Soap and scutoids

Dec. 7, 2018

A century and half ago the blind Belgian scientist Joseph Plateau laid down the basic rules that give the geometry and topology of foams, as dictated by surface tension [1]. Researchers still delight in working out their consequences: it is often a complicated game but it is played according to simple laws, for example that no more than three soap films may meet in a line.

Anyone who looks at the forms of biological cells is struck by the fact that the same rules seem to apply. So when a new type of epithelial (skin) cell arrived on the scene recently [2,3], causing quite a splash in the media [4], physicists in Dublin and Aberystwyth immediately asked: is this shape to be found in a foam under similar circumstances?

Epithelial cells may be visualized as thick crazy paving – idealised as hexagonal, but generally somewhat disordered in shape. Scutoids are associated with the effects of a curvature of this cell layer (as in the back of the beetle from which the name was derived). The new cells have a triangular face at one corner, as if a corner was cut off from a normal cell.

The two foam research groups found that stable scutoids could indeed be induced in a layer of soap bubbles trapped between two curved plates, and computer simulations also reproduced the effect [5]. Plateau's venerable rules suffice to describe and rationalise the scutoids.

As usual, the physicists do not claim to completely describe this complex biological system. But once more they have wielded Occam's Razor to pare down a problem to the bare bones of the simplest explanation.

[1] J.A.F. Plateau, Statique Expérimentale et Théorique des Liquides soumis aux seules Forces Moléculaires, Gauthier-Villars, Paris, 1873.

[2] J.-F. Rupprecht, K.H. Ong, J. Yin, A. Huang, H.-H.-Q. Dinh, A.P. Singh, S. Zhang, W. Yu, and T.E. Saunders, *Geometric constraints alter cell arrangements within curved epithelial tissues*. Molecular Biology of the Cell 28 (2017), pp. 3563–3725.

[3] P. Gómez-Gálvez, P. Vicente-Munuera, A. Tagua, C. Forja, A.M. Castro, M. Letrán, A. Valencia-Expósito, C. Grima, M. Bermúdez-Gallardo, Ó. Serrano-Pérez-Higueras, F. Cavodeassi, S. Sotillos, M.D. Martín-Bermudo, A. Márquez, J. Buceta, and L.M. Escudero, *Scutoids are a geometrical solution to three-dimensional packing of epithelia.* Nature Communications 9 (2018), 2960.

[4] e.g. A. Burdick, *We are all scutoids: a brand new shape, explained,* New Yorker, July 30, 2018 https://www.newyorker.com/science/lab-notes/we-are-all-scutoids-a-brand-new-shape-explained
W. Humphries, *The scutoid: complex new shape discovered in cells*, The Times, August 1, 2018. https://www.thetimes.co.uk/article/the-scutoid-complex-new-shape-discovered-in-cells-mr8s92f0x

[5] A. Mughal, S.J. Cox, D. Weaire, S.R. Burke and S. Hutzler, *Demonstration and interpretation*

***of "scutoid" cells formed in a quasi-2D soap froth,* Philosophical Magazine Letters (2018).** https://doi.org/10.1080/09500839.2018.1552806

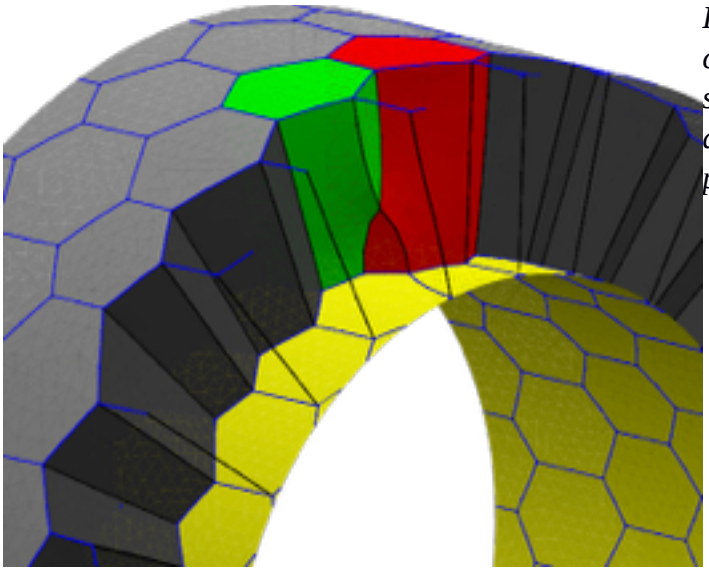

Figure 1: Computer simulation of a foam confined between two concentric cylinders with scutoid cells highlighted in colour. These cells are characterised by a triangular face perpendicular to the bounding cylinders.

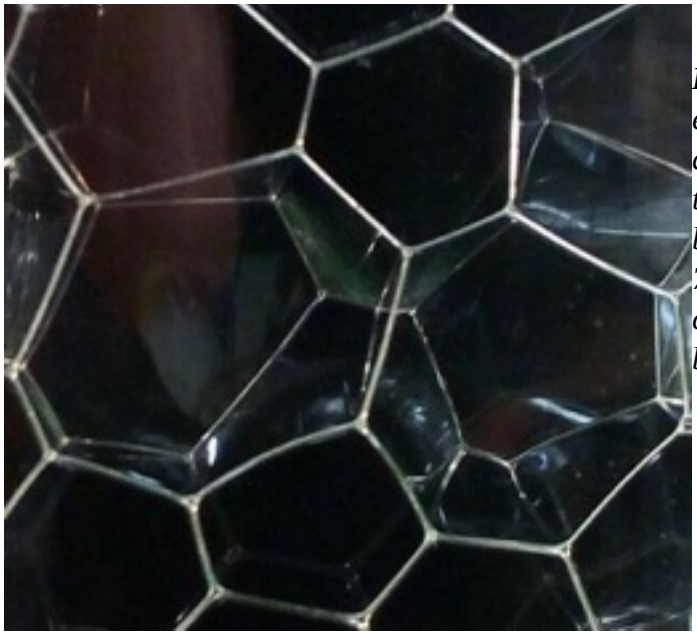

Figure 2: Photograph of scutoids found in experiments using ordinary dishwashing solution and two glass cylinders. Note the small triangular face in the centre of the image. It belongs to the two columnar cells which have a 7-sided face in contact with the top bounding cylinder and a 6-sided face in contact with the bottom cylinder.