

Sequence comparison of fungal beta-tubulins

Protein Alignments for Fungal β -Tubulin Proteins Compared to Human β -Tubulin (v1.1 2011-08-24)

		1	50
<i>NP_821133-HsTUBB1</i>	(1)	MREIVHIQAGQCGNQIGAKFWEVISDEHGLDPTGTYHGSDSLQLDRISVY	
AAA34375-CaB	(1)	MREI IHLSTGQCGNQIGAAFWETICGEHGLDNNGTIVGNNELQKSKLDVY	
P02557-ScB1	(1)	MREI IHIISTGQCGNQIGAAFWETICGEHGLDFNGTYHGDDIQKERLNVY	
AAC21454-SpB1	(1)	MREIVHIQAGQCGNQVGAAFWSTIADEHGLDSAGIYHGTSEAQHERLNVY	
AW324553-AbB*	(1)	MREIVHLQTGQCGNQIGAKFWEVVSDHGLIERDGLYKGTNDLQLERISVY	
BAE64122-Aor-B1	(1)	MREIVHLQTGQCGNQIGAAFWQTISGEHGLDGSVYNGSSDLQLERMNVY	
XP_752456-AfuB1*	(1)	MREIVHLQTGQCGNQIGAAFWQTISGEHGLDGSYN-GSSDLQLERMNVY	
XP_658786-AniB1	(1)	MREIVHLQTGQCGNQIGAAFWQTISGEHGLDGSVYNGTSDLQLERMNVY	
Fungal Consensus	(1)	MREIVHLQTGQCGNQIGAAFW TISGEHGLD SGVY GTSDDLQLERLNVY	
		51	100
<i>NP_821133-HsTUBB1</i>	(51)	YNEATGGKYVPRAILVDLEPGTMDSVRSGPFGQIFRPDNFVFGQSGAGNN	
AAA34375-CaB	(51)	FNEATSGKYVPRAVLVDLEPGTIDNVKTSQIGNLFRPDNFI FGQSSAGNV	
P02557-ScB1	(51)	FNEASSGKWVPR SINVDLEPGTIDAVRNSAIGNLFRPDNYIFGQSSAGNV	
AAC21454-SpB1	(51)	FNEAAGGKYVPRAVLVDLEPGTMDAVKSGKFGNLFRPDNI IYFGQSGAGNI	
AW324553-AbB*	(51)	YNEIGANKYVPRAVLVDLEPGTMDSVRSGPLGNLFRPDNFVFGQSGAGNN	
BAE64122-Aor-B1	(51)	FNEASGNKYVPRAVLVDLEPGTMDAVRAGPFGQLFRPDNFVFGQSGAGNN	
XP_752456-AfuB1*	(50)	FNEANGDKYVPRAVLVDLEPGTMDAVRAGPFGELFRPDNFVFGQSGAGNN	
XP_658786-AniB1	(51)	FNEASGNKYVPRAVLVDLEPGTMDAVRAGPFGELFRPDNFVFGQSGAGNN	
Fungal Consensus	(51)	FNEASG KYVPRAVLVDLEPGTMDAVRAGPFGNLFRPDNFVFGQSGAGNN	
		101	150
<i>NP_821133-HsTUBB1</i>	(101)	WAKGHYTEGAELVDSVLDVVRKEAESCDCLQGFQITHSLGGGTGSGMGTL	
AAA34375-CaB	(101)	WAKGHYTEGAELVDSVLDVVRREAE GCD SLQGFQITHSLGGGTGSGMGTL	
P02557-ScB1	(101)	WAKGHYTEGAELVDSVMDVIRREAE GCD SLQGFQITHSLGGGTGSGMGTL	
AAC21454-SpB1	(101)	WAKGHYTEGAELADAVLDVVRREAEACDALQGFQITHSLGGGTGSGMGTL	
AW324553-AbB*	(101)	WAKGHYTEGAELVDAVLDVVRKEAEGTDCLQGFQITHSLGGGTGAGMGTL	
BAE64122-Aor-B1	(101)	WAKGHYTEGAELVDQVVDVVRREAE GCD CLQGFQITHSLGGGTGAGMGTL	
XP_752456-AfuB1*	(100)	WAKGHYTEGAELVDQVIDVVRREAE GCD CLQGFQVTHSLGGGTGAGMGTL	
XP_658786-AniB1	(101)	WAKGHYTEGAELVDNVVDVVRREAE GCD CLQGFQITHSLGGGTGAGMGTL	
Fungal Consensus	(101)	WAKGHYTEGAELVDAVLDVVRREAE GCD CLQGFQITHSLGGGTGAGMGTL	



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	151	200
<i>NP_821133-HsTUBB1</i>	(151)	LISKIREEYPDRIMNTFSVVPSPKVS DTVVEPYNATLSVHQLVENT DETY
AAA34375-CaB	(151)	LISKIREEF PD TM MATFSVVPSPKVS DTV IEPYNATLSVHQLVENS DETF
P02557-ScB1	(151)	LISKIREEF PDR MM ATFSVLPSPK T SDTVVEPYNATLSVHQLVEHS DETF
AAC21454-SpB1	(151)	LISKIREEY PDR MM ATFSVAP AP K S DTVVEPYNATLS M HQLVENS DETF
AW324553-AbB*	(151)	LISKIREEY PDR MM CTYSVVPSPK V S-----
BAE64122-Aor-B1	(151)	LISKIREEF PDR MM ATFSVVPSPKVS DTV VEPYNATLSVHQLVEHS DETF
XP_752456-AfuB1*	(150)	LISKIREEF PDR MM ATFSVVPSPKVS DTV VEPYNATLSVHQLVEHS DETF
XP_658786-AniB1	(151)	LISKIREEF PDR MM ATFSVVPSPKVS DTV VEPYNATLSVHQLVEHS DETF
Fungal Consensus	(151)	LISKIREEF PDR MM ATFSVVPSPKVS DTV VEPYNATLSVHQLVEHS DETF
	201	250
<i>NP_821133-HsTUBB1</i>	(201)	CIDNEALYD IC F RTL K L T PT Y GD L N H L V SAT M SG V T T CL R FP G Q L N A D L
AAA34375-CaB	(201)	CIDNEALY N I C Q N T L K L P Q P S Y A E L N N L V S S V M S G V T T S L R Y P G Q L N S D L
P02557-ScB1	(201)	CIDNEALY D I C Q R T L K L N Q P S Y G D L N N L V S S V M S G V T T S L R Y P G Q L N S D L
AAC21454-SpB1	(201)	CIDNEAL SS I F A N T L K L I K S P S Y D D L N H L V S A V M A G V T T S F R F P G E L N S D L
AW324553-AbB*	(177)	-----
BAE64122-Aor-B1	(201)	CIDNEALY D I C M R T L K L S N P S Y G D L N H L V S A V M S G V T T CL R FP G Q L N S D L
XP_752456-AfuB1*	(200)	CIDNEALY D I C M R T L K L S N P S Y G D L N H L V S A V M S G V T T CL R FP G Q L N S D L
XP_658786-AniB1	(201)	CIDNEALY D I C M R T L K L S N P S Y G D L N H L V S A V M S G V T T CL R FP G Q L N S D L
Fungal Consensus	(201)	CIDNEALY D I C R T L K L N P S Y G D L N H L V S A V M S G V T T L R F P G Q L N S D L
	251	300
<i>NP_821133-HsTUBB1</i>	(251)	RKLAVN M V PF P R L H F F M PG F AP L T S R G S Q Q Y R A L T V P E L T Q Q V F D A K N M M
AAA34375-CaB	(251)	RKLAVN L V PF P R L H F F M V G Y A PL T S M G S K S F R S V T V P E L T Q Q M F D A K N M M
P02557-ScB1	(251)	RKLAVN L V PF P R L H F F M V G Y A PL T A I G S Q S F R S L T V P E L T Q Q M F D A K N M M
AAC21454-SpB1	(251)	RKLAVN M V PF P R L H F F M V G F A PL A A I G S S S F Q A V S V P E L T Q Q M F D A N N M M
AW324553-AbB*	(177)	-----
BAE64122-Aor-B1	(251)	RKLAVN M V PF P R L H F F M V G F A PL T S R G A H S F R A V S V P E L T Q Q M F D P K N M M
XP_752456-AfuB1*	(250)	RKLAVN M V PF P R L H F F M V G F A PL T S R G A H S F R A V S V P E L T Q Q M F D P K N M M
XP_658786-AniB1	(251)	RKLAVN M V PF P R L H F F M V G F A PL T S R G A Y S F R A V S V P E L T Q Q M F D P K N M M
Fungal Consensus	(251)	RKLAVN M V PF P R L H F F M V G F A PL T S G A S F R A V S V P E L T Q Q M F D K N M M

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301                                     350
NP_821133-HsTUBB1 (301) AACDPRHGRYLTVAAVFRGRMSMKEVDEQMLNVQNKNSSYFVEWIPNNVK

AAA34375-CaB (301) AASDPRNGRYLTVAAFFRGKVSVKEVDEMHKIQTRNSSYFVDWIPNNVQ
P02557-ScB1 (301) AAADPRNGRYLTVAAFFRGKVSVKEVEDEMHKVQSKNSDYFVEWIPNNVQ
AAC21454-SpB1 (301) VAADPRHGRYLTVAAVFRGKVSVMKEVDEQIRSVQTKNSAYFVEWIPDNVL
AW324553-AbB* (177) -----
BAE64122-Aor-B1 (301) AASDFRNGRYLTCSAIFRGKVSVMKEVEDQMRNIQSKNQTYFVEWIPNNIQ
XP_752456-AfuB1* (300) AASDFRNGRYLTCSAIFRGKVSVMKEVEDQMRNIQSKNQSYFVEWIPNNIQ
XP_658786-AniB1 (301) AASDFRNGRYLTCSAIFRGKVSVMKEVEDQMRNIQSKNQSYFVEWIPNNIQ
Fungal Consensus (301) AASD RNGRYLT AAI FRGKVSVMKEVEDQMR IQSKN SYFVEWIPNNIQ

351                                     400
NP_821133-HsTUBB1 (351) TAVCDIPPRGLKMAVTFIGNSTAIQELFKRITSEQFTAMFRRKAFLHWYTG

AAA34375-CaB (351) TAVCSVPPKDLDMSATFIGNSTSIQELFKRVGDQFSAMFRRKAFLHWYTS
P02557-ScB1 (351) TAVCSVAPQGLDMAATFIANSTSIQELFKRVGDQFSAMFKRKAFLHWYTS
AAC21454-SpB1 (351) KAVCSVPPKDLKMSATFIGNSTSIQELFRRLGDQFSAMFRRKAFLHWYTG
AW324553-AbB* (177) -----
BAE64122-Aor-B1 (351) TALCSIPPRGLKMSSTFIGNSTSIQELFKRVGDQFTAMFRRKAFLHWYTG
XP_752456-AfuB1* (350) TALCSIPPRGLKMSSTFIGNSTSIQELFKRVGDQFTAMFRRKAFLHWYTG
XP_658786-AniB1 (351) TALCSIPPRGLKMSSTFIGNSTSIQELFKRVGDQFTAMFRRKAFLHWYTG
Fungal Consensus (351) TALCSIPPRGLKMSATFIGNSTSIQELFKRVGDQFSAMFRRKAFLHWYTG

401                                     450
NP_821133-HsTUBB1 (401) EGMDEMEFTEAESNMNDLVSEYQQYQDATAEDEEDFGEEAEDEA-----

AAA34375-CaB (401) EGMDEMEFTEAESNMNDLVSEYQQYQFEASIDEELELYADEIPLEDAAME-
P02557-ScB1 (401) EGMDELLEFSEAESNMNDLVSEYQQYQEATVEDDEEVDENGDFGAPQNQDE
AAC21454-SpB1 (401) EGMDEMEFTEAESNMNDLVSEYQQYQEAAGIDEGDEEDYEIEEEKEPLEY--
AW324553-AbB* (177) -----
BAE64122-Aor-B1 (401) EGMDEMEFTEAESNMNDLVSEYQQYQDASISEGEEYLEEEPLEHEE--
XP_752456-AfuB1* (400) EGMDEMEFTEAESNMNDLVSEYQQYQDASISEGEEYGEEL-PLAEE--
XP_658786-AniB1 (401) EGMDEMEFTEAESNMNDLVSEYQQYQDASISEGEEYAEELIMEGEE---
Fungal Consensus (401) EGMDEMEFTEAESNMNDLVSEYQQYQDASI EGEYEE EEE E

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                                     451
NP_821133-HsTUBB1  ( 445 ) -----
    AAA34375-CaB    ( 450 ) -----
    P02557-ScB1     ( 451 ) PITENFE
    AAC21454-SpB1   ( 449 ) -----
    AW324553-AbB*   ( 177 ) -----
    BAE64122-Aor-B1 ( 449 ) -----
    XP_752456-AfuB1* ( 447 ) -----
    XP_658786-AniB1 ( 448 ) -----
Fungal Consensus ( 451 )
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Notes & Comments:

Fungal consensus is based on fungal beta-1 tubulins only, but the human beta tubulin is included in the alignment for reference purposes (above alignment, *italics* and underlined).

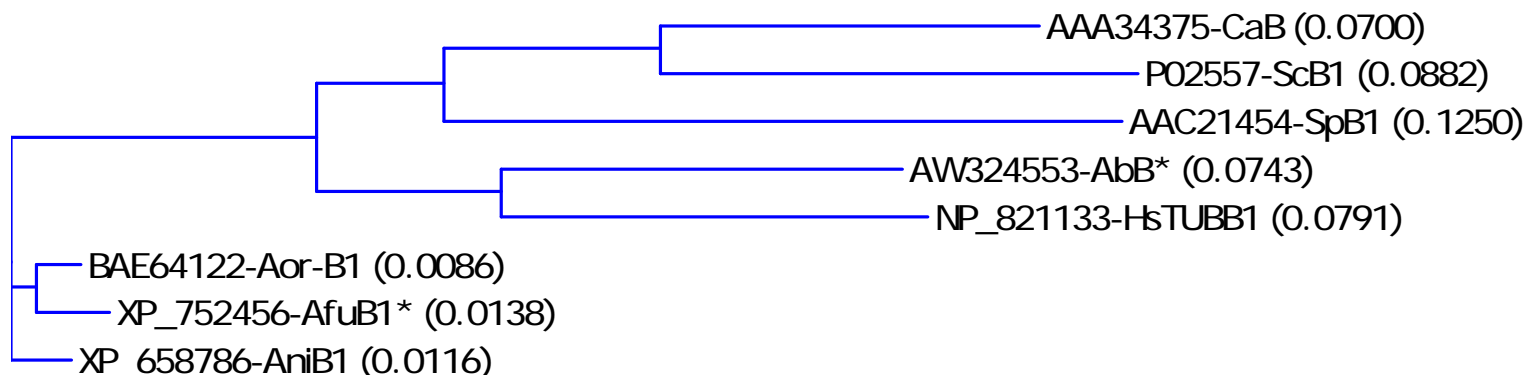
The direct translation of the *Agaricus bisporus* EST (AW324553 indicated with an asterix *) results in 14 additional residues (*HASATSLFRLKPSI*) at amino terminus of the protein, but are probably NOT real.

Note, there is an apparent 19 amino acid insertion (*HGGNTENKEEADACLMGNN*) in the *Aspergillus fumigatus* beta-1 tubulin not seen in any other fungal (including *Afu*- β 2) or human tubulins. However, this is at a point in the protein where some fungal tubulins have 1 or 2 additional bases. So, this might be real, or it might be an artifact, perhaps a cryptic splice site not recognized during the “virtual transcription/translation” used to generate this sequence from the fungal genome sequence. There is no independent sequence data to confirm or reject inclusion. For now it has been manually removed from the sequence (indicated with *) and removed from the alignments, and calculations for phylogenetic trees and identity/conservation tables.

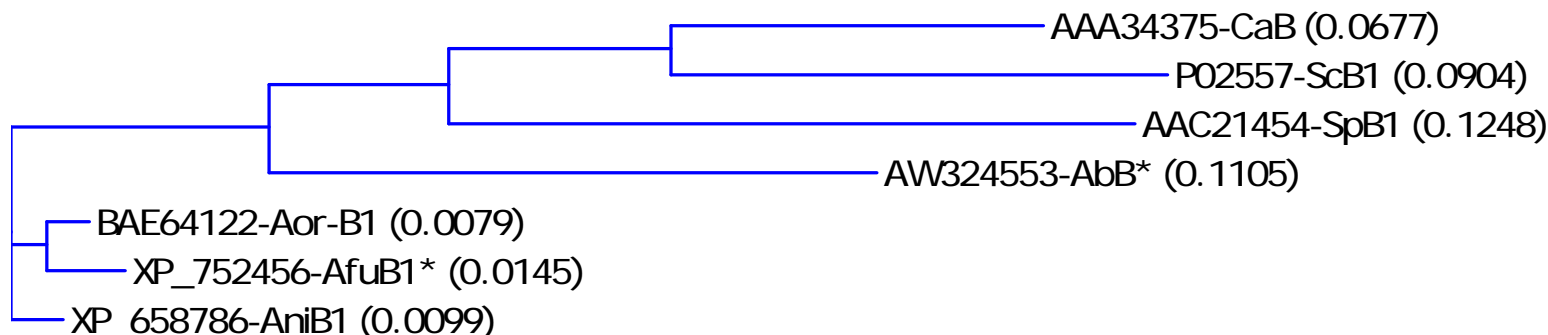


Sequence comparison of fungal beta-tubulins

Phylogenetic Tree for Fungal β -tubulin Proteins Compared to Human β -tubulin



Phylogenetic Tree for Fungal β -tubulin Proteins





Sequence comparison of fungal beta-tubulins

Amino-Acid Identity of Fungal β -tubulin Proteins Compared to Human β -tubulin

	NP_821133- HsTUBB1	AAA34375- CaB	P02557- ScB1	AAC21454- SpB1	AW324553- AbB*	BAE64122- Aor-B1	XP_752456- AfuB1*	XP_658786- AniB1
NP_821133-HsTUBB1	100	75	75	75	85	81	81	81
AAA34375-CaB		100	84	76	75	79	80	80
P02557-ScB1			100	74	71	78	78	78
AAC21454-SpB1				100	74	78	78	78
AW324553-AbB*					100	83	82	84
BAE64122-Aor-B1						100	98	98
XP_752456-AfuB1*							100	97
XP_658786-AniB1								100

Protein Similarity of Fungal β -tubulin Proteins Compared to Human β -tubulin

	NP_821133- HsTUBB1	AAA34375- CaB	P02557- ScB1	AAC21454- SpB1	AW324553- AbB*	BAE64122- Aor-B1	XP_752456- AfuB1*	XP_658786- AniB1
NP_821133-HsTUBB1	100	89	90	88	92	92	92	92
AAA34375-CaB		100	94	89	88	90	90	91
P02557-ScB1			100	88	89	90	90	90
AAC21454-SpB1				100	86	90	89	90
AW324553-AbB*					100	93	91	93
BAE64122-Aor-B1						100	99	98
XP_752456-AfuB1*							100	98
XP_658786-AniB1								100



Sequence comparison of fungal beta-tubulins

Amino-Acid Identity of Fungal β -tubulin Proteins

	AAA34375- CaB	P02557- ScB1	AAC21454- SpB1	AW324553- AbB*	BAE64122- Aor-B1	XP_752456- AfuB1*	XP_658786- AniB1
AAA34375-CaB	100	84	76	75	79	80	80
P02557-ScB1		100	74	71	78	78	78
AAC21454-SpB1			100	74	78	78	78
AW324553-AbB*				100	83	82	84
BAE64122-Aor-B1					100	98	98
XP_752456-AfuB1*						100	97
XP_658786-AniB1							100

Protein Similarity of Fungal β -tubulin Proteins

	AAA34375- CaB	P02557- ScB1	AAC21454- SpB1	AW324553- AbB*	BAE64122- Aor-B1	XP_752456- AfuB1*	XP_658786- AniB1
AAA34375-CaB	100	94	89	88	90	90	91
P02557-ScB1		100	88	89	90	90	90
AAC21454-SpB1			100	86	90	89	90
AW324553-AbB*				100	93	91	93
BAE64122-Aor-B1					100	99	98
XP_752456-AfuB1*						100	98
XP_658786-AniB1							100



Sequence comparison of fungal beta-tubulins

Accessions and Citations

Aspergillus fumigatus (Af293) Note, alignments use manually edited protein sequence to eliminate “insertion”

Protein: XP_752456 (*)
DNA: XM_747636
Evidence: Beta1 designation based on sequence homology, not supported by known biological data

Aspergillus nidulans (FGSC A4)

Protein: XP_658786 (see also P10653)
DNA: XM_653694 (see also M17519)
Evidence: BenA involved in both vegetative growth & asexual sporulation, but tubC is mostly used during sporulation only (see May et al. 1987. Gene 55:231-43; Oakley 2004. Fungal Genet. Biol. 41: 420-7; see also *Asp. nidulans* gene index – TC5874)

Aspergillus oryzae (RIB40)

Protein: BAE64122
DNA: AP007169
Evidence: Virtual translation based homolog, and similarity to partial sequence of benA56 of strain NRR4469 (Acc.AF036805); strong homology to *Asp. flavus* (Acc. M38265).

Candida albicans (original source Strain B792 not ATCC 10231 as used for α -tubulin)

Protein: AAA34375
DNA: M19389
Evidence: TUB2 is only β -tubulin gene in *C. albicans* based on Southern-blot analysis (Smith *et al.* 1988. Gene, **63**: 53-63)



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Saccharomyces cerevisiae

Protein: P02557
DNA: V01296
Evidence: Tub2, (see Neff et al. 1983. Cell, 33: 211-219)

Schizosaccharomyces pombe

Protein: AAC21454
DNA: AF042827 (and see M10347 for genomic DNA)
Evidence: Nda3 is beta tubulin, (see Hiraoka et al. 1984. Cell, 39: 349-58)

Agaricus bisporus

Protein: Virtual translation of EST below, manually edited to eliminate apparent N-terminal addition (indicated by *)
DNA: AW324553 is short EST attributed as β -tubulin.
Evidence: Homolog of β 1 based on short EST sequence (see Ospina-Giraldo *et al.* 2000. Fungal Genet. 29: 81-94)

Homo sapiens

Protein: NP_821133
DNA: NM_178014
Evidence: Known variously as: constitutive; human $h\beta$ 1; tubulin- β 2; TUBB; TUB2A, TUBB2
Unigene: TUBB = Hs.533059