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Improving success rates of assisted reproduction technology by mathematical modelling

Assisted reproduction technology (ART) involves support of oocytes (eggs) and embryos in the laboratory for some period of time, and success rates are known to be highly dependent on laboratory conditions. It is believed that better reproduction of normal in-vivo conditions in the laboratory will bring improved success rates. At the very least knowledge of these conditions provides valuable guidance for setting laboratory conditions. Because measurement of in-vivo conditions is difficult, if not impossible in some circumstances, mathematical modelling is a valuable tool for gaining understanding of in-vivo environments.

We report on mathematical modeling for gaining a better understanding of the nutritional environment of mammalian oocytes in antral follicles. In particular reaction-diffusion models have been used in conjunction with experiments to investigate oxygen and glucose concentrations in the bovine follicle. Unlike oxygen which diffuses readily through cell walls, glucose molecules pass through via facilitated transport mechanisms. The model for glucose transport must reflect this fact and is, consequently, more complicated than that for oxygen. Experimental validation of our models is challenging and will be discussed.

The ultimate aim of this work is to improve the developmental competence of oocytes that have been harvested at an immature stage and matured in the laboratory, a procedure known as in-vitro maturation. The ability to successfully use such oocytes in an IVF program reduces the need for stimulation of the ovary to yield multiple mature oocytes for harvest and use in a traditional IVF program. This, in turn, makes ART available to women for whom ovarian stimulation drugs, as used in traditional IVF methods, are likely to cause life threatening illnesses. Reducing the use of these drugs also has the potential to reduce the cost of IVF.