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On the biophysical properties of microtubules and their importance in health and disease

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Abstract

In this talk I will provide an overview of the many interesting biophysical and biochemical properties of microtubules. The building block of microtubules, the heterodimer of alpha and beta tubulin has been well characterized and is a target for drug discovery, which will be mentioned briefly in this talk. This will be followed by a discussion of the unique polymerization and depolymerization properties of microtubules. With the knowledge of the crystallographic structure of tubulin it has been possible to analyze at atomistic-level detail, its electrostatic properties, molecular mechanics, stability, hydrogen-bond interactions as well as conductive properties in ionic solutions. Charge and dipole values for monomers and dimers as well as polymerized forms of these proteins will be summarized. Continuum approximations for cable equations describing actin filaments and microtubules compare favorably to measurements in buffer solutions showing soliton waves and transistor-like amplification of ionic signals. In addition, experimental evidence for memristive behavior of microtubules supports their hypothesized role in memory storage and information processing. Conductivity and capacitance of tubulin and microtubules have been measured and modeled. A dramatic change in conductivity occurs when tubulin forms microtubules. In living cells, this signals a conductive phase transition coinciding with mitosis in dividing cells. Finally, I will discuss how microtubules play a role in health and various diseases such as cancer.