anaesthetized rats inside an fMRI scanner.

In the vicinity of the optical fibre illuminating the rats' motor cortices, the authors found robust neural and fMRI responses within a conventional time course. This indicates that the direct activation of excitatory cortical neurons somehow triggers changes in local blood flow. Such stimulation of a well-defined subclass of neuron goes a step further than previous sensory stimulation and electrical microstimulation approaches, in which activation was less specific. What's more, Lee *et al.* predict that emerging tools will soon allow cells to be targeted on the basis of not only the genetic markers they express, but also their morphology and tissue topology[9]. If so, a further dissection of the cells that are particularly important for neurovascular coupling should be possible in the future.

While optically stimulating the motor cortex, Lee *et al.* also detected robust fMRI responses in the thalamus, a structure in the middle of the brain to which neurons of the motor cortex project axonal processes (Fig. 1a). Both the neural responses and fMRI responses in the thalamus were more sluggish than in the cortex, which the authors attribute to network delays; this point, however, requires further study.

Intriguingly, direct illumination of the thalamus also resulted in fMRI responses, despite the region's distance from the cell bodies of the manipulated motor-cortex neurons (Fig. 1b). These responses reflect the expression of light-sensitive channels in the cortical axons projecting into the thalamus. Remote optical stimulation of axons — which has previously been combined with electrophysiological recordings[10] to study long-range connections in brain slices — thus offers a new and powerful way to probe anatomical and functional connectivity using fMRI.

The finding that direct excitation of principal neurons leads to positive haemodynamic responses will be important for the research community interested in functional brain imaging, as it shows a causal link between the firing of a class of neuron and the fMRI signal. However, this observation should be interpreted with caution: it is likely that the downstream neural and non-neural elements also make a complex contribution to the vascular response (see Lee and colleagues' discussion[1]).

The main impact of this study[1] will be in providing alternative ways to map neural circuits. The combination of optogenetics and fMRI permits, for the first time, investigation of genetically specified, large-scale networks in the brains of live animals — for example, networks that may be disrupted in mental illness in humans. The method could also allow researchers to track the formation of neural circuits during development, as connections are steered and regulated by patterns of gene and protein expression. And when applied to experimental models of neurological and psychiatric disease, the approach may help to determine when and how certain regions of the brain fail to connect properly. Finally, the anticipated use of optogenetics as a tool for human deep-brain stimulation[9] can readily be combined with fMRI scanning, extending the methods introduced here to the mapping of activity in the human brain.

Specifically, this approach would allow researchers to visualize the responses to stimulation of well-defined cells or axons that are thought to underlie positive therapeutic outcomes in human patients. As ambitious as it sounds, the prospect of shining light into the brain of a conscious patient to map neural circuits may be just around the corner. ■

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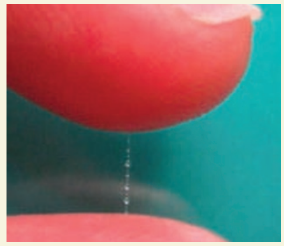
FLUID DYNAMICS

Saliva at a stretch



Reporting in *Nature Physics*, Pradeep Bhat and colleagues explain a vexing phenomenon in fluid dynamics — the 'beads-on-a-string' structures that form in viscoelastic fluids (P. P. Bhat *et al. Nature Phys.* doi:10.1038/NPHYS1682; 2010).

It's easy to observe this effect: take a blob of saliva from the top of your tongue, place it between your thumb and index finger, then slowly pull your digits apart. With practice, you'll form a thread of fluid that initially thins and drains, but that eventually forms a string of different-sized spheres (pictured). Newtonian fluids, such as water, don't do this — instead, the threads quickly break.

Saliva differs from water in containing naturally occurring polymeric molecules that make it viscoelastic. This property was thought to cause the beads-on-a-string effect, yet computer models of viscoelastic liquids couldn't reproduce the phenomenon.

Bhat *et al.* report a new computer model that factors in inertia. They find that inertia causes beads to form even on threads of low-viscosity Newtonian fluids. But in viscoelastic fluids the beads last longer, grow bigger and become more spherical. The authors' simulations also reveal that enhanced radial flow occurs at certain regions of threads, causing additional, smaller beads to form in viscoelastic fluids. They conclude that the beads-on-a-string effect results from the interplay between capillary, viscous, elastic and inertial forces.

The model offers fresh ways to explore the behaviour of materials deformed beyond their equilibrium. This is of relevance to commercial processes such as electrospinning, in which electric charges are used to draw fibres from liquids.

Andrew Mitchinson

PLANETARY SCIENCE

The birth of Saturn's baby moons

Joseph A. Burns

Simulations show that Saturn's nearby moons, after forming on the outskirts of the planet's main rings, get pushed clear of them. This model reproduces the moons' orbital locations and remarkably low densities.

Nearly six years ago, an inquisitive explorer — the Cassini spacecraft — pointed its instruments at targets in Saturn's neighbourhood for the first time. Among its numerous findings[1] was a small surprise: some of the seven diminutive satellites that gather just within and beyond the periphery of the planet's main bright rings (Fig. 1, overleaf) look curiously like flying saucers, and several have patchy, smooth surfaces. Other measurements disclosed that these tiny bodies, dubbed 'ring moons', have remarkably low densities (ranging between 0.4 and 0.7 grams per cubic centimetre), indicating that their interiors contain extensive void spaces. How might such unusual satellites come to be, and might their presence provide any insight into how Saturn's rings originated? By simultaneously simulating the evolution of the rings and of test bodies that were born at their perimeter, Charnoz and colleagues[2] present a convincing case on page 752 of this issue that the ring moons grew by the