kept in at least 10 labs in 10 countries. Stocks of live-attenuated vaccine, currently held in at least 53 labs in 34 countries, are deemed less problematic, although some could, in theory, revert to disease-causing forms.

The FAO and the OIE hope to eventually reduce the number of sites holding live wild viruses to a handful of officially designated labs, ideally located outside regions where accidental releases could have devastating consequences, says David Ulaeto, a virologist and member of the joint advisory committee. Conversely, the agencies plan to centralize stocks of vaccines in a few high-containment repositories in regions at highest risk of disease, so that they can be deployed within hours of any confirmed recurrence of rinderpest. No siting decisions have been made, but one might imagine a repository in Africa, one or two in Asia and one in Europe, says Juan Lubroth, the FAO's chief veterinary officer.

The process of destroying virus or shipping it to centres with high biosafety levels must be done in a way that does not risk its release, says Ulaeto. The FAO and the OIE are working on high-security protocols for shipping the virus and ways to ensure that autoclaves in labs holding it are certified to function at levels guaranteed to provide a 100% kill.

Many countries are reluctant to give up their vaccine stocks in case the disease should reappear and threaten their food supply. They worry about becoming dependent on the willingness of the international community to swiftly provide them with needed vaccines. "The challenge is political," says Bernard Vallat, director general of the OIE. He says that the FAO and the OIE are drafting agreements and international contingency plans that should help reassure countries that swift help would be forthcoming and that they would have guaranteed access to vaccine from FAO–OIE repositories.

Many countries are reluctant to give up their vaccine stocks.

Vallat notes that if Baron proves that PPR vaccines can protect cattle against rinderpest, it would provide an elegant way around such political issues: there would no longer be any need to hold onto rinderpest vaccines. Baron says that he hopes to start the vaccine-challenge trials next spring and complete them by the end of 2014.

Additional potentially promising research areas include other improved vaccines, diagnostics and perhaps disease pathology, says Lubroth. He stresses, however, that the advisory committee will not be prescriptive but open to considering any research ideas put forward by scientists. ■

RADIATION BIOLOGY

Fukushima offers real-time ecolab

But ecologists say they need more funding.

BY EWEN CALLAWAY

Zizeeria maha with abnormal wings.

CHIYO NOHARA & JOJI M. OTAKI

Hours after a magnitude-9 earthquake struck off Japan's eastern coast in March 2011 and triggered the Fukushima nuclear disaster, Marta Wayne e-mailed colleagues in Japan — first to check on their safety, and later to make plans.

The 1986 meltdown of a nuclear reactor at Chernobyl in Ukraine had been a missed opportunity for researchers to gather data on the ecological effects of low-level radiation, she says. Independent scientists didn't gain access to the area for a decade. This time, "I thought immediately that it was important to seize the moment, and study and get data on what the actual outcomes of such a disaster could be", says Wayne, a population geneticist at the University of Florida, Gainesville.

Last week, Wayne and other biologists studying Fukushima and Chernobyl came together at the annual meeting of the Society for Molecular Biology and Evolution in Chicago, Illinois, to report on what they'd learned so far — and what studies they feel are needed for the future. They believe their work on the effects of low-level radiation on animals such as butterflies and sparrows is relevant to understanding the impact of low-level radiation on humans, with implications for appropriate government responses to radiation releases.

The effects of such exposure in humans are poorly understood, says David Brenner, director of the Center for Radiological Research at Columbia University in New York. In an 18 March letter to John Holdren, the US president's chief science adviser, he and his colleagues called for a comprehensive research strategy on the problem. "We're stuck in a dilemma about having to make policy decisions based on nothing more than guesses," he says.

Brenner adds that the risks — mainly of cancer — are small. A March 2013 report by the World Health Organization in Geneva, Switzerland, identified hotspots in Fukushima prefecture where it is predicted that children may experience a slightly increased overall risk of some rare cancers, such as those affecting the thyroid. But most human epidemiological studies are not big enough to pick up small increases in the prevalence of rare conditions.

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Scientists such as Wayne think they can fill in some of the knowledge gaps by studying other species, if they can secure the necessary funding. That has proved enormously difficult in a world where data on the effects of radiation are the subject of heated debate in arguments over the use of nuclear energy.

What Fukushima data do exist are sporadic — and contested. One research flurry concerns butterflies. Joji Otaki, an ecologist at the University of the Ryukyus in Nishihara, Japan, has for more than a decade studied the wing-spot patterns and other traits in a Japanese species, *Zizeeria maha*. "I never dreamed of using it for a nuclear accident," says Otaki, who presented his work at the Chicago meeting. But after the Fukushima meltdown, two of his graduate students convinced him to screen for abnormalities in the butterfly as an environmental indicator of radiation's effects.

The team went to Fukushima in May 2011, two months after the earthquake, when the butterflies emerge from their chrysalises, and again in September 2011. They collected butterflies from sites ranging from 20 to 225 km from the reactor. Insects collected in May showed few problems, but their lab-reared offspring had many abnormalities, such as misshapen wings and aberrant eyespots, and many died as pupae (A. Hiyama *et al. Sci. Rep.* **2,** 570; 2012). Among the September-collected butterflies, more than half of the progeny showed such defects.

Otaki's team also exposed butterflies to radiation doses in the lab akin to those that butterflies near Fukushima might have received. The offspring developed the same problems. "You can come up with alternative explanations, but I think the hypothesis that radiation caused death and abnormalities is the most reasonable," Otaki says. ▶

Tim Mousseau, an evolutionary geneticist at the University of South Carolina in Columbia, says that more studies like these are sorely needed. He is heading to Fukushima this week to begin his third season of field work since the meltdown, tracking birds, insects and other small animals. His team saw die-offs in some insects and declining numbers of some bird populations after one season's work (A. P. Møller *et al. Environ. Pollut.* **164,** 36–39; 2012). He hopes soon to publish three years of observations.

For funding, Otaki says he has had to turn mostly to private foundations. "I think maybe this is a very touchy issue, politically," he says. Mousseau has received money from a German biotechnology company and is now working with researchers supported by the Finnish government. But he says that US government grants are difficult to secure. The Department of Energy has largely stopped funding its research programme in low-dose exposure, and the National Science Foundation and the National Institutes of Health have awarded few grants on the topic. "The only people who seem to be doing any research are adventurous, opportunistic and independent," Mousseau says. "They have some flexibility in what they do and are just doing it on their own without official support."

Other scientists take issue with the reports of ecological harms from Fukushima. They say that Otaki's research is flawed, because wing shape and other butterfly traits vary naturally with geography. "This study's sensational claims should not be used to scare the local population into the erroneous conclusion that their exposures to these relatively low environmental radiation doses put them at significant health risk," Timothy Jorgensen, a molecular radiation biologist at Georgetown University in Washington DC, wrote in a comment on Otaki's 2012 paper. Mousseau's report of harms to birds one year after Fukushima has been criticized for including only one sampling period and lacking baseline data.

Richard Wakeford, an epidemiologist at the University of Manchester, UK, thinks that ecological research on the Fukushima disaster's effects will prove as confounding as efforts to detect health effects in humans exposed to low doses of radiation. Many ecosystems and their species are altered after human evacuations in ways that have nothing to do with radiation, he says.

Wayne says post-Fukushima research needs more support to boost its quality. She and her colleagues are drafting a white paper to establish better standards for collecting, analysing and sharing data. "We don't want disasters to happen so we can collect more data," she says. "But as it has happened, we should learn from it." ■

SPACE SCIENCE

Lasers boost space communications

Optical systems set to handle planetary science's big data.

BY DEVIN POWELL

Before NASA even existed, science-fiction writer Arthur C. Clarke in 1945 imagined spacecraft that could send messages back to Earth using beams of light. After decades of setbacks and dead ends, the technology to do this is finally coming of age.

Two spacecraft set for launch in the coming weeks will carry lasers that allow data to be transferred faster than ever before. One, scheduled for take-off on 5 September, is NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE), a mission that will beam video and scientific data from the Moon. The other, a European Space Agency (ESA) project called Alphasat, is due to launch on 25 July, and will be the first optical satellite to collect large amounts of scientific data from other satellites.

"This is a big step forward," says Hamid Hemmati, a specialist in optical communications at NASA's Jet Propulsion Laboratory in Pasadena, California. "Europe is going beyond demonstrations for the first time and making operational use of the technology."

These lasers could provide bigger pipes for a coming flood of space information. New Earth-observation satellites promise to deliver petabytes of data every year. Missions such as the Mars Reconnaissance Orbiter (MRO) already have constraints on the volume of data they can send back because of fluctuations in download rates tied to a spacecraft's varying distance from Earth. "Right now, we're really far from Earth, so we can't fit as many images in our downlink," says Ingrid Daubar, who works on the MRO's HiRISE camera at the University of Arizona in Tucson. Laser data highways could ultimately allow space agencies to kit their spacecraft with more sophisticated equipment, says John Keller, deputy project scientist for NASA's Lunar Reconnaissance Orbiter (LRO). That is not yet possible, he says. "We're limited by the rate at which we can download the data."

> *"Laser communication becomes more advantageous the farther out you go."*

Today's spacecraft send and receive messages using radio waves. The frequencies used are hundreds of times higher than those put out by music stations on Earth and can cram in more information, allowing orbital broadcasts to transmit hundreds of megabits of information per second. Lasers, which operate at higher frequencies still, can reach gigabits per second (see 'Tuned in'). And unlike the radio portion of the electromagnetic spectrum, which is crowded and carefully apportioned, optical wavelengths are underused and unregulated.

Efforts to develop laser communication systems struggled for much of the twentieth century: weak lasers and problematic detectors derailed project after project. But recent advances in optics have begun to change the situation. "The technology has matured," says Frank Heine, chief scientist at Tesat-Spacecom, a company based in Backnang, Germany.

In the 1980s, Europe took advantage of improved lasers and optical detectors to begin work on its first laser communication system, the Semiconductor Laser Intersatellite Link Experiment (SILEX). Equipped with the system, the ESA satellite Artemis received 50 megabits of information per second from a French satellite in 2001 and then exchanged messages with a Japanese satellite in 2005. The project taught engineers how to stabilize and point a laser in space. But it was abandoned after its intended application — a constellation of satellites to provide Internet services — was dropped in favour of the network of fibre-optic cables now criss-crossing the globe.

Since then, Heine's team at Tesat-Spacecom has created a laser terminal for satellite-to-satellite communication, at a cost to the German Aerospace Center of €95 million (US$124 million). The laser, amplified by modern fibre-optic technology, achieves a power of watts — compared with the tens of milliwatts reached by SILEX. In 2008, terminals mounted on two satellites transferred information at gigabits per second over a few thousand kilometres.

ESA's Alphasat will extend the range of this laser terminal to tens of thousands of kilometres once it is positioned high in geostationary orbit. Future satellites that sport laser terminals in lower orbits will be able to beam as much as 1.8 gigabits per second of information up to Alphasat, which will then relay the data to the ground using radio waves. Alphasat's geostationary orbit means that it can provide