

# Scientists make the 'perfect' foam

Theoretical low-energy foam made for real.

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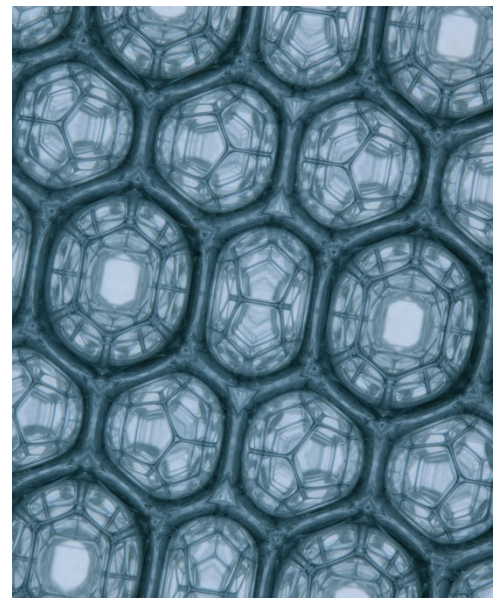
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Physicists working at Trinity College in Dublin, Ireland, have finally made the perfect foam. Whereas most Dubliners might consider that to be the head on a pint of Guinness, Denis Weaire and his co-workers have a more sophisticated answer.

'Perfect' here means the lowest-energy configuration of packed bubbles of equal size. This is a compromise between the surface area of the bubbles and the stability of the many interlocking faces of the polyhedral bubbles in the foam. The Belgian scientist J. A. P. Plateau calculated in the nineteenth century that three soap films are mechanically stable when they meet at angles of  $120^\circ$ , whereas four films meet at the tetrahedral angle of about  $109.5^\circ$ .

So what bubble shape minimizes the total surface area while (more or less) satisfying Plateau's rules? That's essentially the same as asking what shape balloons, or any squashy spheres, will adopt when squeezed together. For centuries, scientists including the French zoologist Georges Buffon have pondered the question, using lead shot and garden peas as a model. The Irish scientist Lord Kelvin thought he had the answer in 1887: the 'perfect foam' is one in which the cells are truncated octahedra, with eight hexagonal faces and six square ones — provided that the faces are a little curved to better fit Plateau's rules.

Kelvin's solution was thought to be optimal for a long time, but there was no formal proof. Then in 1994, Weaire and his colleague Robert Phelan found a better way. It wasn't so elegant — the structure had a repeating unit of eight polyhedra, six of them with 14 faces and two with 12, all with hexagons and imperfect pentagons and again slightly curved. This has 0.3% less surface area than Kelvin's foam.



Ruggero Gabbrielli

The Weaire-Phelan foam is the perfect foam.

But does it really exist? The duo found no definitive evidence of their ideal foam in experiments (conducted with washing-up liquid). Now there is. The key was to find the right container. Normal containers have flat walls, which the Weaire-Phelan (WP) foam won't sit comfortably against. But engineer Ruggero Gabbrielli from the University of Trento figured that a container with walls shaped to fit the WP foam might encourage it to form. He has collaborated with Weaire and his colleagues, along with mathematician Kenneth Brakke at Susquehanna University in Pennsylvania, to design and make one out of plastic.

When Gabbrielli filled this container with equal-sized bubbles, he found that the six layers of about 1,500 bubbles were ordered into the WP structure. They describe their results in a paper to be published in *Philosophical Magazine Letters*.

This isn't actually the first time that the WP foam has been made. But the previous example was built by hand, one cell at a time, from girders and plastic sheets, to comprise the walls of the iconic Olympic Swimming Stadium in Beijing, China.

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*Correction: An earlier version of this story incorrectly described Ruggero Gabbrielli as a physicist. He is an engineer.*