Gathering dust

Get ready to be blown away by a library like no other

THE dusty old library is a bit of a cliché. But take away all the books and you are left with something rather interesting, in its own small way.

Welcome to the dust library. With 63 individual particles catalogued, the collection is hardly dust's answer to the great library of Alexandria, but there are plans to expand. Besides, far from being dry, this is a genre of unexpected delights. If you haven't explored it much, and you probably haven't, you may be in for a pleasant surprise.

Dust means different things to different people. In the trilogy *His Dark Materials*, author Philip Pullman cast it as an esoteric elementary particle – one with consciousness. To you, it might be simply any fine powder, or mostly dead skin, or the state to which we shall all return. For scientists its allure is long-standing: more than a century has passed since geologist J. A. Udden's first laboratory experiments. Today, what's blowing in the wind is of interest to everyone from geologists and environmental scientists to astronomers and health experts.

Dust is hugely diverse. The biggest particles are more than 2 millimetres across; the smallest, less than 0.1 micrometres. Excitingly, some have cosmic origins: around 200,000 tonnes of extraterrestrial material enters the atmosphere each year. This is dwarfed by the 4 billion tonnes from Earth itself, though, more than 90 per cent of which comes from natural sources such as soils, volcanoes, deserts, pollen and sea salt. The human contribution is far smaller, but we are responsible for some of the nastier little particles, including those from car exhausts, industrial emissions and fertilisers.

Our knowledge of dust is also diverse, if a little haphazard. Among other things, we know that British stately homes are covered in a fine layer consisting mostly of skin, hair and fabric fibres; that indoor dust can pose more of a threat to health than the outdoor variety; and that city air is teeming with bacteria from dog faeces (*New Scientist*, 13 August, p 16). But there is one glaring gap in our dusty repertoire, which stems from the fact that the stuff is generally studied in bulk: no one had ever looked at what an individual dust particle is actually made of. Until now.

As with many great scientific breakthroughs, this one was serendipitous. In 2003, James Coe at Ohio State University in Columbus was using infrared light to identify the chemical composition of various substances: different molecules absorb specific frequencies of infrared according to their structure, so the emerging spectrum reveals what is there. Unfortunately, extremely small samples scatter the light, blurring the results. So Coe constructed a sensor containing a nickel mesh with 5-micrometre holes to trap individual particles and prevent scattering. The nickel absorbs infrared light, creating plasmons – electron waves with properties of photons – that help funnel the light through the trapped particles, rather than scattering it. For several years he and his team happily used the mesh to uncover the chemical make-up of all manner of things. Then, a couple of years ago, someone got sloppy, and a routine run with latex spheres embedded in the mesh turned up an unexpected spectrum: dust.

"Usually, if you see dust, you avoid it," says Katherine Cilwa, then a graduate student in Coe's lab and now at the University of Michigan, Ann Arbor. But instead of discarding the duff results, she and her colleagues embraced them, and began looking for ways to attract more dust. Soon, with the help of a miniature suction pump and some ordinary laboratory air they had captured 63 solitary dust particles in their mesh. Once

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these had succumbed to infrared spectroscopy, the world's first dust library was born (*Journal of Physical Chemistry*, vol 115, p 16910). "By studying single particles you see things that you don't see if you average all the spectra together," says Coe.

So what can this unusual library tell us? First, there is the simple parts list. The most common component was organic material, present in 40 of the 63 particles – exactly what is unclear, but it could be anything from pollen to sloughed-off bits of researcher. Quartz, found in 34 particles, came next,

followed by carbonates (17 particles) and gypsum (14). "The minerals blow in," says Coe. "They come from all over the world." Other ingredients included air pollutants and fertiliser chemicals.

Anyone counting will also have noticed that there are already more components than particles. That is because most specks of dust are conglomerates, which means they may take an infinite variety of forms, much like snowflakes. The next obvious step was to find out what individual conglomerates looked like, but pinpointing exactly which speck corresponded to which spectrum wasn't going to be easy. So Coe launched a competition. The first person to capture an electron microscope image of a particle that had already been analysed with infrared light would get to name it. And, if that was not enough, there was a free dinner on offer too. What student could fail to rise to that challenge?

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Face to a spectrum

Quick work saw undergraduate Matthew McCormack crack it first. He had been working with Cilwa from the start, and realised that by making a small mark on the mesh beside a particular dust particle he could record an infrared spectrum and then transfer the mesh to an electron microscope. When he found the telltale mark, he could simply focus the microscope onto the particle and take its portrait. Bingo! McCormack had soon analysed and imaged an irregular lump of detritus, or "Abby" as he named it, in honour of his pet dog.

So now Coe and his team are able to put a face to a spectrum, for the two pieces of dust they have photographed, anyway. Sadly, neither is in the public dust library, but anyone who wants to can see the spectra of the 63 particles that are – an invaluable resource for budding dust experts.

The researchers say their work has particular potential for public health, given that dust-related deaths – mainly from respiratory disease and stroke – are thought to number around 10,000 each year in the UK alone. They note that particles between 3 and 5 micrometres – the very size their device analyses – are among the largest able to make it down our mucus-coated airways and get deep into the lungs. Recent research suggests that organic material causes some of the worst health problems, says Coe. He is currently calibrating the sensor with known chemicals so that his team can tell the exact nature of any organic components they come across.

In future, the approach might be used to determine whether dust lurking in hospitals, schools, factories and elsewhere contains anything dangerous. Coe's students are also collecting samples from smoking lounges and parking lots with the aim of creating reference libraries with particles from different environments. At a time when cuts in public spending threaten more conventional libraries, it is heartening to think that repositories of dust are set to boom. ■

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