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Higher Order Assembly of Microtubules by Counter-ions DANIEL NEEDLEMAN, MIGUEL OJEDA-LOPEZ, URI RAVIV, HERBERT MILLER, LESLIE WILSON, CYRUS SAFINYA — Cellular factors tightly regulate the architecture of bundles of filamentous cytoskeletal proteins, giving rise to assemblies with distinct morphologies and physical properties in vivo, but it is unclear how the microscopic interactions between filaments result in the observed structures. We study a model system consisting of microtubules (MTs) and multivalent cations, and demonstrate the formation of distinct bundle phases. We have characterized the structure of these self-assemblies of MTs from the nanoscale to the mesoscale using synchrotron x-ray scattering and diffraction, video enhanced DIC and fluorescence microscopy, and electron microscopy. Tightly packed hexagonal bundles with controllable diameters are observed for large tri-, tetra-, and pentavalent counterions. Unexpectedly, in the presence of small divalent cations, we have discovered a living necklace bundle phase, comprised of dynamical assemblies of MT nematic membranes with linear, branched, and loop topologies. Supported by NSF DMR-0203755, NIH GM-59288 and NS-13560, and CTS-0103516. SSRL is supported by the U.S. DOE.

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