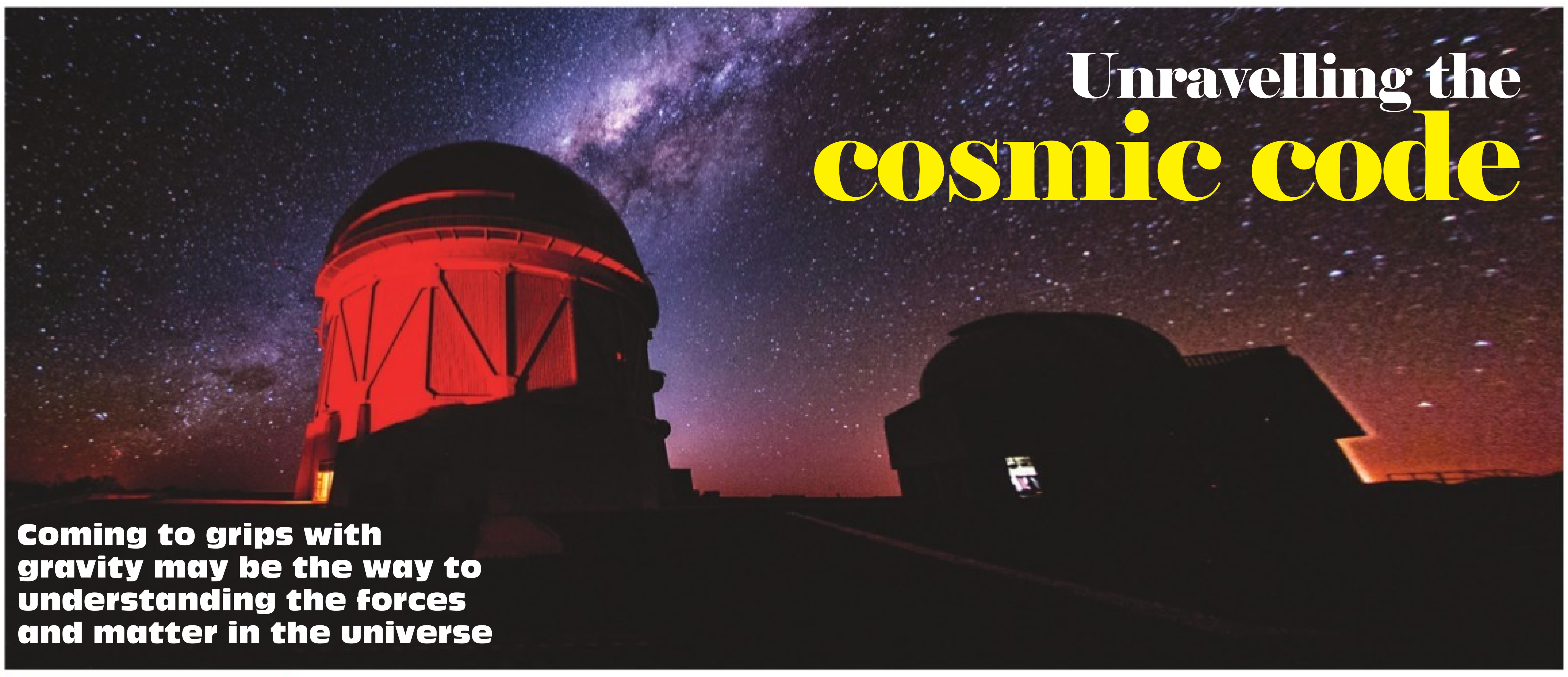
Unravelling the cosmic code



Coming to grips with gravity may be the way to understanding the forces and matter in the universe

S ANANTHANARAYANAN

Detection of gravity waves and the Nobel Prize for the pioneers has put the focus on Albert Einstein's formulation of gravity as a geometric effect that masses have on the structure of space itself. The force of gravity, however, is manifested at the level of planets, stars and the universe and can hardly be made out between objects of normal experience.

On the surface of the Earth, of course, our planet exerts a force on each of us, which we believe we feel. Theoretical physicist and author, Nicholas Mee, however, in his book, *Gravity — Cracking the cosmic code*, argues that none of us has ever felt the force of gravity, for one is weightless during free fall under gravity. What we feel, as our weight, is the reaction of our bones and muscles, to the resistance that the ground we stand upon exerts to hold us where we are.

With this encouraging start, that we do not feel gravity, Mee takes his readers through a rapid, 360 page, guided tour of centuries of contemplation in physics, mathematics, astronomy, art and symmetry, the cosmos and its origin from the Greeks to Galileo, Copernicus, Tycho Brahe and Kepler, to Newton, and then to Einstein and the moderns, on to Stephen Hawking and those that followed. The narration brings characters into the story in sequence, as they introduce, or morph into succeeding roles, along the progress from primitive wonder in the presence of the night sky to the present-day comprehension of how the universe has evolved.

The book starts with an account of the Greek geometers and philosophers who described the first cosmologies. The circle was the perfect shape and the motion of the heavens was naturally described in circles. In keeping with religious beliefs, which assumed divine sanction to these early notions, the first astronomers devised complex mechanisms, based on circles, and faithful to God's Earth being the centre of the universe, to predict tides and the seasons and to explain the movements of the planets.

Astronomers finally discarded the notion of a fixed Earth and recognised the sun as the centre of the Solar System. And then, the advent of the telescope brought into view things in the night sky that had never been seen before. Other planets were seen to have satellites and new planets were discovered. By sighting stars from different locations, when the Earth had changed position from one side of the sun to the other, the stars were seen as not fixed in a shell around the planets, but at great distances. The universe, in a sense, began to expand!

The orbits of planets were found to be not real circles, but ellipses, planets were found to go faster when nearer their host, and the idea grew of an attractive force that grew weaker by the square of the distance. Mee, in his book, systematically builds the run-up to Isaac Newton and his monumental contribution, to mathematics, the laws of dynamics and the law of gravitation, which drove the clockwork precision of the solar system, asteroids and comets.

Newton's formulation of gravity explained the motion of the planets with great accuracy. It was known that, the axes of spinning objects would go around in circles, like the motion of a spinning top. As planets had spin, these movements were observed in the planets too. In the case of Mercury, the innermost of the planets in the Solar System, however, the speed with which the axis of the planet's spin went around did not agree with what was worked out. This was a long-standing mystery, and one explanation attempted was there was another planet, Vulcan, yet to be discovered, whose presence led to this effect on Mercury.

Albert Einstein enters when electricity and magnetism have been understood and elegantly described by James Clerk Maxwell. There was, however, a question of what it was that filled space, even where there was a vacuum, which electromagnetic waves, of which visible light was a form, could traverse. If there was "ether", the medium of light, then, the speed of light should vary in different directions on Earth, for it moved through the ether at 30 kms a second. The problem arose when experiment showed that the speed of light was the same in all directions.

As Maxwell's equations gave the speed of light with no reference to the speed of a source, Einstein reasoned that discrepancies in the way speeds added up must arise from the way we regard distance and time. In the Special Theory of Relativity, so called because it ignores gravitational effects, it is length and time that depend on the relative motion of an object and its observer, and the physical laws work equally for both, so long as one is in uniform motion with respect to the other.

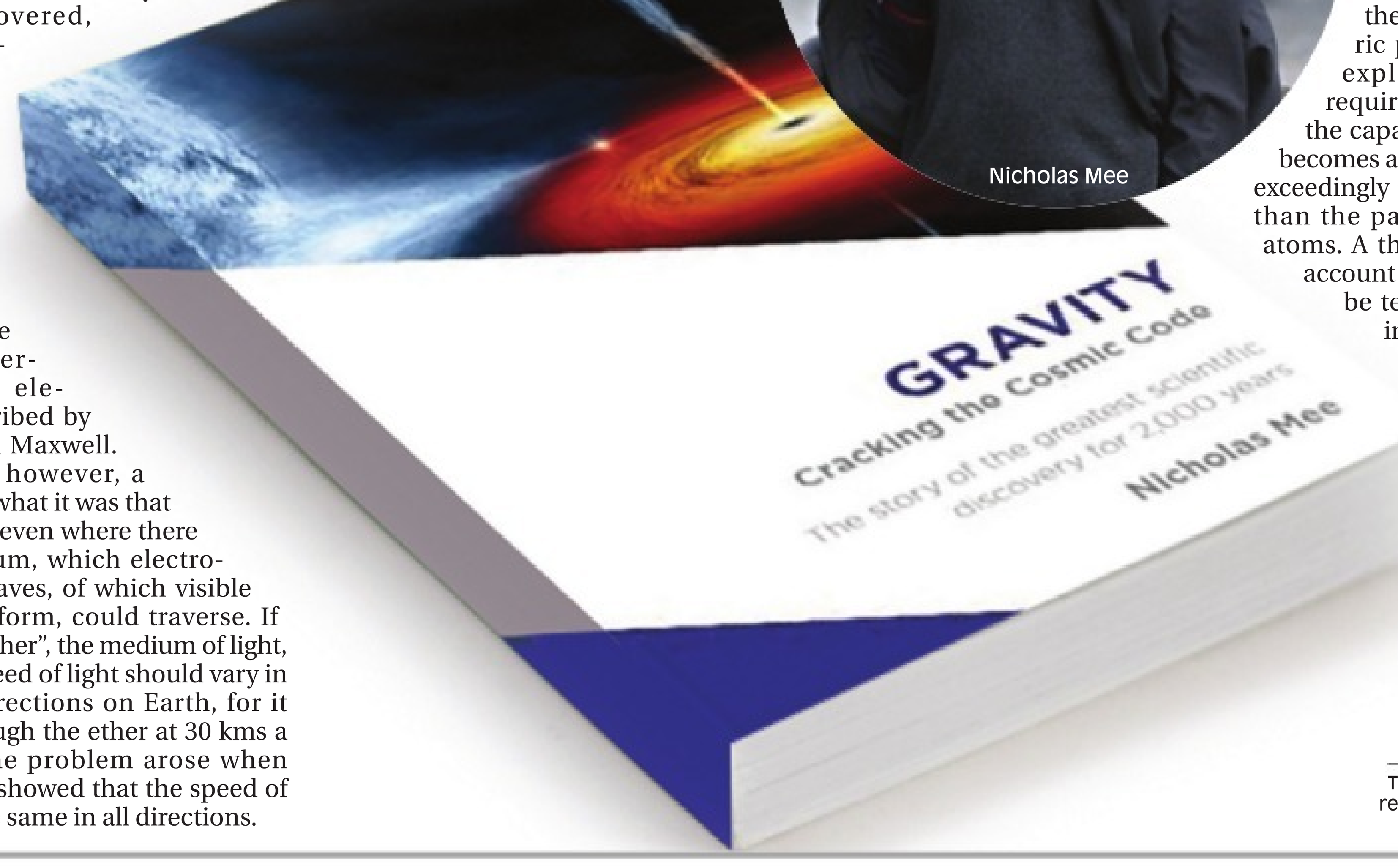
Hence, moving clocks run slower and measuring rods shrink when they move. And then, the mass of a moving body increases with the speed, and mass and energy are equivalent. And as energy used to propel a body gets used up with the increase in mass, no object can move at the speed of light.

Now, mass is the bedrock of the older mechanics, where a heavier body needs a stronger force to set it moving. If heavy and light bodies fall to the ground with the same speed, it is because the heavier body is attracted to the earth with the greater force required to set it moving. Einstein saw something not quite clear in this. Could it be just coincidence that the force of gravity on a body was the same as the force needed to set it in motion? Or was there some principle of the universe that was involved?

With perseverance and abstract mathematics, Einstein arrived at a formulation of gravity as an effect that the presence of a mass has on the shape of space, which is the reason for the attraction of masses, rather than a mysterious "action at a distance", imagined by Newton. And with this formulation, Einstein showed that in the strong gravity felt by Mercury, there was a deviation from Newtonian mechanics and the difference in the speed of rotation of the axis of spin.

The Special Theory of Relativity has also profoundly affected understanding of the working of the sub-atomic world. At this scale, particles behave like waves, and energy and mass are routinely transformed from one to the other. As the particles are small, however, gravitational effects are irrelevant.

Nicholas Mee



Mee leads readers through the maze of ideas used to understand the sub-atomic world. If the first cosmologies were geometric and Einstein saw gravity as a geometric effect that mass had on space, the theories of the elements of matter are built around symmetries and topologies. Mee guides the reader through the different concepts that result in the Standard Model, an extremely successful description of the sub-atomic world, but one that ignores gravity. One important idea is that while the elementary particles of nature, like photons or electrons, are either components of matter or carriers of forces, theories, like Stephen Hawking's String Theory, that attempt to blend electromagnetism — the forces found in atoms and the force of gravity — propose "supersymmetry" where force carrying particles have corresponding matter particles, and vice versa.

Experiments such as the Large Hadron Collider, at CERN, aim to create the high energies needed for these heavy, supersymmetric partners to appear. Mee explains that the energies required are even higher than the capacity of the LHC. Gravity becomes a relevant effect only at the exceedingly small scale, smaller even than the particles in the nuclei of atoms. A theory of matter that can account for gravity would need to be tested at this scale, which implies very high energies.

The confirmation that gravity waves exist holds out the hope of conducting "gravity wave astronomy", which would investigate the very ancient and high energy universe. This, possibly, would help resolve what is outside the capacity of man-made particle accelerators.

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An ancient habit

The science behind why some people love animals and others couldn't care less

JOHN BRADSHAW

The recent popularity of "designer" dogs, cats, micro-pigs and other pets may seem to suggest that pet keeping is no more than a fad. Indeed, it is often assumed that pets are a Western affectation, a weird relic of the working animals kept by communities of the past.

Some people are into pets, however, while others simply aren't interested. Why is that the case? It is highly probable that our desire for the company of animals actually goes back tens of thousands of years and has played an important part in our evolution. If so, then genetics might help explain why a love of animals is something some people just don't get.

In recent times, much attention has been devoted to the notion that keeping a dog (or possibly a cat) can benefit the owner's health in multiple ways — reducing the risk of heart disease, combating loneliness, and alleviating depression and the symptoms of depression and dementia.

As I explore in my new book, there are two problems with these claims. First, there are a similar number of studies that suggest that pets have no or even a slight negative impact on health. Second, pet owners don't live any longer than those who have never entertained the idea of having an animal about the house, which they should if the claims were true. And even if they were real, these supposed health benefits only apply to today's stressed urbanites, not their hunter-gatherer ancestors, so they cannot be considered as the reason that we began keeping pets in the first place.

The urge to bring animals into our homes is so widespread that it's tempting to think of it as a universal feature of human nature, but not all societies have a tradition of pet-keeping. Even in the West there are plenty of people who feel no particular affinity for animals, whether pets or not.

The pet-keeping habit often runs in families — this was once ascribed to children coming to imitate their parents' lifestyles when they leave home, but recent research has suggested that it also has a genetic basis. Some people, whatever their upbringing, seem predisposed to seek out the company of animals, others less so.

So the genes that promote pet-keeping may be unique to humans, but they are not universal, suggesting that in the past some societies or individuals — but not all — thrived due to an instinctive rapport with animals.

The DNA of today's domesticated animals reveals that each species separated from its wild counterpart between 15,000 and 5,000 years ago, in the late Palaeolithic and Neolithic periods. Yes, this was also when we started breeding livestock. But it is not easy to see how this could have been achieved if those first dogs, cats, cattle and pigs were treated as mere commodities. If this were so, the technologies available would have been inadequate to prevent unwanted interbreeding of domestic and wild stock, which in the early stages would have had ready access to one another, endlessly diluting the genes for "tameness" and thus slowing further domestication to a crawl — or even reversing it. Also, periods of famine would also have encouraged the slaughter of the breeding stock, locally wiping out the "tame" genes entirely.

But if at least some of these early domestic animals had been treated as pets, physical containment within human habitations would have prevented wild males from having their way with domesticated females; special social status, as afforded to some extant hunter-gatherer pets, would have inhibited their consumption as food. Kept isolated in these ways, the new semi-domesticated animals would have been able to evolve away from their ancestors' wild ways, and become the pliable beasts we know today.

The very same genes that today predispose some people to take on their first cat or dog would have spread among those early farmers. Groups which included people with empathy for animals and an understanding of animal husbandry would have flourished at the expense of those without, who would have had to continue to rely on hunting to obtain meat. Why doesn't everyone feel the same way? Probably because at some point in history the alternative strategies of stealing domestic animals or enslaving their human carers became viable.

There's a final twist to this story — recent studies have shown that affection for pets goes hand-in-hand with concern for the natural world. It seems that people can be roughly divided into those that feel little affinity for animals or the environment, and those who are predisposed to delight in both, adopting pet-keeping as one of the few available outlets in today's urbanised society.

As such, pets may help us to reconnect with the world of nature from which we evolved.

The writer is a visiting fellow in anthrozoology at the University of Bristol, UK

The Independent

PLUS POINTS

Death by starvation

Thousands of tiny baby penguins starved after changing weather forced their parents to trudge across Antarctica in search of food amid the changing climate.

A colony of 18,000 pairs of Adélie penguins in Terre Adélie, Antarctica suffered the catastrophic breeding failure earlier this year, according to the World Wildlife Fund. The incident happened because unusually extensive sea ice forced their parents to travel further in search of food, leaving their chicks at home to starve, a reminder of the horrifying effects of the changing climate.

The penguins are known as one of the hardiest creatures on the Earth. But they are feeling the horrifying effects of global warming, with campaigners warning that the event should force people to take notice of their problems.

Though Adélie penguins are generally doing well in East Antarctica, where they mostly eat krill, a small shrimp like crustacean. But they are declining in the peninsula, where the effects of climate change are already being felt.

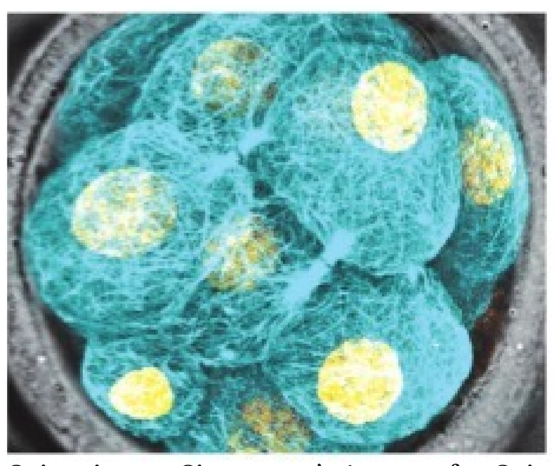
Four years ago, the same colony had another, similar catastrophic shock. It consisted of 20,196 pairs then — and not a single one was able to produce a chick. That time around, unusual amounts of sea ice combined with warm weather and rain, before a rapid drop in temperature. Many of the chicks became saturated and froze to death.

"Adélie penguins are one of the hardiest and most amazing animals on our planet," said Rod Downie, head of polar programmes at WWF, "The risk of opening up this area to exploratory krill fisheries, which would compete with the Adélie penguins for food as they recover from two catastrophic breeding failures in four years, is unthinkable."

A Marine Protected Area would allow the penguins to be kept from activities that could further reduce their numbers, said scientists who work there. "The region is impacted by environmental changes that are linked to the breakup of the Mertz glacier since 2010," said Yan Ropert-Coudert, who leads the penguin programme at the research station next to the colony.

The Independent

Cellular skeleton



Scientists at Singapore's Agency for Science, Technology and Research have discovered how mammalian cells build their internal skeletons during the earliest stages of life. Every cell in the body has an internal skeleton, made of hundreds of fibres called microtubules.

Microtubules grow from a region of the cell known as the centrosome. But in the early stages of embryonic development, cells lack centrosomes; so it has long been a mystery how cells begin to build their skeletons during the earliest stages of life.

Institute of Molecular and Cell Biology researchers have discovered a structure inside cells from which microtubules emanate. This newly-discovered structure called the "microtubule organising centre", seen here as a bridge-like structure connecting a pair of cells, acts as the centrosome of the cell before its formation.

This image of a live mouse embryo at the eight-cell stage of development was imaged in real time using laser-scanning microscopes. Microtubule filaments that form the skeleton of the cells are marked in blue, and the nucleus of each cell in orange.

The image also shows two newly-discovered "microtubule organising centres", prominent bridge-like structures responsible for the formation of cell skeletons during early embryonic development.

The research team, led by Nicolas Plachta at IMCB, believes this discovery will form the basis for new methods to monitor the development of human embryos used in assisted reproduction, and pre-implantation genetic diagnosis — a procedure used to help identify genetic defects within embryos before they are implanted.

The IMCB findings were published in the leading scientific journal Science last month.

The Straits Times/ANN