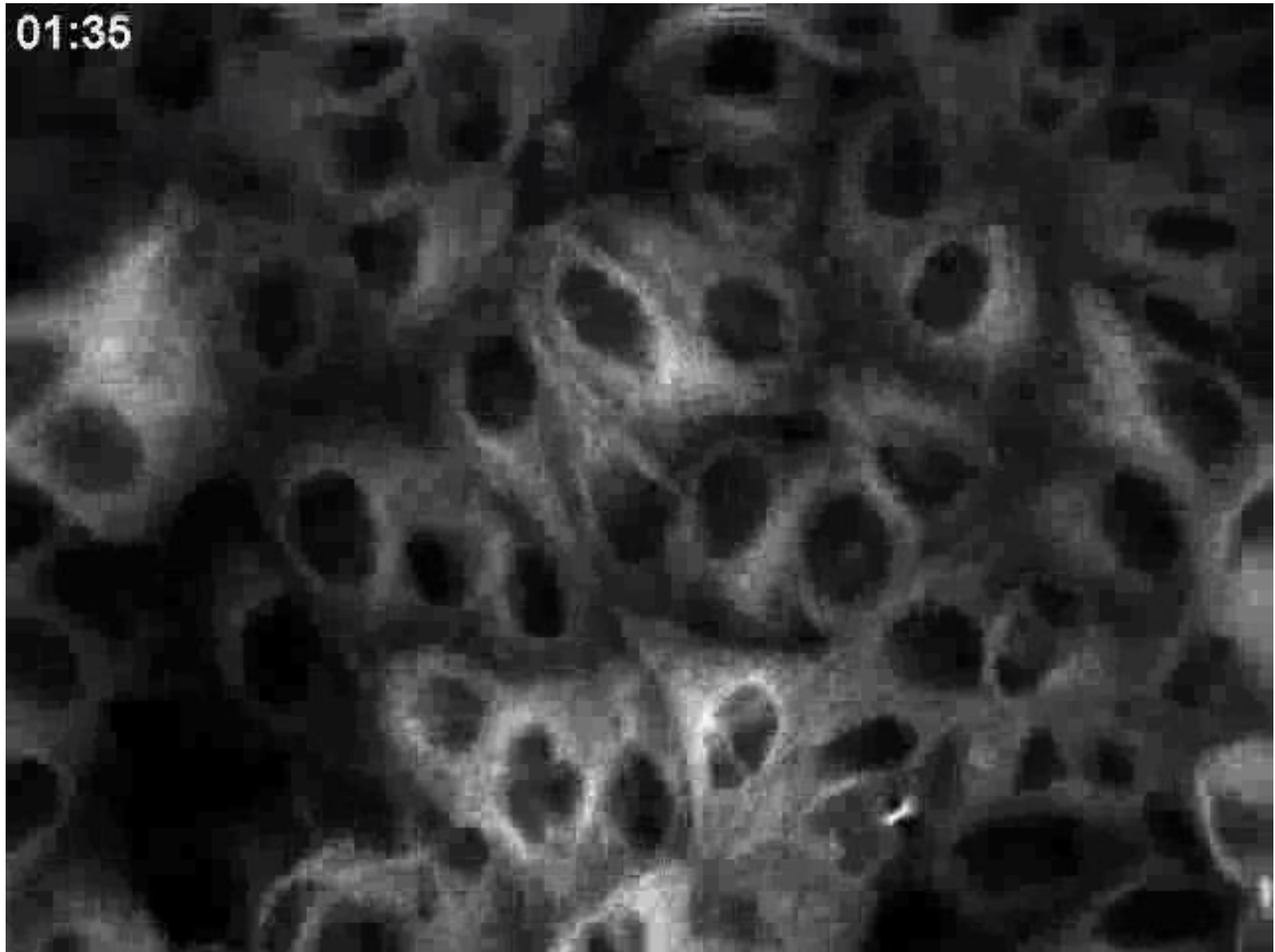
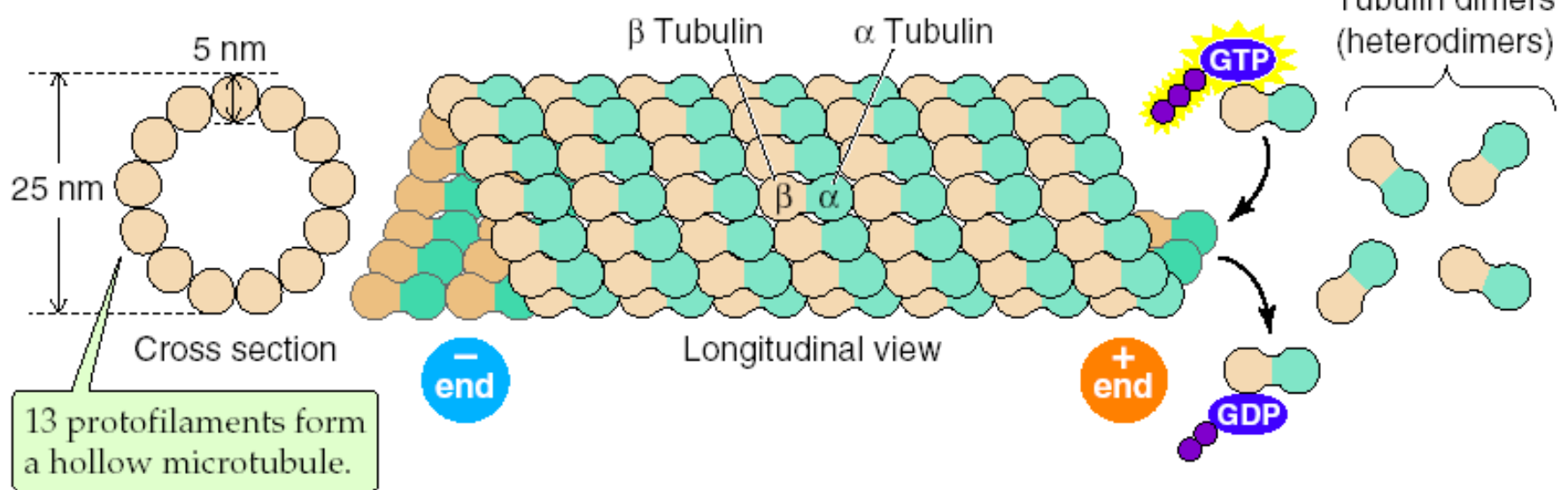


- Microtubules 25 nm diameter
 - bundles of tubulin protofilaments, each 5 nm
- Thick Filaments 10 nm diameter
 - myosin, molecular motor with actin
- Intermediate Filaments 8-10 nm diameter
 - glial fibrillary acidic protein, vimentin
 - dense networks providing mechanical strength
- Thin Filaments 5-8 nm
 - actin

Microtubules - tubulin

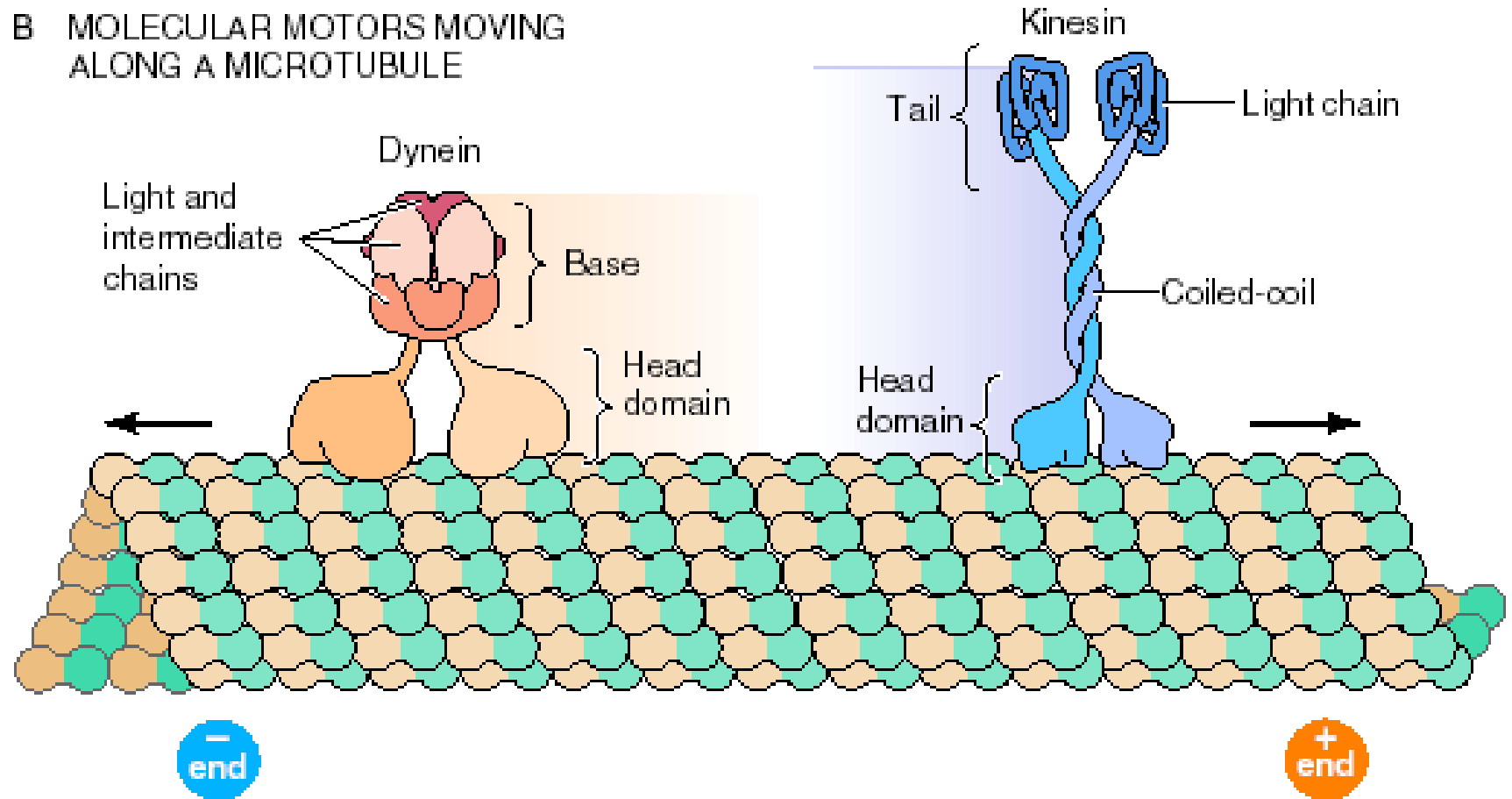


A MICROTUBULE



- monomers assemble roughly three times faster at plus end compared to minus end
- GTP-bound monomers assemble with high affinity. GDP-bound form has lower affinity.
- Activity due to enzymatic activity of tubulin, and other proteins.
- Capping proteins serve to control this assembly and to interface microtubules with cellular structures.
- Serve as scaffolding for intracellular movement

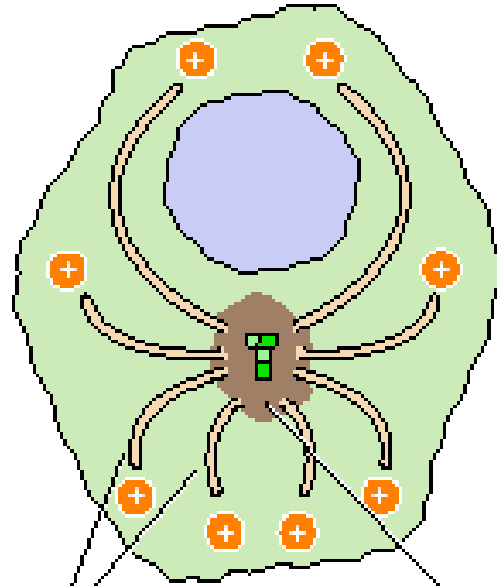
B MOLECULAR MOTORS MOVING ALONG A MICROTUBULE



- Both families of proteins require ATP for activity.
- Dynein has soluble and fiber-associated forms
- Directionality

B MICROTUBULE-ORGANIZING CENTER

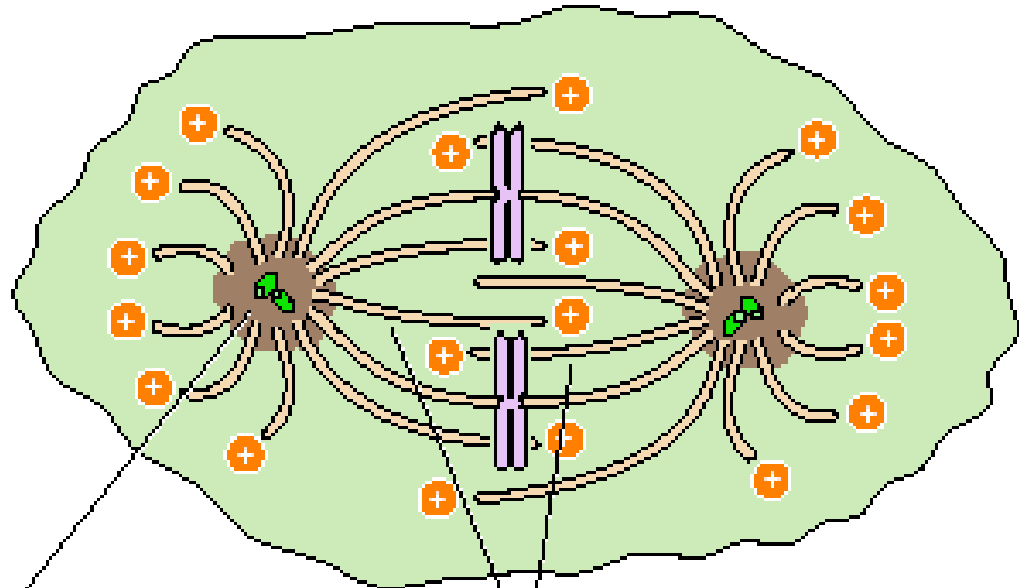
Interphase cell



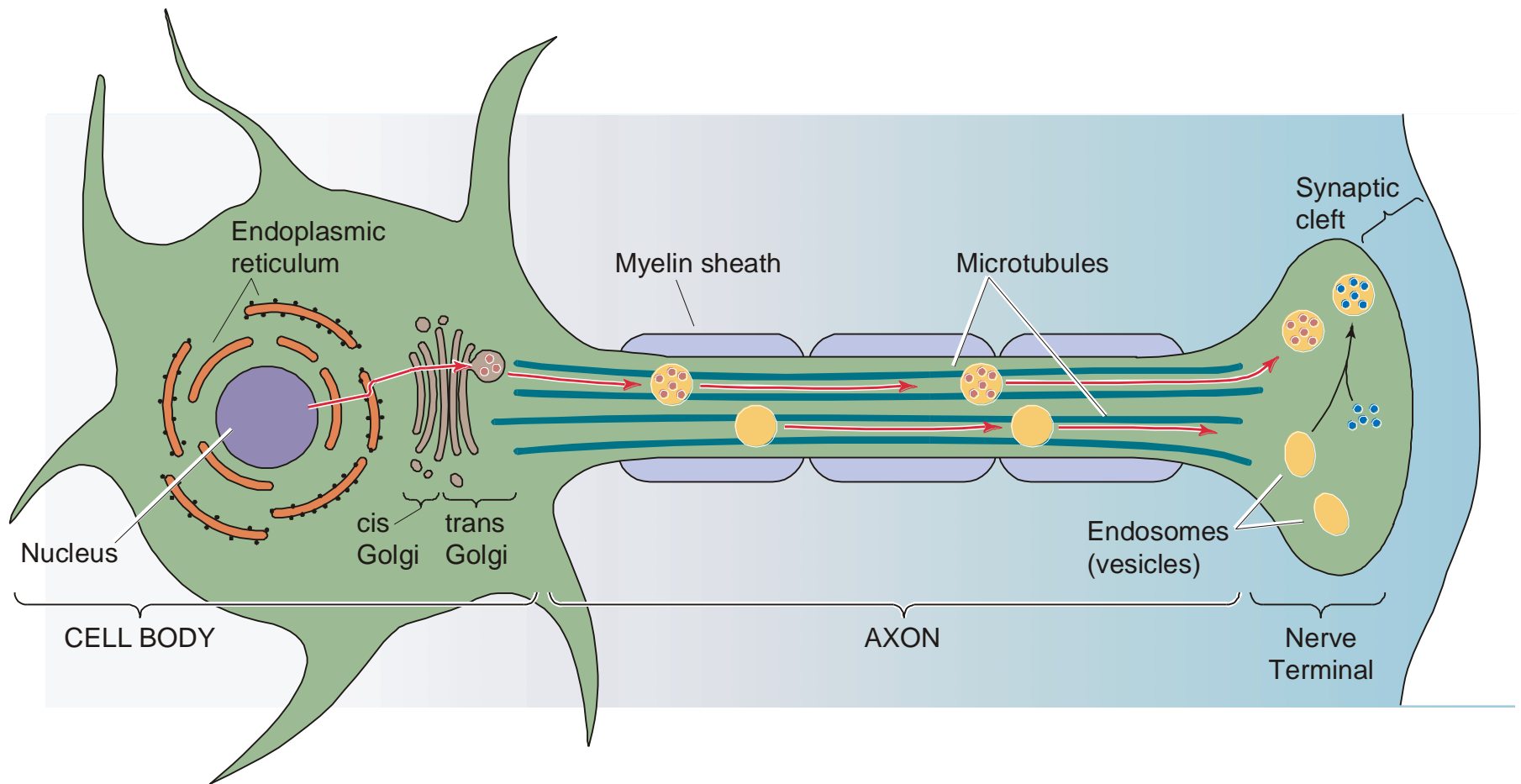
Astral
microtubules

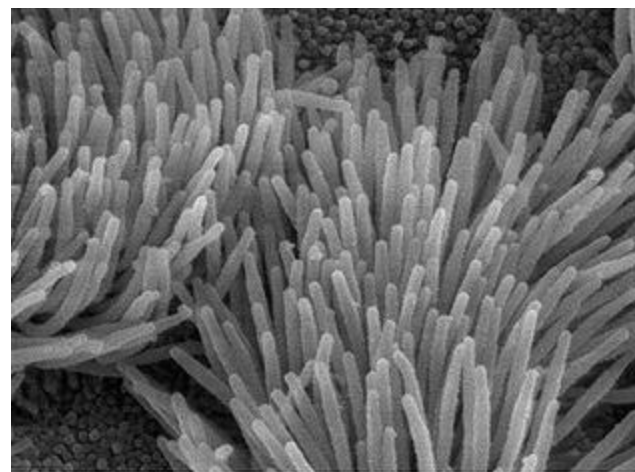
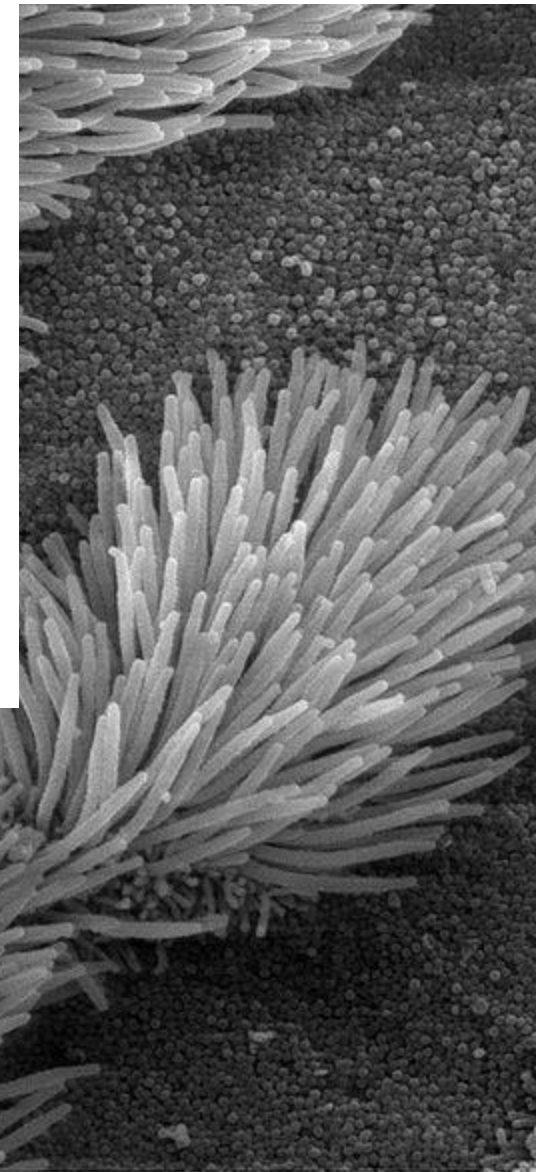
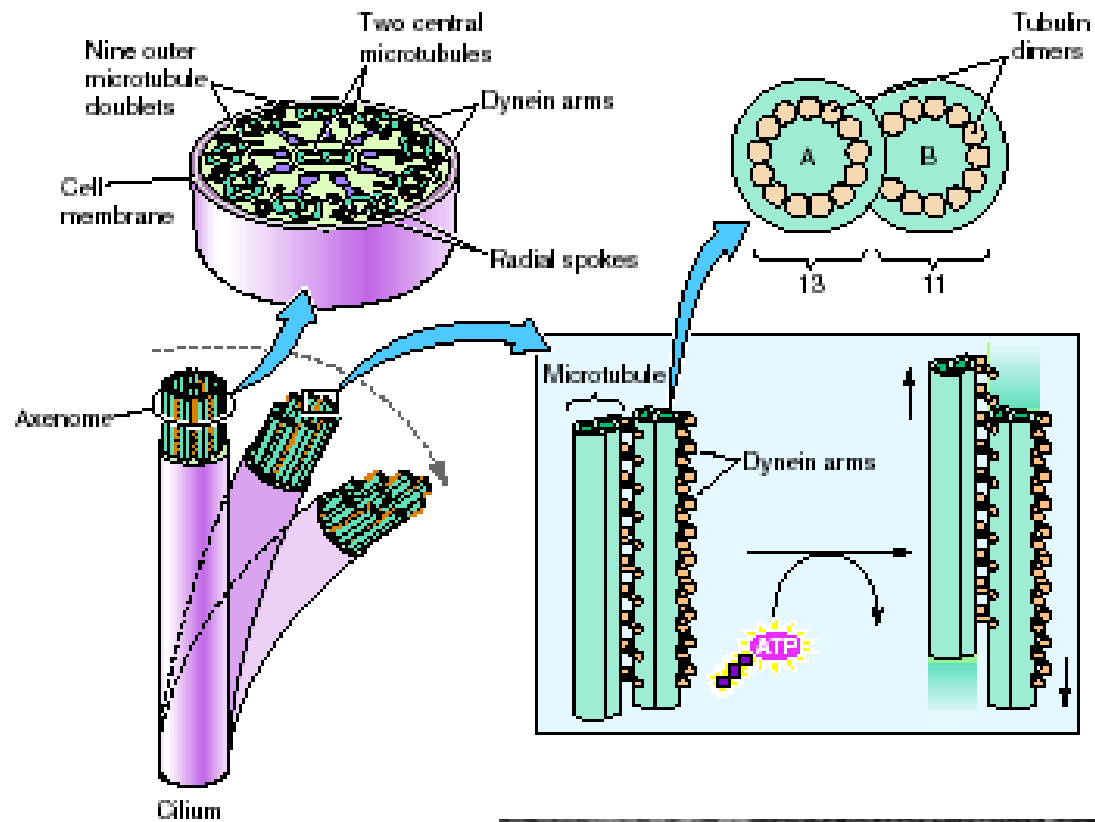
Microtubule
organizing centers
(centrosomes)

Metaphase cell



Kinetochore
microtubules

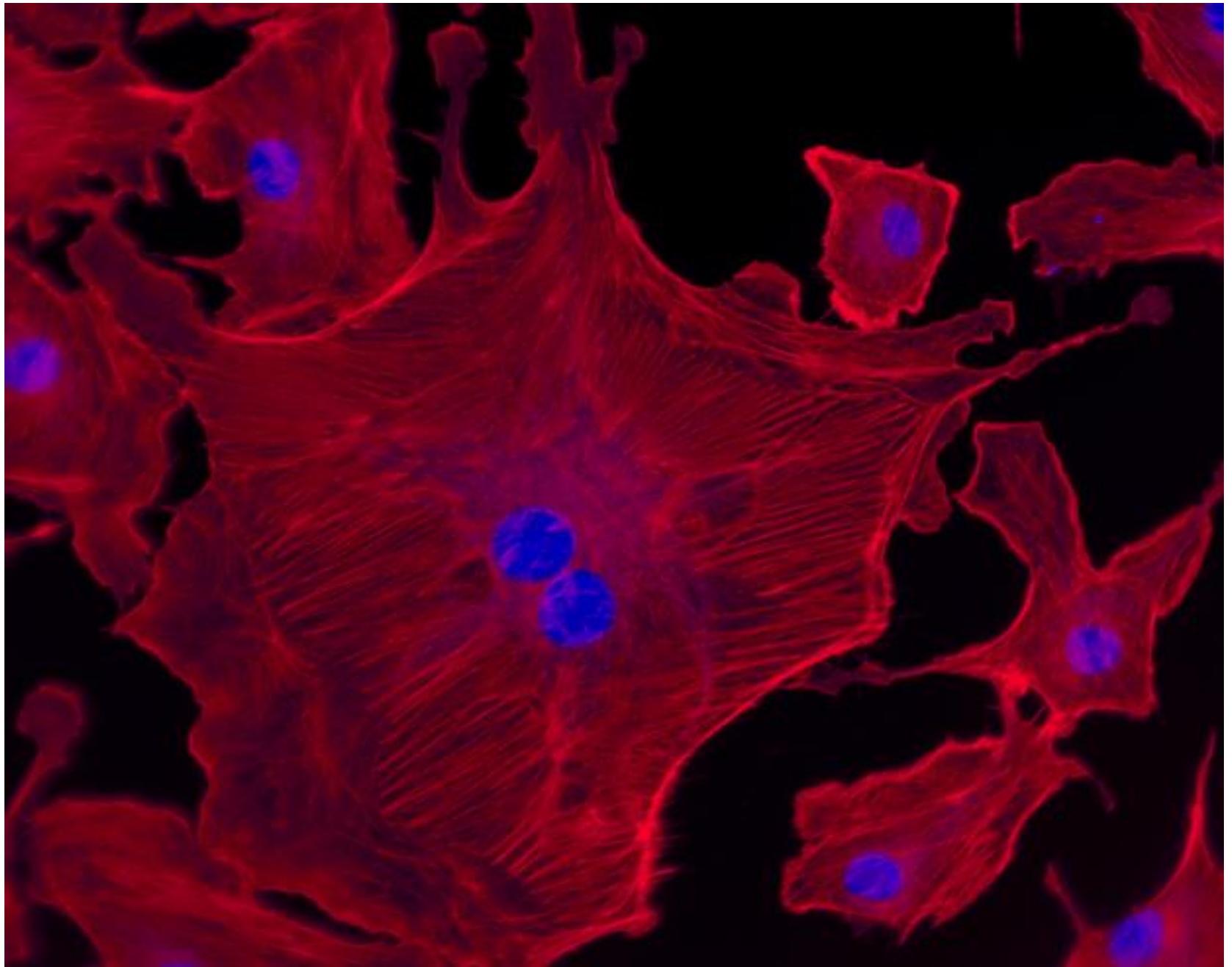


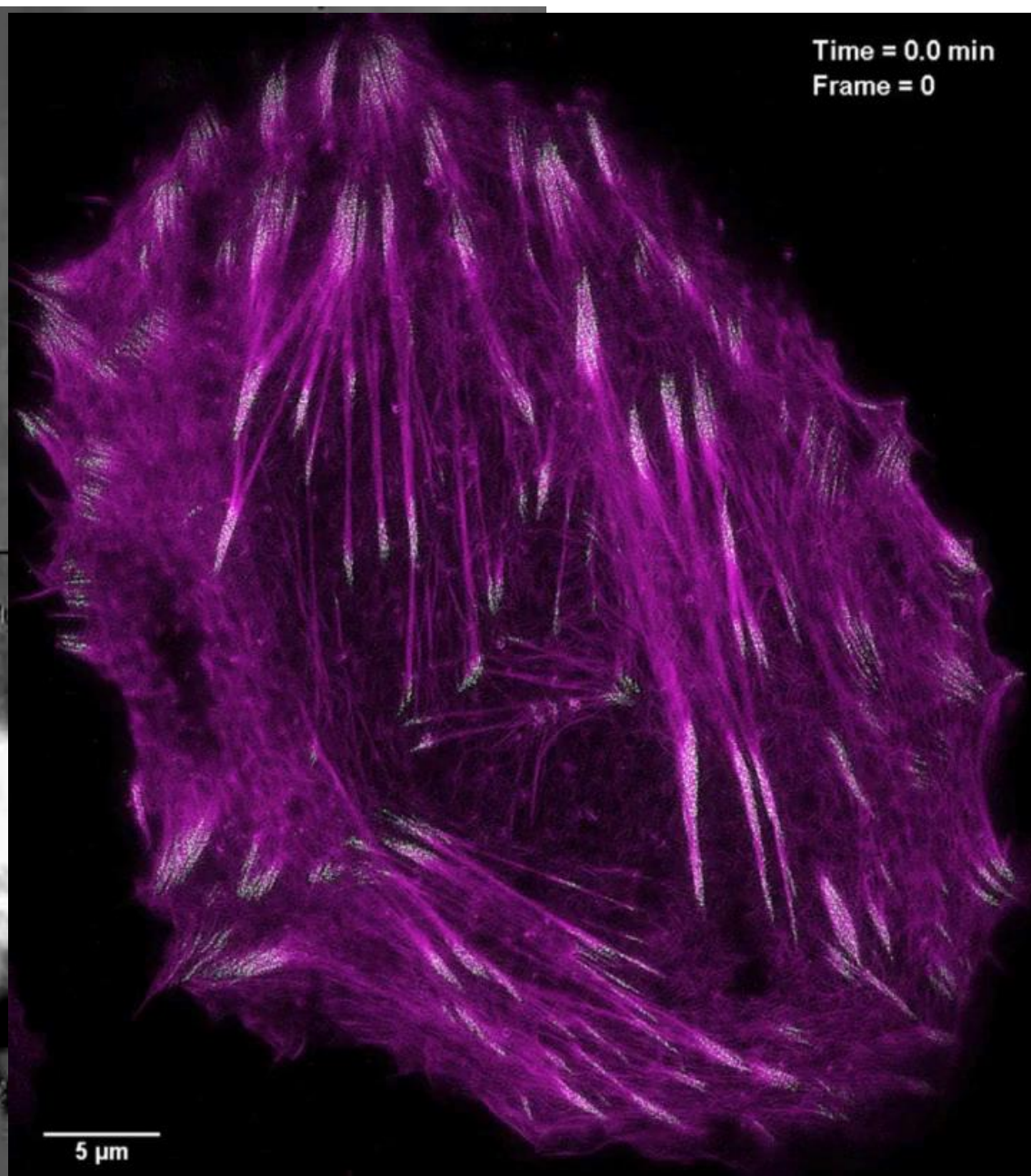
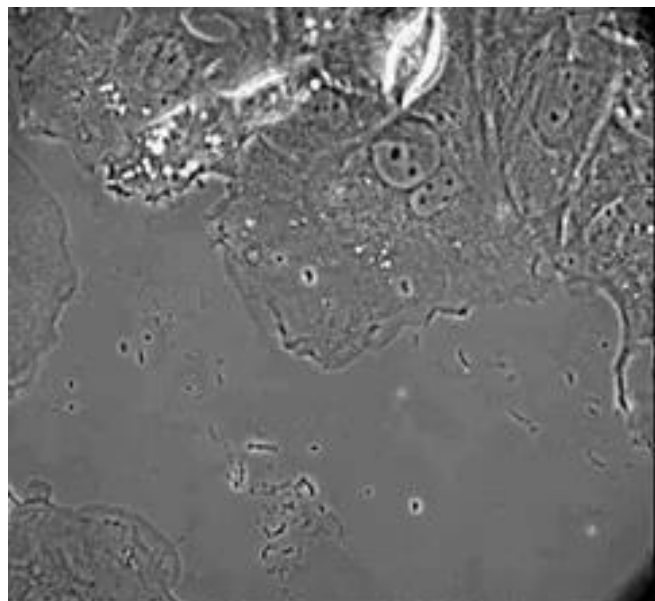


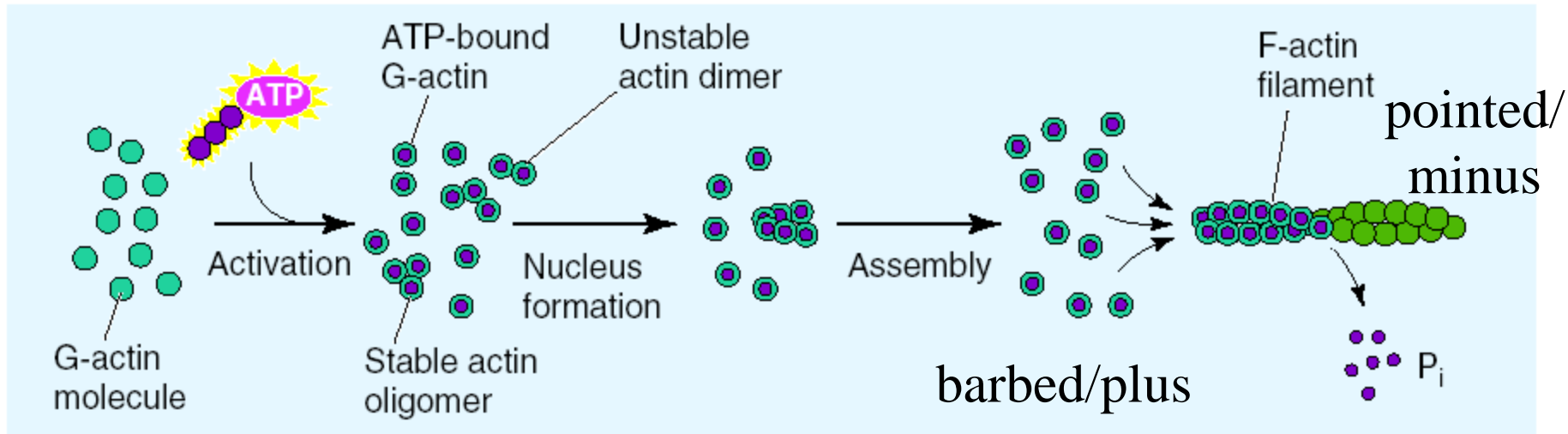
5 µm

Lung 001

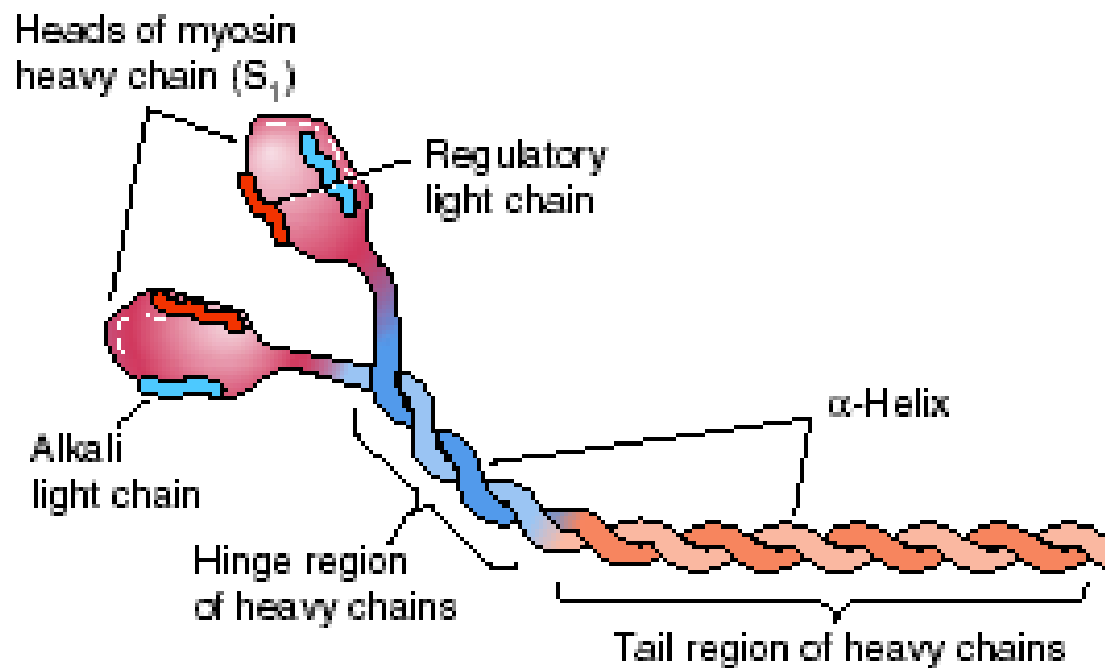
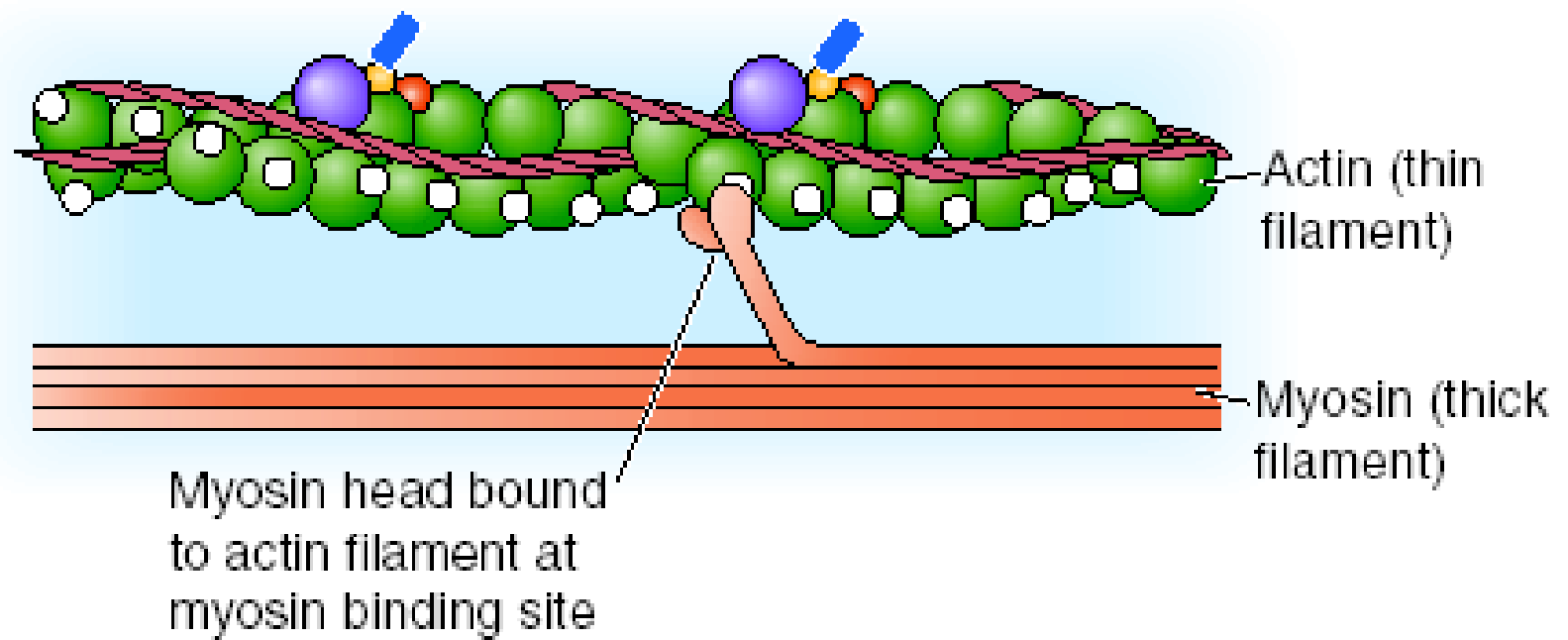
1/20/ 0 REMF 5000X

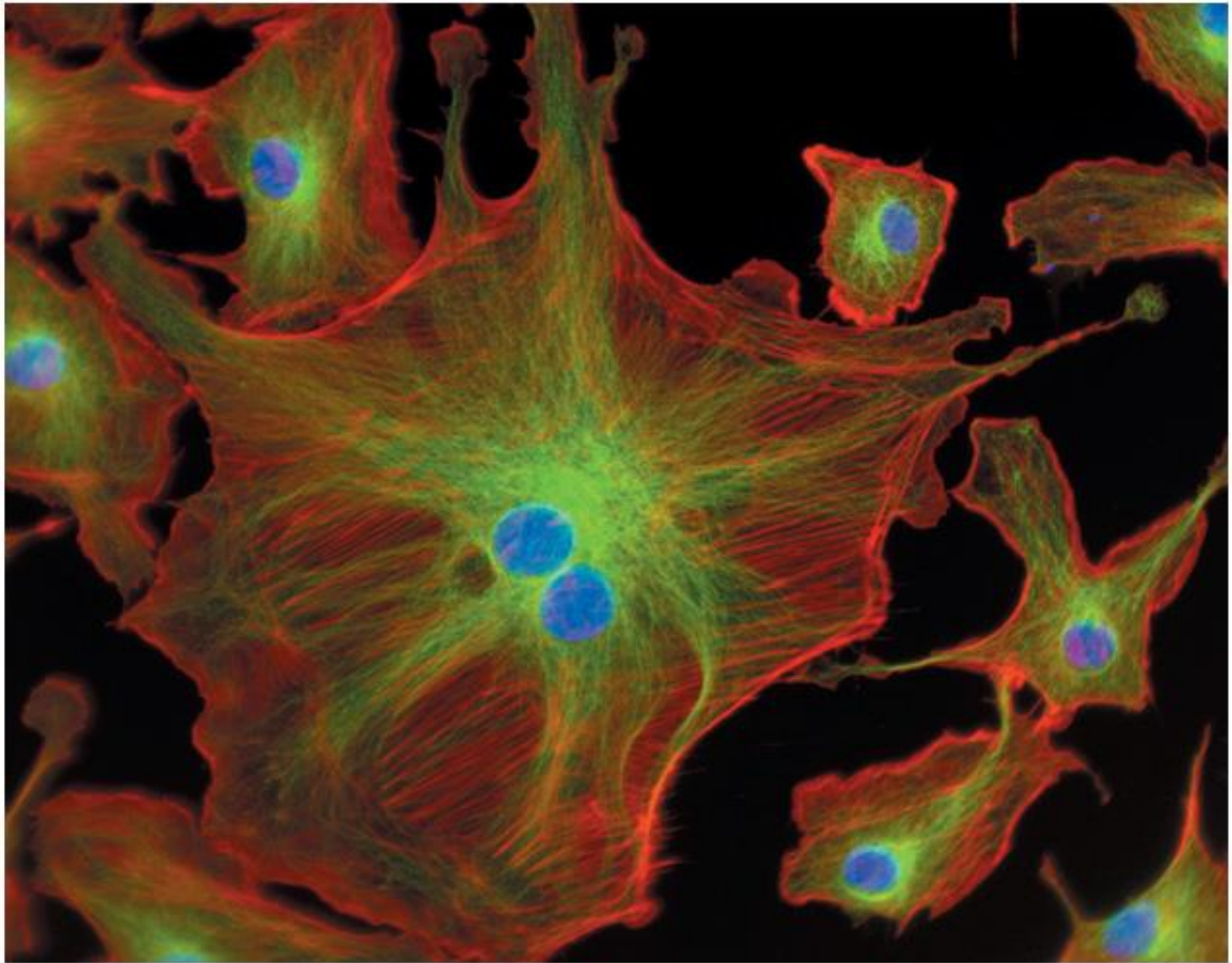






- monomers bind ATP -> high affinity assembly, convert to ADP, lower affinity.
- polarity, much like microtubules, but with some differences that we'll get to
- involved in coordinating cell-cell behaviors and large-scale activity in conjunction with myosins.





<https://xvivo.com/blog/the-inner-life-of-the-cell-animation/>

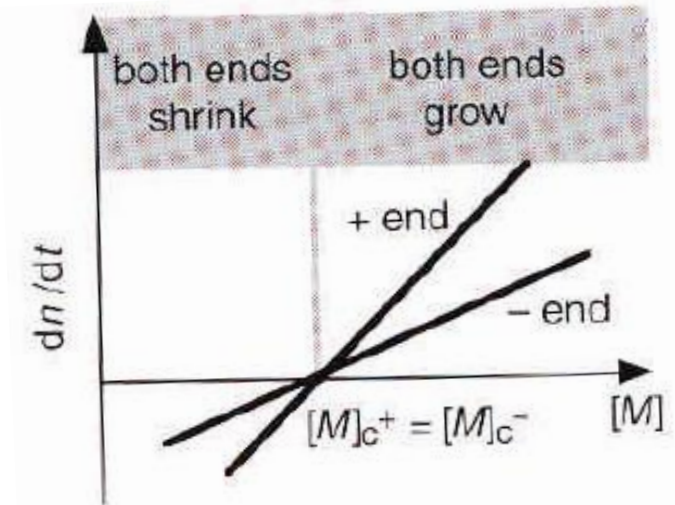
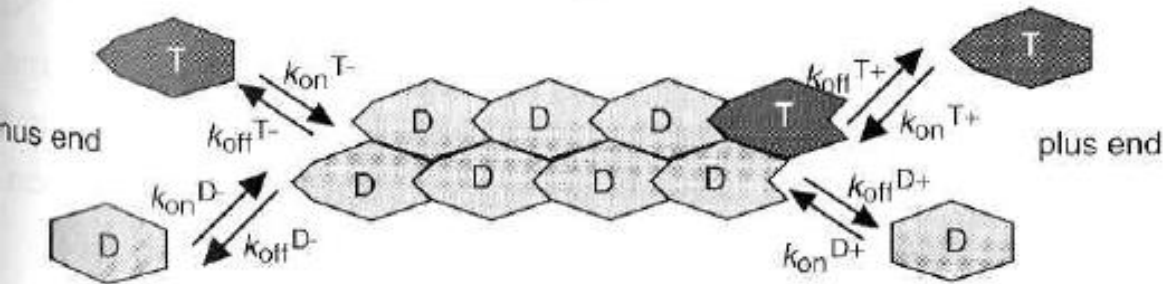


- n = length of filament, in numbers of units
- $[M]$ = concentration of monomer, at the moment unaffected by GTP/ATP/other factors

$$\frac{dn}{dt} = +k_{\text{on}} [M] - k_{\text{off}}$$

$$[M]_{\text{C}} = \frac{k_{\text{off}}}{k_{\text{on}}}$$

Tubulin

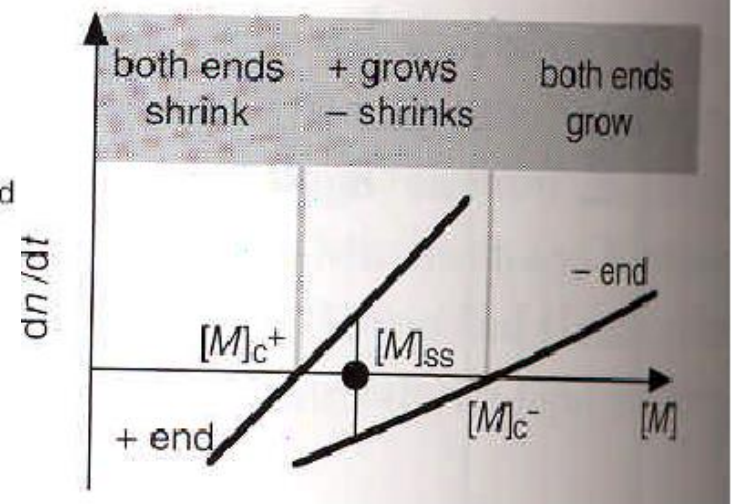
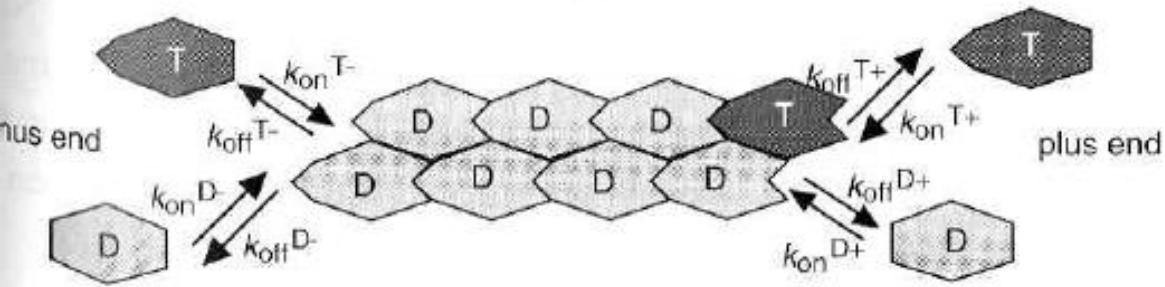


These can be measured for free monomers. For tubulin:

	plus end			minus end		
	$k_{on}, (\mu m \cdot s)^{-1}$	k_{off}, s^{-1}	$M_C, \mu M$	k_{on}	k_{off}	M_C
growing (GTP)	8.9 ± 3	44 ± 14	4.9 ± 1.6	4.3 ± 0.3	23 ± 9	5.3 ± 2.1
disassembly (GDP)	0	733 ± 23	N/A	0	915 ± 72	N/A

from Boal, Mechanics of the Cell

Actin



	plus end			minus end		
	$k_{on}, (\mu m \cdot s)^{-1}$	k_{off}, s^{-1}	$M_C, \mu M$	k_{on}	k_{off}	M_C
ATP-actin	11.6 ± 1.2	1.4 ± 0.8	0.12 ± 0.07	1.3 ± 0.2	0.8 ± 0.3	0.6 ± 0.17
ADP-actin	3.8	7.2	1.9	0.16	0.27	1.7

