

Water dynamics of cells and egg white hydrogel

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Diffusion of ions, proteins and water from a mammalian cell following disruption of the plasma membrane required hours (Cameron et al. 1996). Thus the cytoplasm appears to function more as a hydrogel than as an aqueous solution. Recent studies by Cameron et al. (2010a, 2010b) demonstrate that thick hen egg white is a natural hydrogel with physical properties that mimic cytoplasm (Fels et al. 2009). Seven studies report that the majority of cell water has non-bulk-like properties. However recent reports on the physical properties of bacterial cell water indicate the physical state of cell water resembles that of bulk water (Jasnin et al. 2008, Persson and Halle, 2008, Qvist et al. 2009). In these bacterial studies the cells were first pelleted by centrifugation at a g force of 5,000 – 10,000 x g for 20 to 30 minutes prior to physical measures. Could such a g force have changed the physical properties of cell water?

An experiment was designed to test this possibility using the thick hen egg white hydrogel. Two measures were made on the hydrogel: rate of diffusion of a vital dye (methylene blue, MB) into the gel and the water proton NMR relaxation time (T_1). The g force used ranged from 0 to 14,000 x g.

The results indicate that at a g force of 15,000 for 60 min the rate of MB dye diffusion into the hydrogel was significantly increased. At 300 x g force it took 75 min of centrifugation to cause a significant increase in rate of diffusion of MB dye into the hydrogel.

Exposure of fresh hydrogel to 1500 x g for 30 min caused a significant increase in the proton T_1 relaxation from 989 to 1016 m sec. Centrifugation for 2 hrs. followed by separation of sol from gel phase by filtration revealed a significantly longer T_1 relaxation (1067 m sec) in the sol vs. the gel (934 m sec). No sol filtrate was recovered from the non-centrifuged thick albumen hydrogel.

Fresh skeletal muscle also increased T_1 after centrifugation.

Thus application of a g force near or much less than the g force which was used to pellet the bacterial cells was enough to significantly alter diffusion and the NMR T_1 relaxation time.

This calls into question the conclusions drawn from the bacterial cell water studies that cell water is essentially the same as bulk water. The application of high g force during centrifugation may well have changed the water dynamics of the cells.

Evidence to be presented indicates that the majority of cell water is non-bulk like and can be explained by multiple hydration fractions (Fullerton and Cameron 2007, Cameron et al. 2008, Cameron and Fullerton 2008).

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