complement of RNA molecules transcribed from DNA in many different tissues of the Madagascar periwinkle, *Catharanthus roseus* — the plant from which we get potent and widely used anticancer agents known as monoterpene indole alkaloids (MIAs). These compounds arise from the reaction of a derivative of the amino acid tryptophan with an iridoid derivative, which generates a molecule that is further modified to yield the final MIA products. The authors surmised that the genes encoding enzymes known to be involved in the complex biosynthesis of MIAs would be expressed coordinately and in parallel with previously unidentified genes coding for other steps in the biosynthesis. That is, all of the genes involved in MIA biosynthesis would be expressed together in tissues in which the biosynthesis was occurring.

Geu-Flores *et al.* therefore assembled a list of candidate genes that have expression profiles similar to those of genes known to be involved in MIA biosynthesis. To home in on the gene that encodes iridoid synthase, they narrowed down the list by selecting candidate genes encoding enzymes that were likely to use NADPH or similar cofactors. In this way, they identified a gene similar to the one that encodes an enzyme called progesterone 5β-reductase. Lo and behold, when the authors incubated 10-oxogeranial with extracts prepared from *Escherichia coli* bacteria that had been engineered to express this periwinkle gene, they observed that nepetalactol was biosynthesized in an NADPH- or NADH-dependent manner (NADH is the non-phosphorylated version of NADPH). Geu-Flores *et al.* confirmed that this seemingly unlikely gene encodes iridoid synthase in plants by analysing the enzyme's kinetics, and by observing that MIA formation was lost when levels of the messenger RNA transcripts of the gene were lowered in *C. roseus* leaves.

The authors went on to examine the substrate specificity of the iridoid synthase, and concluded that the cyclization reaction probably requires the formation of an enol intermediate (a compound that contains a C=C–OH group). This implies that variants of reductase enzymes — either naturally occurring ones or those developed using artificial molecular evolution — might be able to generate previously unknown reaction products from 10-oxogeranial. To test this theory, Geu-Flores *et al.* incubated 10-oxogeranial with a fungal reductase enzyme that is unrelated to iridoid synthase, and did indeed recover two novel products. It might be possible to expand the range of reaction products that can be formed by incubating similar reductases with several analogues of 10-oxogeranial. If organisms could be engineered to biosynthesize such analogues as substrates for these reductases, this, too, would open up opportunities for the production of new iridoid derivatives.

Irregular terpenes are found in almost every class of the terpene family. Geu-Flores and colleagues' results therefore lead one to wonder whether as-yet-undiscovered biosynthetic reactions responsible for other irregular cyclic structures will also involve novel mechanisms catalysed by enzymes in unexpected ways. This will be a difficult possibility to confirm. It will be equally difficult to overcome the various technical hurdles that must be faced before the reductase cyclization mechanism for producing diverse chemicals can be harnessed in biotechnological applications. The challenges for the field are therefore great, but such goals would not even have been possible before Geu-Flores and colleagues developed their approach to addressing an outstanding biochemical question — and, of course, without the chemical ingenuity that nature has provided. ■

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APPLIED PHYSICS

An optical trampoline

A neat study shows that a sheet of laser light can be used to reflect light-absorbing liquid droplets and manipulate their trajectories. This observation may open up new ways of controlling and studying aerosols.

DAVID MCGLOIN

We think of light as an ephemeral thing with no substance. We appreciate its warming effect when we step outside on a sunny day, but the idea that light can have a mechanical effect, producing forces, seems counterintuitive. It seems plausible that a small droplet can bounce off a pool of water, unable to break the surface tension. But can we say the same of a droplet hitting a sheet of light? Writing in *Applied Physics Letters*, Esseling and colleagues[1] describe such a phenomenon: an optical 'trampoline'.

In the 1970s, Arthur Ashkin and his co-workers at Bell Laboratories pioneered a new field of research — the manipulation of microscopic particles using light[2]. Ashkin showed that by using a laser he was able to push objects such as glass beads immersed in water and droplets of liquid dispersed in air along the direction of propagation of the laser beam. This radiation pressure could also be used to trap particles by holding them against gravity or, by using two counter-propagating beams, to confine them where the radiation pressure from each beam balanced.

The idea that light could exert these forces was nothing new: James Clerk Maxwell had

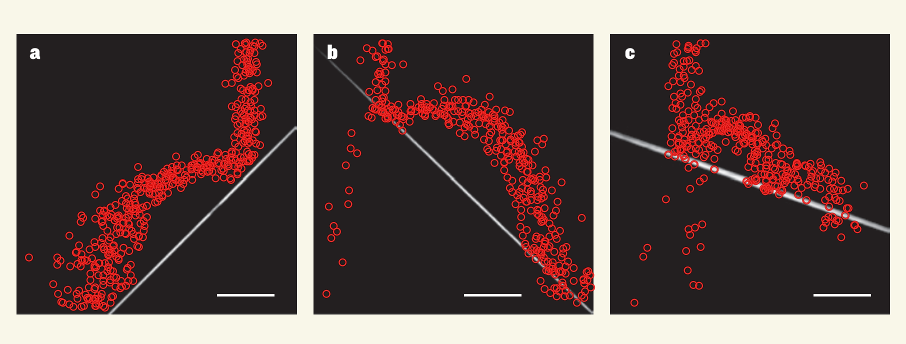

Figure 1 | Bouncing droplets. Esseling *et al.*[1] have used a sheet of laser light (white) to manipulate the trajectory of liquid droplets for several light-sheet inclinations; red circles represent the tracked centres of the droplets. **a**, For an inclination of 45°, droplets starting from the top make a single bounce off the light sheet. **b**, For an inclination of −45°, one bounce is also observed, and some droplets are seen to leak through the light sheet at the initial contact point. **c**, For an inclination of −20°, the droplets bounce twice, passing through the light sheet at the start of the third 'bounce'. Scale bars, 300 micrometres. (Images taken from ref. 1.)

predicted[3] it as a consequence of his electromagnetic theory nearly 100 years previously. However, observing the effect had proved difficult owing to the problem of distinguishing optical forces from thermal effects. Indeed, William Crookes (of Crookes radiometer fame) was able to demonstrate thermal forces on matter in 1901, long before optical forces were definitively observed.

Ashkin's great insight was to understand that, by using optically transparent microscopic objects, he could rely on the forces generated by scattering, reflection and refraction alone and remove the strong, masking thermal forces. His work has led to many applications, with optical-trapping techniques being widely used for studying minuscule forces and microscopic motion in systems ranging from molecular motors to the evaporation dynamics of aerosols.

Ashkin's techniques are limited in part by the types of object that they can trap. It is challenging to work with particles that strongly absorb the laser light being used, because they tend to heat up, and a process called thermophoresis starts to come into play. By heating one side of an object, a thermal gradient is established that results in it moving away from the hotter region and towards the colder one, driving it along the direction of the laser beam. Although this sounds very much like Ashkin's original experiments, thermal forces are up to 1,000 times stronger than radiation pressure.

Previous optical-manipulation techniques have used thermophoresis to trap and control solid particles such as carbon[4]. Esseling *et al.* have now extended this to optically absorbing liquid particles and, by using sheets of laser light instead of simple laser beams, have produced a surface made of light off which liquid droplets can bounce. This behaviour has previously been observed with droplets in emulsions[5], but here the manipulation is carried out in air. By using an inkjet printer head, the authors were able to produce droplets of a uniform diameter of 50 micrometres; ink that absorbed at the laser wavelength of 532 nanometres was used. They then fired the droplets at the light sheet. Depending on the power of the laser and the angle of the light sheet, the droplets could be made to pass through the light or to bounce with well-defined, controllable trajectories (Fig. 1). Multiple bounces could be seen at certain light-sheet inclinations, mimicking a rubber ball bouncing down a smooth slope. A horizontal sheet made with a laser power of 1.8 watts and with a peak intensity of 115 μW μm^{-2} prevented droplets from passing through.

This idea opens up avenues for the control of droplet streams. In particular, the ability to shape optical beams means that parabolic light 'bowls' could be created and used to focus droplets in air and carry out controlled chemical reactions; particles in aerosols could be sorted by rapidly altering the light path down which they travel. Furthermore, the behaviour observed suggests that light-absorbing liquid droplets can be trapped in a similar manner to solid particles. An interest in aerosol particles of all types underpins many areas of atmospheric science as well as combustion studies, for example, and new ways to handle aerosols should allow better and more flexible experiments to be carried out.

Another interesting application is in the development of novel forms of optofluidics — a technique in which light and liquid interact, usually on prefabricated, miniaturized devices called microfluidic chips. A recent advance in aerosol manipulation has been to use such devices to probe the properties of aerosols[6], and the opportunities afforded by Esseling and colleagues' technique would mean that light could be used to route nearly any type of microscopic particle around such a chip, as well as being used to avoid interactions with the chip's walls (not desirable when using liquid droplets). Their technique may also provide opportunities to analyse particles in confined geometries, such as hollow optical fibres[7].

The major open question about this type of technique is how the heating of a droplet caused by its interaction with the light sheet influences the droplet's dynamics and composition. If the goal of manipulating droplets is to investigate the real-world properties of aerosols, then their interaction with the light sheet must have a negligible effect, otherwise the properties of interest will be masked or destroyed. Additionally, many aerosol processes take place in much smaller droplets than those used here. Future experiments will be required to test the limits of the technique. But if all goes to plan, next year's must-have fashion accessory could well be an umbrella made of light. ■

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ASTRONOMY

A truly embryonic star

The discovery of what may be the best example yet of a forming star caught in the moments just before birth provides a missing link in our understanding of how giant gas clouds collapse to form fully fledged stars. SEE LETTER P.83

DAVID A. CLARKE

In the known Universe there are some 10^{22} stars, give or take a factor of ten. Within our own Milky Way, around 20% of the mass can be accounted for by about 2×10^{11} luminous stars, and another 20% or more may be locked up in 'failed' stars — brown dwarfs, which are too small to ignite thermonuclear fusion — and in stellar remnants such as black holes, neutron stars and white dwarfs[1]. That nature has found a way to routinely bring together far-flung wisps of matter, condense it by 24 orders of magnitude, and form the nuclear engines responsible for illuminating the Universe is at the same time astonishing and undeniable. Precisely what that mechanism is, however, is only now being understood by astronomers, and the paper by Tobin *et al.*[2] on page 83 of this issue brings to bear a central and previously missing piece: the first detection and measurement of a truly embryonic star.

The overall picture of how a star forms is as follows[3]. About 5% of the interstellar medium, the rarefied gas filling the regions among the stars, consists of vast (6–150 parsecs in diameter) and cold (tens of kelvin) clouds of molecular gas (mainly hydrogen, with traces of carbon monoxide, water and other molecules). These clouds have densities of about 300 particles per cubic centimetre. Random perturbations, such as nearby supernovae, trigger slightly over-dense regions called clumps to collapse under their own gravity, forming molecular 'cloud cores', which are considerably denser — about 10^5 particles per cubic centimetre.

Cloud cores represent a pseudo-stable midpoint in which built-up internal turbulence provides almost enough support to stop further gravitational collapse. However, through dynamic friction, magnetic braking and the relentless pull of gravity, material gradually rains down towards the centre of the cloud core, where the higher pressure and