On land and under the sea


A fairy circle in the Namib desert


From the paper in Science Advances
The arrow shows Fairy Circle in a P.Oceanica meadow in the Adriatic Sea, as seen from the coast. The picture on the right is of the same Fairy Circle, as seen in a Google Maps satellite image.

When water is scarce, vegetation regulates where it grows, so that it conserves the resource

S ANANTHNARAYANAN

Meadows and vegetation in arid areas sometimes form bare patches, circular and regularly spaced, and are usually surrounded by a ring of more than normal growth. The patches are two to 15 metres across and the remarkable feature is that they distribute themselves in a pattern of hexagons. They are best viewed from a distance and can be seen clearly in satellite images.

The mechanism by which these patches form and why they distribute themselves in a pattern has been a subject of conjecture and somewhat inconclusive study. Earlier this year, Corina E Tarnita, Juan A Bonachela, Efrat Sheffer, Jennifer A Guyton, Tyler C Coverdale, Ryan A Long and Robert M Pringle at Princeton, Idaho, Glasgow, Israel and Kenya, in a paper in the journal *Nature*, brought together the two principal but competing lines of thought on the subject. Another group comprising Daniel Ruiz-Reynés, Damià Gomila, Tomàs Sintes, Emilio Hernández-García, Núria Marbà and Carlos M Duarte, working in Spain and in Saudi Arabia, now propose, in the journal, *Science Advances*, a model to explain the same formations that have been found on the seabed.

A simplistic explanation of fairy circles, as these formations are called, is that grasses position themselves along the periphery of circular patches so that moisture can collect in the central portion, to the benefit of those that stand outside the circle. What this explanation lacks, however, is the mechanism by which this prudent behaviour comes about.

One theory is the action of termites and other insects that feed on the grass in the centre. The other theory is based on "scale dependent feedback", and a tendency for plants to stick with close neighbours and move away from the distant ones. Thus, plants on the periphery of any bare spot would benefit from the greater nutrition saved for them by the bare spot. If they were to move to colonise the bare spot, there would be negative consequences but widening, in the form of a circle, would lead to the greatest benefit of the plants in the periphery.

A proposed mechanism is that the patches start when some plants defeat others in the competition for scarce resources. The patches are then maintained, and grow, because any plant that moves into the circle needs to compete with the stronger plants in the periphery. This is till the patch grows so large that the competitive advantage at the periphery is reduced and the patch gets invaded.

And then there are mathematical models that describe how it is the distribution of different patches in hexagons that maximises the benefit for each of the patches. This is based on the idea that patches are competitors and it is best for each patch to stay stable, equidistant from neighbours in the hexagon pattern.

That a matrix made of hexagons allows many entities to be equidistant from neighbours is seen in many places in nature, one being the patterns that pigments make on animal coats. Another ready example is the way the "base stations" of a cellular phone network are positioned, so that each one is insulated from all others by the six surrounding base stations.

The other, competing model of fairy circles, which may be more empirical, is that the circles arise because of termites that feed on the plants inside the circle. While this explains how the circles arise, there are also instances of patterns that action of insects form over an area. The paper in *Nature* cites the instance of social insects, which build nests like ant-hills. While the insects exploit the surrounding of the nest, reproductive individuals, like new queens or kings, move out to start other colonies. Colonies, however, cannot be close together, as there would be insufficient resources and conflict. A series of nests would hence, in time, tend to form a regular, hexagon-based pattern over a large area.


Fairy circles under the Mediterranean Sea

While these two ideas of how fairy circles come about have so far claimed that one or the other is correct, Corina E Tarnita and her group find that both theories are valid as well as necessary. While it is competing for resources that leadsto the decline of plants within the circles, it is the termites that make sure the circles remain bare and able to concentrate moisture. The presence and the evolution of termites is clearly an adaptation to the adaptation of the grass varieties to shrinking water sources.

The research team then integrated the two models of how fairy circles arise and the interplay of both mechanisms has been found better able to explain the self-organisation of vegetation landscapes as well as make predictions about features that were not noticed before, the paper says.

As fairy circles have been observed only in semi-arid areas, it would come as a surprise that these formations have been found in grasslands that cover parts of the bottom of the sea! The group writing in the journal, *Science Advances*, studies the meadows of the seagrass, *Posidonia Oceanica*, an important part of the ecosystem in the Mediterranean Sea. These grasslands also show complex self-organisation patterns, which have not been noticed so far, the paper says. The mechanism behind fairy circles under the sea is clearly different from that in semi-arid areas and the mechanism has only partly been understood, the paper says.

Seagrass meadows are found along the shoreline of all continents except Antarctica and they provide valuable ecosystem services, the paper says. But they are also among the most threatened of ecosystems in the world. *P Oceanica*, the dominant seagrass of the Mediterranean, supports great biodiversity and is a major agent of $C0_2$ sequestration. But human-caused factors are reducing *P Oceanica* by 6.9 per cent every year. And as it grows and spreads very slowly, the losses are essentially irreversible, the paper says.

The group has developed a model to explain the emergence of the fairy circle seascape and the model shows that the patterns that are seen are the result of local imbalances of competing plant varieties. The model can be extended to other seascape instances and can be used as an indicator of how close the seagrass meadow being observed is to extinction.

This capacity of the model is an important tool to monitor environmental degradation and guide conservation measures, the paper says.

The writer can be contacted at response@simplescience.in

From fantasy to possibility

A breakthrough in human embryo editing could help rid babies of genetic diseases. But the ethical and legal considerations need urgent work, experts have warned

ANDREW GRIFFIN

A landmark study suggests that scientists could soon edit out genetic mutations to prevent babies being born with diseases. The technique could eventually let doctors remove inherited conditions from embryos before they go on to become a child.

That, in turn, opens the possibility for inherited diseases to be wiped out entirely, according to doctors. But experts have warned that urgent work is needed to answer the ethical and legal questions surrounding the work.

Though the scientists only edited out mutations that could cause diseases, it modified the nuclear DNA that sits right at the heart of the cell, which also influences personal characteristics such as intelligence, height, facial appearance and eye colour.

The breakthrough means that "the possibility of germline genome editing has moved from future fantasy to the world of possibility, and the debate about its use, outside of fears about the safety of the technology, needs to run to catch up", said Professor Peter Braude from King's College London. Scientists warned that soon the public could demand such treatment and that the world might not be ready.

"Families with genetic diseases have a strong drive to find cures," said Yalda Jamshidi, reader in genomic medicine at St George's, University of London. "Whilst we are just beginning to understand the complexity of genetic disease, gene-editing will likely become acceptable when its potential benefits, both to individuals and to the broader society, exceeds its risks."

The new research, published in *Nature*, marks the first time the powerful Crispr-Cas9 tool has been used to fix mutations. The US study destroyed the embryos after just a few days and the work remains at an experimental stage.

In the study, scientists fertilised donor eggs with sperm that included a gene that causes a type of heart failure. As the eggs were fertilised, they also applied the gene-editing tool, which works like a pair of specific scissors and cuts away the defective parts of the gene.

When those problematic parts are cut away, the cells can repair themselves with the healthy versions and so get rid of the mutation that causes the disease. Some 42 out of 58 embryos were fixed so that they didn't carry the mutation — stopping a disease that usually has a 50 per cent chance of being passed on.

If those embryos had been allowed to develop into children, then they would no longer have carried the disease. That would stop them from being vulnerable to hypertrophic cardiomyopathy — and would save their children, too.

"Every generation on would carry this repair because we've removed the disease-causing gene variant from that family's lineage," said Dr Shoukhrat Mitalipov, from Oregon Health and Science University, who led the study. "By using this technique, it's possible to reduce the burden of this inheritable disease on the family and eventually the human population."

The heart problem is just one of more than 10,000 conditions that are caused by an error in the gene. The same tool could be used to cut out faults for all of those, and eventually be used to target cancer mutations.

The work could lead to treatments that would be given to patients, once it becomes more efficient and safe. Using such a treatment on humans is illegal in both the US and the UK — but some experts expect that law will soon be changed, and that the legal and ethical frameworks need to catch up with the technology.

There is some suggestion that the editing work could take place in the UK. Though using the research as treatment is illegal there as well as the US, the regulatory barriers are much higher in America and look unlikely to be changed.

In the US, there are various regulations and restrictions on how embryos can be edited, including stipulations that such work can't be carried out with taxpayers' money. UK regulators are more relaxed and liberal about those restrictions, leading to suggestions that it could eventually become the home of such work in the West.

The UK has become the first country that allows mitochondrial replacement therapy, another treatment that opponents warn could allow for the creation of designer babies. "UK researchers can apply for a licence to edit human embryos in research, but offering it as a treatment is currently illegal," said a spokesperson for the Human Fertilisation and Embryology Authority, which would regulate any such experiments.


Individual cells, a few days after injection

"Introducing new, controversial techniques is not just about developing the science — gene editing would need to offer new options to couples at risk of having a child with a genetic disease, beyond current treatments like embryo testing.

"Our experience of introducing mitochondrial donation in the UK shows that high-quality public discussion about the ethics of new treatments, expert scientific advice and a robust regulatory system are crucial when considering new treatments of this kind."

Doctors said that any change in the law would have to strictly keep such treatment to being used for medical reasons, and not for "designer babies" that have other characteristics edited out.

"It may be that some countries never permit germline genome editing because of moral and ethical concerns," said Professor Joyce Harper from University College London. "If the law in the UK was changed to allow genome editing, it would be highly regulated by the Human Fertilisation and Embryology Authority, as is PGD, to ensure it is only used for medical reasons."

But that work has already received significant opposition. Dr David King, director of the Human Genetics Alert, which opposes all tampering with the human genome, said, "If irresponsible scientists are not stopped, the world may soon be presented with a *fait accompli* of the first genetically-modified baby. We call on governments and international organisations to wake up and pass an immediate global ban on creating cloned or GM babies, before it is too late."

Professor Robin Lovell-Badge from the Francis Crick Institute said the research only appears to work when the father is carrying the defective gene, and that it would not work for more sophisticated alterations. "The possibility of producing designer babies, which is unjustified in any case, is now even further away," he said.

The independent

PLUS POINTS

Fatal heat by 2100

Climate change could soon make it fatal to even go outside in some parts of the world, according to a new study. Temperatures could soar so much in southern Asia by the end of the century that the amount of heat and humidity will be impossible to cope with and anyone going outside would die.

The study used new research that looked at the way humidity changes how people's bodies can deal with heat. Temperatures and the amount of moisture will mean that the body will simply be unable to cool itself and so people will die, the researchers found. The regions likely to be hardest hit include northern India, Bangladesh and southern Pakistan, home to 1.5 billion people.

The evidence is based on recent research showing the most deadly effects of hot weather come from a combination of high temperature and high humidity. This is recorded using a measurement known as "wet-bulb" temperature, which reflects the ability of moisture to evaporate. When wet-bulb temperatures reach 35C, the human body cannot cool itself enough to survive more than a few hours. In today's climate, wet-bulb temperatures have rarely gone above 31C anywhere on Earth. But in 2015, the limit was almost reached in the Persian Gulf region, during a year when heat killed an estimated 3,500 people in Pakistan and India.

The new research shows that without serious reductions in greenhouse gas emissions, extreme heat waves could raise wet-bulb temperatures to between 31C and 34.2C. "It brings us close to the threshold of survivability, and anything in the 30s is very severe," said study author Elfatih Eltahir, from Massachusetts Institute of Technology in the US.

By 2100, around 70 per cent of India's population was expected to suffer occasional exposures to 32C wet-bulb temperatures, the researchers wrote in the journal *Science Advances*. And two per cent could be subjected to deadly heat at the 35C limit.

Eltahir added, "With the disruption to the agricultural production, it doesn't need to be the heat wave itself that kills people. Production will go down, so potentially everyone will suffer."

The independent

Smaller the better

Scientists at the University of Sheffield in the UK have discovered a new insight into how one of the most common hospital superbugs causes infections — something which could be used to develop new antibiotic treatments.

The study, led by researchers from the University of Sheffield's department of molecular biology and biotechnology, investigated how *Enterococcus faecalis* — bacteria commonly found in the digestive tracts of humans and multi-resistant to antibiotics — can out-compete other microorganisms and cause life-threatening infections.

E faecalis is frequently responsible for causing hospital-acquired infections such as urinary tract infections, heart valve infections and bacteraemia, however scientists currently have a poor understanding of how this happens.

Now, the University of Sheffield-led research team has discovered several complex mechanisms controlling the maintenance of the distinctive shape of *E faecalis* that forms cell pairs or short chains of cells. The team has revealed that the formation of short chains of cells is a crucial factor in stopping bacteria being recognised as a threat by the immune system. This then enables infection to spread.

Dr Stéphane Mesnage, who led the research, said, "*E faecalis* is an opportunistic pathogen. It is naturally resistant to a wide range of antibiotics, including synthetic penicillin derivatives. Following an antibiotic treatment, *E faecalis* can out-compete other microorganisms to cause infection. Our work suggests that targeting the mechanisms controlling the formation of short chains of cells could be a novel strategy for developing new treatments to fight *E faecalis* infections."