

## Yeast Tubulin

	1		70
Tub1	MREVISINVGQAGCQIGNACWELYSLEHGIKEDGHLEDGLSKPKGGEEGFSTFFHETGYGKFPVRAIYVD		
Tub3	MREVISINVGQAGCQIGNACWELYSLEHGIKEDGHLEDGLSKPKGGEEGFSTFFHETGYGKFPVRAIYVD		
	71		140
Tub1	LEPNVIDEVRNCFPKDLFHPPEQLISGKEDAANNYARGHYTVGREILGDMVLDRIKIMADQCDGLQGFLPTH		
Tub3	LEPNVIDEVRNCFPKDLFHPPEQLISGKEDAANNYARGHYTVGREIVDEVEERIRKIMADQCDGLQGFLPTH		
	141		210
Tub1	SLGGGTGSLGSLLELLELSAEYGGKSKLEFAVYPAPQVSTSVVEPYNTVLTTHTTLEHADCTFMVDNEAI		
Tub3	SLGGGTGSLGSLLELLELSAEYGGKSKLEFAVYPAPQVSTSVVEPYNTVLTTHTTLEHADCTFMVDNEAI		
	211		280
Tub1	YDMCKRNLIIPRPSFANLNLIQAQVSSVTASLRFDGSLNVDLNEFQTNLVVPYPRIHFPVLSYSPVLSKSK		
Tub3	YDMCKRNLIIPRPSFANLNLIQAQVSSVTASLRFDGSLNVDLNEFQTNLVVPYPRIHFPVLSYSPVLSKSK		
	281		350
Tub1	KPFHESNSVSEITNACFEPGNQMVKCDPFRDQKYMAICLLYRGDVVTRDVQRAVEQVKNKKTVCIVDWCPT		
Tub3	KPFHESNSVSEITNACFEPGNQMVKCDPFRDQKYMAICLLYRGDVVTRDVQRAVEQVKNKKTVCIVDWCPT		
	351		420
Tub1	GFKIGICYEPPFATNSQLAVDRAVCMLSNNTTISIAFAWKRIDKPKFDLMYAKRAFPVHWYVGEEMEEGEFT		
Tub3	GFKIGICYEPPFATNSQLAVDRAVCMLSNNTTISIAFAWKRIDKPKFDLMYAKRAFPVHWYVGEEMEEGEFT		
	421		447
Tub1	EAREDLAALERDYIEVGADSYAEEEF		
Tub3	EAREDLAALERDYIEVGADSYAEE--F		

The two  $\alpha$ -tubulin isotypes in budding yeast have opposing effects on microtubule dynamics in vitro  
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 EMBO 2003

## Human Tubulin

**Table 1**  
**Characteristics of Human Tubulin Isoforms**

Tubulin Isoform <sup>a</sup>	Gene	Accession number	pI	Protein mass (Da) <sup>b</sup>	Mass (Da) of CNBr C-terminal peptide <sup>c</sup>	CNBr C-terminal peptide
$\alpha$ 1A	TUBA1A	NP_006000	4.94	50135.6	2860.19	AALEKDYEEVGVDSVEGEGEEGEEY
$\alpha$ 1B	TUBA1B	NP_006073	4.94	50151.6	2860.19 <sup>*</sup>	AALEKDYEEVGVDSVEGEGEEGEEY
$\alpha$ 1C	TUBA1C	NP_116093	4.96	49895.3	2590.04	AALEKDYEEVGVDSADGEEGEEY
$\alpha$ 4A	TUBA4A	NP_005991	4.95	49924.4	2633.07	AALEKDYEEVGVDSVEDEEGEE
$\alpha$ 3C	TUBA3C	NP_005992	4.98	49959.6	4150.77	EEGEFSEAREDLAALEKDYEEVGVDSVEAEAEEGEEY
$\alpha$ 3D	TUBA3D	NP_525125	4.98	49959.6	4150.77	EEGEFSEAREDLAALEKDYEEVGVDSVEAEAEEGEEY
$\alpha$ 3E	TUBA3E	NP_997195	4.97	49916.6	4090.71	EEGEFSEAREDLAALEKDYEEVGVDSVEAEAEEGEEY
$\alpha$ 8	TUBA8	NP_061816	4.94	50093.6	4156.72	EEGEFSEAREDLAALEKDYEEVGVDSFEENEGEFF
$\alpha$ -like 3	TUBAL3	NP_079079	5.68	49908.7	3058.40	EEAEFLAAREDLAALERDYEEVAQSF
$\beta$ I	TUBB	NP_821133	4.78	49670.8	3366.33	NDLVSEYQQYQDATAEEEDFGEEAEFEA
$\beta$ II	TUBB2B	NP_821080	4.78	49953.1	3466.36	NDLVSEYQQYQDATADEQGEFEEEGEEDA
$\beta$ III	TUBB3	NP_006077	4.83	50432.7	1624.64	YEDDEESEAQGPK
$\beta$ IVa	TUBB4	NP_006078	4.78	49585.8	3350.38	NDLVSEYQQYQDATAEEGFEFEAEFEVA
$\beta$ IVb	TUBB2C	NP_006079	4.79	49831.0	3479.42	NDLVSEYQQYQDATAEEGFEFEAEFEVA
$\beta$ V	TUBB6	NP_115914	4.77	49857.1	3551.41	NDLVSEYQQYQDATAANDGEEAFEDEEIEDG
$\beta$ VI	TUBB1	NP_110400	5.05	50326.9	810.35	EPEDKGGH

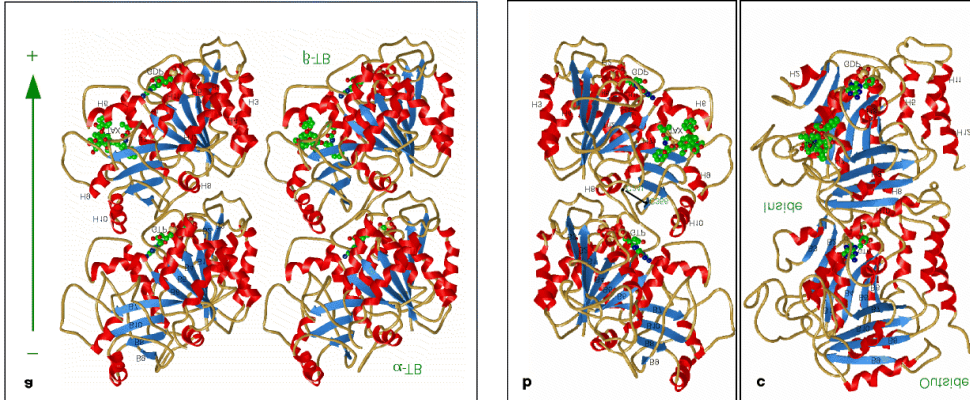
<sup>a</sup>  $\alpha$ -Tubulin nomenclature reflects the revised nomenclature for the  $\alpha$ -tubulin gene family (Khodiyar, V. K., et al. *Genomics*, 2007, 90, 285–289).

<sup>b</sup> Protein mass is the average mass.

<sup>c</sup> CNBr peptide mass is reported as the monoisotopic neutral mass.

Methods Cell Biol. 2010;95:105-26. doi: 10.1016/S0091-679X(10)95007-3.  
 Methods in tubulin proteomics.  
 Miller LM1, Xiao H, Burd B, Horwitz SB, Angeletti RH, Verdier-Pinard P.

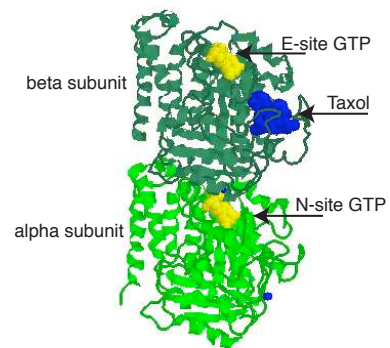
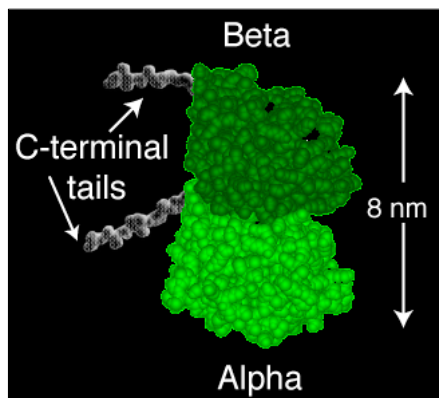
## Tubulin Structure



### Structure of the tubulin dimer by electron crystallography

Eva Nogales, Sharon G. Wolf and Kenneth H. Downing  
*Nature* **391**, 199-203(8 January 1998)

## Tubulin Structure



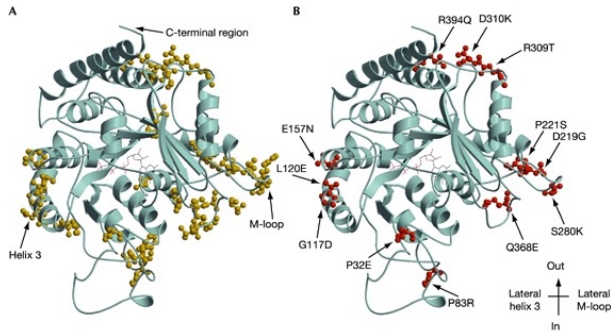
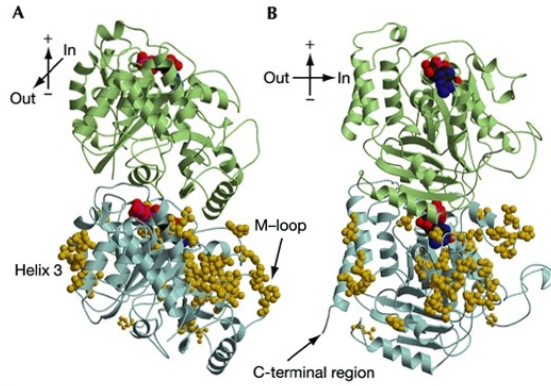
Ross Thesis, 2000

# Yeast Tubulin Structure

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1
Tub1 MREVISINVGAGCCIGNACWELYSLEHGTFDGHLEDGLSKPKGGEGFSTFFHETGYGKVPRAIYVD 70
Tub3 MREVISINVGAGCCIGNACWELYSLEHGTFDGHLEDGLSKPKGGEGFSTFFHETGYGKVPRAIYVD
71
Tub1 LEPNVIDEVRHPEYDLPHEPOLIDKSDAANNYARGHYTVGRELDGMLDIRIMADCCDGLQGLPPTH 140
Tub3 LEPNVIDEVRHPEYDLPHEPOLIDKSDAANNYARGHYTVGRELDGMLDIRIMADCCDGLQGLPPTH
141
Tub1 SLOGOTSGLGSLLELLESLVYGGKSKLEFAYVPAPQSTSVSEYPTNTLTHHTLEHADCTPMVDNEAI 210
Tub3 SLOGOTSGLGSLLELLESLVYGGKSKLEFAYVPAPQSTSVSEYPTNTLTHHTLEHADCTPMVDNEAI
211
Tub1 YIKCKRNIDIPRPSGNLNLIAQVSSVTASLRFDSGLANVDLNEFQNLVVPYRHFPLVSYSHLSK 280
Tub3 YIKCKRNIDIPRPSGNLNLIAQVSSVTASLRFDSGLANVDLNEFQNLVVPYRHFPLVSYSHLSK
281
Tub1 EPHESNSVSEITNACFPFGNQMKCDHDKKYMALLLYRGDVVTRDVRQAVEQVKNKKTVDVDMCPT 350
Tub3 EPHESNSVSEITNACFPFGNQMKCDHDKKYMALLLYRGDVVTRDVRQAVEQVKNKKTVDVDMCPT
351
Tub1 GFKIGICYEPPATNLSLAVDRVCMLSNTSISLAWKRILKFDLMYAKRAFPHVYVGGMEGEFT 420
Tub3 GFKIGICYEPPATNLSLAVDRVCMLSNTSISLAWKRILKFDLMYAKRAFPHVYVGGMEGEFT
421
Tub1 EAREDLAALERDYEVGADSYAREEET 447
Tub3 EAREDLAALERDYEVGADSYAREEET

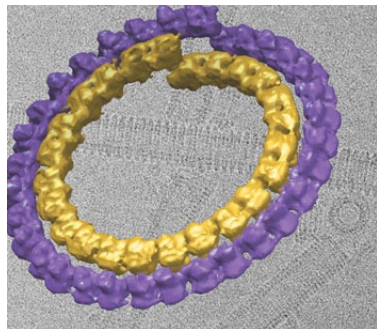
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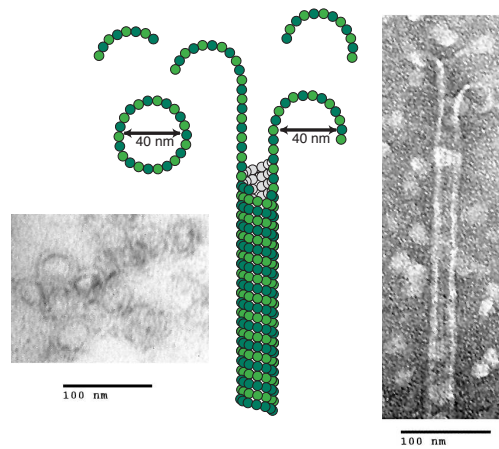
# Building with Tubulin

## GDP Double Ring



[http://www2.lbl.gov/Science-Articles/Archive/assets/images/2005/Jun-22/GDP\\_rings.jpg](http://www2.lbl.gov/Science-Articles/Archive/assets/images/2005/Jun-22/GDP_rings.jpg)

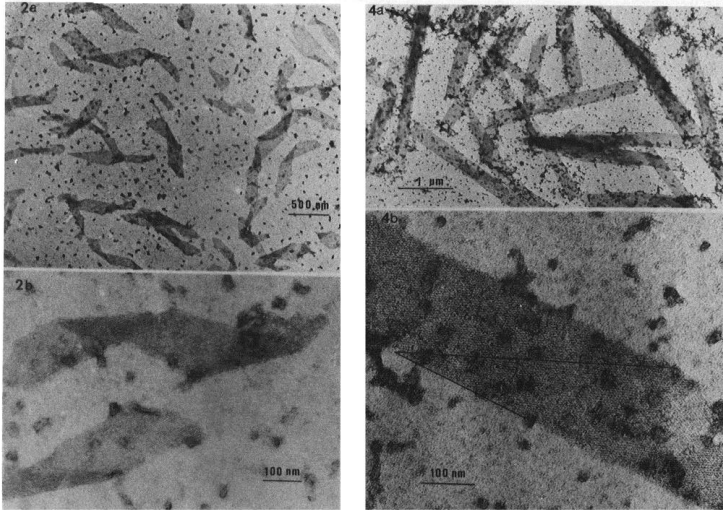
## Microtubules



Ross Thesis, 2000

# Building with Tubulin

## Zn Sheets



## Zn Macrotubes

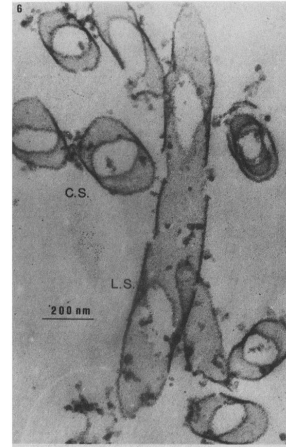
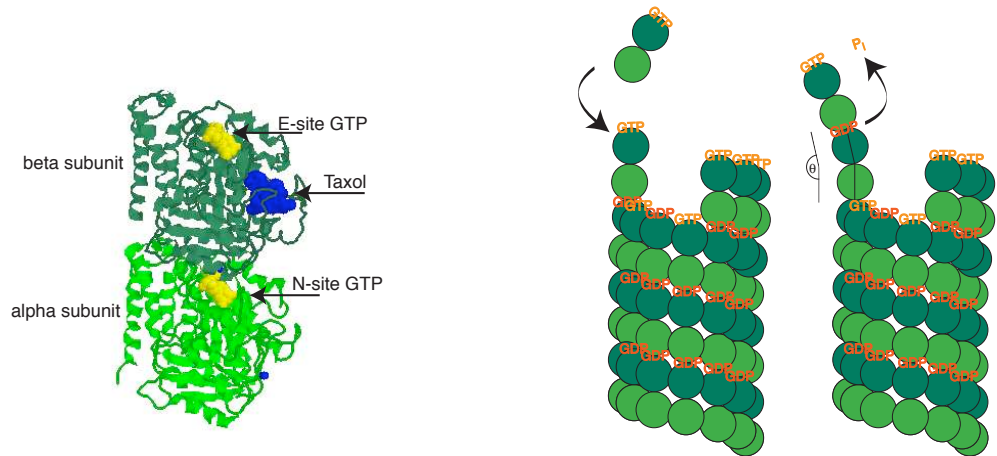


FIG. 2 (left). Sheets I formed from microtubular protein (2.5 mg/ml),  $Zn^{2+}/EGTA = 0.90 + GTP$ ,  $37^\circ 30 \text{ min}$ , *a*,  $\times 19,500$ , *b*,  $\times 93,750$ .  
 FIG. 4 (right). Sheets III formed from P-cellulose-purified tubulin (1.3 mg/ml),  $Zn^{2+}/EGTA = 1.00 + GTP$ ,  $37^\circ$ , 1 hr. *a*,  $\times 13,100$ , *b*,  $\times 127,500$ ; width  $\sim 210 \text{ nm}$ ;  $\theta \sim 25^\circ$ .

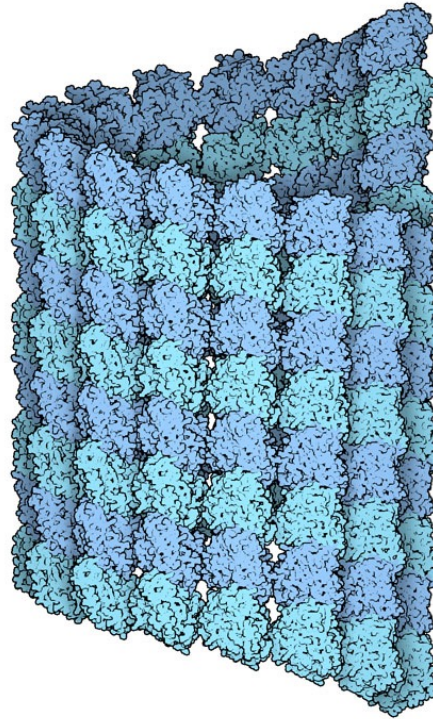
## Tubulin Structure - Dimer Curvature



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## Microtubule Structure



[http://www.rcsb.org/pdb/education\\_discussion/molecule\\_of\\_the\\_month/images/175-Microtubules\\_3j2u.jpg](http://www.rcsb.org/pdb/education_discussion/molecule_of_the_month/images/175-Microtubules_3j2u.jpg)

## Microtubule Dynamics

