“Hands-on” practical class activities to engage students in basic principles of cell physiology

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Successful understanding of basic principles of cell physiology provides a strong foundation on which to build more detailed study of biomedical sciences. Active learning of these principles in large undergraduate classes is challenging, as delicate experimental procedures and expensive equipment that can be needed to measure single cell properties. These obstacles can be overcome by using simulated computer experiments, and good programs exist to do this (Moore & Stuart, 2016; Barry, 2015). However, valuable learning experiences can be gained by active experimentation in Physiology and we have developed a number of simple and cheap practical classes to illustrate basic cell physiology principles. In our cellular fluid homeostasis practical, we measure the haematocrit of human red blood cells, to which we separately add the Na^+ ionophore, monensin (10-20 μM, 0.1-0.2% DMSO), the potassium ionophore, valinomycin (10-20 mM, 0.1-0.2% DMSO), and a DMSO vehicle control. Students fill glass haematocrit tubes with each of the three samples, and then centrifuge the samples to separate the whole blood sample into plasma and red blood cells. The proportion of red blood cells (the haematocrit) is increased by 4-7% in the monensin sample, due to Na^+ influx leading to H_2O influx and cell swelling. Conversely haematocrit values in the valinomycin samples are 2-5% lower than control, due to cell shrinkage secondary to K^+ efflux. The small drug-induced changes are consistently observed. This novel and simple experiment effectively demonstrates that fluid (H_2O) moves across cell membranes due to osmotic forces induced by ionic fluxes. A second practical class in Excitable Cell Physiology uses artificial (Selemion©) membranes to simulate ion selective biological membranes. Using a simple Perspex chamber and a voltmeter, students use different KCl solutions to measure membrane potentials that develop across the artificial membrane in the presence of KCl concentration gradients. Students work on either an anion or cation-selective membrane and must deduce both the selectivity of their membrane and work through principles of electrochemical gradients. We have used this approach to quantify the selectivity of the cationic ($PK^+ : PCl^- = 68.2 \pm 28.6$, n=5) and anionic ($PK^+ : PCl^- = 0.010 \pm 0.005$, n=3) membranes. Our package of hands-on learning activities re-enforces important cellular physiology concepts to 1st year students, which should assist with their further understanding of physiology and medicine.

Barry PH. (2015) http://web.med.unsw.edu.au/phbsoft/

Moore JW, Stuart AE. (2016) http://neuronsinaction.com/