



Aftershocks in the Courtroom

An Italian judge will soon decide whether 30 people died because seven experts downplayed the risk of a major earthquake in L'Aquila in 2009

L'AQUILA, ITALY—"Stay calm. See you tomorrow morning." Those were the last words that Linda Giugno heard from her brother Luigi, at about 1 a.m. on 6 April 2009. Both lived in the central Italian town of L'Aquila, and Linda had phoned Luigi, a forester, because she was frightened by the latest in a long series of small- and medium-sized tremors that had shaken the town over the previous 3 months. Luigi said he didn't think there was any danger, and that there was no need for him to wake up his wife, who was due to give birth later that day, and their 2-year-old son.

A little more than 2 hours later, at 3:32 a.m., L'Aquila was struck by an earthquake with a moment magnitude of 6.3. Luigi, his wife, son, and unborn daughter were crushed to death as the 18th century building in which they lived collapsed—four of the quake's more than 300 fatalities.

Linda Giugno told her awful tale from the witness stand in a packed, silent courtroom here in October 2011—one of the first of many moving testimonies in a controversial manslaughter trial that has gripped L'Aquila

and scientists around the world.

On trial are seven men—four scientists, two engineers, and a government official—who participated in a meeting of an expert panel of Italy's Civil Protection Department (DPC) known as the National Commission for the Forecast and Prevention of Major Risks, which met on 31 March 2009 in L'Aquila to assess the ongoing series of tremors.

After the group adjourned, two members gave a press conference, accompanied by local officials. On that occasion, prosecutors say, they gave L'Aquila's inhabitants the mistaken impression that they had nothing to fear, and as a result, some people who would otherwise have fled their homes during subsequent tremors stayed inside—and were killed on 6 April. Indeed, when the prosecutor asked Linda Giugno why her brother was so sure there would be no destructive earthquake, her answer was clear: Experts quoted on TV news reports had said that there would be no tremors stronger than those already experienced.

The trial in L'Aquila has drawn huge international attention, as well as outrage and pro-

tests. In 2010, more than 4000 scientists from Italy and around the world signed an open letter to Italian President Giorgio Napolitano, calling the allegations "unfounded," because there was no way the commission could reliably have predicted an earthquake. Alan Leshner, CEO of AAAS (the publisher of *Science*) called the indictments "unfair and naive" in a 2010 letter to Napolitano.

Yet as the trial unfolded here over the past year, a more complex picture has emerged. Prosecutors didn't charge commission members with failing to predict the earthquake but with conducting a hasty, superficial risk assessment and presenting incomplete, falsely reassuring findings to the public. They have argued in court that the many tremors that L'Aquila experienced in the preceding months did provide at least some clues about a heightened risk.

Meanwhile, a recorded telephone conversation made public halfway through the trial has suggested that the commission was convened with the explicit goal of reassuring the public and raised the question of whether the scientists were used—or allowed themselves to be used—to bring calm to a jittery town.

The trial is now in its final weeks; more than 100 witnesses have testified, including

Deadly toll. L'Aquila's 2009 earthquake killed 309 people and ruined the city's Medieval center.

geophysicists, engineers, public officials, psychologists, an anthropologist, as well as many friends and relatives of the victims. On 24 and 25 September, the prosecution presented its closing arguments in speeches totaling about 13 hours and asked for 4-year prison sentences for each of the seven defendants; this week, the defendants' lawyers were scheduled to start delivering their closing arguments. Finally, it will be up to a single judge, 43-year-old Marco Billi, to decide. His verdict is due by 23 October.

Tense and nervous

L'Aquila, the capital of the Abruzzo region, is in one of Italy's most seismically active areas. It lies practically on top of a fault that forms part of a larger system following the Apennine mountain chain for most of the length of the country. The town was struck by major earthquakes in 1349, 1461, and 1703—the latter the most lethal one, killing an estimated 2500 people. In 1985 and 1995, L'Aquila experienced so-called swarms, large numbers of fairly small tremors taking place over several weeks. They caused nervousness—but no major shock occurred.

Another swarm took place in the first few months of 2009, with tremors gradually becoming more frequent and more powerful (see graphic). They made the townsfolk increasingly tense and nervous, says geologist Antonio Moretti of the University of L'Aquila. That tension, he says, was com-

pounded by the predictions of Gioacchino Giuliani, a technician at the National Institute of Nuclear Physics near L'Aquila.

Giuliani says he can predict earthquakes by measuring increased emissions of radon gas from Earth—a theory that has been under investigation for decades but that most seismologists dismiss. Giuliani reportedly predicted that a strong tremor would strike the town of Sulmona, an hour's drive southeast of L'Aquila, on 29 March. The prediction triggered panic but it was wrong, and on 31 March, Giuliani was reported to the police for issuing an unjustified alarm, lead-



House of justice. With L'Aquila's old courthouse heavily damaged, the trial is being held in this makeshift building.

ing him to stop making public pronouncements on earthquakes.

Against this backdrop, the local magnitude of the tremors increased abruptly to 4.1 on 30 March, and Guido Bertolaso, then head of DPC, decided to convene the Major Risks Commission. Normally, the commis-

sion meets in Rome, but this time Bertolaso asked the group to travel to L'Aquila. The meeting's aim, according to a DPC press release issued on 30 March, was to "provide the citizens of Abruzzo all the information available to the scientific community on the seismic activity of the last few weeks."

Just ahead of the meeting, one of the commission members had already sounded very reassuring notes in an interview with local television station TV Uno. Bernardo De Bernardinis, then-deputy head of DPC and a hydraulic engineer, had said that the tremors posed "no danger" and that "the scientific community continues to confirm to me that in fact it is a favorable situation." The ongoing tremors helped discharge energy from the fault, De Bernardinis explained. Trial witnesses later said this was particularly reassuring because it suggested the danger decreased with each tremor. When the interviewer suggested that people could relax by pouring themselves "a good glass of wine," De Bernardinis replied "absolutely," and recommended a good Montepulciano.

The meeting itself kicked off at about 6:30 p.m. at the headquarters of Abruzzo's regional government and finished within an hour. Afterward, De Bernardinis gave a press conference along with the commission's then-vice-president, volcanologist Franco Barberi of the University of Rome (Roma Tre). They were joined by two officials who had attended the meeting:

The Seven Defendants

MEMBERS OF ITALY'S NATIONAL COMMISSION FOR THE FORECAST AND PREVENTION OF MAJOR RISKS IN 2009

REGARDED AS MEMBERS OF THE COMMISSION BY VIRTUE OF THEIR PRESENCE AT THE 31 MARCH MEETING AND THEIR EXPERTISE



Franco Barberi. Volcanologist at the University of Rome (Roma Tre), the commission's then-vice-president. Said during the meeting that the magnitude of tremors is very unlikely to increase in a swarm.



Enzo Boschi. Then-president of Italy's National Institute of Geophysics and Volcanology (INGV) and the country's most prominent geophysicist. Said the seismic swarm provided no signal of an impending major earthquake.



Gian Michele Calvi. Seismic engineer at the University of Pavia and president of the European Centre for Training and Research in Earthquake Engineering. Said future tremors shouldn't seriously damage buildings.



Claudio Eva. Seismologist at the University of Genova.



Bernardo De Bernardinis. Hydraulic engineer, then-deputy head of Italy's Civil Protection Department (DPC). Said minor tremors were "favorable" and suggested relaxing with a glass of Montepulciano.



Mauro Dolce. Seismic engineer, director of DPC's seismic risk office. Produced the meeting's official minutes.



Giulio Selvaggi. Seismologist at INGV and director of the National Earthquake Centre until he resigned in June of this year. Insists he was not a member of the commission but simply accompanied Boschi.

L'Aquila Mayor Massimo Cialente and the regional councilor responsible for civil protection, Daniela Stati.

The tenor of the statements they made, as reported in newspaper articles and television reports, was: Stay calm; it's not possible to predict earthquakes, but we don't expect a major quake is on the way. The newspaper *Il Tempo* reported De Bernardinis as saying that an increase in the magnitude of the tremors was not expected, while TV network *Abruzzo24ore* quoted Cialente as saying that "there should be absolutely no risk" of substantial damage to buildings.

Traditionally, prosecutors argued, people in L'Aquila had been trained by their parents to leave their homes as soon as they felt the ground shake, to avoid the effects of any further, potentially larger, tremors. That was what happened on the day before the meeting, when the magnitude-4.1 event happened; many people gathered near the castle or in one of the town's squares until they felt confident enough to go home. But the meeting of the Major Risks Commission changed many minds, contends the prosecution. "It was as if we were anesthetized, like someone had removed our primitive fear of the earthquake," the court was told by local surgeon Vincenzo Vittorini, whose family stayed inside the night of 5–6 April. "After that damned meeting, they instilled in us the idea that something terrible couldn't happen."

When the earthquake struck, with its epicenter little more than 3 kilometers from the town center, Vittorini lost his wife and daughter. The quake left 309 people dead, at least 1500 injured, and more than 65,000 were forced to leave their homes. More than 3 years later, the town seems frozen in time; most of the city center is abandoned, many of its streets still cordoned off, with some houses completely destroyed. Many older buildings are kept in a straitjacket of metal braces, while more modern apartment blocks have gaping holes that in some cases reveal pieces of furniture that are still standing.

A swarm's significance

With the original courthouse badly damaged in the quake, the trial is being held in a simple, bright blue building on an industrial estate several kilometers outside the town. Inside, there is barely enough room for the defendants and a small army of lawyers to sit, leaving standing room only for many friends and relatives of the victims and journalists.

For Fabio Picuti, the main prosecutor in the trial, the earthquake was the start of an unusual foray into a complex scientific field. Picuti is from L'Aquila and has spent most of his career investigating local organized crime, but he tells *Science* that he has studied the sci-



In session. Public prosecutor Fabio Picuti (left) talks to Judge Marco Billi (right).

ence of the case extensively. He argues that had the commission members properly analyzed the seismic and other data at their disposal on 31 March 2009, and conveyed the results of that analysis accurately to the public, 30 of the victims of the earthquake would not have stayed indoors on the night of 5–6 April.

In his 509-page indictment, Picuti acknowledges that the experts were right to assert that predicting earthquakes is impossible, and that making buildings resistant is the best way to reduce risks. But he argues that these statements were of little use. He told the court that the minutes of the meeting in fact show the defendants to have made a series of "banal and self-contradictory" statements,

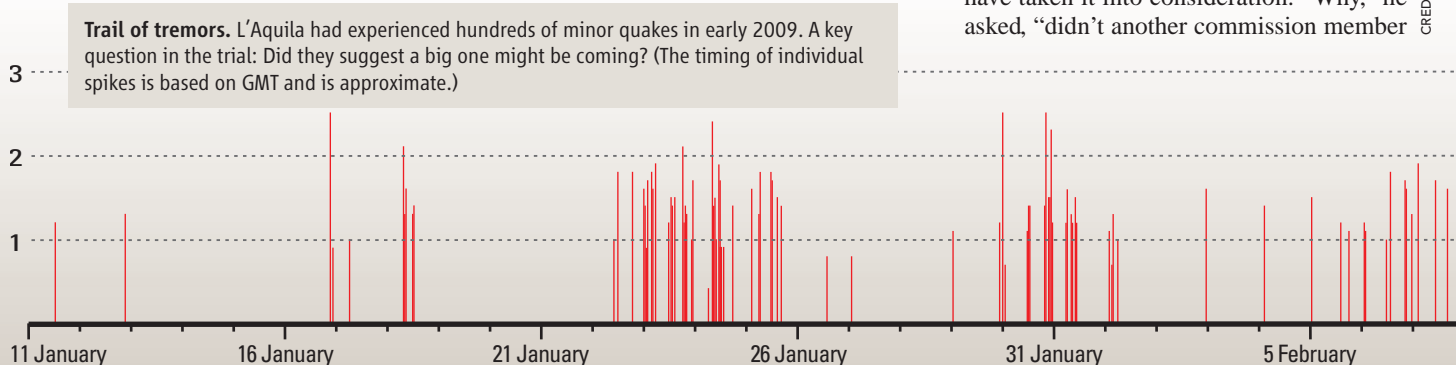
many of which were "at best scientifically useless" or, worse, "misleading."

Central to the prosecution's case is the swarm and what it implied about the risk of an impending quake. The scientists on the commission thought the swarm neither increased nor decreased the probability of a major earthquake. "A swarm, of whatever kind and of whatever duration, is never, and I underline never, a precursor of large seismic events," seismologist Giulio Selvaggi of the National Institute of Geophysics and Volcanology (INGV) told local newspaper *Il Centro* 3 weeks before the quake. (Selvaggi is one of three defendants who weren't officially on the commission but are regarded as members by the prosecution because they attended the 31 March meeting and had relevant expertise.) Barberi, who was the commission's vice-president, is quoted in a draft version of the meeting minutes as saying that "a seismic sequence doesn't forecast anything."

In their testimony, the defendants stuck to that opinion. Enzo Boschi, a geophysicist at the University of Bologna who for decades was the most prominent Italian geophysicist, told the court: "I refuse to admit that a seismic sequence, whether consisting of big or small tremors, can tell us a big earthquake is on its way." Boschi's lawyer, Marcello Melandri, adds that the experts did not undervalue the significance of the swarm. Melandri tells *Science* that the commission "did not reassure" during its meeting, adding that "it wasn't said that the earthquake wouldn't happen or that it would happen."

Picuti pointed out during his summing up that L'Aquila's 1461 and 1703 quakes were also preceded by foreshocks—and argued that the defendants knew this and should have taken it into consideration. "Why," he asked, "didn't another commission member

LOCAL MAGNITUDE



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say: ‘No, Professor Barberi, we can’t make such a definite statement; let’s instead talk in terms of probability—that very rarely a seismic swarm can evolve into a strong tremor?’ If this had been written in the minutes, I certainly wouldn’t be spending my time here discussing this.”

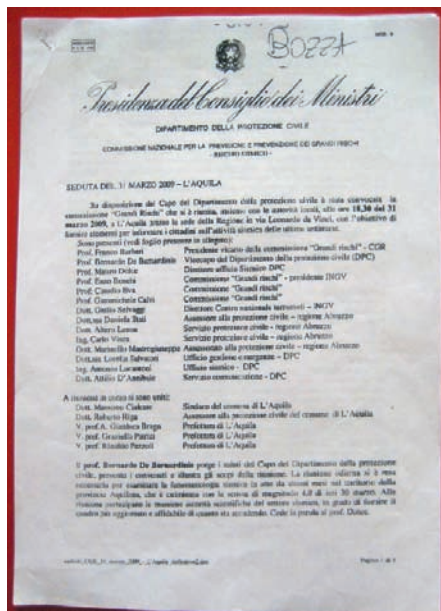
As Picuti also pointed out in the courtroom, the defendants’ position appears to differ from that of the International Commission on Earthquake Forecasting for Civil Protection (ICEF), which DPC set up in the wake of the L’Aquila quake to review the state of earthquake forecasting. In its report, issued in May 2011, ICEF said the occurrence of small or medium tremors does tend to increase chances of a large quake in the near future, even if the absolute probability remains low.

ICEF Chair Thomas Jordan, an earth scientist at the University of Southern California in Los Angeles, tells *Science* that the idea that swarms tell us nothing at all “is not quite right.” Many swarms do not lead to main shocks, but a few do, he says. “The frequency of main shocks is greater during swarm activity than it is without swarms,” he explains. “That’s where you get the notion that there is a probability increase.”

Apparent inconsistencies

Picuti also pounced on apparent inconsistencies in the commission’s assessment. One was a statement made during the meeting by Boschi. According to the meeting’s draft minutes, Boschi had said that the “periods of return [of major earthquakes in Abruzzo] are on the order of 2–3000 years. ... It is improbable that in the short term there will be a tremor like that of 1703, even if it can’t be ruled out absolutely.” Yet Boschi co-authored a 1995 study that estimated the probability of an earthquake of at least 5.9 in magnitude occurring in the L’Aquila area before 2015 at 1—in other words, it was certain to happen. “The head of Italy’s seismologists said [in the meeting] that it was improbable that there would be a major earthquake,” Picuti told the court. “It’s a shame he didn’t also inform them of his own study.”

Also under the prosecutor’s spotlight was



Risk assessment. Draft minutes of the 31 March 2009 meeting.

a statement made by Barberi during the meeting. According to the draft minutes, he said tremors within a swarm tend to have the same magnitude, “and it is very improbable that in the same swarm the magnitude will increase.” But Christian Del Pinto, a seismologist who attended the meeting as an observer, pointed out in testimony during the trial that the magnitude of the tremors had already jumped up—on 30 March, the very day before the meeting. It was therefore wrong to rule out further sudden rises in magnitude, Del Pinto said. Picuti told the court that Del Pinto’s observation was “dramatically important,” because that phrase, as reported by the press, led people to their deaths. “Hence the judgment of guilt,” he said.

Barberi’s lawyer, Francesco Petrelli, says he can’t address Barberi’s comment before making his final arguments in court, which he was due to do as *Science* went to press. But he says the minutes don’t provide a word-by-word account of what was said in the meeting, and that “you have to read the text in its entirety and not in its single phrases.”

The public prosecutor also tackled what was perhaps the most controversial statement made by a member of the Major Risks Commission. In his now-infamous comments before the meeting, De Bernardinis said that

the swarm was actually “a favorable situation” because it caused a “continuous discharge of energy,” implying that it decreased the risk of a major quake. Other members of the commission told the court that this idea was not correct. Selvaggi, for example, described it as “a bit like an urban legend,” because the energy released by smaller tremors is insignificant compared to that given off in a damaging earthquake. But Picuti argued that the commission’s experts effectively sanctioned the notion when Barberi asked the other scientists for their opinion on this specific point. Based on the draft minutes, Picuti told the court that “none of them said a word.”

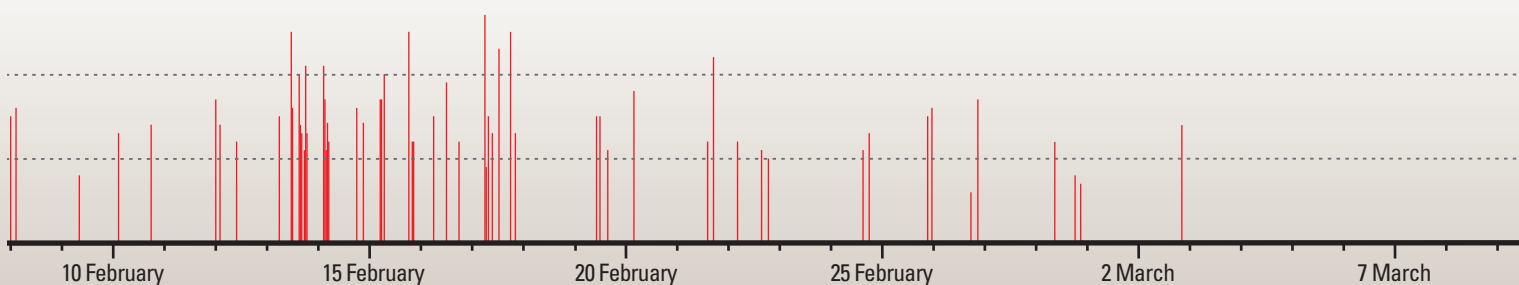
Chorus without soloists

In the course of the trial, new evidence also shed light on why the meeting was held in the first place—and played a role in attempts to shift the blame.

In January, *La Repubblica* released the bombshell recording of a telephone call made the day before the commission’s meeting. In it, then-civil protection head Bertolaso tells councilor Stati that he was convening the commission “not because we are frightened and worried” by the swarm but because “we want to reassure the public.” Bertolaso described the meeting as “more of a media operation.”

Boschi told the court that all Bertolaso apparently wanted to hear from the commission was that earthquakes can’t be predicted. “I imagined something more in-depth” from the meeting, Boschi told the court. The judge asked Boschi why he hadn’t objected to the discussion’s narrow scope. “For me, the head of the situation is the head of the civil protection,” Boschi replied, “and if he asks me to say this and that, I will say it.”

Moretti, the L’Aquila geologist, believes the mounting tension in the town forced Bertolaso to try to calm the public, and that the scientists were therefore constrained to make reassuring statements. “The scientists were forced towards an evidently mistaken decision and then abandoned,” he says. But Paolo Scandone, a geologist at the University of Pisa and a commission member in the 1980s, believes that the panel should have



insisted on sticking to the science. “The scientists perhaps weren’t lucid enough to say no to the administrators,” he says.

Similarly, opinions vary on where the responsibility lies for De Bernardinis’s controversial comments. Melandri tells *Science* that De Bernardinis’s comments were “his words” and not those of the commission. “The prosecutor has not distinguished between the different commission members,” Melandri says.

But Picuti argued that De Bernardinis reflected the position of the commission as a whole, describing the commission as “a chorus without soloists, an organism that speaks with a single voice.” De Bernardinis’s words “correspond exactly” with what was said during the meeting, Picuti told the court. “I realized during the course of the trial that De Bernardinis is the victim, the victim of the seismologists,” he said.

In his own testimony, De Bernardinis told the court that had the other commission members given him different advice about the possibility of a major quake, he would have taken action. “If they had said to me that the risk had increased,” he said, “I would have called Bertolaso [the civil protection department’s head] straightaway.”

Fonts of true knowledge

Even if the commission’s statements were wrong or misleading, for Judge Billi to convict the defendants of manslaughter, he must be satisfied that there was a direct causal link between their conduct and the victims’ decision to stay indoors on the night of 5–6 April 2009. That’s why a minor battle in the trial focused on the evidence for such a causal relationship. Testifying for the defense, neurologist Stefano Cappa of San Raffaele Hospital in Milan said that a direct link is impossible to prove because press reports and minutes relating the commission’s conclusions “typically transmitted information that was ambiguous, generic and nonspecific.”

The prosecution brought in Antonello Ciccozzi, an anthropologist at the University

of L’Aquila, who argued in a written report that to the townspeople, the commission was made up of “maximum scientific authorities” and fonts of “true knowledge” not available to other people. Maurizio Cora, a lawyer who lost his wife and two daughters when their house collapsed, agreed. He told the court that he and his family awaited the statements of the commission “like manna” from heaven; on the evening of 5 April, together they “reasoned” on the basis of the commission’s statements that there would be no more powerful tremors than those already experienced. Reassured, they went to bed.

If Billi does find the defendants guilty, there will almost certainly be an appeal, which, with two or even three stages, could last up to 6 years, according to Fabio Alessandrini, a lawyer representing relatives and friends of the victims seeking damages. Given their different roles, only some defendants may be found guilty, Alessandrini says, and sentences may vary. Fines, which would probably be paid by the state rather than the defendants, could amount to tens of millions of euros, Alessandrini says. Bertolaso is now being investigated separately for manslaughter because of his role.

Jordan, the chair of the earthquake forecasting commission ICEF, does not believe anybody is guilty of manslaughter. De Bernardinis, he says, “made statements that were scientifically incorrect,” but he argues that he and his colleagues were engaged in a difficult balancing act—to communicate subtleties about changing seismic risk while trying to counter baseless predictions. “I think with hindsight they didn’t get that balance right, but I know from personal experience that it’s very tricky in those situations to say the right kind of things.”

Willy Aspinall, a professor of natural hazards and risk science at the University of Bristol in the United Kingdom, is more critical. He says the commission was hindered by an overcritical view of earthquake prediction that currently dominates the field. Past

failures to predict earthquakes have resulted in “mainstream seismology setting its face against any idea of prediction,” to the extent, Aspinall says, that many in the field also oppose the use of the less ambitious probabilistic forecasting. “Unfortunately, the experts thought it was evacuate or nothing,” he maintains. “In L’Aquila, people are used to sleeping in cars, and they shouldn’t have been dissuaded from that in my view.”

But Aspinall worries about the effect that a guilty verdict could have on scientific advice concerning natural hazards. He was chief scientist at the Volcano Observatory for the Caribbean island of Montserrat when an eruption killed 19 people in 1997. The enquiry into the deaths didn’t result in a criminal trial, but “the upshot is that the most sensible and best informed scientists are shying away” from giving advice on the island, he says. “If the L’Aquila scientists are found guilty,” he reckons, “we could end up with the charlatans and the mavericks.”

The best way to avoid such problems in the future, Jordan says, is to clearly delineate the role of the scientists and that of authorities responsible for civil protection. Experts should provide “carefully constructed probabilistic statements” regarding the risk, he says, which decision-makers would then use to choose the best course of action.

Vittorini, the surgeon who lost his wife and daughter, says he isn’t looking for the indicted to end up in prison either. The trial was “not a witch hunt,” he says. Its aim was to find out what mistakes were made and who was responsible, so that perhaps a similar tragedy can be prevented. “We need to change the mentality,” he says. “We need to make sure that people don’t [look to] reassure.”

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Edwin Cartlidge is a science writer in Rome.

