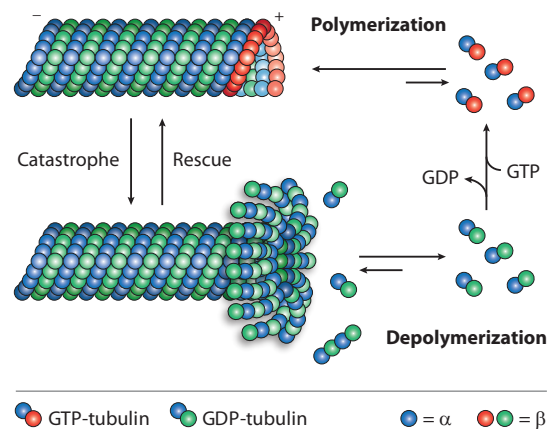


# The Tubulin Code

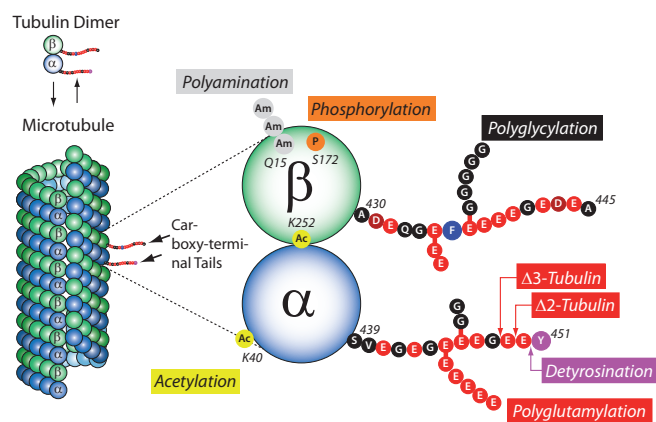
## Post-translational Modification Antibodies

The internal organization, shape, motility and life cycle of eukaryotic cells are all controlled by a complex network of polymeric filaments called the **cytoskeleton**, which includes actin filaments, intermediate filaments and microtubules. These polymers have important roles in arranging and maintaining the integrity of intracellular compartments. **Microtubules (MT)** are the largest cytoskeletal components involved in intracellular transport (cell signaling), cell migration/trafficking, cell division and proliferation. Microtubules control differentiative processes involving intracellular rearrangements and changes in morphology. Complex microtubule structures form the core components of centrosomes and the centrioles important for mitosis, and the core structures of cilia and flagella, which are called axonemes. Despite their functional diversity, all microtubules are assembled from heterodimers of  $\alpha$ -tubulin and  $\beta$ -tubulin. Soluble  $\alpha$ -tubulin- $\beta$ -tubulin dimers polymerize into polar microtubules in the presence of GTP. Understanding of the cell structure and function is essential for gaining deeper knowledge of normal pathways such as morphogenesis, wound healing, neurogenesis and immune response, as well as abnormal processes such as metastasis and tumor-related angiogenesis.

In **neurons**, microtubules, actin filaments and neurofilaments compose the cytoskeleton, maintaining cell polarity, architecture and morphology. Regulation of microtubules polymerization is controlled by microtubule associated proteins, post-translational modifications of tubulin  $\alpha$  and  $\beta$ , microtubules and signaling molecules. Deregulation of the neuronal cytoskeleton/MT function constitutes a key insult during the pathogenesis of nervous system diseases, leading to neurodegenerative diseases, including Amyotrophic Lateral Sclerosis, Alzheimer's Disease (AD), Hereditary Spastic Paraplegia, Parkinson's disease (PD) and others. **Posttranslational modifications (PTMs)** are highly dynamic and often reversible processes where protein functional properties are altered by addition of a chemical group or another protein to its amino acid residues. Tubulins and microtubules are major substrates for PTMs. PTMs include tyrosination/de-tyrosination, D2-tubulin formation, acetylation, phosphorylation, polyamination, ubiquitination, polyglutamylolation and glycylation. PTMs are involved in fine-tuning of interactions between microtubules and different MT-interacting proteins.



**FIGURE 1:** Microtubule dynamic instability. Polymerizing and rapidly depolymerizing polymers coexist at steady state.



**FIGURE 2:** Tubulin PTM Overview. Adapted from C. Janke; *J. Cell. Biol.* 206, 461 (2014).

**LIT:** The tubulin code: molecular components, readout mechanisms, and functions: C. Janke; *J. Cell. Biol.* 206, 461 (2014) • The tubulin code at a glance: S. Gadadhar, et al.; *J. Cell Sci.* 130, 1347 (2017) • The tubulin code and its role in controlling microtubule properties and functions: C. Janke & M.M. Magiera; *Nat. Rev. Mol. Cell Biol.* 21, 307 (2020) • The Tubulin Code, from Molecules to Health and Disease: E.D. McKenna, et al.; *Annu. Rev. Cell Dev. Biol.* 39, 331 (2023) • Emerging roles for tubulin PTMs in neuronal function and neurodegenerative disease: J. Teoh & F. Bartolini; *Curr. Opin. Neurobiol.* 90, 102971 (2025)

**Antibodies see Backpage!**

UNIQUE

## Validated Post-translational Modification-specific Antibodies

ANTIBODIES	PID	PRODUCT DESCRIPTION	APPLICATION
<b>anti-Polyglutamylation Modification, mAb (GT335)</b>	AG-20B-0020	Recognizes most forms of polyglutamylated tubulin ( $\alpha$ - and $\beta$ -tubulin), independent of the length of the glutamate side chains. No specificity to particular tubulin isoforms nor to tubulin from particular species are observed. Detects also other (poly)glutamylated proteins.	ICC (IF), IHC, IP, WB
<b>anti-Polyglutamate chain (polyE), pAb (IN105)</b>	AG-25B-0030	Recognizes C-terminally located linear $\alpha$ -glutamate chains of 4 and more glutamate residues.	ICC (IF), IHC, WB
<b>anti-<math>\alpha</math>-Tubulin (acetylated), mAb (TEU318)</b>	AG-20B-0068	Detects K40 acetylation of $\alpha$ -tubulin; signal specifically increased by modification with tubulin acetyl transferase $\alpha$ -TAT1.	ICC (IF), WB
<b>anti-Acetyl-<math>\alpha</math>-Tubulin (Lys40), Rabbit mAb (RM318)</b>	REV-31-1204-00	Reacts to $\alpha$ -tubulin acetylated at Lysine 40. No cross-reactivity to non-acetylated $\alpha$ -tubulin at Lysine 40.	ICC (IF), WB
<b>anti-<math>\beta</math>-Tubulin (<math>\beta</math>-monoE), pAb (IN115)</b>	AG-25B-0039	Selectively labels glutamylation of $\beta$ -tubulin due to its specificity to a sequence motif (GE(*-E)F) that only exists in $\beta$ -tubulin isoforms.	ICC (IF), IHC, IP, WB
<b>anti-Tubulin (glycylated), pAb (Gly-pep1)</b>	AG-25B-0034	Recognizes mono or bi-glycylated tubulins. Detects other glycylated yet unidentified protein.	ICC (IF), IP, WB
<b>anti-Delta2-Tubulin, pAb (IN120)</b>	AG-25B-0044	Recognizes the posttranslationally modified form of $\alpha$ -tubulin known as $\Delta$ 2-tubulin.	ICC (IF), WB
<b>anti-Delta2 <math>\alpha</math>-Tubulin, Rabbit mAb (RM447)</b>	REV-31-1339-00	Reacts to $\Delta$ 2 $\alpha$ -tubulin, a C-terminally trimmed version of $\alpha$ -tubulin that lacks a C-terminal glutamyl-tyrosine group.	ICC (IF), WB
<b>anti-Detyrosinated <math>\alpha</math>-Tubulin (human), Rabbit mAb (RM444)</b>	REV-31-1335-00	Detects detyrosinated human $\alpha$ -tubulin. Detyrosination consists of the removal of the C-terminal tyrosine to expose a glutamate at the newly formed C-terminus.	ICC (IF), WB

## Other Tubulin Antibodies

ANTIBODIES	PID	PRODUCT DESCRIPTION	APPLICATION
<b>UNIQUE anti-Tubulin-GTP, mAb (rec.) (MB11)</b>	AG-27B-0009	Recognizes human, mouse, rat and drosophila tubulin-GTP.	ICC (IF)
<b>anti-<math>\alpha</math>-Tubulin, mAb (rec.) (F2C)</b>	AG-27B-0005	Recognizes human, mouse and bovine $\alpha$ -tubulin.	ICC (IF), WB
<b>anti-<math>\alpha</math>-Tubulin, Rabbit mAb (RM113)</b>	REV-31-1016-00	Reacts to $\alpha$ -tubulin, including tubulin $\alpha$ -1A chain and tubulin $\alpha$ -1B chain.	ICC (IF), IHC, ChIP, IP, WB
<b>anti-<math>\beta</math>-Tubulin, mAb (AXO45)</b>	AG-20B-0085	Recognizes almost all isoforms of $\beta$ -tubulin specifically in cells and tissues of human, mouse and ciliates.	ICC (IF), IHC, IP, WB
<b>anti-<math>\beta</math>-Tubulin, mAb (rec.) (S11B)</b>	AG-27B-0008	Recognizes human, mouse, rat, pig, drosophila and monkey $\beta$ -tubulin.	ICC (IF), WB

## APPLICATIONS:

ChIP: Chromatin IP; ICC: Immunocytochemistry; IF: Immunofluorescence; IHC: Immunohistochemistry; IP: Immunoprecipitation; WB: Western Blot