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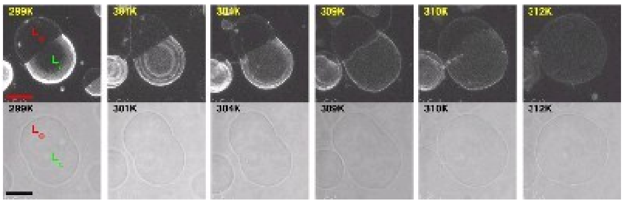
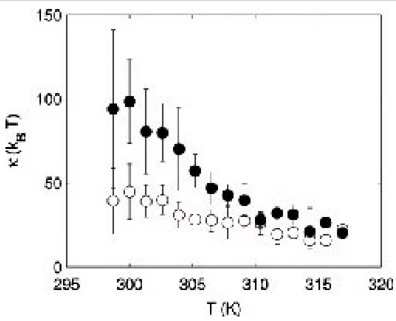
Giant vesicles get heated

More than a hundred different lipid species are mixed together in the membranes of mammalian cells. The composition is tightly controlled, and a major challenge is to understand the functional significance of this molecular diversity. Previous studies have shown that the lipid bilayer mechanical properties can regulate and direct membrane protein functions. The bilayer formed by a ternary lipid mixture of a saturated phosphocholine (DPPC), an unsaturated phosphocholine (DOPC) and cholesterol, is a good model system of the plasma cell membrane, reproducing the liquid-liquid phase separation as a function of temperature that is present in physiological compositions. Cholesterol very effectively modulates the properties of the lipid layers. Yoon *et al* made giant unilamellar vesicles, and measured how the bending moduli of the phases in this system (mixed and de-mixed) varied as a function of temperature. The mechanical moduli are an important factor affecting the overall morphology of the system, and by tuning the mechanics the cell can favour or prevent the budding of smaller vesicles.



De-budding process



Bending rigidity for ternary membranes

As temperature is varied, the bending moduli of coexisting liquid phases change and as a result the vesicle moves between a spherical and a partially budded morphology.

Researchers at the Universities of Cambridge and Exeter are studying mechanics of ternary lipid mixture giant vesicles near phase separation, using a non-invasive contour detection technique in video microscopy that measures the fluctuations of the membrane position. Lipid composition in various mammalian cell membranes has been found to be near a miscibility critical point, where cholesterol rich domains can form spontaneously. In this thermodynamic state, a slight change in the temperature, or in lipid or protein compositions may trigger domain formation, furthermore even in the mixed state there are large transient concentration fluctuations. The effect of these processes at the biological level is still not fully understood. This recent advance is a clarification of how lateral phase separation and domain formation relate to the membrane mechanical properties.

The mechanical properties of vesicles, both during the domain coarsening phase and in the fully phase separated condition, have been studied. The researchers found that as the temperature increases in the de-mixed state, the bending rigidities of the separated phases decrease and approach a similar value, as shown in the figures. Interestingly, the bending rigidity of the cholesterol rich phase has stronger temperature dependence than that of the softer and more disordered phase. This may be due to the trajectory of the binodal line on the ternary phase diagram, as temperature is changed. In addition, it was found that in the model system the fixed-volume constraint plays a crucial role, preventing the vesicle from budding off into two spheres of different composition.

About the author

Dr Young-Zoon Yoon, is a visiting researcher in the Biological Soft Systems Sector of the Cavendish Laboratory, University of Cambridge, UK from Sungkyunkwan University, Korea, funded by an international research programme of KICOS. He has also worked on red blood cell mechanics, and currently is exploring how mammalian cells adapt to micro- and nano-structures. John P Hale is a PhD student in the School of Physics, University of Exeter, where Dr Peter G Petrov is a Senior Lecturer. Dr Pietro Cicuta is a Lecturer in the Biological Soft Systems Sector of the Cavendish Laboratory.

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