In the case of the petroleum industry, companies pushed into deep-water locations without doing sufficient research or making the investments needed to prevent — and respond to — problems that might arise from drilling in such an extreme environment. And the US government did not have sufficient oversight of the industry. Both the government and the petroleum companies seemed to think that there was little risk of the type of blowout that caused the accident. "The Deepwater Horizon disaster exhibits the costs of a culture of complacency," concluded the presidential commission charged with investigating the spill.

Similar overconfidence ruled parts of the seismological community in Japan. Official maps of the seismic hazard in the country draw heavily on records of past earthquakes. But because no great earthquake had struck off the coast of Sendai in recent centuries, the hazard assessments did not take such a large event into account (see *Nature* doi:10.1038/nature10105; 2011, and *Nature* **471,** 556–557; 2011). Some researchers were more cautious. They pointed to geodetic data showing that strain was increasing in the region and to geological signs of a tsunami in 869 that was much larger than anything more recent. But such evidence did not undermine seductive faith in the official quake risk-assessment method, which turned out to be fundamentally flawed. In addition, the designers of the Fukushima nuclear power plant failed to adequately prepare for the possibility that their back-up generators would fail, and misjudged how hard it would be to re-establish electrical power after a tsunami.

One lesson that must be taken from these tragic events is that many of our critical systems are simply unable to withstand situations that are entirely possible. Think the oil and gas industry has learned the lessons of Deepwater Horizon? Don't hold your breath. The rush to exploit the resources exposed by dwindling Arctic ice cover seems riddled with the same dismissal of legitimate risks of rare but plausible events with terrible consequences (see page 162).

Such critical systems — and society at large — must be made more resilient: the core elements of society need to function even when disasters strike. And many fields, ranging from seismic engineering to urban planning for the impacts of climate change, are working to build up this resilience.

"Critical systems must be made more resilient."

In practice, this means strengthening crucial buildings and other infrastructure, developing back-up power systems and planning for multiple tiers of failures. It also requires better training for local communities and government officials in how to respond. Earthquake and tsunami drills are common in places such as California and Japan, but other regions, too, need to engage in these and other types of exercises that simulate massive oil spills, nuclear crises, terrorist attacks and hurricanes, to name a few.

On 28 April, almost two million people in the United States will take part in the Great Central US Shakeout by responding as if a large earthquake had taken place in the New Madrid Seismic Zone, which 200 years ago produced the strongest historical quakes in the conterminous United States. This relatively simple public exercise will be followed up a few weeks later by a more detailed drill involving federal, state and local managers.

Such simulations are essential to probe emergency plans for weaknesses before the real hazards come along, which they will. ■

Universal truths

Rejection of broad commonality in structure of languages has implications for all sciences.

Since at least the days of Aristotle, a search for universal principles has characterized the scientific enterprise. In some ways, this quest for commonalities defines science: without it, there is no underlying order and pattern, merely as many explanations as there are things in the world. Newton's laws of motion, the oxygen theory of combustion and Darwinian evolution each bind a host of different phenomena into a single explicatory framework.

In physics, one approach takes this impulse for unification to its extreme, and seeks a theory of everything — a single generative equation for all we see. It is becoming less clear, however, that such a theory would be a simplification, given the proliferation of dimensions and universes that it might entail. Nonetheless, unification of sorts remains a major goal.

This tendency in the natural sciences has long been evident in the social sciences too. Here, Darwinism seems to offer justification, for if all humans share common origins, it seems reasonable to suppose that cultural diversity could also be traced to more constrained beginnings. Just as the bewildering variety of human courtship rituals might all be considered to be forms of sexual selection, perhaps the world's languages, music, social and religious customs and even history are governed by universal features. To filter out what is contingent and unique from what is shared might enable us to understand how complex cultural behaviour arose and what guides it in evolutionary or cognitive terms.

That, at least, is the hope. But a comparative study of linguistic traits published online today (M. Dunn *et al. Nature* doi:10.1038/nature09923; 2011) supplies a reality check. Russell Gray at the University of Auckland, New Zealand, and his colleagues consider the evolution of grammars in the light of two previous attempts to find universality in language.

The most famous of these efforts was initiated by Noam Chomsky, who postulated that humans are born with an innate language-acquisition capacity — a brain module or modules specialized for language — that dictates a universal grammar. A few generative rules are then sufficient to unfold the entire fundamental structure of a language, which is why children can learn it so quickly. Languages would diversify through changes to the 'parameter settings' of the generative rules.

The second, by Joshua Greenberg, takes a more empirical approach to universality, identifying traits (particularly in word order) shared by many languages, which are considered to represent biases that result from cognitive constraints. Chomsky's and Greenberg's are not the only theories on the table for how languages evolve, but they make the strongest predictions about universals.

Gray and his colleagues have put them to the test using phylogenetic methods to examine four family trees that between them represent more than 2,000 languages. A generative grammar should show patterns of language change that are independent of the family tree or the pathway tracked through it, whereas Greenbergian universality predicts strong co-dependencies between particular types of word-order relations (and not others). Neither of these patterns is borne out by the analysis, suggesting that the structures of the languages are lineage-specific and not governed by universals.

This does not mean that cognitive constraints are irrelevant, or that there are no other universals dictated by communication efficiency. It is surely inevitable that cognition sets limits on, say, word length. But such 'universals' seem likely to be relatively trivial features of languages, just as may be the case for putative universals in music and other aspects of culture.

The conclusion? We should perhaps learn the lesson of Darwinism: a 'universal' mechanism of adaptation says little in itself about how a particular feature got to be the way it is, or about how it works. This truth has dawned on physicists too: universal equations are all very well, but the world actually consists of particular solutions, and these are generally the result of contingent history. One size does not always fit all. ■

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WANO

Q&A Laurent Stricker
Nuclear safety chief calls for reform

Laurent Stricker, chairman of the World Association of Nuclear Operators (WANO), says that the disaster at Japan's Fukushima Daiichi nuclear plant should mark a turning point for an industry that many experts believe has become complacent about the safety of its reactors. Created in 1989, WANO is an international forum, headquartered in London, that brings together all nuclear power plant operators, along with governments and nuclear experts, to improve operational safety across the industry. Stricker is a nuclear engineer and former power plant director, and is also the senior adviser on nuclear affairs to the French utility company EDF.

Should Fukushima prompt WANO to change its remit?
Until now, WANO has addressed lessons learned from reactor operations, but not reactor design issues. I think in the future it should, in particular so that when operators modify their designs they draw more on analyses of past accidents.

It is not easy to designate one reactor design as safer than another. Rather, one must look at the particular case of each reactor's implementation, and its location. A reactor exposed to the threat of a tsunami doesn't face the same risks as a reactor of the same design elsewhere.

Population proximity is also very important. Japan, like many other countries, has several enormous nuclear sites near dense populations, so those demand even higher safety margins. After Fukushima, I believe that safety reviews should also consider the risk of accidents at several reactors at the same site at the same time. Often the current plans are only done for an accident in one reactor at a site.

We also need to be prepared for events exceeding what a reactor was designed to withstand, and to learn how best to cope with accidents such as a loss of electricity supply and cooling capacity, as happened at Fukushima Daiichi. That means having the right emergency procedures and equipment, and regular emergency drills, often involving the local population. Some countries do this very well; others do it much less, or not at all.

In October, WANO will bring together in China the chief executives of all the nuclear operators to discuss lessons learned from Fukushima, and any changes needed to WANO's mandate. WANO needs to be in a position to verify that every nuclear operating company has plans to cope with unforeseen accidents.

Has the industry been overconfident that a serious nuclear accident is now impossible?
Absolutely. I worry about overconfidence. People think we have good designs, we have good operators, we have good procedures and good safety authorities, so they think everything is fine.

Does the International Nuclear Events Scale distort the true safety record of the industry, with 'near misses' being registered as low-level incidents rather than potential disasters?
I think you are right. And it's true that the scale of severity is used in very different ways from one country to another. You also have differences in transparency from one country, and from one operator, to the next. At WANO, for example, we ask member companies to report incidents to us so that we can analyse them and share lessons from them. But between 5% and 7% of the power plants don't report any events in a given year. As an operator, I'm convinced that anyone running a nuclear power plant is bound to have something to report over the course of a year.

Could greater international oversight improve safety?
My point of view is that there are not enough plans in place to immediately help an operator in another country to cope with an accident.

Also, for countries that are relatively new to operating nuclear power plants, peer review before plant start-up is essential because serious accidents have often occurred in new reactors shortly after start-up. WANO sends teams of 20–25 engineers from other nuclear plants to review the functioning of the new plant for about three weeks and to provide a confidential report. The International Atomic Energy Agency has a similar programme that does five or six similar reviews per year; WANO has greater resources and conducts about 40 of these reviews a year. At our meeting in China, I will propose increasing their frequency.

I have also proposed that if operators fail to make progress on issues flagged by these reports as 'areas for improvement', then WANO should be authorized to dispense with its obligations of confidentiality.

If there is another major accident, is nuclear energy finished?
I fear so. As we have seen at Fukushima, an accident in one country has consequences for all nuclear operators elsewhere. ■

INTERVIEW BY DECLAN BUTLER
(Edited and translated from French.)

TEPCO

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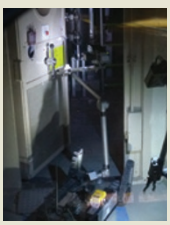

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CORRECTIONS

The news story 'China faces up to 'terrible' state of its ecosystems' (*Nature* **471,** 19; 2011) stated that more than 25% of China's grasslands have been lost in the past decade. The percentage should have been 2.5%

The Editorial 'Universal truths' (*Nature* **472,** 136; 2011) should have referred to Joseph Greenberg, not Joshua Greenberg.