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Mount Stromlo Observatory near Canberra was destroyed by a bush fire in 2003. Although it was devastating for the staff, the calamity led to new initiatives.

LAB SAFETY

When disaster strikes

Researchers whose labs have been destroyed advise flexibility and forward planning.

BY JOSIE GLAUSIUSZ

Glaciologist Martin Sharp at the University of Alberta in Edmonton, Canada, vividly remembers a particular Sunday in early 2017. At midday on 2 April, a freezer malfunction at the Canadian Ice Core Archive (CICA) caused the partial melting of one-eighth of the facility's 1,409-metre collection of ice cores, the oldest of which dated back more than 60,000 years. The centre had opened just six months earlier, and its systems had been functioning reliably.

Not only did the cooling system inside one of the facility's two freezers fail, the warning system that was designed to send an alert in the event of a malfunction failed as well, explains Sharp, who is CICA's principal investigator (PI). The university became aware of the problem only when the freezer temperature hit 35 °C, triggering a fire alarm.

It was a holiday weekend, and all of the scientists were off campus. "When I got there, maybe an hour and a half after it was initially discovered, it was like a sauna," Sharp says, "with steam visible in the air and water on the floor."

Sharp and his colleagues immediately shifted the partially melted cores — some 13% of the collection — into a functioning freezer. In the moment, there was little else to be done, although the team worried about accidentally analysing refrozen meltwater instead of unaffected, pristine ice.

Sharp is among a select club of scientists that few would envy. These researchers' laboratories, or priceless artefacts or samples, have ▶

been damaged or destroyed in explosions, floods, hurricanes, fires or other disasters. Many dealt with the trauma by diving straight into the work of reconstruction. Some report that they emerged from the experience with greater resilience, after introducing better safety standards and installing effective alarm systems, or because they had been given a blank slate to take their research in a different direction. Others derive strength from continuing their research abroad, reasoning that this is the best way to thrive and contribute to their field.

Researchers who have faced a lab disaster say that it is crucial to create safety protocols and to review — and practise — emergency plans regularly with all lab members. Scientists at institutions where hurricanes and other violent weather events occur frequently need to make longer-term plans for coping with climate change, deciding whether to rebuild or relocate.

Connections with other labs — in case it is necessary to move — are crucial. PhD students and postdoctoral researchers can ensure that their labs have suitable safety standards and adhere to them, keeping logs of near misses. They can also protect their work by digitizing it and uploading it to a digital repository, so that a record remains.

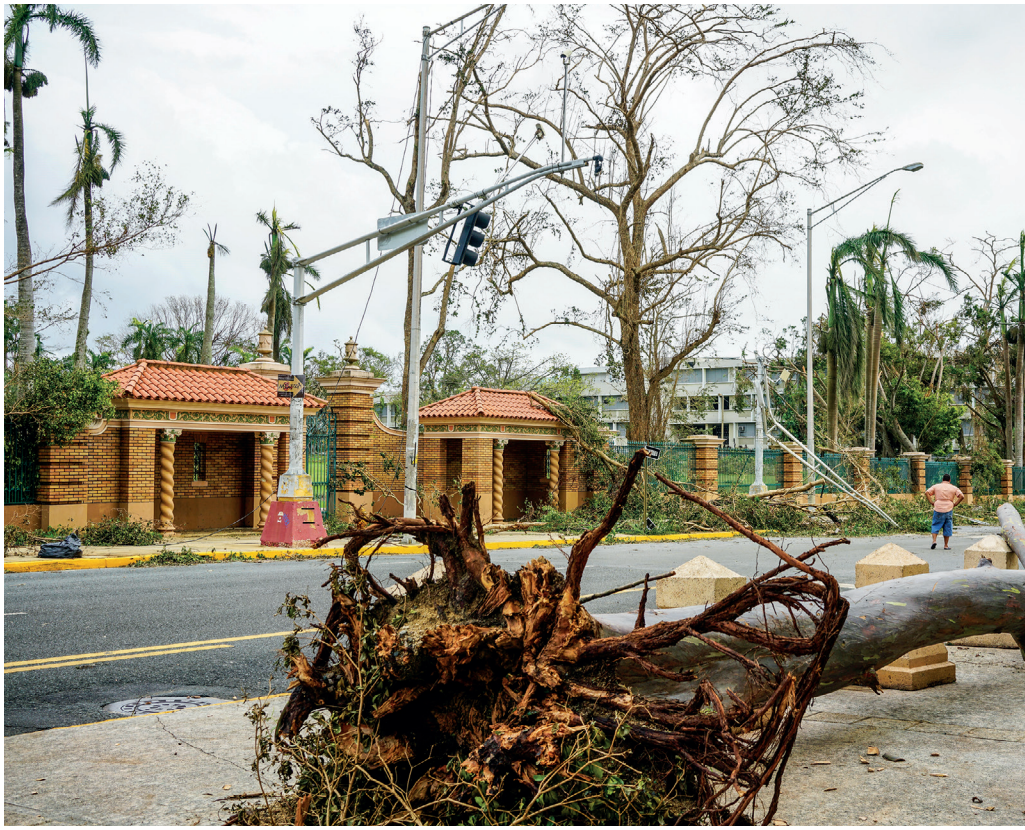
Sharp advises PIs to envisage the worst-case scenario and to prepare a protocol, ensuring that staff members know which items are the most crucial for future research and where they are kept, so that these can be rescued first.

Then, he says, the entire lab should run exercises to determine the plan's efficacy. "Don't trust the technology, even if you have a lot of confidence in it," he says, because technology failures are at the root of many lab disasters. And the losses from such disasters can be exacerbated by failures in lab-response procedures.

After the partial meltdown, Sharp's team set about re-evaluating the lab's emergency plan and reinforcing CICA's warning system; twice-daily updates of freezer temperatures are now sent to the mobile phones of ten staff members. The archive has also introduced a system of colour-coded cores, indicating the order in which they should be rescued in an emergency.

TRAUMATIC AFTERMATH

Accidents and disasters can take a huge psychological and emotional toll. Microbiologist Fathiah Zakham has vivid memories of the air strikes that targeted the Red Sea port city of Hodeidah in Yemen in spring 2015, and she still suffers flashbacks from that terrifying time. "We were hearing the voices of explosions, of air strikes, of attacks," she recalls. On 27 May that year, catastrophe struck: a bomb completely destroyed the Faculty of Medicine and Health Sciences at Hodeidah University, where Zakham's lab was located, killing four security men. "It was a very new building, and it became a mass of rubble," she says.



Hurricane Maria flooded Belinda Pastrana's lab in Puerto Rico, prompting her to move to Massachusetts.

PABLO PANTOJA/GETTY

In the aftermath of the attack, Zakham decided to leave Yemen, and won a Swiss Government Excellence Scholarship to do postdoctoral research at Lausanne University Hospital, where she started working in July 2017. She is now a postdoc at the University of Helsinki, where she researches and develops tools for diagnosing viral haemorrhagic fevers.

"I'm working every day at the lab, and I'm writing, researching different articles, I'm attending conferences and different scientific events," says Zakham, who was awarded the 2017 Al-Kharafi Prize by the World Academy of Sciences, which recognizes exceptional female scientists from countries that are lagging scientifically. "But it's very difficult to recover. I still imagine how I was running with my students, how they were crying."

The impact of loss is fresh for anthropologist Luiz Fernando Dias Duarte, who recalls the rage he felt when fire engulfed the National Museum of Brazil in September 2018, destroying its 20-million-strong collection of fossils, books, ceramics, Egyptian sarcophagi and priceless South American archaeological artefacts (see p. 312). "My immediate reaction was of intense anger," says Duarte, the museum's deputy director. The museum, housed in what was once the palace of Brazil's imperial family in Rio de Janeiro, had no sprinkler system and firefighters were ill-equipped: the closest hydrants were broken, forcing them to use water from a nearby lake.

"The risk of fire was very great, and we were completely aware of this," Duarte says, explaining that the museum had planned to move some of its valuable collections to new buildings, with financing approved just three months before the fire. "It was a very hard loss," he adds, explaining that he also lost his own archives, correspondence, books, journals and other publications totalling about 7,000 titles.

But although the blaze took a huge emotional and psychological toll, Duarte rallied quickly, throwing himself into reconstruction, fundraising and seeking replacement collections and donations of books, as well as negotiating new channels for scientific partnership. The museum now has pledges of financing from Germany, the United Nations Educational, Scientific and Cultural Organization and Brazil's federal government, as well as promises of replacement books and specimens from institutions in Europe, China and the United States.

"Go on fighting," Duarte advises scientists who are struggling with such crises. "When I'm engaged in organization, I feel safer."

He and Sharp urge other scientists to be frank about the significance of what is lost in such a debacle. Sharp spent a week responding to what he calls a frenzy of phone calls and e-mails from journalists after the University of Alberta held a press conference on the morning after the meltdown.

That openness, says Sharp, helped a great deal, because media reports reached a larger audience, including those with relevant expertise, who offered to help however they could.

Neither Sharp nor Duarte says that they found media interest in the debacles to be intrusive. "Dealing with media calls did take up a lot of time, but it was time well invested because it created opportunities to talk about ice-core science, climate change and atmospheric-pollution issues that would not have come up otherwise," says Sharp. "It resulted in a lot of positive advice and input from people who had had similar experiences. That has really helped us."

Duarte says that he perceived no negative consequences from his media interviews. It is imperative, he says, that the public continues to be aware of the challenges in the National Museum's reconstruction.

Openness, agrees chemist Dominick Casadonte, is key. Casadonte was chair of the chemistry and biochemistry department at Texas Tech University in Lubbock in January 2010, when then-PhD-student Preston Brown lost three fingers, punctured his eye and suffered burns in a university chemistry lab.

Brown, who was stirring a volatile compound, had removed his protective goggles before the mixture exploded. Casadonte, the third person at the scene, was horrified when he saw the extent of the student's injuries. In an interview two months later with the US Chemical Safety Board, he recalls saying that he never wanted a recurrence in any lab with which he is associated.

Casadonte became determined to improve the safety culture at Texas Tech, and to be open about it. "A lot of schools that have accidents just basically try to cover it up, or circle the wagons, to try to not let things out," he says. "We had a very courageous vice-president for research, Taylor Eighmy, now president of the University of Texas at San Antonio, who said 'No, we're going to be transparent, we're going to be public, and the process of transforming our safety culture can be an example for others around the country.' So we all collectively decided to do that."

New safety rules at the university require all incoming graduate students, staff members and teaching assistants in chemistry to take a course in chemical safety. In addition, they mandate barcoding of all chemicals with safety classifications, and strict penalties, including closure, for labs that ignore safety protocols. Texas Tech also maintains a database of near misses and lessons learnt to help avoid accidents recurring.

BOUNCING BACK

Some scientists say that their institutions emerged stronger after a disaster, with improved facilities. Matthew Colless, director of the Research School of Astronomy and Astrophysics at the Australian National University in Canberra, was a senior fellow at Canberra's Mount Stromlo Observatory when it was destroyed by a bush fire in January 2003. The ferocious fire swept across Canberra, killing 4 people, incinerating more than 400 houses and destroying the observatory's 6 telescopes and all of its workshops.

When Colless surveyed the scene of destruction two days later, he saw only smoking ruins. Fortunately, the modern telescopes — which Colless was using to map dark and ordinary matter in a very large galactic survey — were at Siding Spring Observatory, 600 kilometres away.

Colless left in 2004 to work at the Australian Astronomical Observatory near Sydney; when he returned to Mount Stromlo as director in 2013, he says, the observatory was in a much stronger position than it would have been if the fire had not happened. Observatory directors were able to reconstruct and rebuild with financing from the Australian federal government — after a long battle with insurers.

Now, because the observatory no longer has to maintain heritage telescopes — the oldest of which dated back to 1911 — it can invest in new initiatives. "Once they're burnt to the ground, they don't require a lot of money to maintain them," Colless says. "You put a plaque up in front of them, let the rain in, and let them become romantic ruins."

"It's very difficult to recover. I still imagine how I was running with my students, how they were crying."

Like Sharp, Colless advises developing a plan for when disaster strikes — including good insurance. But that plan, he adds, does not necessarily mean rebuild. "You have to stop and think, is that really what you want to do? Maybe there are other, smarter things you can do. Every one of these crises is an opportunity."

Long-term planning might be crucial for universities affected by more frequent flooding caused by climate change, says Charles Connerly, director of the School of Urban and Regional Planning at the University of Iowa in Iowa City.

That university, which is built on a flood plain, suffered an estimated US$743 million in damage during a flood in June 2008. The university relocated some departments and rebuilt them on higher ground, with the aid of federal funding.

Connerly argues for a regional solution, despite its cost: to restore the entire watershed to a more natural state that could better absorb flooding, by building and restoring wetlands. "We don't know what climate change is going to bring. The amount of storms we're getting is increasing dramatically," he says. "If it's only going to get worse, then maybe we have to come up with a more appropriate solution, one that better respects the watershed."

BLESSING IN DISGUISE

Kathryn Moore, whose work at New York University (NYU) focuses on the immunology of cardiovascular disease, also recommends recalibrating following a disaster. In October 2012, her basement mouse facility in New York City flooded in the wake of Superstorm Sandy, and the simultaneous power cut caused the loss of hundreds of NYU's unique mouse strains, including ten of Moore's, which had taken years to develop. She also lost many of her tissue sections of atherosclerotic plaques that were stored in −80 °C freezers.

"Losing all that was almost like starting from scratch," Moore says. "It was an amazing experience of being given a blank slate: to take the most exciting projects and think about what we really wanted to do. It changed the direction of my science." She and her team moved away from studying atherosclerosis in live mice to short-term *in vitro* studies on non-coding RNA.

"I think that rather than spending time feeling sorry for ourselves, we focused on how we're going to rebuild. That was really important for morale," Moore says. She recalls that individual responses to such a disaster can vary widely. Although some respond with action, others in her team of 15 scientists were traumatized and had a difficult time moving forward. "I learnt not to judge people who got stuck in place," she says, "and to be patient." Moore was able to place two of her postdocs in colleagues' labs elsewhere.

Belinda Pastrana also dealt with relocation after Hurricane Maria struck Puerto Rico in September 2017. She moved her company, Protein Dynamic Solutions, from an incubator site associated with the University of Puerto Rico to Boston, Massachusetts. Pastrana, the business's founder and chief executive, and her team had developed a laser infrared microscope to evaluate protein structure and stability.

Maria destroyed the Caribbean island's power grid and blew away some of Pastrana's solar panels. She lost 20 years of work, and her company's waterlogged lab, invaded by mould, was rendered unsafe for work.

Had she stayed at the university where she had taught for 20 years and helped to create a PhD programme, she would have had to abandon her business and its important technology. "I felt a moral responsibility to make this company a success," she says. By continuing her research elsewhere, she can provide funding to the university through royalties from her licensed patents.

Pastrana recommends that researchers continue to build and foster their scientist networks long before any crisis, as well as afterwards. She found alternative labs for her graduate students to complete their PhDs. Think outside the box, she adds, and "find alternate routes to pursue your science and your passion".

That, too, was Zakham's strategy. "Moving from the country [Yemen] was not an option — it was an obligation," she says. In leaving, she was able to reignite her career, and support female scientists back home. "Life should continue," she says. "We shouldn't give up." ■

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