THIS WEEK

EDITORIALS

Earthrise at 50

An iconic photo of Earth from the Moon was taken by Apollo 8 astronaut William Anders in December 1968. It inspired people then, and can do so again.

It takes an eye for a certain type of detail to look at a photo of the bejewelled Earth hanging in the sky over the sterile terrain of the Moon and see, not the fragility of humanity's only home, but a barren lunar crater. But look carefully and it's there. And now that crater has a new name: Anders' Earthrise.

The Working Group for Planetary System Nomenclature of the International Astronomical Union (IAU) approved the naming of the crater — and another nearby, called 8 Homeward — to mark the 50th anniversary of the Apollo 8 mission that orbited the Moon, and more specifically, the famous photograph taken from on board of Earth rising over the lunar surface. Snapped on 24 December 1968 by astronaut William Anders, *Earthrise* is often labelled as one of the most important and influential photographs in science, if not all of human history.

Needless to say, the status of the image is not down to the circular dent captured in one corner. Instead, it's because the photograph — which seems to show Earth rising above the Moon's horizon — has been credited with starting the environmental movement. Readers of Rachel Carson's book *Silent Spring* — which highlighted the damaging impacts of pesticides on the natural world six years earlier — might argue with that common trope. But it's undeniable that *Earthrise* was profoundly important in raising awareness and focusing minds. For the first time, people could see their planet framed against the black emptiness of eternal space and appreciate its technicolour beauty as well as its utter insignificance in the Universe.

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An entire generation suddenly saw the planet as isolated and vulnerable, and very difficult to replace. (A later generation would experience this for themselves, with the publication of another iconic picture of the planet: the *Pale Blue Dot*, taken from a distance of 6 billion kilometres by the Voyager 1 probe on St Valentine's Day in 1990.)

The view of Earth from space is much the same now as it was then. (Just witness the stunning images released earlier this year from the GOES-16 satellite, which show the planet in extraordinary detail.) But how we think about such images has drastically changed.

For many millions of people, the end of 2018 sees a better, more prosperous world than the one the Apollo 8 astronauts returned home to 50 years ago. Human progress, driven by advances in science, medicine and technology, has radically improved average living standards, health and life expectancy. But Earth itself is panting to keep up. Only two months ago, the Intergovernmental Panel on Climate Change issued its most urgent warning yet about the effects of climate change, warning that a temperature rise of even 1.5 °C — which most experts agree is inevitable — will bring devastating droughts and floods.

It's likely to be much worse than that, however. Last week, the world's politicians met in Poland to discuss next steps on a global climate agreement that could be the last, best hope to stem climate change. The deal will make insufficient change to the amounts of damaging greenhouse-gas emissions we hurl into the atmosphere.

Powerful images show what is at stake. But they also show what we can still achieve: that we do not have to be passive observers, trapped by the scale and magnitude of the Universe and its problems. We can act. We can make things happen.

Take *Earthrise*, the picture and the phenomenon. We did that. The Moon is tidally locked to Earth and that fixes the planet's position in the lunar sky. Earth doesn't rise from the Moon and only seemed to do so for the Apollo 8 astronauts because their craft was speeding above the surface, gradually revealing more of Earth as it travelled. Even as the planet hung there in the blackness of infinity, the people who saw it were moving forwards. We still can. ■

Fur and fossils

Feather-like structures on pterosaurs open up a world of colour.

Pterosaurs are the first known vertebrate group to have evolved powered flight — preceding birds and bats by many millions of years. Ranging from the size of small birds to that of small planes, pterosaurs lived alongside the dinosaurs and went extinct at the same time. Many things about these creatures remain mysterious, not least their origin — the earliest pterosaur fossils found so far seem to have been fully capable of flight, and there is no confirmed transitional fossil to show from which reptilian group they emerged.

This is different from, say, birds. Revelations over the past two decades that bird-like feathers were present on dinosaurs — ground dwelling and with the flight capability of a sack of spanners — have illuminated our understanding of the evolution of birds and their characteristic structures.

That the bodies of at least some pterosaurs were clothed with a kind of fuzz has been known (or at least suspected) since the 1830s, but this fluffiness became a focus of study only after the description of the exceptionally hirsute Kazakh pterosaur *Sordes pilosus* in 1971.

Pterosaur fluff, comprised of what are technically known as 'pycnofibres', is structurally different from mammalian fur or hair. Each pycnofibre is a short, simple filament with a canal running down the centre, and is much more superficially attached than the deeply rooted hairs of mammals. Pycnofibres have been observed on the heads, limbs and bodies of several pterosaur fossils.

Ironically, given that they could fly, discussion of feathers and feather-like structures has tended to ignore pterosaurs. Instead it has focused on non-avian dinosaurs, which couldn't. As a result, the relationship — if any — between pterosaur pycnofibres and dinosaur feathers has been obscure.

No longer. A paper this week in *Nature Ecology and Evolution* shows that some pycnofibres, far from being simple monofilaments, had branching or brush-like structures — just like the feathers found on birds and their closest dinosaur relatives (Z. Yang *et al. Nature Ecol. Evol.* **3**, 24–30; 2019).

The study suggests, therefore, that pycnofibres could share an evolutionary origin with dinosaur and bird feathers. And the common ancestor of birds, dinosaurs and pterosaurs might also have been able to produce such pycnofibre structures.

The study's evidence comes from fossils of two sparrow-sized pterosaurs between 160 million and 165 million years old (a shade earlier than the earliest known bird, *Archaeopteryx*, which is around 150 million years old), from the Jurassic period of China.

The pterosaurs have four distinct kinds of pycnofibre: the regular monofilaments seen in other pterosaurs; a type with a brush at the distal ends; a variety in which brush-like filaments sprout from the middle of the main fibre; and a fourth, in which several fibres meander from a common root. Structures corresponding to all four types of pycnofibre have been found associated with various dinosaurs, underlining the case that pterosaurs are indeed related to dinosaurs.

Importantly, each kind of fibre is not distributed randomly on the bodies of the two pterosaurs. The simple monofilament form is found all over the body; the brush-like form on particular regions of the head, limbs and tail; and the curious form with sprouting filaments is restricted to the head. The fourth form, which closely resembles the down of bird chicks, is found on the wing membranes.

This distinct distribution indicates that each type had a biological function, and that one kind of filament was not simply the decayed product of another.

What were these functions? Pycnofibres of the first and second type might have provided insulation and streamlined the body shape to minimize aerodynamic drag, as feathers do in birds and fur does in bats. The sprouting type on the head might have functioned similarly to the sensory bristles found on the heads of modern birds. The downy, fourth kind of fibre might have helped to keep the wings warm, as it's known that feathers with this structure are much more efficient at trapping warm air than is mammalian hair.

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Moreover, the pycnofibres contain remnants of melanosomes — organelles that are typically found in feathers, feather-like structures and mammalian hairs, and that help to lend these structures their distinctive colours. When applied to the pterosaur fuzz, a technique called Fourier-transform infrared spectroscopy produces the same spectra as those found in birds both ancient and modern, as well as red (but not black) human hair.

For the first time, we can visualize pterosaurs with a touch of colour, as we can fossil birds, dinosaurs and even dinosaur eggs. Flying alongside the earliest birds and even some very early flying mammals, pterosaurs must have made the skies of the Mesozoic Era a riot of life and colour. ■

Computer games

Classical and quantum machines are battling for computational superiority.

Will 2019 be the year when quantum computers show they have the right stuff? Google says so — one of the company's labs, in Santa Barbara, California, has promised that its state-of-the-art quantum chip will be the first to perform calculations beyond even the best existing supercomputers.

And Google isn't alone. A number of other companies, big and small, are working steadily towards the same symbolic goal. Venture capitalists have poured money into dozens of quantum-computing start-up companies. Excitement and anticipation are mounting.

In a stark reminder of the power of quantum computing, in May, two theoretical computer scientists solved a 25-year-old conjecture (go.nature.com/2eatyco). They confirmed that quantum computers are — in an admittedly abstract setting — vastly more efficient than classical ones at particularly complex tasks, such as testing whether a set of numbers is random.

Still, such work does not justify the expectations that now surround quantum computing. A recent report by the US National Academies of Sciences, Engineering, and Medicine (penned by leading Google and Microsoft researchers, among others) stressed the technical hurdles that lie in the way of building practically useful quantum computers. Creating such machines will take at least a decade, the report says.

Theoretical physicist Seth Lloyd at the Massachusetts Institute of Technology in Cambridge speaks for many when he says the field is in a period of explosive progress — but that the hype is also getting out of control. "The whole quantum-computing field is just going hogwild right now," he says.

Is a quantum computer even needed? High-profile work by an 18-year-old computer scientist earlier this year suggests not, at least for one specific task. Ewin Tang effectively taught an old computer a new trick — one that was previously thought to need a quantum system.

She developed an extremely efficient classical algorithm — that is, one that can run on an ordinary computer — for 'recommendation systems', such as those that certain websites use to try to guess a consumer's tastes (E. Tang Preprint at https://arxiv.org/abs/1807.04271; 2018). Her work produced a much faster version than current, relatively sluggish systems. Tang's algorithm is not necessarily practical to use, so it won't replace current algorithms unless it is substantially improved — in its current form, it would be useful only with data sets of truly gigantic proportions. But a quantum algorithm that was in development for that same task has now been rendered moot, before it ever had a chance to run on an actual machine.

Last month, Tang, who is now at the University of Washington in Seattle, doubled down. She and two colleagues demolished the quantum advantage of another type of algorithm for certain machine-learning tasks (A. Gilyén *et al.* Preprint at https://arxiv.org/abs/1811.04909; 2018). A different team at the University of Texas in Austin reached the same conclusion independently (N.-H. Chia *et al.* Preprint at https://arxiv.org/abs/1811.04852; 2018). Computer scientists responded to the news with memes that, for example, compared Tang to a gladiator slaughtering the hopes and dreams of the quantum community. And it was a bittersweet moment for Tang's co-author, Seth Lloyd — he wrote the quantum algorithm that was trounced.

Some in the field argue that these uses of classical computing are actually successes for quantum computing, because they show how the quantum way of thinking can have an impact, even before quantum computers exist. Specialists also point to problems for which quantum computers have long been known to have a proven advantage, such as web searches. In other cases — such as factoring large integers into primes or simulating the electronic properties of materials — scientists think that quantum computers are still likely to have an advantage, although this has not yet been demonstrated mathematically.

Quantum computers are a not-yet-existent technology in search of problems to solve. Meanwhile, researchers are seeing how far classical strategies can be taken. Both are valid research avenues. A quantum device remains a laudable goal. But it's not the only route to the future. ■