Solution scattering and high-pressure biology

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The degree to which hydrostatic pressure alters the structure of a biomolecule is directly related to how well its atoms and those of the surrounding solvent are packed. Though protein cores are generally quite densely packed and incompressible, cavities and other types of voids are essential for biological function. Pressure is therefore a tool that selectively alters imperfectly packed regions of potential biological significance. But rather than simply compressing to fill in voids, biomolecules tend to respond in more dramatic ways to reduce total volume: For example, water can be forced into hydrophobic cavities resulting in dissociation of complexes at modest pressures and progressive unfolding of domains at more extreme pressures. Lipid bilayers, lipid mesophases, and liquid-liquid phase separation (LLPS) are also highly sensitive to pressure. All these types of pressure-induced changes are readily observable with small-angle X-ray solution scattering (SAXS). Drawing upon recent user examples from our high-pressure biological scattering facility, we will illustrate the structural information that can be gleaned from high-pressure SAXS measurements, some technical considerations for high-pressure work, and future directions.