Molecular Identity of Cellular Water Compartments

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This presentations reviews physical evidence of categorical changes in water properties caused by association of water dipoles with partial charge pairs NH^+ and CO^{-} on the backbone of macromolecular proteins. Irreducible charge separation results from the stiffness of bonds in the protein backbone. The elevated electrostatic energy of adjacent charge pairs in air is reduced when placed in water due to the high dielectric coefficient of water. The change in free energy binds polar water molecules to the protein either as single water bridges (one water molecule) or double water bridges (three water molecules) depending on the minimum separation of the adjacent partial charges. The compartmental differences in water properties were first identified in tendon (nearly monomolecular collagen) that demonstrated stoichiometric hydration limits of h(g/g) = n x 0.0658 g/g for n = 1, 4 and 24 or h = 0.0658, 0.263 and 1.6 g/g for single water bridges, backbone hydration and monolayer hydration. A wide range of physical properties of water on homopolypeptides, fibrillar proteins, globular proteins, cells and lens tissues demonstrate similar compartmentalization of water that lead to the conclusion that nearly all water in biological cells is bound in the first water monolayer on protein surfaces. The molecular water compartments have different properties due to differences in orientation, immobilization and motion of polar water molecules responding to the local electric field at the protein surfaces.