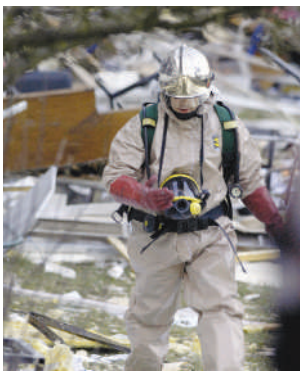
SPECIAL REPORT

How dangerous is chemistry?

The death of a French professor in a laboratory explosion in March was a shocking reminder that research can be a risky business. **Mark Peplow** and **Emma Marris** investigate whether chemistry deserves its reckless reputation.

Something that felt like an earthquake hit the French town of Mulhouse on 24 March. The explosion at the National Institution of Higher Learning in Chemistry (ENSCMu) killed Dominique Burget, a 41-year-old photochemist. It also sent ripples of concern around the world.

Although official investigations are expected to last until the end of the year, it appears that residues of the flammable gas ethene in a pressure vessel were responsible. Burget was working in the lab above the explosion and had nothing to do with the experiment, which also severely injured a 19-year-old student in the room next door. "She is now out of danger and comes back to the school next week," Serge Neunlist, director of ENSCMu, said on 23 May. The explosion caused roughly €10 million (US$130 million) of damage and destroyed about 4,000 m^2 of the building, which will take at least three years to rebuild.



B. FERRANDEZ/AFP/GETTY

A fireman checks what's left of the Mulhouse laboratory.

Chemistry's reputation for big bangs might suggest that Mulhouse was no freak accident. Gather any group of chemists together and before long they are likely to be exchanging stories about heart-stopping near-misses or discussing someone involved in a serious accident.

Is chemistry really so dangerous? Those responsible for the safety of research labs say such stories may perpetuate out-of-date myths. "A lot of it is reminiscence to 'the good old days' of chemistry," says Alan Kendall, safety officer at the University of Oxford, UK.

"There's a public perception that is years behind the reality," agrees Richard Firn, a biologist who chairs the laboratory safety committee at the University of York, UK. "Things have changed a lot in the past 10 to 15 years."

Swathes of occupational-health legislation in the 1970s, which established, for example, the US government's Occupational Safety and Health Administration (OSHA) and the UK Health and Safety Executive (HSE), have spurred the change in culture.

One of the most important factors is that risk assessment is now built into scientists' routines. Each chemical used comes with a list of potential risks and appropriate safety precautions, although unpredicted toxicity can affect even the most careful chemist, as Karen Wetterhahn found to her cost in 1996 (see 'Cautionary tales').

And practices such as eating lunch at the bench, mouth pipetting and washing hands with benzene (now known to be a carcinogen) have largely been consigned to history — apart from the odd emeritus professor reluctant to change methods that they have used for decades.

Better analytical techniques also mean that reactions can be run on much smaller scales, significantly reducing the danger, says Lawrence Gibbs, associate vice-provost for environmental health and safety at Stanford University, California.

"Academic institutions are now much more safety-conscious than when I was a student during the 1940s," agrees Edward Arnett, emeritus professor of chemistry at Duke University, Durham, North Carolina, and chair of the National Academy of Sciences research panel that penned the classic *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*. "I call that the kamikaze era of laboratory safety," he says.

"The thing that radicalized me on safety was when I got a job with a small company in Philadelphia," he recalls. "I took over my job a couple of days after they buried my predecessor, who died of hydrofluoric acid poisoning. It was my job to make sure nothing like that ever happened again."

Yet despite the increase in legislation, it is surprisingly difficult to get national statistics on scientific accidents. In the United Kingdom and United States, for example, universities are obliged to report upwards only those accidents with serious consequences, such as hospitalization. This means that national agencies can remain oblivious to potentially major incidents if no one was seriously injured. And they do not tend to keep figures for different fields — the HSE, for example, groups all its accident figures for schools, colleges and universities into a single number, making it difficult to discern safety trends or to tell if one type of lab is more risky than another.

Having a national register of accidents would be "immensely useful", says Sara Cooper, director of health and safety at the University of Cambridge, UK. Because officials at the HSE are responsible for writing the codes of practice that university labs have to follow, "they need to understand, sector by sector, what we have to cope with", she argues.

It is possible to glean some information by talking to individual universities, however. Most accidents on campus involve trips and falls, like any workplace. Firn adds that most student injuries come from playing sports,

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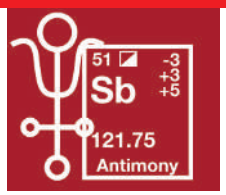

CHEMISTRY BLOG
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http://blogs.nature.com/thescepticalchymist/

BRAD WILSON/GETTY

Is anyone there? Academic chemists often end up working alone late at night.

while stress is by far the major cause of ill-health in universities.

In labs, safety officers contacted by *Nature* agreed that chemistry generates the most accident reports. However, the vast majority of these involve undergraduates cutting themselves on glassware.

Ian Gillett, safety director at Imperial College London, cautions that such evidence may reveal little about the inherent dangers of chemistry. He points out that chemistry involves more practical work than other disciplines, chemists may be more vigilant about accidents than others, and in any case it is impossible to gauge how many minor disasters go unreported.

"I don't feel that there is a significant difference between chemistry labs and other labs," agrees Gibbs, pointing out that biology, for example, carries its own set of risks, namely infection.

Others agree that the risk of infection is often underplayed compared with that of chemical accidents. "People's risk perception is skewed by the drama of an explosion," says Firn. Gillett adds that the most serious lab accidents at Imperial have involved accidental infections with hepatitis A and vaccinia virus. "Pathogens are where I would be more anxious about what's going on," he says.

But what does seem clear is that academic labs are more dangerous than those in industry, with a more relaxed approach to safety.

"We find that the accident rate [in universities] is 10 to 50 times greater than in the chemical industry," says James Kaufman, president of the Laboratory Safety Institute in Natick, Massachusetts. "In DuPont, if a guy hits his thumb with a hammer in Singapore, the chairman of the board has a report on his desk," he says. "Imagine if that happened in academia."

"In industry we often say that we are surprised more people aren't injured in academic labs," agrees Derek Lowe, a research chemist who blogs on "In the pipeline" (www.corante.com/pipeline). "In universities, people are still learning, and people work all hours. If you are there alone at three in the morning, that's seen as a good thing."

"I took over my job a couple of days after they buried my predecessor."

Martin Pitt, compiler of *Bretherick's Handbook of Reactive Chemical Hazards*, says that although risks have been much reduced in recent decades, there are still two key areas where academic labs could do a lot better. "Labs are too crowded," he says, and such overcrowding raises the risk of spills.

Waste disposal is the other major issue. Most chemistry labs have open bottles where solvents are dumped along with the black gunk left from failed reactions. "It's virtually impossible to say what will happen in these mixtures," says Pitt. Such arrangements also make it too easy for people to dump noxious chemicals —and responsibility for them — in a communal spot. ■

Cautionary tales

BLINDED BY ROOM TEMPERATURE

In 1970, K. Barry Sharpless was an assistant professor at the Massachusetts Institute of Technology. Having finished work for the day, and sans safety glasses, he checked in on a graduate student who was sealing a glass tube immersed in a bath of liquid nitrogen. Holding the tube up to the light, Sharpless saw the level of liquid in the tube drop suddenly — oxygen that had been inadvertently condensed by the chill of the bath was rapidly turning back into a gas. Before he could move, the tube exploded, and fragments of glass destroyed one of his eyes. In the following weeks, "the pain was terrific", he remembers. While he retained vision in one eye, he says his lesson is straightforward: "There's simply never an adequate excuse for not wearing safety glasses in the laboratory at all times." Sharpless went on to win the 2001 Nobel Prize in Chemistry, and is now at the Scripps Research Institute in La Jolla, California.

UNEXPECTED POISON

When Karen Wetterhahn, a professor and toxic-metals expert at Dartmouth College, Hanover, New Hampshire, spilled a couple of drops of dimethyl mercury on her hand in August 1996, she quickly cleaned it up and assumed that her latex gloves had stopped the toxic chemical reaching her skin.

Five months after the accident, Wetterhahn was having difficulty walking and her speech started to slur. Tests later showed that she had 80 times the lethal dose of mercury in her blood. After losing her vision and hearing, she slipped into a coma and died in June 1997, aged 48. The tragedy shocked chemists, who were surprised at how easily the mercury had penetrated Wetterhahn's glove and how toxic the compound was.

SAFETIES OFF

When the refrigerator-sized cylinder of liquid nitrogen exploded on 12 January 2006, it was standing on a tiled floor in a lab at Texas A&M University, College Station.

The blast peppered the lab's walls and doors with tile shrapnel and the cylinder shot upwards, straight through the thick concrete ceiling and into the lab above, taking out windows, doors and an entire lab wall.

Investigators later found that two safety release valves on the cylinder had been removed and replaced with wire plugs, turning the cylinder into a pressure bomb. No one was hurt, but only because the explosion happened at about 3 a.m. **M.P.**

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