНОЙ САМОСБОРКИ К МАКРОСКОПИЧЕСКОЙ РЕГУЛЯЦИИ



РАЗДЕЛИМОСТЬ САМОСБОРКИ И РЕГУЛЯЦИИ ПОЛОЖЕНИЯ

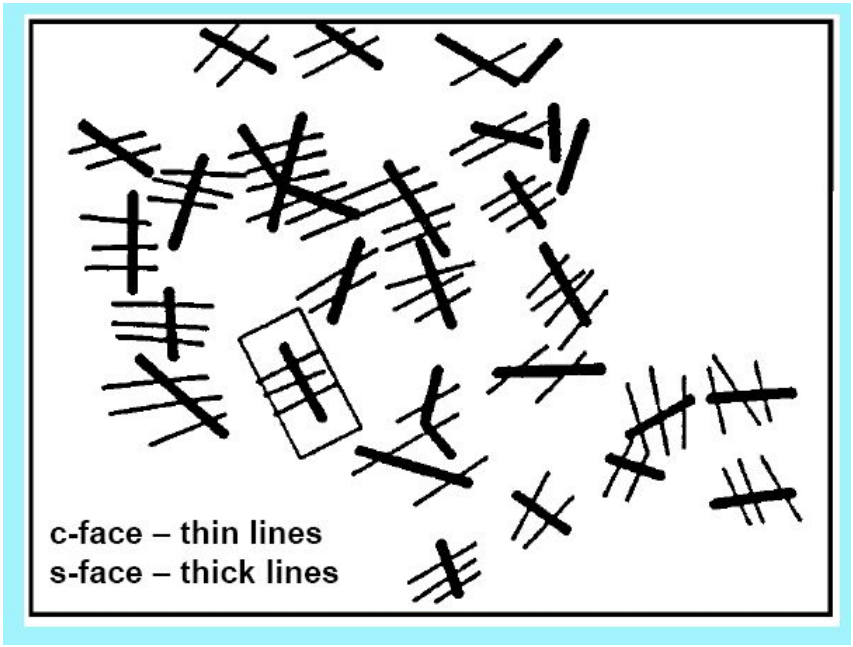


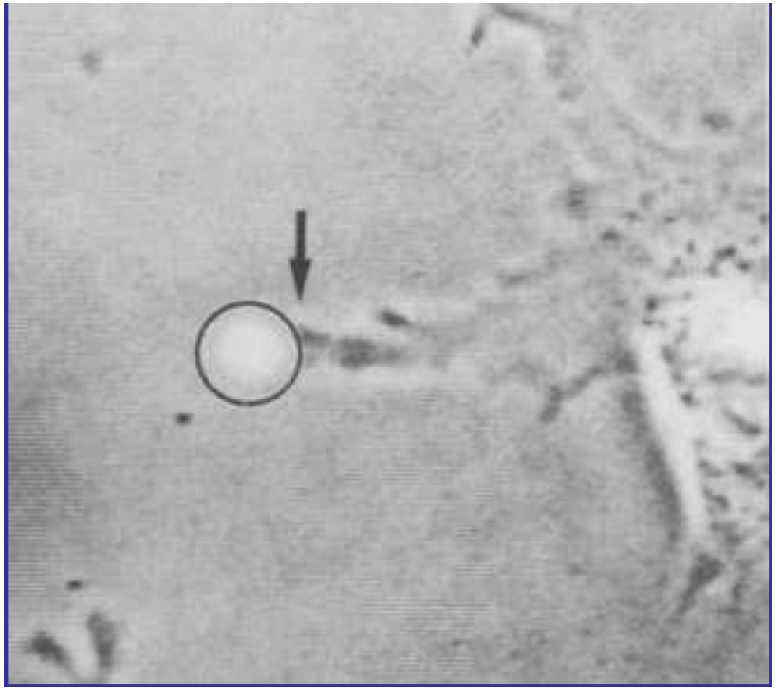


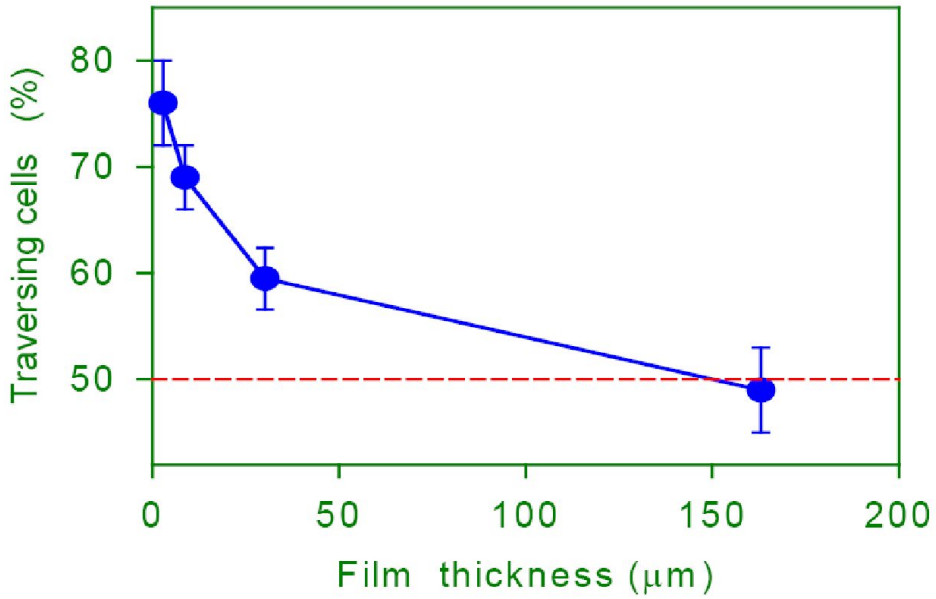


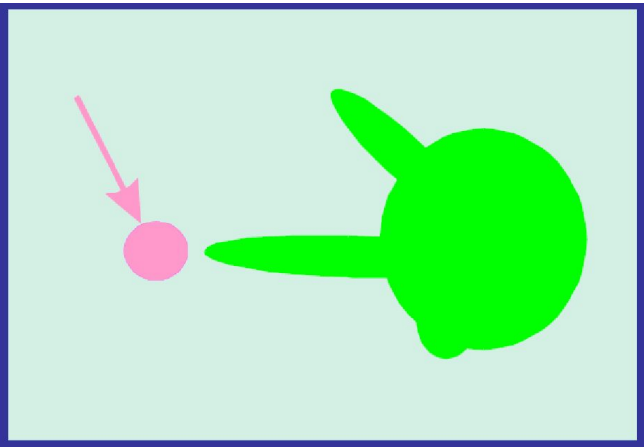
Electric oscillation field generated by living cells.

Communication between BHK cells in the red or near infrared range (*Albrecht-Buehler G.*).

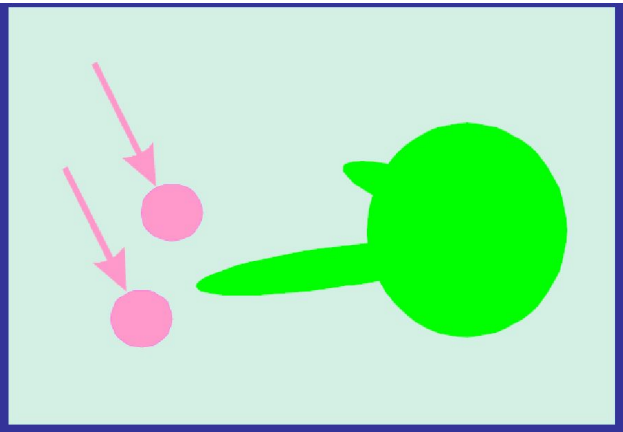








A schematic picture of extension of separate lamellipodium (green) towards latex particles (pink) scattering infrared light of 800 nm wavelength (3T3 cells).



A schematic picture of extension of a 3T3 cell towards two separate light sources of 800 nm (latex particles). Extension may be formed first to one light source and then to the other.