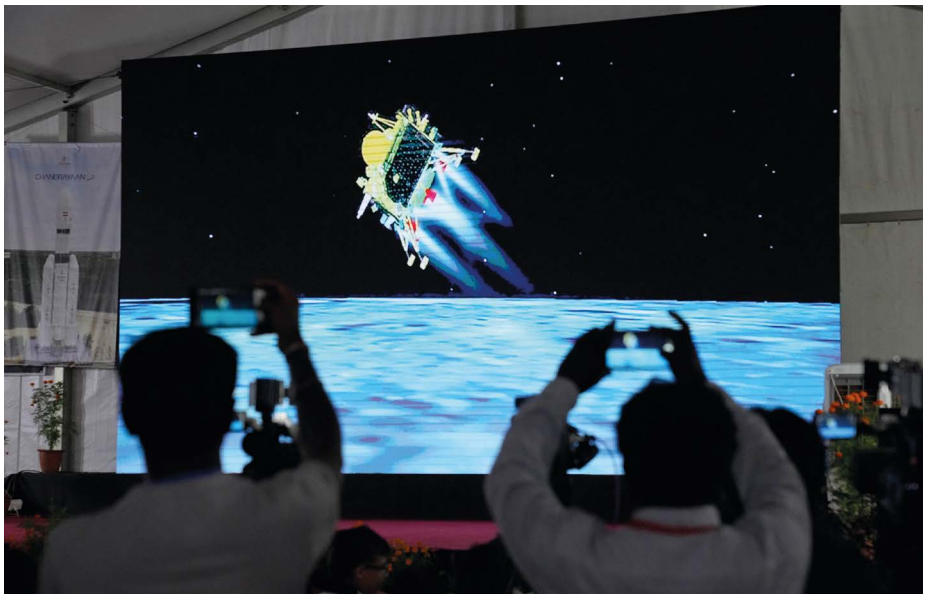


A live telecast of the Chandrayaan-3 landing.

AIJAZ RAHI/AP VIA ALAMY

The Moon's south pole — a challenging region to land in — has drawn interest from many nations because of the possibility that it contains water ice, and the large craters near it could offer clues about the composition of the early Solar System. Several missions are heading there in the coming years, and on 19 August, a Russian craft, Luna 25, crashed into the Moon just days before it was to attempt a landing at the south pole.

"The recent crash of Russia's Luna 25 spacecraft is a stark reminder of just how difficult it is to land successfully on the Moon," says Marc Norman, a planetary geochemist at the Australian National University in Canberra. Craft from Israel and Japan have also crashed while attempting controlled lunar landings. In this century, only China's Chang'e missions have landed on the Moon and conducted surface operations. The United States and the Soviet Union are the only other nations that have ever successfully landed craft on the lunar surface.

National boost

India's success instils confidence in the technological competence of the country's space industry, says Kavya Karampuri, a mission systems engineer at Bengaluru-based company KaleidEO, which specializes in Earth-observation-based space-data analytics. It could attract global investment in the Indian private space sector and foster international collaborations and innovation at Indian universities, laboratories, start-up companies and research communities, says Karampuri.

India's partially successful 2019 Chandrayaan-2 mission launched an orbiter with eight functioning instruments. But the module carrying the Moon rover crashed into the lunar surface in the final moments of its landing.

ISRO learnt from that failure and made several design changes to the lander–rover portion of the mission.

These include a laser sensor that measures the real-time velocity of the spacecraft relative to the Moon, algorithms to handle unanticipated deviations in propulsion or trajectory and to better judge the landing terrain, bigger and more numerous solar panels, more fuel and a heavier lander equipped with four sturdier legs that can handle a higher landing velocity. The craft also targeted a larger landing area: 4 kilometres by 2.4 kilometres, compared with the 0.5 kilometre by 0.5 kilometre region selected for the previous mission.

Landing at the Moon's south pole is difficult because it involves positioning the spacecraft at an angle different from that used in previous landings, and the area has rough terrain.

The spacecraft has to enter a polar orbit — in which it passes above both poles of the Moon — that is at right angles to the Moon's orbit, says Norman. "This requires additional energy to move the spacecraft into an 'unnatural' orbit, which introduces uncertainties on critical aspects such as velocity and location of the spacecraft."

A lack of detailed data on the region's gravity and surface characteristics compounds the problem, says Norman. "For example, if the spacecraft lands in a crater, on a slope, or the leg of the lander catches on a boulder, the mission could be compromised."

'Moonquakes' near the area add complexity, says geologist Saumitra Mukherjee at the Jawaharlal Nehru University in New Delhi, whose team analysed images sent by India's first lunar mission, Chandrayaan-1. That craft launched in 2008 and detected cliffs and signs of displaced underground rocks in two craters near the lunar south pole.

Poor lighting from the Sun is another challenge. "Some areas are completely in the dark, others are in the light, but with extreme sun angles, essentially blocking out any terrain features," says Torin Clark, an aerospace engineer at University of Colorado Boulder. "This is in contrast to the *Apollo* landings, where the landing sites and timing were specifically chosen to ensure quality lighting of the lunar terrain" such as rocks and craters.

Chandrayaan-3's success came about a week before ISRO's next major mission — its first to study the Sun — which is scheduled to launch in the first week of September.

WHAT IS AN EMBRYO? SCIENTISTS CALL FOR DEFINITION TO CHANGE

Lab-grown structures that could develop into fetuses could be defined — and regulated — as embryos.

By Philip Ball

It is time for a redefinition of the human embryo, a team of researchers has proposed. Advances in recent years have shown that human stem cells can be used to make embryo-like structures, called embryo models, that can recreate some features of early embryo development. Such research raises ethical dilemmas because these entities don't meet formal definitions of embryos, so are not covered by regulations governing embryo research.

In a paper published in *Cell* on 17 August[1], biologist Nicolas Rivron at the Institute of Molecular Biotechnology in Vienna and his colleagues suggest a new definition of human embryos that would include embryo models that acquire the potential to develop into a fetus.

Stem-cell researcher Berna Sozen at Yale University in New Haven, Connecticut, says

that a redefinition of the embryo would be timely, "not only to better reflect our current knowledge but also to pave the way for more accurate and inclusive discussions within the scientific community".

Clusters of cells

Embryo models are clusters of embryonic stem (ES) cells that can begin to differentiate and organize themselves in ways that resemble the development of an early embryo. (Alternatively, they can be made from induced pluripotent cells – mature cells reprogrammed into a stem-cell-like state.) Some embryo models also include cells that are the progenitors of supporting tissues in the uterus, such as extra-embryonic cells that form a yolk sac and trophoblast stem cells that produce the placenta.

Researchers can use embryo models to study development without the ethical and legal constraints that apply to real embryos. Currently, many countries follow a 2016 recommendation of the International Society for Stem Cell Research (ISSCR) that no human embryo may be cultured outside the body beyond 14 days after fertilization. The limit means that research on later developmental stages – which could help researchers to understand the causes of miscarriages and developmental defects – rely mainly on animal models, which are not always reliable guides to human development.

Last year, researchers reported mouse embryo models that could develop to a stage equivalent to an embryo 8.5 days after fertilization[2,3] – approaching half of the gestation period. The embryo models had a body axis and nascent head, limbs and heart. Human embryo models have not yet got that far, but this year some of the same researchers reported human embryo models cultured *in vitro* to the equivalent stage, 13–14 days after fertilization[4,5].

Such embryo models, resembling embryos after the stage at which they have implanted in the uterus, could not develop into fetuses even if they were to be implanted into a womb (a procedure that would be illegal for humans in many countries). But embryo models of the pre-implantation stage five to seven days post-fertilization, called blastoids, might be able to continue further along the developmental trajectory[6]. The ISSCR calls these integrated embryo models, and recommends that they be used in research only after careful review by scientific and ethical committees.

Tipping point

"It is now clear that scientific advances are narrowing the biological and therefore ethical and legal gaps between embryo models and embryos," Rivron and his colleagues wrote in the *Cell* paper. "In the future, embryo models may pass a 'tipping point' after which, in our view, most of the ethical distinctions with an embryo would disappear."

In April this year, researchers showed that blastoids made from monkey ES cells and other cell types could induce pregnancies when implanted in monkeys, although the pregnancies all aborted spontaneously[7]. "We can foresee that the most complete embryo models will at some point tip over to become embryos giving rise to individuals," says Rivron.

Legal definitions of embryos vary between countries, but are generally designed to refer to those made either by fertilization of an ovum by sperm, or by cloning – for example, by transferring a nucleus from a non-reproductive cell to an egg. No definition currently includes embryo models, says Alfonso Martinez Arias, a developmental biologist at the University Pompeu Fabra in Barcelona, Spain, and co-author of the *Cell* paper.

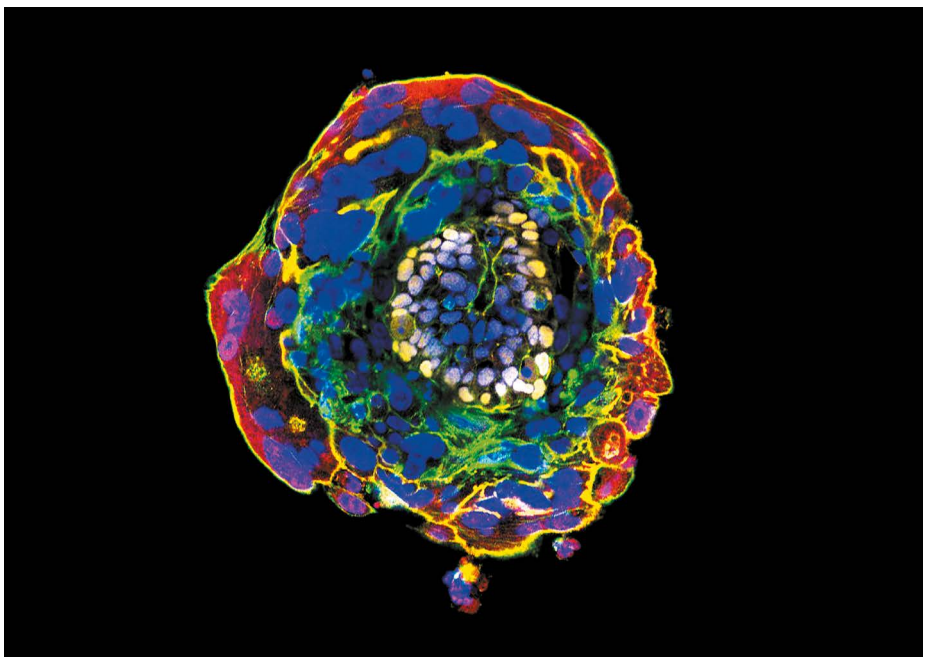
Rivron, Martinez Arias and their colleagues argue that whether or not an embryo model could grow to at least the fetal stage should be the key issue for deciding on its moral and ethical status. They propose that an embryo be defined as "a group of human cells supported by elements fulfilling extraembryonic and uterine functions that, combined, have the potential to form a fetus", and that this should hold "regardless of how they came into being". Precisely which fetal stage this refers to should be a topic for further discussion, they say.

"The most complete embryo models will at some point tip over to become embryos giving rise to individuals."

Alison Murdoch, who researches reproductive medicine at Newcastle University, UK, says that the proposal "will be critical" in a planned review of embryo-research regulations by the Human Fertilisation and Embryology Authority, an independent UK regulator.

But Sozen stresses that "none of the current human embryo models even come close to meeting this threshold". And Jacob Hanna, a stem-cell biologist at the Weizmann Institute of Science in Rehovot, Israel, says that it might be too soon for the field to start formalizing such distinctions. "Embryo models are at very rudimentary stage," he says, "and trying to make changes at such an early stage can create unwanted or misleading outcomes that are hard to resolve later."

"Currently, the formation of integrated embryo models requires the use of naive cells that rapidly accumulate genetic abnormalities and are too abnormal to form a fetus," says Rivron. But he adds that "we need to think ahead to the possibility that these technical obstacles can be removed". Martinez Arias says that what counts as a genuine embryo model, rather than as simply a cell or tissue culture, also needs consideration. Otherwise, "we are going to confuse the scientists and the public", he says.



ZERNICKA-GOETZ LAB/Y. CAMBRIDGE UNIV./SPL

Eleven days after fertilization, the cells in this human embryo have begun to differentiate.

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