► the Ergenekon trial are being punished for stances unrelated to terrorism: all six are staunch secularists and have defended secularism by, for example, seeking to uphold a ban on headscarves in Turkey's universities.

The delegation's report also describes the plight of scientists, including one of the six just sentenced, accused in three further major political trials — known as Sledgehammer, the KCK Operations and the Postmodern Coup. All the political trials had been assigned to special anti-terrorism courts, but these were abolished last year following criticisms that they ignored evidence. Many observers believe that the trials, which the report described as “highly irregular”, were used as an excuse to round up and silence government critics.

The Sledgehammer trial, which involved 365 people charged with attempting a military coup in 2003, ended last year. Industrial engineer Faruk Yarman, one of just two civilians to be charged, was sentenced to 13 years in prison. The report calls for his release.

Political scientist Büşra Ersanlı was arrested in 2011 as part of the KCK Operations, and charged with membership of a violent Kurdish-rights organization. She was released from pre-trial detention in July 2012; the report calls for a fair and expeditious trial for her.

And Kemal Gürüz, one of the six scientists sentenced this week, was arrested and detained in June last year as part of the Postmodern Coup trial (see *Nature* <http://doi.org/h47>; 2012).

A chemical engineer who was head of Turkey's Council of Higher Education from 1995 to 2003, Gürüz had been a vociferous proponent of the headscarf ban. He attempted suicide in prison in June this year. This week, he was sentenced to 13 years and 11 months in prison in the Ergenekon trial; he is still awaiting trial under the Postmodern Coup.

Pamuk, who holds joint positions at the Bosphorus University in Istanbul and the London School of Economics, says that many academics believe scientists such as Gürüz have been drawn into terrorism trials for reasons of revenge. “Many were university rectors,” he says. “When they were powerful, they may have offended those who are now close to this government and are now in a position to retaliate.” Pamuk expects all the scientists sentenced in the Ergenekon trial to appeal, but says that they are unlikely to win.

Guniz Gürüz, a chemical engineer at the Middle East Technical University in Ankara and Kemal Gürüz's wife, told *Nature* that pressures on the family have been extreme. “We are going to appeal,” she said through tears after hearing his long sentence, adding, “Kemal has never had a proper explanation for why he was detained.” ■

Much of the discussion about the humane killing of research animals centres on rodents.

ANIMAL RESEARCH

Best way to kill lab animals sought

Researchers debate most humane methods of dispatch.

BY DANIEL CRESSEY

Killing research animals is one of the most unpleasant tasks in science, and it is imperative to do it as humanely as possible. But researchers who study animal welfare and euthanasia are growing increasingly concerned that widely used techniques are not the least painful and least stressful available. This week, experts from across the world will gather in Newcastle upon Tyne, UK, to debate the evidence and try to reach a consensus.

“There are lots of assumptions made about the humaneness of various techniques for euthanizing animals,” says Penny Hawkins, deputy head of the research animals

department at the Royal Society for the Prevention of Cruelty to Animals, a charity based in Southwater, UK. “Sometimes an animal might not appear to be suffering, but might be conscious and suffering.”

Much of the debate centres on rodents, which make up the vast majority of research animals. Current techniques for killing them include inhalation methods — such as chambers that fill with carbon dioxide or anaesthetic gases — and injecting barbiturates. Physical methods include cervical dislocation (breaking of the neck), or decapitation with specialist rodent guillotines (see ‘Methods used to kill lab rats’).

Experts hotly debate which method is

PROS AND CONS

Methods used to kill lab rats

Some methods recommended by the American Veterinary Medical Association.

Barbiturate injection: Fast-acting, but injection may cause pain.

Inhaled anaesthetic (halothane, isoflurane, sevoflurane or desflurane): Useful when restraint of animal is difficult.

Carbon dioxide: Acceptable, but chamber must be filled over several minutes and not

pre-filled. Death to be verified afterwards or ensured by physical method.

Cervical dislocation: Causes rapid death, but skill must be learned.

Decapitation: Useful when tissues must be free of euthanasia chemicals.

Unacceptable: Nitrous oxide alone; nitrogen or argon asphyxiation (unless animals already anaesthetized); opioids.

PASCAL GOETGHELUCK/SPL

preferable. The most-discussed question at the meeting is likely to be about the use of CO₂.

"People do still worry about CO₂ and it's still almost certainly the most widely used method [for killing rodents]," says Huw Golledge, who studies the anaesthesia of lab animals at Newcastle University, UK. Golledge organized the meeting, which is backed by the London-based National Centre for the Replacement, Refinement and Reduction of Animals in Research. Its aim is to update a 2006 consensus document produced by international experts to give guidance to researchers working with animals.

CO₂ is used to make rodents unconscious. They are then killed by either asphyxiating them with the gas, or by another method. But increasingly, studies suggest rodents find CO₂ stressful.

Evidence for this comes mainly from 'aversion studies'. A key study by animal welfare researcher Daniel Weary's group at the University of British Columbia in Vancouver, Canada, shows that albino rats will move away from a dark compartment filling with CO₂ into a brightly lit box, despite disliking bright lights. The study found that they were less likely to move away from isoflurane, also used in euthanasia (D. Wong *et al. Biol. Lett.* <http://doi.org/ncv; 2012>).

Other evidence is contradictory (H. Valentine *et al. J. Am. Assoc. Lab. Anim. Sci.* **51**, 50–57; 2012), but Weary is firm in his beliefs. "Our own results indicate CO₂ is highly aversive," he says.

There are also question marks over physical methods. Performed perfectly with animals accustomed to being handled, cervical dislocation may be the best method, but it may not be practical for killing large numbers of rodents.

The issues are even more uncertain for the new animal models that scientists are pursuing. For example, a huge increase in the use of zebrafish has put them on the meeting's agenda. Although much progress has been made with lab rodents, says Weary, "there's been much less work on fish welfare in general".

Widely used guidelines on animal euthanasia from the American Veterinary Medical Association (AVMA) in Schaumburg, Illinois, were updated earlier this year, in part to adapt to changes in the animals used in labs, with zebrafish guidance one of the additions. The association says it expects the lab animals section of these guidelines to continue to expand.

Some of this guidance comes with regulatory teeth. Later this year, the US National Institutes of Health, which funds biomedical research, says that it expects "full implementation" of the AVMA guidelines, with previously approved projects reviewed using them.

Regulation is also driving more unusual animals onto the agenda. New legislation on the treatment of laboratory animals is currently being incorporated into the laws of European Union member states and will cover cephalopods, in some nations for the first time (see *Nature* <http://doi.org/fk65pb; 2011>). ■

OPTICS

Squeezed light mutes quantum noise

Silicon zip reduces energy fluctuations in laser beams to improve sensitivity of optical motion sensors.

BY DEVIN POWELL

Oskar Painter spends his time carving silicon blocks into shapes that interact with light in strange ways. The latest of these — what Painter calls "Legos for adults" — squeezes the light from laser beams to push the limits of what they can measure.

By eliminating some of the noise caused by quantum effects, researchers can use squeezed light to illuminate movements too small to see with normal light. Painter's silicon sculpture, built on a microchip, could boost the sensitivity of sensors that use lasers to monitor motion, such as the gyroscopes that keep track of an aircraft's orientation.

"We have an opportunity to push the performance of these sensors by orders of magnitude," says Painter, an applied physicist at the California Institute of Technology in Pasadena, whose team reports how it squeezes light on page 185 (ref. 1).

All light is plagued by quantum noise, especially at the low powers typically required by sensors. These energy fluctuations blur the defined peaks of classical light waves, fundamentally limiting the precision of measurements.

Squeezing the light can suppress some noise, but Heisenberg's uncertainty principle demands a trade-off. A squeeze that reduces noise in one dimension — the height of a light wave's peaks, for instance — must be balanced by a stretch that adds noise in another, such as the distance between the peaks. Researchers therefore have to match the direction of the squeezing to the direction of the measurement.

Efforts to put light-squeezing to use have so far focused on gravitational-wave detectors, which search for faint ripples in space-time by timing laser beams as they bounce between mirrors 4 kilometres apart. Passing ripples should stretch or compress the laser beams ever so slightly. But measurements with normal laser light are limited by quantum noise, and have so far failed to detect any disturbances attributable to gravitational waves.

Hoping to improve the next generation of measurements, researchers at the Laser Interferometer Gravitational-Wave Observatory

(LIGO) in Hanford, Washington, added a dose of squeezed light by passing laser light through a crystal. In July, they reported that they had achieved a sensitivity better than the standard limit imposed by quantum noise². This represents a step towards the ultimate goal of doubling LIGO's sensitivity, says team member Nergis Mavalvala, a physicist at the Massachusetts Institute of Technology in Cambridge. "We have to work hard to strip the noise out of the light," she says.

Painter's silicon device potentially offers a simpler way to squeeze light, although only at frequencies too high to be useful for gravitational-wave detectors. The device looks

"We have to work hard to strip the noise out of the light."

like a zip; photons bouncing around between its two arms push them apart with a force dictated by the amount of noise in the light. As the

size of the gap changes, the zip tunes the frequency of the light — just as a finger sliding along a guitar string changes the pitch of the sound produced — and squeezes out some of the fluctuations.

The prototype tends to leak light, so it can suppress only about 5% of the noise. "The absolute level of squeezing is relatively low," says Warwick Bowen, a physicist at the University of Queensland in Brisbane, Australia. Painter says he will next be working with higher-quality zips, which could cut out as much as 90% of the noise.

But he will have some competition. A team at JILA in Boulder, Colorado, a joint institute of the University of Colorado and the US National Institute of Standards and Technology, has already created a vibrating silicon nitride membrane that boasts a 32% reduction in noise. JILA physicist Cindy Regal and her colleagues will report their work in a paper under review at *Physical Review X* (ref. 3). "It has been technically challenging to get to this regime," says Regal. ■

1. Safavi-Naeini, A. H. *et al. Nature* **500**, 185–189 (2013).
2. The LIGO Scientific Collaboration *Nature Photon.* **7**, 613–619 (2013).
3. Purdy, T. P., Yu, P.-L., Peterson, R. W., Kampel, N. S. & Regal, C. A. Preprint at <http://arxiv.org/abs/1306.1268> (2013).