Chapter 1

Mysteries of everyday life

? Why is the place you want on a map so often at the edge?

Whenever I encounter one of these little frustrations of everyday life, I apply the maxim of Ian Fleming's character Goldfinger: once is happenstance, twice is a coincidence but three times is enemy action. That is, if the little irritation in question crops up often enough to make you suspect there is some malign force at work, you are probably right. The frustration of finding the place one is looking for in awkward parts of the map is a case in point: it happens so often that it looks very much like a manifestation of Murphy's Law, according to which "If something can go wrong, it will". This suspicion is confirmed by some simple school geometry. Picture a square map, with the "awkward bit" being the strip-like region around its perimeter. Surprisingly, even if the width of this strip-like region is just one-tenth that of the whole map, it mops up a prodigious thirty-six per cent of the total area. Thus, every time you look for some location of such a map, there is a better than 1 in 3 chance it will turn up in that bit around the edge. What fools us is the fact that although it looks pretty narrow, the region tracks the largest dimensions of the map, which gives it a surprisingly large total area.

The situation is marginally worse with road atlases, as they also have awkward bits to either side of the central crease. Doing the same geometrical sums, it turns out that for a typical atlas page, there's around a fifty per cent chance of a given location being inconveniently positioned on the page.

Cartographers have been trying to combat Murphy's Law of Maps for years and have introduced innovations such as fold-out flaps on one edge of the map. These alter the geometry of the pages and thus the relative areas of map and awkward bits, though not by much. Fortunately, in 2002, that wonderful British institution the Ordnance Survey introduced the ultimate solution to Murphy's Law of Maps, the OS Select service, which produces customized maps centred on anywhere in Britain.

? When driving, why do we arrive at obstacles like narrow bridges at the same moment as a car coming the other way?

Many scientists would probably dismiss this as mere selective memory: that is, people just forget the times when they encounter such obstacles and drive past unhindered. While this may well be part of the explanation, I suspect there is something more going on – tied to the fact that, on seeing an obstacle ahead, we look to see what cars coming the other way are likely to cause problems. Clearly, cars much closer than us to the obstacle, or much further away, aren't likely to be a problem, so very sensibly we fret most about those around the same distance away. Given that cars on a stretch of road tend to travel at around the same speed, this makes it a racing certainty we'll reach the obstacle at the same moment as the car coming the other way. So why are we so surprised? Probably because, sitting in our own car, we only see cars speeding towards us – and tend not to realize that we're both moving towards each other at similar speeds.

? Why does the outward part of a journey seem longer than the return?

This seems to be a very common perception and in my experience, the effect is strongest when making a journey for the first time. I am not aware of any formal research but the most plausible explanation I've come across lies in the fact that the outward journey ends only when one has arrived right outside the unfamiliar destination. By contrast, the return journey feels as if it's coming to an end once one begins to see familiar landmarks and this can happen when one is still some distance from home. Other factors may also be important. For example, there is the dreaded "Are We There Yet?" syndrome, by which young children make even the shortest journey interminable. This may well be a consequence of the fact that an hour constitutes a ten-fold bigger proportion of a three-year-old's life than of the harassed parent doing the driving – even a 30-year-old could be excused for asking if arrival was imminent after sitting in a car for ten hours.

? Should the milk be put in before or after the tea?

Some say that "milk first" is a tradition based on the need to protect thin china cups from the thermal shock of hot water, while chemists have argued that milk-first combats the production of bitter compounds as the tea brews. British Standard BS 6008: "Method for Preparation of a Liquor of Tea" calls for milk to be put in first, in the ratio of 1.75 ml of milk for every 100 ml of tea, which, by my reckoning, is barely a teaspoonful per cup. I daresay this is all true but it seems only wise to match the amount of milk to the strength of the brewed tea – which can only be judged once you've seen it poured into the cup. I therefore count myself among the milk-after camp, along with George Orwell, who in 1946 wrote an article on tea in the London *Evening Standard* stating: "by putting the tea in first and then stirring as one pours, one can exactly regulate the amount of milk".

? Is there any real benefit in warming the pot before making tea?

Many people seem convinced that swilling boiling water around the pot and then pouring it away is a key part of making the perfect cup of tea, the idea being that it helps the pot stay hotter longer, ensuring a better brew. Given the thermal inertia of the average teapot, I doubt this ritual makes much difference. More likely, it removes any of the bitter-tasting tannins remaining in the pot from the previous brew.

? Why does a kettle of water quieten down just before it starts to boil?

The "lull before the steam" effect is linked to the way the water is heated. Kettles are usually warmed from their base, so that the water down there reaches boiling point first. As the bubbles of vapour form, they rise up through cooler liquid, cooling as they go. Unable to maintain enough pressure to keep the surrounding liquid at bay, they suddenly collapse with a pop. Put enough of those together and you get the familiar rumble of a kettle heating up. As the heating continues, however, the bulk of the liquid starts to reach boiling temperatures, allowing big bubbles to go the distance, right to the surface. The result is a deeper, quieter sound – signalling the onset of boiling throughout the liquid, and tea time.

? Is it true that boiling water makes ice cubes more quickly than cold?

Over the years, I've come across several twists on this one, such as "do very hot cups of tea reach a drinkable temperature

faster than those that are merely hot?". All involve the phenomenon of cooling but include some traps for the unwary. The basic rule is that the bigger the temperature difference between an object and its surroundings, the faster it cools. So, a very hot cup of tea will indeed cool more quickly than a less hot one. That doesn't mean it becomes drinkable sooner: it just means that it quickly reaches the same temperature as the other cup – but then cools at just the same rate. Add in the fact that it was much hotter to start with and it's clear that the hotter cup will actually take *longer* to become drinkable. By the same logic, it's also clear that boiling water cannot freeze faster than cold water. Well, up to a point. The trouble is, boiled water isn't just hotter than cold water: it also contains fewer dissolved gases and thus freezes at a slightly higher temperature. Evaporation also reduces the mass of water that has to be chilled. In the right conditions, the result can be faster formation of ice-cubes – a phenomenon sometimes termed the *Mpemba Effect*, after the Tanzanian student who first discovered it in 1969.

? Is there a fast way of removing ice from car windscreens?

To escape the chore of scraping with an old credit card, or the expense of special aerosol sprays, many people are tempted to use warm water – only to find their windscreen freezing over again once they are on the road, with potentially lethal consequences. Iced-up windscreens are a sign that temperatures have been below zero for quite some time, so the glass will require a fair amount of heating to warm back up. Pouring hot water will melt the ice but once that's done, the thin layer of tepid, rapidly-evaporating water running down the screen has little heat left to warm the glass and quickly turns back to ice.

Happily, this doesn't mean that we are condemned to using those tedious scrapers. For ice to re-form, we need more than just sub-zero temperatures: pretty obviously, there also has to be water. So, the secret to rapid removal of ice is to pour warm water over the windscreen *and* the windscreen wipers – and then quickly switch the wipers on at their highest speed. The wipers remove the thin layer of water that would otherwise turn into ice, keeping the windscreen ice-free until you are on the road and the windscreen heater is working. For side windows, pour the warm water on from the top and remove the meltwater with a rubber-edged window-cleaner. It's a trick I've used successfully in the Alps at minus 18 °C (just remember to thaw out the rubber of the wipers with the warm water first, to prevent them tearing).

? What makes Super Glue so strong?

Super Glue was discovered in 1942 by Dr Harry Coover of the Eastman Kodak Company, during research into materials suitable for making transparent components. Searching for a suitable material for a plastic gun sights, he investigated the properties of the compound methyl cyanoacrylate but found it had an annoying propensity to stick to anything with which it came into contact. Dr Coover came across methyl cyanoacrylate again nine years later, while supervising a team working on heat-resistant plastics for fighter aircraft canopies. Again, the substance proved frustratingly sticky but this time it dawned on Dr Coover that he had discovered a new form of adhesive, one which required neither pressure nor heat to glue objects together. Remarkably, the glue was activated by the presence of even minute amounts of water – such as the layer of moisture that, as a result of natural humidity, coats everything. Kodak took up the product and it was first marketed in 1958.

The strength of Super Glue comes from its ability to turn itself from a collection of individual molecules into a chain whose links are extremely hard to break. Electrons from water molecules affect the bond between two carbon atoms in the basic cyanoacrylate molecule, turning it into a double-ended hook that can link up with other glue molecules. These in turn supply electrons to other molecules, triggering the formation of a chain of molecules that binds objects together with impressive strength. The

process is so fast and so sensitive to the presence of water that the manufacturers of Super Glue mix it with a tiny amount of acid, to stop it curing too easily. A little moisture – even that on a fingertip – is enough to undermine the acid stabilizer and the chain-forming process gets underway with a vengeance.

Having been perhaps a little slow to realize the potential of Super Glue, Dr Coover was well ahead of the game in patenting its use in surgery, gluing human tissue together without the need for stitches. Super Glue was first used in this way in the Vietnam War and is now often used in minor surgery.

Why is a bicycle more stable once it's moving?

I used to think the answer to this one was a combination of simple mechanics plus practice. That is, when learning to ride a bike we train ourselves to cancel out the wobbling we get on starting off by shifting our weight slightly, via the handlebars. Once we're on our way, the gyroscopic effect of the spinning wheels starts to take effect, making the bike even more stable. However, I've learned that the dynamics of anything involving spinning bits is never straightforward and routinely discuss such questions with my personal guru on theoretical mechanics, Dr Ron Harrison, erstwhile lecturer in the subject at City University, London. After several weeks of reading around the subject, calculations and email exchanges with Dr Harrison, my suspicions that this is a very tough question have been confirmed.

Even those who have studied the problem in depth do not agree on the finer details of bicycle stability. They do at least agree on one thing: bikes don't need riders to stay upright; just a push to get them travelling above around five miles per hour will do the trick. It's the source of the inherent stability that causes the arguments. Detailed analysis shows that the much-vaunted gyroscopic effect of the spinning wheels, often thought to explain bike stability (not least by science columnists), is pretty unimportant. Surprisingly, the chief reason moving bikes stay upright is because of the shape of the forks holding the wheels in place. These usually point forward towards the ground, so that an imaginary line drawn from them would touch the ground some way ahead of the wheel. It may only amount to an inch or so but this amount of "trail" makes all the difference to bike stability, bringing forces to bear on the wheels that damp out wobbles. According to Dr Harrison's calculations, a bike with vertical forks – and thus no "trail" – would wobble ever faster as it speeds up, becoming increasingly hard to control. Of course, with practice, any bike is rideable – even a unicycle, whose vertical forks give it zero trail. Even so, it's clear that those outrageously-angled forks on Peter Fonda's motorbike in *Easy Rider* aren't quite so silly after all.

? Why does the British tax year start in the first week of April?

The odd timing of the tax year is a hangover from the days when the New Year began on 25 March – the Feast of the Annunciation; nine months before Christ's birth-day. That all changed when, in 1752, Britain adopted the Gregorian calendar, a reform which moved New Year's Day to 1 January but left the financial year unchanged. The reform also added extra days on to the old calendar dates, so that the start of the tax year was shunted from the last week of March to the first week of April – where it's stayed ever since.

? Can magnets wear out?

Toy magnets sometimes come with warnings not to drop them or heat them up, lest they lose their magnetic power. Yet, even if they are treated with care, magnets eventually, albeit very slowly, lose their strength. This is because magnets owe their properties to the existence of vast numbers of "domains", each around 1 mm across, packed with atoms whose spinning electrons are aligned. This highly ordered state is the origin of the magnetism and also of the vulnerability of magnets to heating or

dropping, which jolts some of the domains out of alignment. Even if a magnet avoids such a fate, it will eventually fall prey to the effects of ambient heat and electromagnetic fields, which damage the alignment and steadily weaken the magnetic force. Fortunately, it is a very slow process; a modern samarium-cobalt magnet takes around 700 years to lose half its strength.

? Why are only some substances magnetic?

For all its familiarity, magnetism is a manifestation of very fundamental physics, ultimately linked to the orbital motion and spin of the electrons in atoms. Certain arrangements of these spins – such as those in iron atoms – create intensely magnetic materials but as all substances contain spinning electrons, everything is magnetic: water, wood – even frogs. The reason we don't think of them as magnetic is because the effect is pretty feeble, around a billion times weaker than in metals like iron. Thus, while it is possible to pick up a toothpick using a magnet, it requires an intense magnetic field – around 200,000 times stronger than the Earth's. It can be done: the German physicist Werner Braunbeck levitated small bits of apparently non-magnetic graphite in 1939, while French physicists did the same with blobs of water in 1991. The most spectacular achievement so far came in 1997, when a team led by Dr Andre Geim at the University of Nijmegen in the Netherlands succeeded in levitating a frog. And yes, humans could also be levitated – at least in principle. However, generating the necessary magnetic field would require the output of a nuclear power station, which seems a bit excessive for a party trick.

? Why does a magnet held near a television produce weird colours?

This baffled scientists for almost half a century. The effect was discovered in 1858, well before the invention of television, by the German physicist Julius Pluecker, who experimented with passing electricity through glass tubes from which virtually all the air had been sucked out. He found that the eerie glow given off by these tubes could be bent by magnets. The explanation emerged in 1897, when the Cambridge physicist Joseph Thomson showed that the glow was caused by what we now call electrons and that these can be affected by magnetic forces. The average television (or computer screen) exploits the phenomenon to create coloured images, firing electrons at the screen to create the picture. When a bar magnet is brought near the screen, the electrons are pulled off course, creating weird colours. Moving the magnet around isn't hazardous to health but it can damage the image, by permanently magnetizing the system used to direct the electron beam. Most modern screens have "degaussing" circuitry, which eliminates any lingering magnetism every time they're switched on but personally I wouldn't take the risk, and would steer any magnet-wielding children away from the television and computer.

? Why do television screens have red, blue and green dots?

At school we are taught that to create all the colours of the rainbow, one needs red, blue and yellow but not green. The explan-ation lies in the difference between colours formed by reflected light – for example, from paint – and those formed by emitted light. Paints produce colour by absorbing all but one colour from the white light striking them. This "subtraction" method demands the presence of yellow, as, when this is combined with blue, it mops up everything but green. On the other hand, televisions create colours directly, using emitted light and to produce all colours by this "addition" method requires red, blue and green.

? Do microwave cookers destroy vitamins in food?

They certainly could – just as any form of cooking would, if the food were heated to destruction. If used correctly, so that

they don't overheat the food, the end result of microwaving will be at least as nutritious as that of conventional cooking: there is nothing special about microwaves that makes them more likely to destroy vitamins or other nutrients. The possibility of damage to nutrients was extensively reviewed by scientists in the early 1980s and the conclusion was that there were no significant harmful effects. Indeed, the only surprising finding was that microwaving at low power can mean the food retains more of its nutritional value than it would if cooked conventionally.

Why does blood look blue under the skin?

There was a time when I thought the blood coursing through our bodies really was blue and only became red when it came into contact with air. Having my first blood test put me right on that – but I still couldn't understand why it looked blue under the skin. The explanation emerged in the mid-1990s, following research by Dr Lothar Lilge and colleagues at the Ontario Laser and Light Wave Research Centre, Canada. They showed that when light strikes white skin, the longer, redder wavelengths penetrate deeper and end up absorbed by the blood vessels. As a result, the light reflected back from the skin over a blood vessel has a relatively high proportion of the shorter, blue-violet, wavelengths – making the blood look as if it really is blue. The effect isn't as obvious with dark-skinned people, as the melanin responsible for their skin tone absorbs almost all the wavelengths of light at the skin's surface.

What causes the interference on the radio when moving around?

These annoying "susch-susch" noises are due to *multipath interference*, caused by the radio picking up reflections of FM signals. Having a wavelength of just a few metres, such signals are vulnerable to reflections from everything from mountains to office blocks to cranes – even people walking by. Moving the radio just a few inches can be enough to cure the problem but if that doesn't work you may need to invest in something a bit more sophisticated than the bits of wire manufacturers usually supply as an aerial.

? Why do small aircraft seem to travel so much faster than airliners?

It's an optical effect called parallax. We judge the speeds of objects by comparing how quickly they pass across our field of view. Small aircraft typically fly at much lower altitudes than airliners, making them closer to us, which means they cross our field of view much more quickly, despite their much lower speed. Similarly, orbiting satellites can, despite travelling at over 18,000 mph, seem to move more slowly across the night sky than aircraft, because they are so far away. Parallax was put to impressive use by Gerry Anderson and his team of animators in *Thunderbirds*, when they created the illusion of huge spaces by having layers of scenery behind model vehicles and moving the layers progressively more slowly the further they were from the models – just as they would appear to do in real life.

? Why do boomerangs come back?

Boomerangs are commonly thought to be the invention of Aboriginal Australians but over the years they have turned up at archaeological sites as far apart as Arizona and India; the oldest known specimen, around 23,000 years old, carved from mammoth tusk, was found in a cave in Oblazowa Rock, southern Poland, in 1987. It thus seems that the spectacular flying abilities of boomerangs have been independently discovered many times. Despite their prehistoric origins, their aerodynamics are anything but primitive and exploit an ingenious combination of lift and spin. To provide the lift, the boomerang is launched from an almost upright position, at an angle of around 15 degrees to the horizontal. This allows it to spin and cut through the air at an oblique angle, deflecting it and generating lift as it goes. The famed ability of the boomerang to return home again comes from the fact that, because of its spin, the upper part of its “wing” cuts through the incoming air at a relatively higher speed than the lower part and thus generates more lift. This creates a turning force on the boomerang, which starts to follow a circular path, rather like a spinning toy gyroscope slowly pirouetting on its stand. Oddly enough, just how big a circular path the boomerang follows doesn’t depend on how hard it’s thrown, or how fast it spins: it’s fixed primarily by its wingspan and shape, which are a compromise between spin and lift. Thrown well, boomerangs will happily fly long, looping trajectories of over 400 ft.

? What causes the lemon pips in a gin and tonic to rise and fall?

It’s not just lemon pips in gin and tonic; the same weird phenomenon can be seen by dropping a raisin into fresh fizzy water. First, it will sink to the bottom of the glass, then perform an odd little dance, before coming back up to the surface and starting the cycle again. The explanation lies in the effect of the crinkly surface of the pip on the carbon dioxide in the drink. Being slightly denser than the liquid, the pip sinks to the bottom, where the dissolved carbon dioxide molecules become trapped in its nooks and crannies. After a while, enough accumulate to form bubbles, which boost the effective volume of the pip to the point where its density becomes lower than that of the surrounding liquid and it starts to rise. On the surface, the bubbles burst, the gas molecules escape, the pip loses its buoyancy – and it sinks, beginning a repeat performance.

? How high is the pressure inside an aerosol can?

According to the British Aerosol Manufacturers’ Association, aerosol cans are pressurized to between 2 and 8 atmospheres, equivalent to around 30 to 120 pounds per square inch. If punctured or heated they can explode with potentially lethal violence, especially if they also contain an inflammable fluid. For that reason, the cans are only part-filled with fluid and designed to withstand some expansion, through their concave base and tops. Aerosol cans are also individually tested, before leaving the factory, by being passed through a hot water bath to raise the pressure in the can and test its strength and integrity. They also carry warnings about the need to avoid using near sources of heat. Sadly, these are not always heeded and the effects can be pretty devastating. In February 2000, an elderly woman in Maryland allowed some aerosol cans in her mobile home to come into contact with the pilot light of her gas stove and they exploded like grenades, blowing out the windows and making the walls buckle. It’s worth bearing in mind that it is not just a naked flame that can cause an aerosol can to detonate: in hot summers aerosol cans have been known to explode simply after being left on the seats of cars parked in the sun.

? How do the stripes get into striped toothpaste?

No, the tube isn’t filled with stripy toothpaste. Indeed, most of it is filled with plain white toothpaste; the trick to the stripes lies in the top of the tube, whose sloping neck contains coloured gel. When the tube is squeezed, the white paste flows towards the open neck of the tube and on its way pushes up against the sloping part. This causes some of the coloured gel to be squeezed into slots that run around the inside of the nozzle at the very top of the tube, directing it on to the surface of the emerging white paste – resulting in stripy toothpaste.

How do spectacles with "pinhole" lenses work?

Sometimes called *stenopaeic spectacles* (from the Greek for "holed"), these are often advertised as a remedy for myopia and they look like a complete con. A trawl of the medical literature failed to provide any evidence to back the claims – but neither did it produce any evidence contradicting them.

Whatever; the basic principle makes scientific sense. Blurred vision is caused by the failure of the eye to bring all the rays of light entering the eyeball to a sharp focus at the retina, producing multiple overlapping images, which appear as "blurring". One obvious way to reduce this is to block out all but those rays coming more or less straight into the eye – an effect known to photographers as "stopping down". This is precisely what the stenopaeic spectacles do; the pinholes drilled into the "lens" screen out all but those rays heading straight into the eye. The effect is much greater depth of focus, with objects at a wide range of distances all appearing less blurred.

One drawback is that, as less light enters the eye, everything looks somewhat darker. Far more seriously, the pinholes all but eliminate peripheral vision. Stenopaeic glasses are thus potentially lethal when driving or operating machinery. Even so, they seem perfectly safe for tasks like reading, especially if one can't be bothered – or afford – to buy prescription sunglasses. In emergencies (such as when the football results come up on television) when I can't find my glasses, I have resorted to an even simpler solution and improved my vision by peering through the holes in a Rich Tea biscuit.

Why is aluminium foil painful if it touches your fillings?

The unpleasant tingling sensation feels like an electric shock – which is pretty much what it is. When a tiny bit of foil from, say, a sweet wrapper hits the mercury amalgam in fillings, it creates a tiny battery, with electrons flowing from the