Ingredients that make amazing science features

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Features are a consumer product (or at least should be enjoyable!)

Rocks of ages

Meteorites tell of our solar system's turbulent past. But finding them is no easy matter, says Sophia Chen

A MAN with a Stetson perched on his head reclines in his chair, an assortment of rocks displayed in front of him. A second man in a fedora browses the collection, pausing over one specimen. The size of a chocolate bar, the silvery rock is inlaid with a mosaic of grainy grey shapes.

"What are you asking for that one?" asks the fedora.

"Oh, somewhere around five thousand," replies the Stetson.

It's a routine exchange at the annual Tucson Gem, Mineral & Fossil Showcase in Arizona, a marketplace for international collectors of petrified wood, dinosaur bones, gold and more. Except there's something special about this rock: it came from space.

The man in the Stetson, Marvin Killgore, hunts and trades meteorites. It's not an easy living. Rocks from space fall anywhere, any time, and many look unremarkable to the untrained eye. Killgore honed his skills in more than 40 countries over 27 years. Catch him at an idle moment, and his eyes are trained on the ground. "I'm always prospecting," he says. "I found a meteorite in the parking lot here last year."

Collectors aren't the only ones interested in his wares. Meteorites are objects of great scientific interest – they are time capsules from the solar system's birth, encoding clues about how our cosmic neighbourhood came to be, and maybe about why life blossomed in at least one part of it. To piece together the full picture, we need more of them. Killgore and his ilk's trained eyes won't be enough. It's time for some cleverer ways of finding space rocks.

Across town from the gem show, some of Killgore's prize specimens are on display at the University of Arizona. The collection of space shrapnel there comes in a bewildering array of varieties: silvery iron-nickel asteroid cores, a grey-pink lunar rock, an olive-faced boulder the size of a newborn calf.

But such flashy rocks are rare. About 85 per cent of meteorites, space rocks that actually reach Earth's surface, are of a type called ordinary chondrites. Often homely grey lumps that won't earn you much cash, these are scientific treasure troves. Each is packed with spheres called chondrules, ranging in size from pepper flakes to marbles. They formed when molten rock droplets cooled 4.6 billion

"Often just homely grey lumps, meteorites are scientific treasure troves"

years ago, long before any planets existed in the solar system. "With a chondrite, you have the oldest rock you'll ever hold in your hand," says planetary scientist Dolores Hill, who leads tours of the exhibition.

Meteorites like this could help us figure out some of our cosmic backyard's deepest mysteries, such as why the planets exist in a neat arrangement of four rocky worlds followed by four gas giants. In the burgeoning number of other planetary systems we now know of, it's far more common to see a mixed line-up with gas giants that have migrated inwards to mingle with their rocky cousins. Why are we so different? One proposal is that Jupiter may have barrelled inwards before retreating to its current position.

Another theory says there was no water on the young Earth, in which case it was probably delivered later on by collisions with other bodies like asteroids or comets. Jupiter's gravity might have helped slingshot these bodies towards Earth – depending on where it was.

Chondrites and other meteorites mainly come from the asteroid belt, a repository of material from the solar system's early days

Intro

Billboard

Backstory

Rarest rocks

Even though there are lots of space rocks out there, they're rare on Earth

1.9m
ASTEROIDS IN THE ASTEROID BELT
larger than 1 kilometre across

13,095
NEAR EARTH OBJECTS
that are more than 30 metres across

51,000
SPACE ROCKS
weighing more than 1 kilogram hit Earth's atmosphere every year

4590
METEORITES
weighing more than 1 kilogram reach the ground every year

30,000
METEORITES
have been found by searching at random

1149
METEORITES
have been found by seeing a meteor fall

SOURCES: NASA, METEORITICAL BULLETIN DATABASE, METEORITES AND THE EARLY SOLAR SYSTEM II, EDITED BY DANTE LAURETTA AND HARRY Y. MCSWEEN (UNIVERSITY OF ARIZONA PRESS)

that sits between the orbits of Mars and Jupiter. Examining the chemical composition of any fragments that come our way can tell us where they ultimately came from. We could then run computer simulations exploring how the gas giants might have moved around in the early solar system, and how this could have kicked asteroids from where they were born into the orbits they ended up in.

In particular, the farther out the asteroid material was when it formed from the cloud of dust and gas surrounding the early sun, the more laden it would have been with deuterium, a heavy isotope of hydrogen that has a neutron in its atomic nucleus. So analyse the ratio of hydrogen to deuterium in meteorites and you can tell roughly where their parent rock was born.

A neat idea – but there are a few stumbling blocks. First, there's what keeps people like Killgore in business: the sheer rarity of meteorite finds on Earth. Second, there's the fact we have a biased sample, consisting only of the sorts of rocks that cross Earth's orbit. Finally, although analysing isotopes can point to where a rock originally formed, it doesn't reveal its most recent orbit, limiting the accuracy of any simulations.

Dante Lauretta of the University of Arizona is pursuing one obvious solution: get space rocks of known providence by grabbing them where they lie. He leads NASA's OSIRIS-REx mission, which plans to take samples from a 500-metre-diameter asteroid called Bennu in 2022.

But such missions are expensive, so we need better ways to bulk up the harvest of space shrapnel. One well-worn method is to head to Antarctica. Meteorites that fall on the continent's high interior get buried in the ice and carried towards the coast as the ice slowly slips towards the sea. But then they meet the rising underlying terrain of the Transantarctic Mountains, where they can be forced upwards to the surface. For the past 40 years, the US government has sponsored hunts along the base of the mountain range as part of the Antarctic Search for Meteorites programme. Researchers combing the ice on snowmobiles have now found more than 21,000 objects, including meteorites from Mars and the moon.

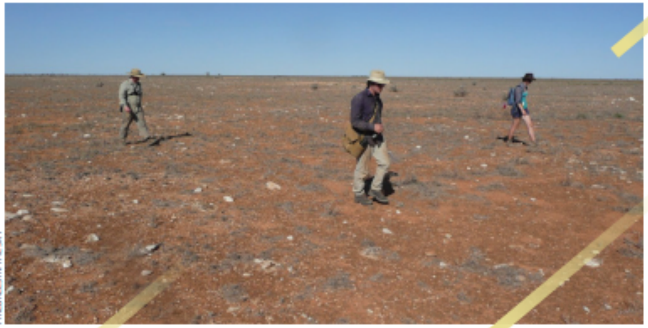
Conel Alexander of the Carnegie Institution of Washington and his colleagues have found another source to harvest in Antarctica: space dust. This is a mixture of material, some of it shed from comets, some of it that has just never coalesced into larger rocks and has been hanging around in space since the early days of the solar system.

There's no hope of distinguishing this dust from the grains made on Earth – at least not in most places. "The air at the South Pole is so clean that there's very little terrestrial dust," Alexander says. "Most of the dust, hopefully, is from outer space." To sample it, the team recently installed a 6-metre-high "vacuum cleaner" with an inlet tube that sticks out like a trunk. Alexander expects that much of the dust has had a very different life from your average meteorite. His preliminary analysis suggest that some of it is very old, and along with the chondrules possibly represents the first solids formed in the solar system.

More samples from different sources help ease the first and second problems of meteorite hunting, but there is still the crucial third problem of pinpointing where the material came from. "All we can do," says Hill, "is analyse the specimens, group them together, and say that maybe these were formed in the same region or from the same object."

Getting around this last problem means knowing not just where a meteorite fell,

Australia's Nullabor plain isn't a hospitable place to search



FIREBALLS IN THE SKY

Potted history

The Meat
(The new stuff)

Space rocks are easy to spot against the Antarctic ice

ANSMET/NASA

but how it fell, in the hope of reconstructing its trajectory and so its origin. But most meteorites are like Killgore's parking lot rock: a lucky find without context. Killgore sometimes locates meteorites in a more systematic way by tracing how they disrupted weather radar. But much of the search is by walking and looking, often using a metal detector or a walking stick with a magnet stuck on the end.

Ten years ago Phil Bland of Curtin University in Perth, Australia, started experimenting with a smarter way. He and his colleagues created the Desert Fireball Network, made up of 50 cameras spread across the desert of southern and western Australia. Each captures night-long exposures of the sky, including the luminous path of any meteors. A fireball's size reveals how large the rock is and whether it will burn up in the atmosphere. Bland's team measures its trajectory on multiple cameras and calculates where the meteorite landed. Then they drive into the desert.

Their first hunt began on the night of 20 July 2007 with a bright white fireball that had ripped through Earth's atmosphere at 13 kilometres per second. After months of work, the team traced the fall to a spot in the Nullarbor plain.

The following year, Bland and seven others set out in a truck and three cars carrying water supplies for two weeks of camping. "It wasn't great searching country," Bland says. But combing through clusters of short, hardy shrubs, and marking the area they covered on GPS devices, they found a meteorite on their first day, within 100 metres of their prediction. Bland later found another chunk, making 324 grams of rock by the end of the trip. They christened their find the Bunburra Rockhole meteorite, after a nearby cave. "It was a very nice way to start," says Bland.

Since then they have recovered three more meteorites, convincingly better than similar camera networks in North America and Europe that cover areas rich in vegetation where the rocks are trickier to spot. "Most of them have only delivered one meteorite each over 10 years," Bland says.

His team now has a different problem: having estimated the locations of 15 further meteorites, they're struggling to recruit enough people who know what a meteorite looks like and are willing to sleep in the middle of nowhere for weeks to bring them in.

Crucially, trajectory mapping from the camera networks can point to where a meteorite came from. "You can get the entire orbital history of this rock," Bland says. That is the first step to a more detailed chemical map of the entire asteroid belt, and perhaps some answers as to what happened in the early solar system.

The Bunburra rock itself demonstrates some of this promise. It turns out to be a type called a eucrite, which lacks the internal chondrules of a chondrite. But it's an unusual sort, originating not from the asteroid belt, but from an orbit almost entirely contained within Earth's.

All this, along with what we're learning about other planetary systems (see "Exoasteroids", left), is revealing ever more secrets buried in space rocks. But nothing will replace old-fashioned prospecting, says Lauretta, largely because camera networks like Bland's cover only a small fraction of land. Places like the Sahara and Atacama deserts will continue to be the territory of collectors like Killgore.

Back at the meteorite booth in Tucson, the man in the fedora decides not to buy the rock. Killgore says that no longer bothers him much. Since he started sharing his samples with scientists, he has come to appreciate his wares for the information they contain. It's just one more reason to keep collecting these postcards from the solar system. ■

"Meteorite hunters often use just a walking stick with a magnet stuck on the end"

EXOASTEROIDS

What can we hope to know about asteroids in other solar systems? Nothing, you might say: surely they are far too tiny and distant.

Jay Farihi at University College London would disagree. He has been watching "exoasteroids" fall into stars called white dwarfs. They produce flashes of light that are particularly clear because white dwarfs shine so purely. "They act like a white sheet of paper," says Farihi.

Against that background he can detect the signatures of chemical elements. These reveal that the exoasteroids come in a variety of types. Some are largely iron, others a mixture of elements – just like the asteroids in our solar system.

That is a surprise: we thought the rich mix of asteroids in our cosmic neighbourhood was down to a very peculiar set of circumstances, in which the radioactive decay of the rare isotope aluminium-26 melted some early space rocks. Heavy iron sank to their cores, leaving a rocky outer crust, and collisions then broke those rocks apart.

We didn't expect aluminium-26 to be prevalent everywhere, so the fact that rocks have apparently melted and split in other solar systems is prompting a rethink.

"That appeals to a lot of scientists," says Farihi. "It's like, great: we're not special. Good."

Sophia Chen is a science writer based in Tucson, Arizona

Boxes.. Ask yourself, is this a separate "sell"?

Real new stuff here (involves its own mini-backstory)

Ending

What makes a feature? (i)

- Feature ingredients:

- Protagonist
- Goal
- Twists and turns
- An arc of reason
- Pay off
- A reason for the reader to care (now)

Other tools…

- Lots of different ways to think about it. Here are some tools:

- Star Wars (twists and turns)
- What's: "Wow and now"
- Coverlines

- Does it fit with our pitching guidelines at: https://www.newscientist.com/in209-guide-for-freelancers/

Thanks a lot!

The shape of water
It’s not one liquid, it’s two

Are you dream-deprived?
It’s not how much sleep, it’s what you do with it

Jurassic farce
No one can agree what a dinosaur is

What’s wrong with the sun?

Is the greatest law of physics about to be broken?
The coming quantum thermodynamics revolution

Do no evil?
How the big tech firms made monkeys out of us - and how to make them good again

Types of feature

- **Ideas or discoveries that overturn important scientific ideas or common assumptions**
  - Something's wrong with the sun
  - Unlimited willpower
-
- **Ideas or discoveries that make you go WOW!**
  - Heal yourself from within a dream
  - Antigravity: when things fall up
  -
- **Discoveries that answer long-standing scientific questions**
  - Real life Maxwell's demon experiment
  - Ocean observatories
  -
- **Authoritative reporting on the science behind stories of public concern** ("you've read about this issue; here's what the evidence says". Good if conclusions are unexpected.)
  - Frack on or frack off?
  - Nuclear war
  - Radicalisation
  -
- **Things that are great or helpful to know, often related to health or self-improvement** (aka: "news you can use")
  - Exercise myths
  - How to make and break habits

Technology trends poised to change the way the world works (trick is to get ahead of the curve or move the story on)

- The right questions about AI
- Universal basic income

The definitive guide to… (This is probably a difficult pitch because many of the ideas are not new. But still worth a try if you know your stuff)

- The multiverse
- Numbers
- What we learned from Cassini

Fun, quirky or unusual stories with a science or technology angle (especially at Christmas. But pitch us these in June!)

- New blue
- Chocolate quarantine centre

"Nerdnip" (stories that take you inside some world you've never thought about before)

- Wind atlas
- Problem with fences

Amazing yarns (just amazingly told stories, often with well-developed locations, characters and plots)

- Quasicrystal quest
- Unexplained fairy circles

Coverlines

- Features generally go on the cover and we have two lines to do sell them there. General idea is:

1. Grab attention
2. Convert that attention into curiosity

- TIPS:
- Overall you're looking to create a curiosity gap that needs filling
- Engage people emotionally, not just intellectually. Eg use humor, puns, cultural references, jokes.
- Rhythm
- Gappy words like "secret" can help..

Pitching

- Get in touch early with a paragraph to check we aren't already doing it and check we're vaguely interested
- Assuming answer is positive, demonstrate that the feature has all the necessary ingredients
- Simple as that!

Intros

- Straight into the action?
- Dropped intro
- Witty/funny intro
- Think of the “e” shape
- You want to convince people they’re in good hands

Something familiar: you instantly “get” it.

Surprise!

ON 11 November last year, a small birthday party was held in an apparently unremarkable hangar on the outskirts of Geneva, Switzerland. Nothing too fancy, just a few people gathered around a cake. The honourees were there. Well, sort of – they were still locked in the cage where they had spent their first year. But then again, there is no other way to treat a brood of antimatter particles.

The antimatter realm is so bizarre as to be almost unbelievable: a mirror world of particles that destroy themselves and normal matter whenever the two come into contact. But it’s real enough. Cosmic rays containing antiparticles constantly bombard Earth. A banana blurts out an anti-electron every hour or so. Thunderstorms produce beams of the stuff above the planet.

Making and manipulating antimatter ourselves is a different kettle of fish. Hence that birthday party held at the particle physics centre CERN, celebrating on behalf of a quadruplet of antiprotons. There’s a lot we would like to learn from these caged beasts and their ilk, not least this: do they fall up?

Introduce a cool idea
Create a curiosity gap

It’s a scene…

Humour

LOS ANGELES, 2025. Two police detectives gaze at a body sprawled on the floor of a seedy hotel room. One scans test results on a tablet screen. “No prints or DNA. If this was our guy, he was careful to clean up.” Her partner sweeps a microbe sensor through the musty air. The readout pings: a match. “It was him. Six hours ago. Looks like he moved back in with his girlfriend.” A grunt. “And they got a new dachshund.”

Like our hapless suspect, we all leave traces of our microbes behind. We are haloed by an invisible nebula of bacteria, fungi and viruses. It’s inevitable that this gets transferred onto the things we touch, the people we meet, even the air we pass through. It’s our vaporous calling card. Recently we have started learning to unravel its message, and the results look set to change forensic science and policing for good.

Promise

Generate curiosity

KWANDENGEZI is a beguiling neighbourhood on the outskirts of Durban. Its ramshackle dwellings are spread over rolling green hills, with dirt roads winding in between. Nothing much to put it on the map. Until last year, that is, when weird signs started sprouting, nailed to doors, stapled to fences or staked in front of houses. Each consisted of three seemingly random words. Cutaway.jazz.wording said one; tokens.painted.enacted read another.

In a neighbourhood where houses have no numbers and the dirt roads no names, these signs are the fastest way for ambulances to locate women going into labour and who need ferrying to the nearest hospital. The hope is that signs like this will save lives and be adopted elsewhere. For the residents of KwaNdengezi in South Africa aren't alone – recent estimates suggest that only 80 or so countries worldwide have an up-to-date addressing system. And even where one exists, it isn't always working as well as it could.

Poor addresses aren't simply confusing: they frustrate businesses and can shave millions of dollars off economic output. That's why there's a growing feeling that we need to reinvent the address – and those makeshift three-word signs are just the beginning.

"The intro illustrates a wider thing you should care about"

"Read on to find out more"

Intro

Billboard

Backstory

Meat

Twists and turns come here

Pay off

Ending

Paragraphs

- You want to avoid: “Another aspect is xxxx”
- Instead create a sense of progression
- Make your transitions smooth and elegant.
- Think about them like the story in miniature – strong start and finish, with any boring but necessary details (eg people’s affiliations) buried in the middle

What was this primeval atom, and where did it come from? Such questions can't be posed without some trepidation. Stephen Hawking famously argued that asking what came before the big bang is like asking what is north of the north pole. Since time itself was created at that moment, he reckoned, the question of a prior origin is meaningless.

That hasn't stopped physicists from trying to pick it apart. Lemaître himself floated the possibility of a phoenix universe, whose expansion slows, reverses and ultimately collapses into a new primeval atom – before bursting outwards into life once again.

A more elaborate version of this cyclical story was proposed at the turn of this century by Paul Steinhardt at Princeton University, Neil Turok, then at the University of Cambridge, and others. In their ekpyrotic hypothesis – a name derived from an Ancient Greek word for a conflagration – an early speck of our universe drifted around in another dimension, eventually smashing into another universe, liberating untold energy and sparking explosive growth.

Wild as that may sound, some proposals get wilder. Take inflation, a widely supported theory that supposedly explains how the primeval atom blew up from something infinitesimal, before expanding at the more leisurely pace we see today. This growth spurt was instigated by a random fluctuation in a quantum field, and something similar could happen at any time and any place. That not only means that other universes could be invisibly branching off from ours, but also suggests our own universe could be one branch of an infinitely old multiverse.

Yet whether we invoke ekpyrotic collisions or infinite inflation, attempting to demystify the big bang as a moment that recurs throughout eternity doesn't get us any closer to describing exactly what happens in that key moment.

Thanks a lot!!

- Other feature editors are available…
- Not all stories are features…
- Not all stories are best sold to NS…

- Thanks: to Richard Webb, Graham Lawton and may others at NS

Quirky or unsual stories
Mysteries
Physics
Chemistry
Transport/engineering

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