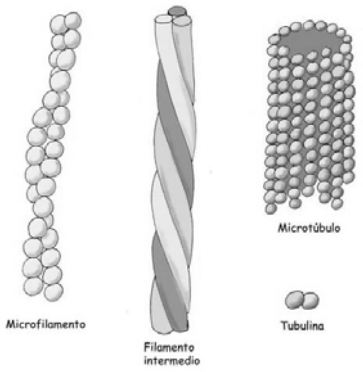
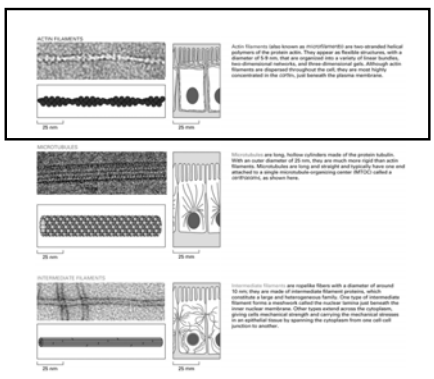
PROGRAMA DE BACHILLERATO

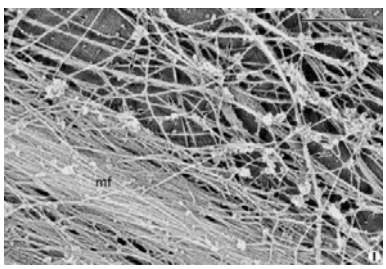
Biología - 2010

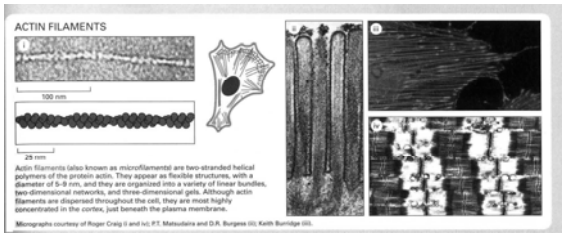
ESTRUCTURA Y DINAMICA DEL CITOESQUELETO

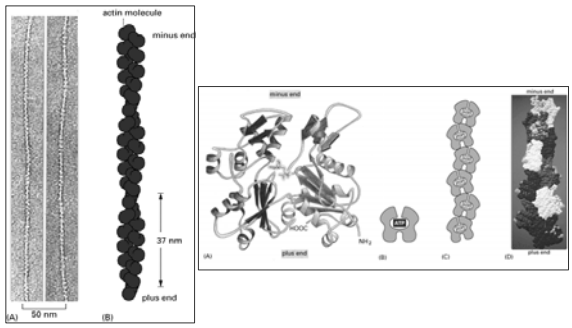
- Prof. Héctor R. Contreras.

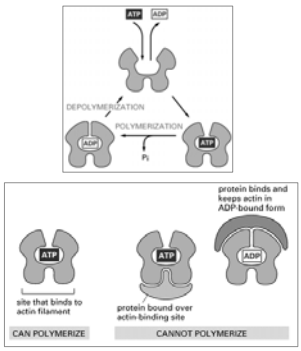


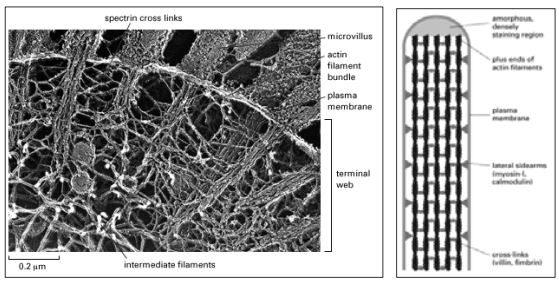


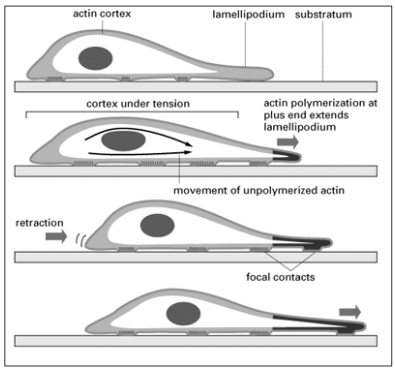


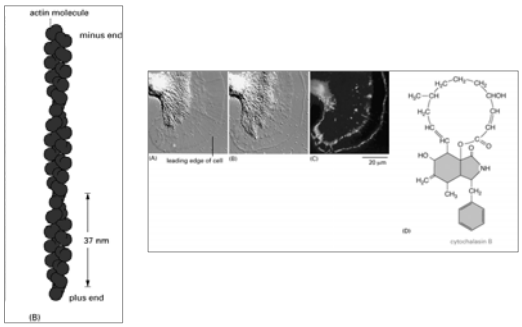

ACTIN FILAMENTS
100 nm
25 nm
Actin filaments (also known as microfilaments) are two-stranded helical polymers of the protein actin. They appear as flexible structures, with a diameter of 5–9 nm, and they are organized into a variety of linear bundles, two-dimensional networks, and three-dimensional gels. Although actin filaments are dispersed throughout the cell, they are most highly concentrated in the cortex, just beneath the plasma membrane.
Micrographs courtesy of Roger Craig (i and iv); P.T. Matsudaira and D.R. Burgess (iii); Keith Burridge (iii).

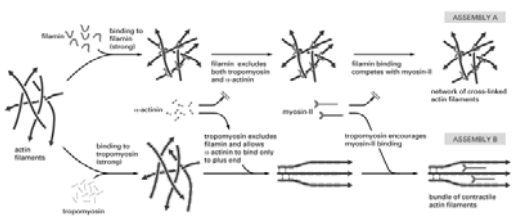

actin molecule
minus end
37 nm
plus end
50 nm
(A)
(B)
(C)
(D)

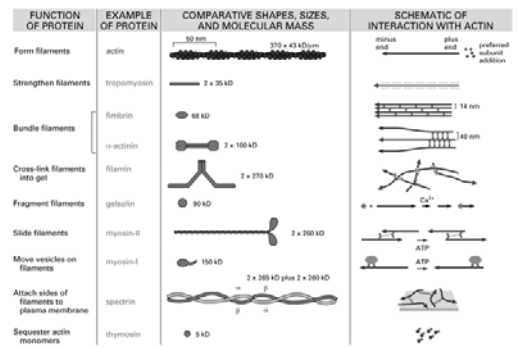

ATP
ADP
DEPOLYMERIZATION
POLYMERIZATION
Pi
protein binds and keeps actin in ADP-bound form
site that binds to actin filament
protein bound over actin-binding site
CAN POLYMERIZE
CANNOT POLYMERIZE

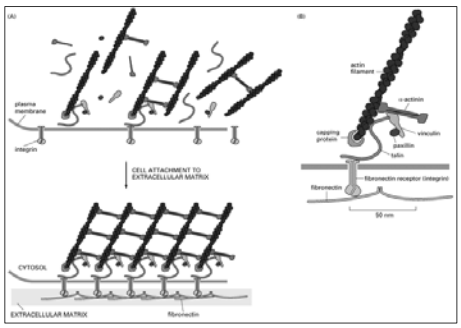

spectrin cross links
microvillus
actin filament bundle
plasma membrane
terminal web
0.2 μm
intermediate filaments
amorphous, densely staining region
plus ends of actin filaments
plasma membrane
lateral sidearms (myosin I, calmodulin)
cross-links (villin, fimbrin)

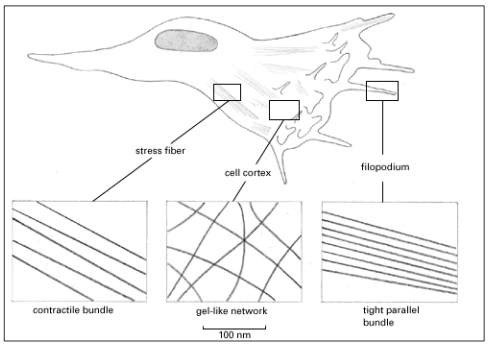

actin cortex
lamellipodium
substratum
cortex under tension
actin polymerization at plus end extends lamellipodium
movement of unpolymerized actin
retraction
focal contacts

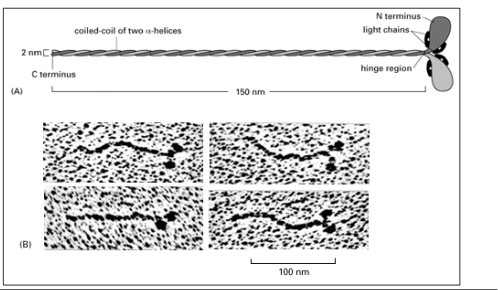

actin molecule
minus end
37 nm
plus end
(B)
leading edge of cell
20 μm
cytochalasin B

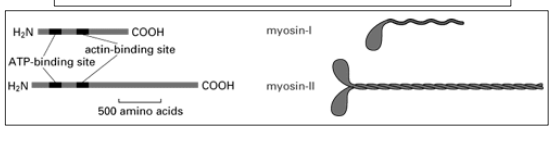

filamin
binding to filamin (strong)
filamin excludes both tropomyosin and α-actinin
filamin binding competes with myosin-II
ASSEMBLY A
network of cross-linked actin filaments
α-actinin
myosin-II
actin filaments
binding to tropomyosin (strong)
tropomyosin excludes filamin and allows α-actinin to bind only to plus end
tropomyosin encourages myosin-II binding
ASSEMBLY B
bundle of contractile actin filaments
tropomyosin

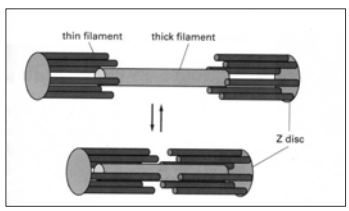

FUNCTION OF PROTEIN
EXAMPLE OF PROTEIN
COMPARATIVE SHAPES, SIZES, AND MOLECULAR MASS
SCHEMATIC OF INTERACTION WITH ACTIN
Form filaments
actin
50 nm
370 × 43 kDa/μm
minus end
plus end
preferred subunit addition
Strengthen filaments
tropomyosin
2 × 35 kD
Bundle filaments
fimbrin
68 kD
14 nm
α-actinin
2 × 100 kD
40 nm
Cross-link filaments into gel
filamin
2 × 270 kD
Fragment filaments
gelsolin
90 kD
Ca2+
Slide filaments
myosin-II
2 × 260 kD
Move vesicles on filaments
myosin-I
150 kD
ATP
2 × 265 kD plus 2 × 260 kD
Attach sides of filaments to plasma membrane
spectrin
α
β
Sequester actin monomers
thymosin
5 kD

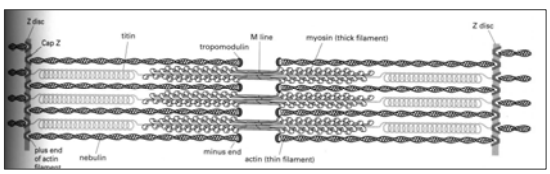

(A)
(B)
plasma membrane
integrin
CELL ATTACHMENT TO EXTRACELLULAR MATRIX
CYTOSOL
EXTRACELLULAR MATRIX
fibronectin
actin filament
α-actinin
capping protein
vinculin
paxillin
talin
fibronectin receptor (integrin)
50 nm

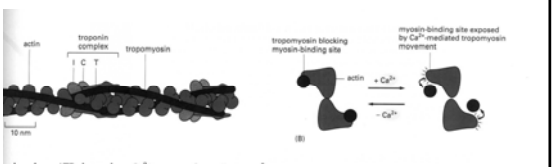

stress fiber
cell cortex
filopodium
contractile bundle
gel-like network
tight parallel bundle
100 nm

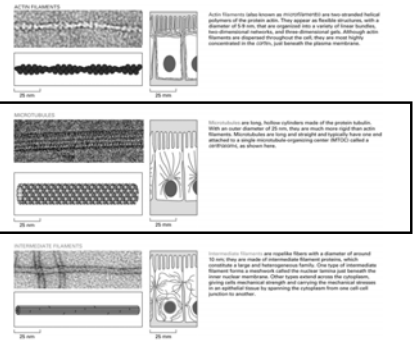

coiled-coil of two α-helices
N terminus
light chains
2 nm
C terminus
hinge region
(A)
150 nm
(B)
100 nm


H_2N
COOH
actin-binding site
ATP-binding site
H_2N
COOH
500 amino acids
myosin-I
myosin-II


thin filament
thick filament
Z disc


Z disc
Cap Z
titin
tropomodulin
M line
myosin (thick filament)
Z disc
plus end of actin filament
nebulin
minus end
actin (thin filament)


actin
troponin complex
I C T
tropomyosin
10 nm
tropomyosin blocking myosin-binding site
actin
+ Ca^{2+}
- Ca^{2+}
(B)
myosin-binding site exposed by Ca^{2+}-mediated tropomyosin movement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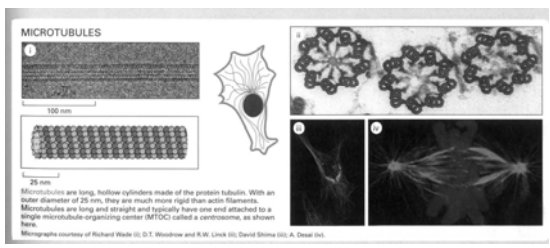
25 nm
MICROTUBULES
Microtubules are long, hollow cylinders made of the protein tubulin. With an outer diameter of 25 nm, they are much more rigid than actin filaments. Microtubules are long and straight and typically have one end attached to a single microtubule-organizing center (MTOC) called a centrosome, as shown here.
25 nm
INTERMEDIATE FILAMENTS
Intermediate filaments are ropelike fibers with a diameter of around 10 nm; they are made of intermediate-filament proteins, which constitute a large and heterogeneous family. One type of intermediate filament, the nuclear lamin filament, forms a meshwork just inside the inner nuclear membrane. Other types extend across the cytoplasm, giving cells mechanical strength and carrying the mechanical stresses in an epithelial tissue by spanning the cytoplasm from one cell-cell junction to another.
25 nm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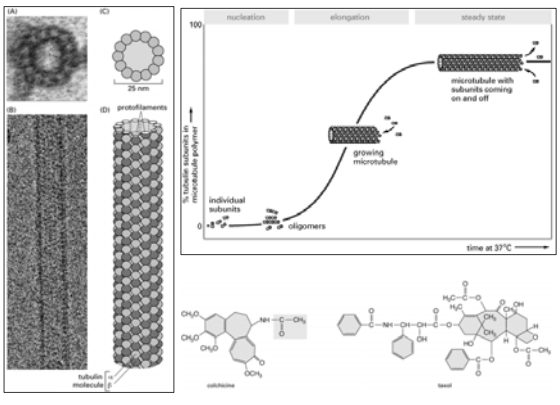
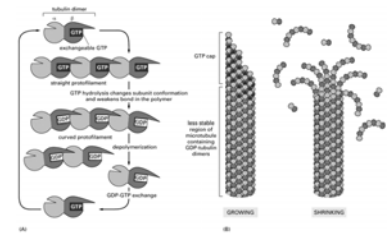
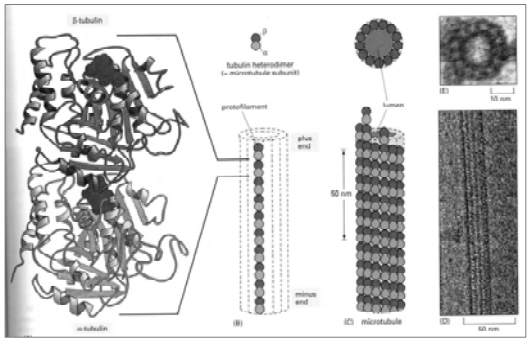
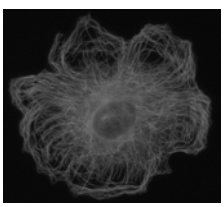
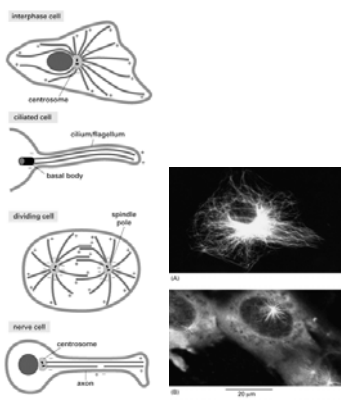
Micrographs courtesy of Richard Wade (i); D.T. Woodrow and R.W. Linck (ii); David Shima (iii); A. Desai (iv).

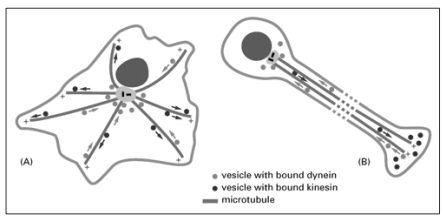

(A)
(C)
25 nm
(B)
(D)
protofilaments
tubulin molecule
nucleation
elongation
steady state
100
% tubulin subunits in microtubule polymer
0
individual subunits
oligomers
growing microtubule
microtubule with subunits coming on and off
time at 37°C
colchicine
taxol

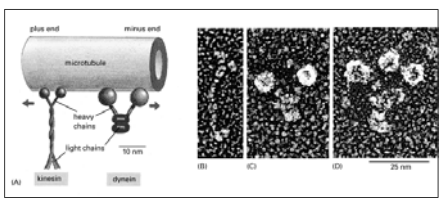

tubulin dimer
exchangeable GTP
straight protofilament
GTP hydrolysis changes subunit conformation and weakens bond in the polymer
curved protofilament
depolymerization
GDP-GTP exchange
GTP cap
less stable region of microtubule containing GDP-tubulin dimers
GROWING
SHRINKING

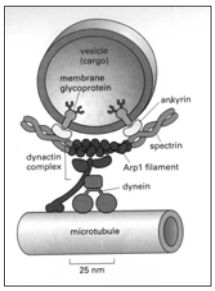

β-tubulin
α-tubulin
tubulin heterodimer
protofilament
plus end
minus end
50 nm
lumen
microtubule
(A)
(B)
(C)
(D)
5 nm
50 nm

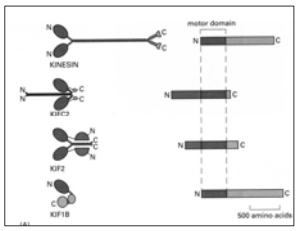


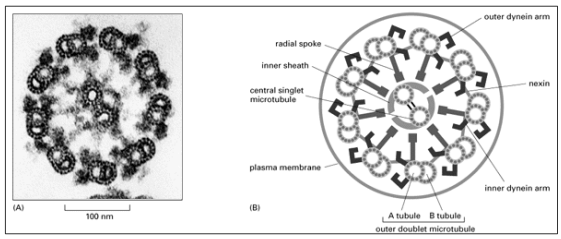

interphase cell
centrosome
ciliated cell
cilium/flagellum
basal body
dividing cell
spindle pole
nerve cell
centrosome
axon
(A)
(B)
20 μm

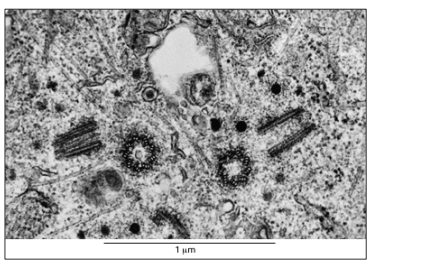

(A)
(B)
vesicle with bound dynein
vesicle with bound kinesin
microtubule

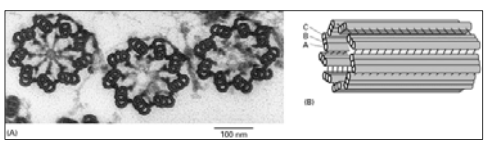

plus end
minus end
microtubule
heavy chains
light chains
10 nm
(A)
kinesin
dynein
(B)
(C)
(D)
25 nm

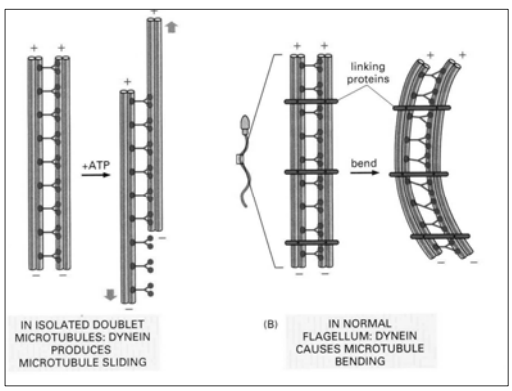

vesicle (cargo)
membrane glycoprotein
ankyrin
spectrin
dynactin complex
Arp1 filament
dynein
microtubule
25 nm

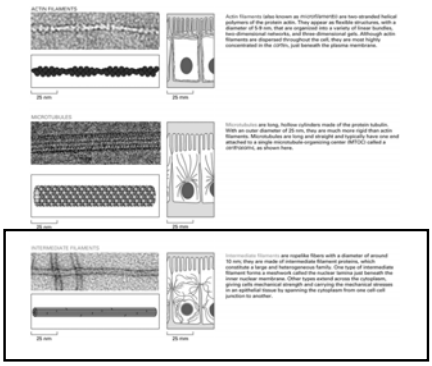

motor domain
KINESIN
KIF3
KIF2
KIF1B
500 amino acids


(A)
100 nm
(B)
outer dynein arm
radial spoke
inner sheath
central singlet microtubule
nexin
plasma membrane
inner dynein arm
A tubule
B tubule
outer doublet microtubule


1 μm


(A)
100 nm
(B)


+ATP
linking proteins
bend
IN ISOLATED DOUBLET MICROTUBULES: DYNEIN PRODUCES MICROTUBULE SLIDING
(B)
IN NORMAL FLAGELLUM: DYNEIN CAUSES MICROTUBULE BENDING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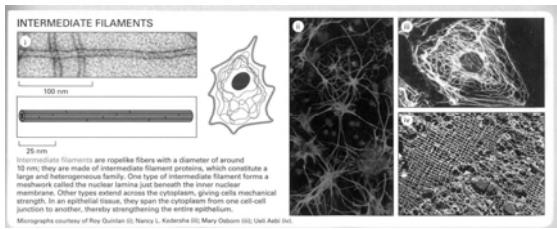
INTERMEDIATE FILAMENTS
i
100 nm
25 nm
ii
iii
iv
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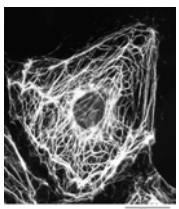
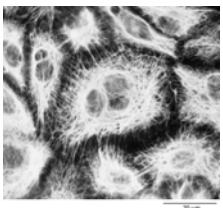
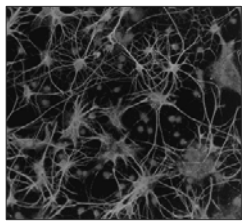
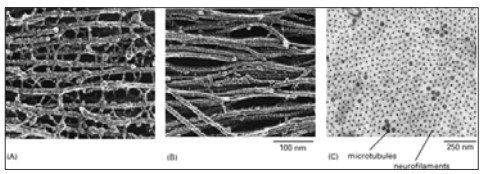
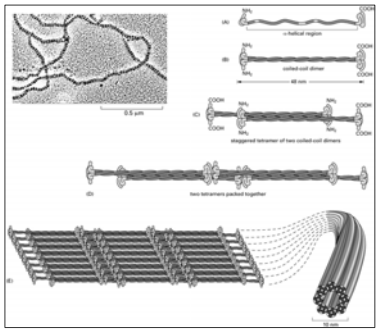
Micrographs courtesy of Roy Quinlan (i); Nancy L. Kedersha (iii); Mary Osborn (iii); Ueli Aebi (iv).

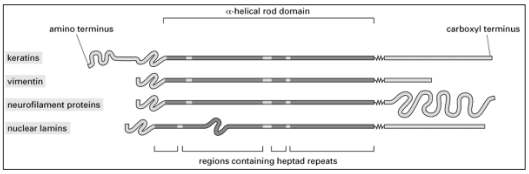

20 μm

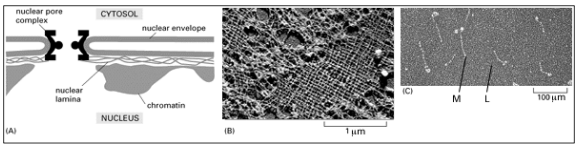

20 μm




(A)
(B)
100 nm
(C) microtubules
250 nm
neurofilaments







Type of IF	Component Polypeptides (mass in daltons)	Cellular Location
Nuclear lamins	lamins A, B, and C (65,000–75,000)	nuclear lamina of eucaryotic cells
Vimentinlike proteins	vimentin (54,000)	many cells of mesenchymal origin, often expressed transiently during development
	desmin (53,000)	muscle
	glial fibrillary acidic protein (50,000)	glial cells (astrocytes and Schwann cells)
	peripherin (66,000)	neurons
Keratins	type I (acidic) (40,000–70,000) type II (neutral/basic) (40,000–70,000)	epithelial cells and their derivatives (e.g., hair and nails)
Neuronal intermediate filaments	neurofilament proteins NF-L, NF-M, and NF-H (60,000–130,000)	neurons


COMPONENTES DEL CITOESQUELETO
MICROFILAMENTOS
FIILAMENTOS INTERMEDIOS
MICROTUBULOS
ESTRUCTURA
Bandas sólidas, 7 nm de diámetro, puede llegar a varios cm. de longitud (músculo)
Bandas sólidas .8 a 10 nm de diámetro y 10 a 100 µm de longitud
Tubos huecos. 25 nm de diámetro, pueden medir más de 50 µm de longitud
PROTEINA
Actina (la mayoría) y/o miosina
Citoqueratina, vimentina, desmina, neurofilamentos, f. glias
Tubulina
FUNCION
Contracción muscular
Cambios de forma celular
Citocinesis en células animales
Flujo citoplasmático
Movimiento de seudópodos
Mantenimiento de forma celular
Unión de microfilamentos en célula muscular
Soporte de actividad de neuronas
Movimiento de :
cromosomas durante división celular
organelos dentro del citoplasma
cilios y flagelos