reversing the search strategy, and looking for FRBs in similarly strange galaxies, as well as trying to locate the origin of single bursts when they occur. And heated debate arose over whether all FRBs are likely to come from the same kind of source as the repeater, and so whether astronomers might detect repeated signals from all FRBs if they look for long enough. "The answer was definitely maybe," says Burke Spolaor. But there could be different kinds of sources, leaving open the question of how much one repeater can teach about FRBs in general, she adds.

### CUTTING BIAS

A major issue is how to avoid bias. The fact that they were discovered by researchers looking for pulsars — small, dense, rotating stars — could bias the generation of theories about FRBs: astronomers might be drawn to models involving objects similar to pulsars. Detection bias is also an issue, in part because many FRB searches are piggy-backed onto those that are optimized for finding sources within the Milky Way that repeat regularly, rather than sporadic extragalactic events. The more astronomers look, the more they find FRBs in unexpected locations and with unusual features.

To ensure that astronomers are seeing a representative sample, they need to look for signals across a broader range of frequencies, says Burke Spolaor. They should also pay more attention to the polarization of FRB light, she adds, which can provide clues about the environment of the source.

About 30 telescopes are looking for FRBs, and dedicated searches are increasing. The conference buzzed with excitement about the Canadian Hydrogen Intensity Mapping Experiment (CHIME), a radio telescope in Canada that should start hunting for FRBs later this year and could see as many as a dozen a day.

But observations need to be better coordinated, says Berger. Delegates planned efforts to automatically release FRB results in real time for follow-up by other telescopes, as is already done for other kinds of fleeting astronomical signal.

Although FRBs remain a mystery, the field has surged forward since Lorimer identified the first burst. The fact that the community now agrees, for instance, that the bursts are extragalactic is a big step forward. Lorimer's wife, West Virginia University astrophysicist Maura McLaughlin, initially doubted they were even extraterrestrial, Lorimer told the meeting. "The community was quite sharply divided about it, even in our own household. We've come a long way since then." ■


1. Lorimer, D. R., Bailes, M., McLaughlin, M. A., Narkevic, D. J. & Crawford, F. *Science* **318,** 777–780 (2007).
2. Spitler, L. G. *et al. Nature* **531,** 202–205 (2016).
3. Chatterjee, S. *et al. Nature* **541,** 58–61 (2017).



JAVIER SORIANO/AFP/GETTY

**People in Madrid demonstrate against the high price of hepatitis C drugs.**

PUBLIC HEALTH

# Hepatitis C drugs stoke patent fight

*Lawsuits in India and Argentina seek to reduce drug costs.*

BY AMY MAXMEN

The liver disease hepatitis C is the new battleground for lawsuits intended to slash the cost of life-saving medicines. In February alone, five suits were filed in India and Argentina claiming that the latest class of antiviral drugs does not warrant the 20-year patent monopoly that manufacturers have sought in those countries.

In the 2000s, successful challenges to patents on HIV drugs gave poor nations access to high-quality 'generic' copies of the medications at rock-bottom prices. Now, buoyed by that success, activists are applying the same strategy to a fresh wave of hepatitis C drugs. They note that the standard 12-week course of treatment costs more than the average annual salary for millions of people in middle-income countries.

Public-health experts say that expanding access to the drugs would have immediate benefits. Roughly 177.5 million adults worldwide are infected with the hepatitis C virus, which can cause liver cancer and cirrhosis if left untreated — but the latest antiviral medications have revolutionized care. The first to reach the market was sofosbuvir, sold under the name Sovaldi by Gilead Sciences of Foster City, California; clinical trials of the drug in combination with other medications have shown a cure rate of 95% or more. "If these medicines were made widely available, you could make a plan to eliminate this disease," says Brook Baker, a law specialist at Northeastern University in Boston, Massachusetts.

As the world's main supplier of generic drugs, India is at the centre of the current patent fight. Patient advocates celebrated when the country's patent office rejected Gilead's application for a basic patent on sofosbuvir in January 2015, on the grounds that it was not scientifically inventive enough to warrant exclusivity, despite its clear medical advantages. But an Indian court overturned the decision last May — and that verdict in turn is now being contested.

Four of the lawsuits filed in February target other Indian patents on sofosbuvir and two related drugs, Gilead's velpatasvir (sold in combination with sofosbuvir under the name Epclusa) and Daklinza (daclatasvir) from Bristol-Myers Squibb in New York City. The fifth challenges Gilead's application to ▶

patent sofosbuvir in Argentina.

"The science behind sofosbuvir doesn't merit these patents," says Tahir Amin, director of the Initiative for Medicines, Access and Knowledge in New York City. The activist group is involved in a dozen ongoing lawsuits related to patents for hepatitis C drugs — including the cases in India and Argentina, and others in Brazil, the European Union, Egypt and Ukraine.

Some of the suits argue that sofosbuvir, velpatasvir and daclatasvir are not sufficiently inventive to warrant a patent. Others challenge Gilead's attempts to obtain additional patents on sofosbuvir by modifying it slightly, to extend the company's intellectual-property rights — a practice called evergreening. "This battle is about trying to ensure that Gilead has the shortest possible monopoly," says Leena Menghaney, who runs a drug-access campaign in South Asia for the charity Médecins Sans Frontières, which is supporting the lawsuits.

Gilead notes that it has taken steps to reduce the cost of its antiviral medications for hepatitis C — offering tiered pricing for sofosbuvir and other drugs, on the basis of factors such as a nation's economic status and the volume of medicine that it requires. The list price for a 12-week course of sofosbuvir is US$84,000 in the United States, $50,000 in Turkey and Canada, about $6,000 in Brazil and just $900 in Egypt.

Gilead has also licensed 11 manufacturers in India to produce cheaper generic versions of its hepatitis C drugs for sale in 101 developing countries. The generic medications retail for $300–$900 per treatment course in countries where they are permitted; in return, Gilead receives a 7% royalty payment to keep its access-to-medicines programme running.

***"This battle is about trying to ensure that Gilead has the shortest possible monopoly."***

This system draws on lessons that Gilead learnt during lawsuits and protests over access to HIV medications in the early 2000s, says Clifford Samuel, Gilead's senior vice-president of access operations and emerging markets. "We got a tremendous amount of criticism in the early days of our HIV programme, and it refined us," he says.

But that does not appease Amin, who says that Gilead's deals with generic-drug manufacturers do not reduce the cost of its hepatitis C medications in middle-income countries. One analysis published last year found that sofosbuvir and related drugs are too pricey for those nations (S. Iyengar *et al. PLoS Med.* **13,** e1002032; 2016). Using these drugs to treat every person infected with hepatitis C in Poland would cost 1.6 times the country's annual expenditure on medicines for all conditions. The price of one course of treatment is equal to about six years of earnings for the average Pole.

Gilead intends to protect its patents in high- and middle-income countries, while working to improve access to drugs through discounts and tiered pricing. "We need revenue to put back into the development of drugs for other diseases," Samuel says.

The company has already recouped its original investment in sofosbuvir. It acquired the drug in 2011 when it bought Pharmasset, a biotechnology company in Princeton, New Jersey, for $11.2 billion. Since sofosbuvir hit the market in 2014, the drug and two similar medications have earned Gilead $46 billion.

Menghaney expects the first hearings in the new wave of patent lawsuits to come in six months to a year. But she's already looking to new frontiers. "I hope these battles in developing countries lead people to challenge weak patents and evergreening patents in the United States," she says. ■

ECOLOGY

# How to kill wild animals humanely for conservation

*Guidelines aim to reduce pain and suffering in animals destined for culling.*

**BY EMMA MARRIS**

Every year, trained professionals kill millions of wild animals in the name of conservation and human safety, and to protect agriculture and infrastructure. Commercial pest-control operators, government agents and conservationists trap beavers, poison cats, shoot wolves and gas rabbits in their warrens with varying levels of ethical oversight. Now, animal-welfare experts and conservationists are making a bid to ensure that these animals get the same consideration given to pets and even to laboratory animals that are killed.

People use methods such as carbon dioxide gas, drowning and painful poisons, to kill non-native or 'pest' animals, says Sara Dubois, chief scientific officer for the British Columbia Society for the Prevention of Cruelty to Animals in Vancouver, Canada. She thinks these methods are inhumane. But no one bats an eye, she says, because those animals are considered 'bad'.

Dubois is the lead author of a set of guidelines published on 9 February in *Conservation Biology* (S. Dubois *et al. Conserv. Biol.* http://doi.org/b2c2; 2017). The authors — a group of animal-welfare experts, conservationists and government researchers from around the world — hope the principles will become a model for the ethical review of projects that include killing wild animals. The principles are the result of a 2015 workshop in Vancouver.

## A BETTER DEATH

The document incorporates the latest findings in animal-welfare science, which tries to quantify the pain and suffering animals experience in different situations, including when they are killed. It says that control actions should be undertaken only if they support a clear, important and achievable goal. In addition, the fact that an animal is non-native, or considered a 'pest' or 'feral', is not, by itself, reason enough to get rid of them.

The principles are sound, says Bruce Warburton of Landcare Research, a government-owned research company in Lincoln, New Zealand. He was not involved in creating the guidelines, but has studied the animal-welfare impacts of pest control for two decades. Warburton adds that the principles would reduce the number of available animal-control tools and would be likely to incur a cost, at least initially.

Matt Heydon, a species-protection expert at Natural England, a government advisory group based in York, UK, says the principles tend to favour animal welfare a little more than do the ones his organization uses, but are broadly similar. "We approach the issue with a slightly greater emphasis on biodiversity, although animal welfare is also very important to us," he says.

The US Department of Agriculture's division of Wildlife Services kills millions of animals every year to protect agriculture and address other human–animal conflicts. A spokesperson noted that the department already follows "euthanasia guidelines from the American