

How to Fossilise Your Hamster

**And Other Amazing Experiments
for the Armchair Scientist**

Mick O'Hare

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Extract

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Anyone undertaking any of the experiments described in this book does so entirely at their own risk. Children must always be supervised by a responsible adult. General warnings are given throughout the text, but whether or not a warning is given, it is the responsibility of the reader always to take appropriate precautions and to exercise due care. No responsibility for any consequences, however caused, will be accepted by the author, *New Scientist*, Profile Books, or any of the individuals and organisations acknowledged for their assistance or contributions.

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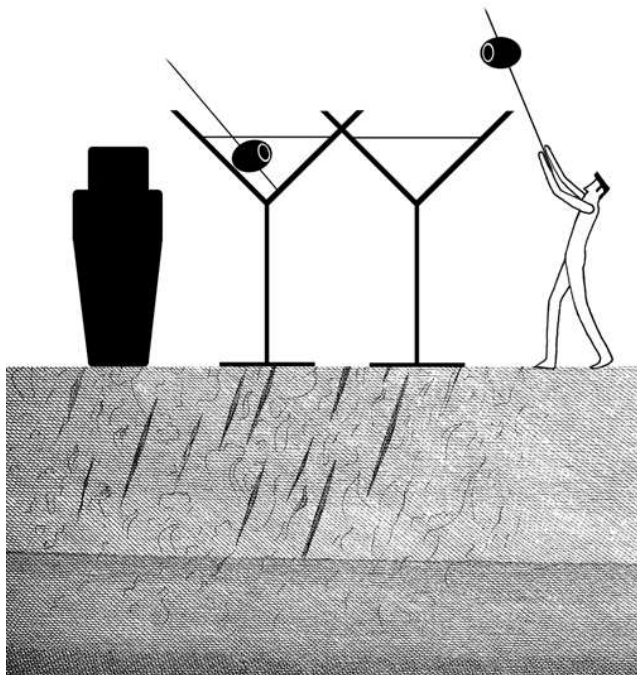
Introduction

Experiments are what make science tick. Observing, recording and observing again have taught us everything we know about our universe and the world around us. Without experimental evidence, science is reduced to little more than a set of theories. Real scientists – from Newton and the apple to Pavlov and his dogs – get out there and observe or, in the case of readers of *New Scientist* magazine, they go into the kitchen or garden and prove just why and how things happen. And when scientists have observed and recorded what they have seen, they repeat the experiment to ensure its results are verifiable.

Which is what this book is all about – experimenting and seeing for yourself. It's where the real pleasure in science lies. Science isn't boffins in labs, it's people experimenting wherever they are and using whatever is to hand. By reading this book you'll understand how great science has been achieved through experimentation.

In true *New Scientist* fashion, we focus on the trivial. You can find out why shaken and stirred martinis taste different, but not why the universe is expanding. You'll learn how to extract iron from your breakfast cereal, but you won't discover what's inside a black hole. The big stuff can come later, after you've been inspired by the experiments here. Best of all, you'll be able to ensure that your dear departed hamster is preserved for eternity (though you won't be able to discover just how long eternity is).





While not every entry can be termed an experiment, they all allow you to try out simple things at home that demonstrate science in action. These range from the chemical (why do cola and Mentos make such an explosive mix?) to the biological (why do some things pass straight through the digestive system apparently untouched?). And we've unearthed a preponderance of experiments featuring alcoholic drinks – *New Scientist* is staffed by journalists after all. While these ones are for adults only, the rest are aimed at the entire family. Children should be supervised when carrying out any of the experiments we describe. For although they have been chosen with safety in mind, a few involve potentially hazardous materials (hot water, matches, knives...), so care needs to be taken.

Some of the experiments will almost certainly need a large outdoor space to try out, but you should be able to attempt most of them as soon as you get this book home or shortly after a trip to the local shops. Hardly any require specialist equipment. If you need further instruction on how to make them work, you'll find some of them on our website – www.newscientist.com/hamster.

The best science is always collaborative, so I am grateful to all the readers of *New Scientist*, colleagues, scientists and smart people everywhere who have helped make this book possible – a roll call appears on pages 197–200.

Finally, remember: scientists' theories are there to be challenged. If you carry out the experiments in this book and draw different conclusions, let us know – you will find our contact details in the Acknowledgements. Science is constantly evolving in response to new evidence; that is what makes it so wonderful and enlightening. There's nothing we'd enjoy more than being proved wrong by someone who has carried out an experiment from this book and arrived at a different conclusion. After all, real scientists always experiment, not once, not twice, but again and again ...

Mick O'Hare



1 In the Living Room



Cream on

Why does a 2 mm layer of cream on Tia Maria create rapidly circulating and swirling patterns?

This is a perfect experiment for the after-dinner tabletop laboratory, and as it's one that *New Scientist* brought to the attention of the world, we feel particularly smug. Use a good, single pouring cream – milk is too runny, double cream too thick. You can even drink the end product.

What do I need?

- a wide-bottomed glass
- single cream
- a bottle of Tia Maria
- a spoon

What do I do? Pour 1 cm of Tia Maria into the glass and add a very thin layer of single cream, poured gently over the back of the spoon so that it spreads over the surface of the Tia Maria.

What will I see? The surface of the cream will break up into a pattern of cells as it reacts with the Tia Maria.



What's going on? The swirling patterns are caused by convection – the bulk movement of fluids usually caused by temperature differences. However, in this case the convection is driven by a difference in concentration between the two liquids. This is called solutal convection.

The alcohol in the Tia Maria is the driving force. After the cream is added, the alcohol begins to diffuse through it. When it reaches the surface it alters the surface tension, reducing it. Areas unaffected maintain their higher surface tension and so pull the low-surface tension liquid areas towards them. As the surface liquid is pulled away, Tia Maria moves up to fill its place. This has even less surface tension than the liquid pulled away and the process becomes self-sustaining as a convection cycle is created. This will last as long as a difference in concentration between the cream and the Tia Maria remains.

Surface tension convection is known as Marangoni convection. It plays a part in drying different paints and causes patterns such as those seen in wine 'legs' running down the inside of a drinking glass (see 'Drinker's legs' experiment on page 13). Similar effects are seen in rolling clouds or oil frying in a pan. Tia Maria is something of an oddity though, because in other systems the convection cells are circular or hexagonal.

PS: We are especially pleased to include this experiment because when the question was first asked in *New Scientist* nobody knew the answer, which led to a group of researchers studying the phenomenon and writing the definitive paper on the subject.

Want to read more? The paper can be read in *Physica A*, vol. 314, p. 291.

Over the top

Sparkling wine or beer poured into a dry glass froths up spectacularly, but if the inside of the glass is wet, it doesn't. Why?

Quite frankly, we are amazed at the number of home experiments you can do that involve alcoholic drinks. If you are only interested in experimenting, you don't have to drink the wine or beer, but ...

What do I need?

- freshly opened sparkling wine and/or beer
- champagne flutes and/or beer glasses
- olive oil
- a tablespoon of sugar
- dust (look behind the wine rack)

What do I do? Pour some of the wine or beer rapidly into a vertical glass so that it froths up to the rim, let the bubbles subside and then add more.

What will I see? The second batch of liquid will not have the same frothing effect as the first.

What's going on? Beer, sparkling wine and other fizzy drinks are supersaturated with gas. Although the laws of thermodynamics favour the gas bubbling out of the dissolved state, bubble formation is unlikely since bubbles must start small. Because the pressure of these tiny bubbles can reach about 30 atmospheres in a bubble only 0.1 micrometres in diameter and the solubility of gases increases with increasing pressure (Henry's law), the gas is forced back into solution as quickly as it comes out.



However, bubbles can form around dust particles, surface irregularities and scratches. These areas, known as nucleation sites, are hydrophobic (they repel water) and allow gas pockets to form without first forming the tiny bubbles. Once the gas pocket reaches a critical size, it bulges out and rounds up into a properly convex bubble, the radius of curvature of which is sufficiently large to prevent the self-collapse described earlier.

Then there is a cascade effect. If the bubbles reach a certain critical number per unit volume, this in itself constitutes a physical disturbance and results in the release of yet more bubbles.

Nucleation may be precipitated by a variety of imperfections. Minute salt crystals, such as calcium sulphate, may be present if the glass has been left to dry by evaporation after being washed in hard water. Or there may be tiny cotton fibres if the glass has been dried with a tea cloth. Dust particles may have settled on the glass if it has been left standing upright on a shelf for any length of time. And tiny scratches will be present on the inside surface of all but brand-new glasses.

Once the inside of the glass is wet, any salt crystals will have dissolved and any cotton fibres will no longer function as centres of nucleation. Most of the dust particles and all of the scratches will, of course, still be there. However, these will have been coated with liquid and the fresh carbonated liquid will reach them very slowly, by diffusion. Bubbles will still be produced, but at a rate that is too slow for the cascade effect to come into play. As a result, the drink will not froth over.

To demonstrate this, take a glass and thoroughly coat the inside with olive oil, which is a more efficient surface-covering agent than water. Then add the wine or beer (if you are feeling frugal, use a carbonated drink such as lemonade). The effervescence will be nil or minimal. Throw in the dust you scraped from behind the wine rack and see how it can affect the behaviour of the liquid. Finally, add a few million centres of

nucleation from a large spoonful of granulated sugar and prove to yourself how volcanic the effervescence can be.

PS: Thanks to modern production techniques, today's glasses are of such good quality that some manufacturers build in deliberate imperfections, especially in beer glasses, in order to generate enough bubbles to maintain the head on the top of your tipple.

There are almost certainly similarities between this experiment and the Mentos and cola effect from the 'Over-reaction' experiment on page 194, although the jury is still out on why Mentos and cola produce quite such a spectacular effect. If you are going to do either of these indoors, go for the wine or beer version ...



White water drinking

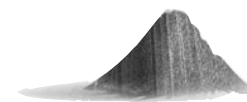
Why do anisette-based drinks, such as Pernod, ouzo or sambuca, turn white when water is added?

This is an interesting effect because two completely colourless liquids combine to produce an opaque white one, immediately transforming something that was in solution and invisible into something insoluble and visible.

What do I need?

- drinks glasses
- a bottle of pastis, ouzo or sambuca
- a jug of water

What do I do? Pour one of the three anisette-based drinks or, if you wish to be a true scientist running controls alongside your main experiment (see the 'Fizz fallacy' experiment on page 28), a glass of all three. Add water.



What will I see? The drinks will turn from clear to milky white or, in the case of pastis, milky yellow.

What's going on? Anisette-based drinks rely on aromatic compounds called terpenes for their flavour. These are soluble in alcohol, but not in water. The 40 per cent or so alcohol by volume present in the drinks is enough to keep the terpenes dissolved, but when water is added they are forced out of solution as the alcohol content of the drink falls, to produce a milky-looking suspension.

Absinthe, a similar drink based on wormwood, gives a more impressive green suspension. Terpenes are responsible for a lot of the harsher plant scents and flavours found in the drink, including those of lemon grass and thyme.

PS: Absinthe, always legal in the UK, but rarely drunk for many decades due to a paucity of producers, is now undergoing a revival. However, dealers need a special licence to sell it and it remains an almost mythical spirit reputed – but not proven – to have psychotropic effects. However, its toxicity means that it is still illegal in other parts of the world, including the USA, where the Food and Drug Administration states that the presence of the chemical thujone in absinthe has harmful neurological effects, although absinthe producers claim thujone levels are insufficient to induce any response in humans. Interestingly, pastis was first produced by the distillers Pernod and Ricard after absinthe was banned in France in 1915. They removed the wormwood and added more star anise to produce one of the first versions of the drink you've been experimenting on.

You only drink twice

Is there any difference between a vodka martini that is shaken, not stirred?

James Bond is famously fastidious in demanding that his martinis are only ever served shaken. Apparently, there *is* a difference...

What do I need?

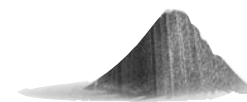
- a decent recipe for a vodka martini. The following one, in which olives and citrus fruit are added prior to shaking or stirring, comes from www.drinkoftheweek.com
- 140 ml of vodka
- eight drops of vermouth
- two olives and twists of lime or lemon
- cocktail shakers
- martini glasses

What do I do? Mix the ingredients in a jug (gently, to avoid any undue shaking or stirring). Carefully divide the mixture into two cocktail shakers. Shake one, stir the other, then pour the martini into two separate glasses.

What will I see? Not a lot, except two exquisite cocktails, but you may – just may – be able to taste the difference. Ideally you'll need to recruit a volunteer for a blind tasting – don't tell them which is which.

What's going on? Supposedly, when a martini is shaken not stirred it 'bruises' the vodka spirit in the drink. To seasoned martini drinkers this alters the taste.

However, there is great debate as to what is really happening. It is impossible to bruise alcoholic spirit in the way that you can bruise fruit (or indeed your arm) because it is a



liquid and has no vascular system, although the olive and citrus fruit (if you add them to the cocktail mix before shaking or stirring as our recipe does) can be bruised by the shaking action, thus releasing flavoursome oils and juice. Other recipes, however, eschew adding olives and fruit beforehand so that only the vodka and vermouth are shaken or stirred, thus ruling out botanical intervention in the flavour. We suggest you repeat this experiment adding the olives and fruit after shaking or stirring and see if you can tell the difference.

Nonetheless, martini drinkers can still detect a difference when the vodka and vermouth are shaken or stirred without the olives and fruit. This is because a martini is usually drunk within seconds of preparation, rather than minutes. The tiny bubbles caused by the shaking mean that a well-shaken martini is cloudy. This has an effect on the texture of the drink – it is less oily than the stirred version – and hence the taste is ever so slightly altered.

The bubbles from shaking can also partially oxidise the aldehydes in the vermouth in the way that the flavour of red wine alters when we oxidise it – commonly known as letting the wine ‘breathe’. This can alter the flavour of the martini – again, ever so slightly.

So now that you know, be honest – can you tell the difference between shaken and stirred?

PS: Agent 007 has provided *New Scientist* with plenty of material over the years. One of the most surprising discoveries we made was that the kind of silencer that Bond uses when ruthlessly dispatching the bad guys is more myth than fact. It seems Hollywood has taken great liberties with silencers and most real ones are much larger than the cigar-tube sized versions shown in the Bond films, and are very difficult to fit and remove. And if James Bond did manage to fit a silencer quickly enough, his gun would not produce the distinctive ‘phut’ we hear in the films – more of a firm crack,

similar to the sound of a car door being slammed. For, despite what you see in the movies, it is almost impossible to silence a gun because the gap between the cylinder and the barrel allows gas to escape. Sadly, because this is a book of experiments that you can try at home, we cannot recommend a trial of this particular 007 phenomenon. We include it merely on a whim to add to the ambience of your vodka martini experiment.



Drinker's legs

What causes the thin, separated films that run down the inside of a glass containing whisky or other spirits?

These are known as ‘legs’ and are often considered the measure of a good spirit. You can be the judge of this if you try a variety of spirits and check out whether the good ones show the phenomenon best.

What do I need?

- a glass tumbler (or several)
- whisky (and other spirits if you wish to compare and contrast)
- water

What do I do? Pour a decent measure of whisky and swill it round the glass. Do the same with a glass of water of the same volume. Take sips of both and watch the liquids drain back into the bottom of the glasses down the sides. You can try other spirits and see if they show a difference.

What will I see? The thin film of whisky draining back into the glass after you have swirled it and sipped it will separate into rivulets, which will be roughly equally spaced. These are the ‘legs’ mentioned above. Water, however, drains back more



rapidly, 'legs' do not develop and the most you will see on the inside of the glass is a few beads of liquid.

What's going on? This phenomenon was first correctly interpreted by James Thomson, the elder brother of Lord Kelvin (best known for his scale of absolute temperature measurement and his work on thermodynamics). In an 1855 paper entitled 'On certain curious Motions observable at the Surfaces of Wine and other Alcoholic Liquors', published in *Philosophical Magazine* (vol. 10, p. 330), Thomson explained that the effect is caused by capillary motion, or surface tension, explained in both 'Flower power' and the 'Floaters' experiments on pages 21 and 58.

Alcoholic drinks are mixtures of ethanol and water, from which the ethanol – which has a lower boiling point than water – evaporates faster than the water when the drink has been poured. The surface tension of ethanol is lower than that of water and the different rates of evaporation induce conflicting forces between the more watery regions of the drink and the more alcoholic regions. In effect, the watery and alcoholic regions are pulled apart, leaving legs of increasingly watery liquid as the ethanol evaporates and the watery remains start to trickle back down the glass under their own weight.

Thomson's paper won him little fame. This kind of surface tension convection is now known as Marangoni convection after Carlo Marangoni, who worked on similar studies 20 years later. (See the 'Cream on' experiment on page 5.)

Marangoni convection can cause other remarkable effects. For example, if the whisky is placed in a very flat dish and exposed to the air, the whole body of liquid becomes divided into hexagonal columns that circulate as the alcohol evaporates. Unfortunately, this is difficult to see in the home lab.

Normal convection in liquids, caused by density differences, usually swamps the effect of Marangoni convection and it cannot get to work except in special circumstances like

the side of your whisky glass. However, in the weightless conditions of space, Marangoni convection rules supreme and is therefore a fertile topic for research by space scientists.

PS: 'Legs' in liquors and wines have been noted for millennia. The first account may even have appeared in the Bible: 'Look not thou upon the wine when it is red, when it giveth his colour in the cup, when it moveth itself aright' (Proverbs 23:31). It seems that even then the effect was considered an indicator of good-quality alcohol.



Yo ho ho

Why does dark rum form a frothy scum on the top of the drink when mixed with cola, but white rum does not?

As you have now discovered, adults should never turn down the chance to experiment with alcohol. Here's a chance to try one of the world's most popular drinks, the Cuba libre, while engaging in some serious scientific endeavour.

What do I need?

- a bottle of dark rum
- a bottle of white rum
- cola
- lots of tumblers (all good experiments are repeated to ensure consistency of results)
- a good detergent

What do I do? Pour a decent measure of white rum into one tumbler and a similar amount of dark rum into another. Top up the glasses with cola (the less you use, the more dense the resulting scum will be).

