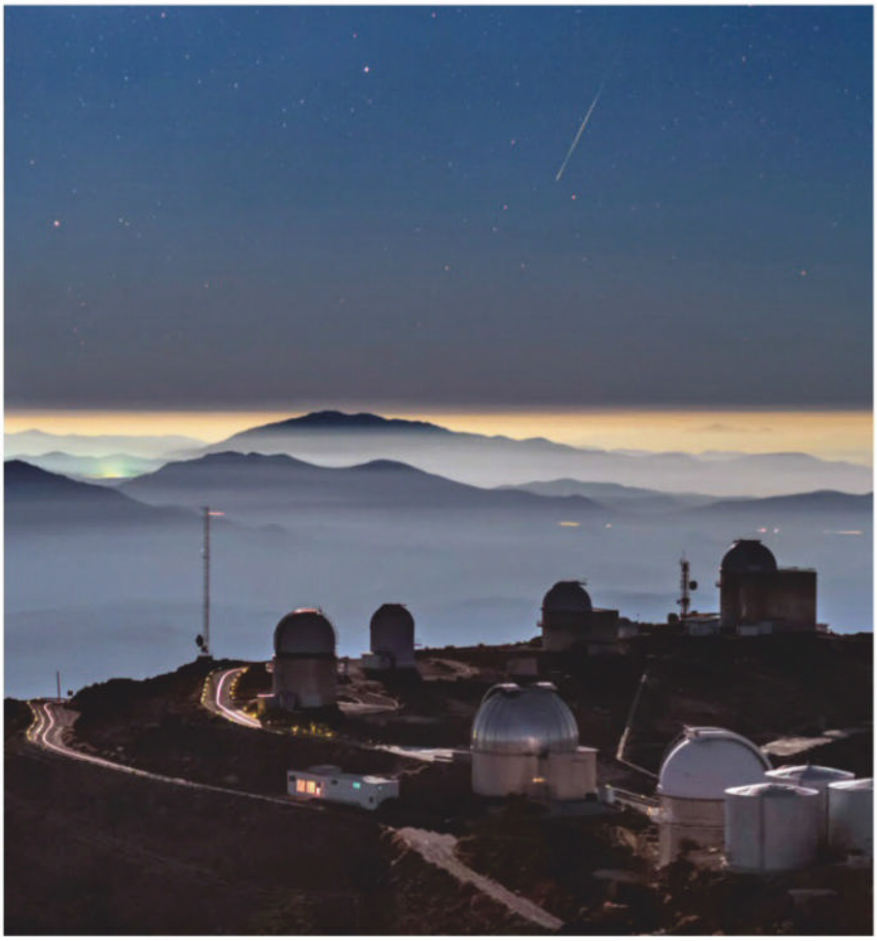

Also in this section

Space rocks

Skyfalls

Networks of cameras are making it easier to track meteors, and find the bits that actually reach the ground

EVERY DAY between 100 and 600 tonnes of rock hurtles into Earth's atmosphere. The reason so little of this bombardment makes it to the planet's surface is that much of it is burnt up by atmospheric friction, which creates the fireball that is the visible sign of a meteor's arrival. As for the bits that do get through, once landed, they are known as meteorites.

Roughly 60,000 objects of meteoritic origin have been picked up and catalogued. Most are fragments from a much smaller number of individual falls. Of these falls, only 36 were observed as they arrived with enough fidelity to calculate the orbit of the original meteor before it entered the atmosphere. If more such data were available it could, by showing where the rocks came from, cast more light on the composition of the solar system. It might also help in moving orbiting spacecraft out of danger.

The tracking of meteors is carried out by arrays of cameras on Earth. The oldest of these is the European Fireball Network (EFN), which dates back to 1951 and is operated by the Astronomical Institute of the Czech Academy of Sciences. When it launched its equipment was primitive—two groups of eight cameras capturing images on glass photographic plates using all-night-long exposures. Each camera group covered half the sky. Now, the network deploys 24 state-of-the-art digital cameras equipped with fish-eye lenses in 18 stations scattered across Austria, the Czech Republic and Slovakia. Two more stations, in Germany, are planned for later this year.

The digital cameras take back-to-back photographs, with 35 second exposures, from dusk to dawn. Fish-eye lenses allow a single exposure to cover the whole sky immediately above each camera. If more than one camera sees the same fireball—which is usually the case—that meteor's course can be triangulated, with a precision of about ten metres, by comparing the images. This yields two valuable pieces of information. Plotting the path backwards reveals the rock's orbit before it slammed into Earth's atmosphere. Projecting it forward suggests a potential landing site.

The EFN's cameras also contain radiometers that measure changes in a fireball's luminosity 5,000 times a second. This reveals the rock's entry speed, its probable mineral make-up, the amount of fragmentation and deceleration rate. If the data indicate anything is likely to have reached the ground, an alert is automatically emailed to the network's operators.

Dark flight

To calculate an impact's location, researchers take into account how wind affects the trajectory during 20km or so of "dark flight", after a fireball has burned out. A decade ago, half of meteorites found as a result of the EFN's data were within 500 metres of the predicted spot. That figure has now shrunk to 100 metres. Pavel Spurný, ▶▶

the network's co-ordinator, usually keeps the impact zone secret until his team, or trusted helpers, can search for it. Meteorites have commercial as well as scientific value. Giving the game away too early risks losing finds to professional collectors.

The EFN's hardware was not hugely expensive. The network's cameras cost about $30,000 a piece. Operating the system adds $114,000 a year, according to Dr Spurný. But it has improved the success rate enormously. Between 1951 and 2014, when the new cameras started to be rolled out, rocks from five falls were recovered. Since then, that total has doubled. Even so, cloudy skies can foil the instruments. And meteorites, many of which are small and dark, are not always easy to find in the vegetation and darkish soils of central Europe.

For all these reasons, Phil Bland, a British meteorite expert, reckoned the pickings are better on the flat, brushless, lightly coloured deserts of Western Australia—a place where, as a bonus, the skies are mostly clear. Dr Bland, who works at Curtin University, in Perth, has therefore set up what he calls the Desert Fireball Network (DFN). This now sports 52 camera observatories, though the cameras themselves are, at $10,000 a pop, cheaper and less snazzy than the EFN's. These cameras keep a persistent eye on the western third of Australia's night sky.

The DFN has been a success. It has produced, Dr Bland says, a big data set "of gorgeous orbits" for incoming rocks. The number of meteorites believed to have landed has overwhelmed the team's resources. They have recovered stones from four falls, but are in need of adventuresome volunteers to mount expeditions into the outback to gather the remains of more than 30 others.

In America, meanwhile, the NASA All-sky Fireball Network, run by America's space agency, operates 18 cameras across the United States. Its goal is not to find meteorites, but to protect spacecraft from collisions. By studying fireballs, the agency's Meteoroid Environment Office in Huntsville, Alabama, which operates this particular network, improves estimates of the number, size, speed and trajectory of space rocks in areas where satellites operate. The forecasts of Earth's periodic peak bombardment by objects from a cloud of cometary debris called the Draconids, for example, has improved from an accuracy of about two hours in 2012 to just 30 minutes today, says Bill Cooke, who runs the project.

Dr Cooke's team use the data the network collects to calculate the risks faced by individual spacecraft. NASA publishes these numbers so that insurance underwriters can take them into account, as can mission operators. In areas with higher collision risks, controllers may temporarily shut down high-voltage subsystems that, if struck, might fry the spacecraft they are part of, or reorient a craft so that the narrow edges of its solar panels face any onrushing space rocks, minimising the risk of impact.

Protective measures

Spacecraft engineers also use Dr Cooke's data to design better "bumper shields". These consist of layers of Kevlar and other materials spaced so that they gradually break apart an incoming meteor, depriving it of energy. To keep launch weights down, not all sides of a spacecraft are shielded equally, usually the rear is the most heavily armoured part.

To gauge a projectile's destructive power, one must know its speed. A team at the University of Western Ontario, in Canada, clocks meteors smaller than grains of sand. Using high-frequency radar, the team fires pulses into the sky 500 times a second, day and night. These detect not meteors themselves, but rather the trails of ions, generated by friction within the air, that they leave behind. The radar sees this as a "giant wire in the sky", says Peter Brown, the team leader. An array of microphones sensitive enough to measure shock waves from meteors a centimetre or more across provides additional data. Dr Brown puts the average speed of such shooting stars at about 20km a second—significantly faster than many had thought.

That is bad news for satellites. But if the various meteor-monitoring networks around the world can help improve the forecasting of peak meteoric activity, then the number of spacecraft suddenly found to be in peril will be reduced. ■

Biochemistry

Sniffing out Parkinson's

Chemicals that give sufferers a unique smell have been identified

HIPPOCRATES, GALEN, Avicenna and other ancient physicians frequently used odour as a diagnostic tool. Although scent is not used nearly as often in modern medicine, it still has its place. Paramedics are routinely taught to spot the fruity smell on the breath of diabetics who have become hyperglycaemic and gastroenterologists are trained to detect the odour of digested blood. But there has been scant evidence of a smell associated with neurodegenerative disorders. Now one has been found for Parkinson's disease.

Frequently causing tremors, rigidity and dementia, Parkinson's is both debilitating and substantially shortens life expectancy. The rate at which these symptoms appear and worsen cannot be stopped or slowed yet but its most harmful effects can be staved off with drugs. As with many diseases, the earlier the intervention, the better. Yet herein lies one of the greatest


Mrs Milne's extraordinary nose at work

challenges—there are no tests that diagnose whether Parkinson's is actually present. The best that neurologists can do is study the symptoms and theorise about whether someone actually has the disease. Hence the search is on for a better form of diagnosis. Unexpectedly, scientists are now literally following someone's nose.

Joy Milne, a retired nurse from Perth, Scotland has an extraordinary sense of smell. Known as hyperosmia, Mrs Milne's condition allows her to detect odours that are imperceptible to most people. In 1974 Mrs Milne noticed an odd musky smell around her house that had not been present before. In 1986, her husband, Les Milne, was diagnosed with Parkinson's. He lived with the disease for a number of years and while the symptoms were initially manageable with medication, this became harder over time. Eventually, he was forced to retire and, while attending Parkinson's support groups, Mrs Milne noted something extraordinary. Everyone with the disease had the same distinctive odour that her husband had developed in 1974. It was shortly after that realisation that she started collaborating with researchers.

Musky odour

By providing Mrs Milne with shirts worn by Parkinson's patients, researchers found she was able to identify that the smell was concentrated along the upper back, and not in armpits as previously assumed. Most remarkably, of the control subjects without the disease, Mrs Milne found one to have the musky odour. Nine months later that person was diagnosed with the disease.

All this led Perdita Barran of the University of Manchester, in Britain, to set out to discover what was producing the telltale odour that Mrs Milne could detect.

Previous work found that patients with Parkinson's had a tendency to overproduce a waxy compound on the skin of their upper backs. Known as sebum, Dr Barran speculated that something trapped within this compound was producing the odour. Keen to find out, Dr Barran and her colleagues set up an experiment.

The team analysed sebum samples from 43 people suffering from Parkinson's and 21 who were not. The sebum samples were collected on gauze and warmed to release any volatile compounds that might be found within them. Mass spectrometry and gas chromatography were then used to identify whether there were volatiles present and what they were. For a subset of the patient samples, Mrs Milne smelled the compounds before they entered the mass spectrometer and pressed a button when the distinctive odour was present.

As Dr Barran reports in ACS *Central Science*, the mass spectrometer identified four compounds, perillic aldehyde, hippuric acid, eicosane and octadecanal, in the vaporised sebum of the Parkinson's disease patients that were at entirely different levels to those in the healthy group. To test whether these different levels of compounds were generating the smell that Mrs Milne was detecting, Dr Barran presented them to her and confirmed that they were, indeed, responsible for the musky odour.

While relatively small in size, Dr Barran's experiment is the first to reveal the specific compounds that generate the unique smell of Parkinson's. Assuming larger follow-up experiments replicate her findings, the work paves the way for the development of a device, a sort of electronic nose, that could sniff the upper backs of patients to quickly determine who has the disease and who does not. That would allow drugs to help mitigate the symptoms to be administered all the sooner. ■

Robot baristas

The ultimate coffee machine

Inhumanly good service coming soon to a café near you

GAVIN PATHROSS likes his Americano at a particular strength, with exactly 2.8 shots of espresso, an order that human baristas struggle to get right. But the baristas at Ratio, his new coffee shop in Shanghai, are anything but human. Customers specify, order and pay for their coffee via their smartphones. A robot arm then grinds the beans, pumps shots of espresso and carries out the rest of the work. The robot can supply water and coffee in any ratio desired—hence the shop's name. Once it has prepared the beverage, it passes the finished product to a human waiter for serving.

One lump or two?

Ratio's robot baristas are part of a trend. Hamburger joints and other fast-food outlets are starting to be robotised in some places. Now it is the turn of cafés. Mr Pathross's Shanghai shop is, at the moment, a one-off. But Coffee Haus is a commercial system intended for deployment in airports, offices and other high-volume locations. It is the brainchild of Chas Studor, founder of Briggo, a firm in Austin, Texas. Under his guidance Briggo's engineers have developed a device that is a couple of metres tall, four metres across, and can turn out 100 cups an hour.

Briggo has cut human beings out of the loop completely. A Coffee Haus machine lets you order and pay for your coffee via an app—and, if you have done so remotely, keeps your drink in a locked area, accessible via a code which it texts to you. For those present, the Coffee Haus robot provides a certain amount of theatrical appeal (a window lets you watch the coffee being made). But Mr Studor says the real aim is not theatre but to carry out the same processes as a standard coffee bar does, with robotic precision. For example, a big challenge for human baristas is that different types of coffee have different ideal "extraction parameters"—how many beans to how much water, brewed at what temperature and for how long. During busy spells, humans sometimes struggle to get all of these things right every time. The robot is inhumanly perfect.

Café X in San Francisco takes advantage of the showy appeal of robots. Its computer arm, which is described as having "a quirky personality," even waves to customers. Café X sells mostly from kiosks in streets and shopping malls. Orders can be made from an app or via touch screen at the kiosk itself. But it has not dispensed with human attendants and has someone on hand to talk to customers and provide a human touch.

All developers of robot baristas stress the speed, reliability and consistency of their systems. They give the convenience of vending-machine coffee without the horror of it. And coffee is only the start. Soon, such devices will be making tea and other drinks at the tap of an app. Human servers, meanwhile, will be freed from the drudgery of preparing endless lattes, to concentrate on customer service. Whether the outcome is viewed as people and machines each playing to their strengths in a harmonious team, or a corporate techno-dystopia with a Starbucks twist, is perhaps—like preferences in coffee—a matter of taste.

Pest control

A bug in the system

How whiteflies hack the way plants communicate

WHEN SOME plants are attacked by herbivores they fight back by producing irritants and toxins as their leaves get chewed up. Certain insects, however, can resist these defences. Among the best at doing this, and hence one of the most troublesome crop pests, is the whitefly. Remarkably, as new research shows, whiteflies enhance their dastardly deeds by hacking a biological early-warning communications system used by plants.

When whiteflies launch an attack, plants respond by producing jasmonic acid as a defence mechanism. This hormone triggers the production of compounds that interfere with an insect's digestive enzymes, making it difficult for them to feed. But plants can produce a different substance, salicylic acid, to help ward off pathogens, such as a virus. Whiteflies trick the plant into behaving as if it was threatened with a disease rather than an insect infestation. This is possible because whiteflies have compounds in their saliva that dupe plants into producing more salicylic acid and less insect-repelling jasmonic acid. This ruse makes it much easier for them to infest the plant.

Raising the alarm

Peng-Jun Zhang and Xiao-Ping Yu of Jiliang University in China, and their colleagues, wondered whether there might be more to it than that. In particular they decided to investigate what happened to the rallying cry plants make when they are under attack by insects or disease.

That idea might appear to have been lifted from the film "Avatar", set on a fictional moon where plants communicate. But in recent years researchers have found that plants do have the ability to raise an alarm when they are threatened. Sometimes this is sent in biochemical messages via root and symbiotic fungal connections in the soil, and sometimes through chemicals released into the air.

The alarm signals give warning to nearby plants of an imminent threat so that they can prepare to defend themselves. When a pathogen is causing harm, the signals drive a population-wide production of salicylic acid. If insects are the problem, the plants make jasmonic acid as well as special compounds that summon predators to eat the insects.

As they report in *Proceedings of the National Academy of Sciences* this week, Drs Zhang and Yu found that whiteflies not only deceive individual plants, making them respond as they would to a disease not an insect, but also spoof their alarm system making them spread the erroneous message. This makes neighbouring plants more vulnerable.

To show this, the researchers set up an experiment growing tomato plants in glass chambers. Some plants were infested with whiteflies and some left alone. After several days, the air from each chamber was passed into similar chambers containing a healthy tomato plant and left for 24 hours. These new plants were then infested with whiteflies. Although the number of eggs laid on all the plants was much the same, on those exposed to the air of infested plants the new generation of whitefly nymphs developed much more quickly.

The researchers ran the experiment again but this time looked closely at the compounds produced by plants exposed to the different air samples. They found that while jasmonic acid was produced at the expected high levels during a whitefly attack by plants contained in healthy air, plants exposed to air from infested plants only produced half those levels. Salicylic-acid production showed the reverse trend, with plants exposed to healthy air samples before a whitefly attack producing very little of it and those exposed to air samples from infested plants producing a lot.

Given these findings, Drs Zhang and Yu argue that if the biochemical mechanism driving plants to send out incorrect warning signals can be found, it might be possible to come up with more effective agricultural countermeasures. That could help farmers protect their crops from a sneaky pest that worldwide costs hundreds of millions of dollars annually. ■

Let's pretend we're viruses

Solar power

Gathering the rays

Getting more power from a solar panel

EVEN THOUGH solar panels have improved over the years they are still not very efficient at doing their job. Standard panels using silicon-based solar cells typically convert 17-19% of the sun's energy into electricity. It is possible to use more exotic solar cells to make panels that are some 40% efficient, but these can cost around $300 a watt compared to just under $1 for some silicon versions. Hence the better panels are used in specialist roles, such as powering spacecraft.

Now, a middle way seems to have been found. Insolight, a startup from the Swiss Institute of Technology in Lausanne, has developed a panel that uses expensive high-efficiency solar cells, but does so in such a fashion that should make its panels competitive with the standard silicon variety. The new panel has been confirmed in independent tests to be 29% efficient.

Insolight employs so-called multi-junction solar cells, which are similar to those on spacecraft. These capture energy from a much broader spectrum of sunlight by using a stack of different materials, such as gallium arsenide and gallium indium phosphide. Fabricating such cells is complex and costly.

Insolight, though, is extremely parsimonious in their use. Instead of spreading them across an entire panel, they are spaced well apart in a grid that covers just 0.5% of the surface. The panel is then covered with a protective glass layer that contains optical lenses above each cell. This way sunlight falling on the panel is concentrated onto the cells below. To ensure maximum exposure, a mechanism moves the position of the panel by a few millimetres horizontally, enough to follow the trajectory of the sun.

Such panels would still cost a bit more than standard silicon ones, but as Laurent Coulet, Insolight's chief executive, points out, what matters is the final cost of the electricity they produce. He reckons that in mass production his panels will work out cheaper, going well below silicon's $1 a watt to 30-40 cents a watt. Moreover, a hybrid panel could be made using the Insolight system and silicon cells covering the remaining 99.5% of the panel's surface. Such a panel would help harvest diffuse light in places where conditions are often cloudy.