their dry weight) is undoubtedly a contributory factor, and led to raised bogs being described by the late Sir Harry Godwin[2] as "huge flat sponges". It is the nature of a sponge to hold water against gravity by the matric forces of capillarity, and this view of the hydrology of raised bogs was generally accepted until relatively recently[3] — despite the fact that this notional model of the system could not account in physical terms for the high water table found within the peat domes.

In 1982 Ingram[4] developed a model of raised-bog hydrology based upon the concept of the two-layered bog structure that had been put forward by Ivanov in Russia[5]. In this model a thin layer of actively developing peat (the acrotelm) overlies the bulk of the peat mass (the catotelm) which is more compacted and is permanently saturated with water. The hydraulic conductivity of the acrotelm is high (that is, water moves easily through it), but the hydraulic conductivity of the catotelm is low, so the deeper layers of peat are effectively impermeable to either the lateral or vertical movement of water. In Ingram's model, the water supply of the raised-bog surface comes entirely from rainfall; and because this water cannot drain vertically through the peat dome, it moves laterally through the acrotelm, and the water which does not evaporate is ultimately shed at the dome edges. Rather than a simple sponge, the raised bog is like a hemisphere of solid rubber coated with a thin layer of sponge and is fed by water falling from above.

The dependence of raised bogs upon rainfall for their water supply (ombrotrophic mires) is the essential feature that differentiates this type of mire from fens (flow-fed, rheotrophic mires). It is interesting to find, therefore, that raised bogs can develop even in continental areas subject to relatively low precipitation, as in the northwest of Minnesota where annual precipitation is only 55–64 cm.

It is here that Glaser and his colleagues[1] have re-examined hydrological models of peat development. They studied 127 of the abundant domed mires in a wetland region of flow-fed fens, and conducted surveys of hydraulic head gradients through wet and dry weather conditions. They also analysed the chemistry of pore water to determine the influence of groundwater. They discovered that raised bogs are situated over discharge regions for groundwater so that during dry periods there is an upward movement of water from the peat/mineral base into the dome. The effect of this is to maintain a higher water table within the raised mire system. In wet periods, however, there is a reverse movement as a consequence of the excess supply of water at the surface from rain.

These findings raise some important questions for wetland ecologists. Are raised bogs in more continental climates generally

**Fluid dynamics**

## Long drops in free fall

There is something fascinating about things in free-fall. Remember watching the crew of Skylab chase wobbling globules of drink around with a straw? Scientifically worthier, but perhaps just as much fun, is a new study of superdeformed drops in zero gravity, performed on the Space Shuttle Columbia and reported last month (Apfel, R. E. *et al. Phys. Rev. Lett.* 78, 1912–1915; 1997).

A single water drop "the size of a ping-pong ball", is initially held in an extremely oblate shape by the sound from four powerful loudspeakers. The speakers are turned off, and the blob oscillates freely. The first half-oscillation is shown here: within less than half a second, the pancake becomes a lemon, a sausage and finally a peanut.

Such extreme deformations would not be possible without the addition of some surfactant, or detergent, which reduces the surface tension of the drop and so prevents the narrow neck in the last image from pinching off, leaving two drops behind. Here, just $1.4 \times 10^{-4}$ grams per millilitre of the chemical Triton X-100 is enough to substantially change the bulk flow properties of the fluid.

But the details of surfactant behaviour in this nonlinear, nonequilibrium regime aren't well understood. Fortunately, the approximate behaviour of the drop can be predicted by numerical calculations that assume a uniform surface tension; the upper row of outlines shows the result. Comparing the prediction with the real blob, Apfel *et al.* found that the fluid's dynamic surface tension was higher than its measured static value. That may be because the surfactant doesn't have time to reach saturation levels on the whole surface during each phase of the oscillation.

As well as the obvious relevance to the behaviour of surfactant-bearing liquid drops, the authors speculate that their experiment may provide insights into exploding stars and hyperdeformed atomic nuclei.

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