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No magic fix for carbon

Carbon capture and storage projects promise to make a dent in global emissions — but only as part of a broader programme of technology deployment and economic incentives.

The international pantomime that is climate-change politics is filled with heroes and villains, who jump onto and off the stage and trade places as time passes and the focus of attention changes. But one character endures: the fairy godmother, a single brilliant idea or advanced technology who with a single wave of her wand can introduce some magic to save the planet. It is a seductive and appealing plot twist, partly because it guarantees a happy ending, and partly because that happy ending comes about without any serious sacrifice by the dramatis personae. This *deus ex machina* principle of screen-writing — plot the hero or the world into a seemingly impossible corner and have the solution appear from nowhere in a puff of inspired smoke — infuriates science-fiction fans everywhere.

Over the past decade or so, carbon capture and storage (CCS) has been the fairy godmother of climate change, or at least of the politicians who have pledged in ever more ambitious terms to tackle the problem. Dig into most political promises to slash greenhouse-gas emissions by headline amounts — 80% by 2050, that kind of thing — and there she is. A significant proportion of the promised cuts are the result not of declines in carbon dioxide production, but of attempts to trap damaging emissions at source and divert them under the ground rather than into the atmosphere. Clean coal, CCS technology, capture-ready: the idea has spawned its own subplots and terminology. Regulations on carbon pollution permitted from new fossil-fuel-fired power plants are also being drawn up, on the assumption that CCS is feasible, and that it can be implemented on a massive scale.

Some of this political ambition has been backed with public investment. According to the International Energy Agency (IEA), from 2007 to 2012 more than US\$12 billion of public funds around the world were made available to projects to demonstrate that the concept could work. Impressive perhaps, but hardly sufficient. The IEA has also said that to make the promised contributions to emissions targets, by the middle of this century CO₂ storage would have to be a well-developed industry in its own right — bigger than last year's global oil and gas industry, with all of the associated infrastructure. About 25 million tonnes of carbon dioxide are already piped under the ground each year for a variety of reasons. The IEA says that must rise to 7 billion tonnes by 2050.

As we report on page 20, two coal-fired power plants in North America are preparing to nudge up the modest annual amount of CO₂ sequestered. The Boundary Dam Power Station in Saskatchewan, Canada, will probably be first. It is scheduled to switch on later this year, and if it does so it will win a global race. For the first time, a commercial-scale plant that supplies electricity to the grid will capture and store most of its emissions, about 1 million tonnes of CO₂ a year. (Whether this is a good thing for the environment depends on your point of view: the gas will be sold to an oil company and squeezed underground to help to flush out the stubborn reserves of an oilfield.)

Following close behind is a more modern coal plant in Kemper County, Mississippi, designed to capture 3.5 million tonnes of CO₂ a year — about two-thirds of its total emissions. This captured gas will also go towards enhanced oil recovery when the plant starts to operate towards the end of this year.

The concept works. The question is, at what cost? As Howard Herzog, a CCS researcher at the Massachusetts Institute of Technology in Cambridge, says in the News story: “The technology is ready to go. The problem is that policies aren’t in place to make projects economic.” Well, quite.

The commercial market for CO₂ is small and unlikely to expand any time soon. Schemes to make companies pay for their emissions were intended to penalize polluters and level the playing field for clean but pricey alternatives, but they are struggling. However cheap CCS technology might get, a coal or gas plant that scrubs its exhaust gases to capture the carbon will always be more expensive to run than one that does not — making it the first to be turned off when demand for electricity falls outside peak times.

Many questions remain about the long-term viability of a serious and sustained CCS contribution to the global effort to reduce greenhouse-gas emissions, not least how to guarantee that stored carbon stays stored. But by this time next year, the coal plants in Saskatchewan and Mississippi could give politicians around the world sufficient proof that the concept can be deployed — not as a fairy godmother to spirit away their problems, but as part of a broader suite of technologies. Then they just have to decide what to wish for. ■

False positives

A correlation between error rate and success undermines promise of stem-cell trials.

When it comes to stem-cell therapies, the stakes are high — but not as high as the hopes of people who are severely ill. Over the past few years, dozens of small, early-phase clinical trials have tested the value of adult stem cells in treating debilitating or life-threatening heart disease. Results have been mixed, but most peer-reviewed academic reports have hinted that patients may be helped. This has, understandably, encouraged clinicians to move potential therapies into large and expensive phase III trials to establish whether the treatments can fulfil their promise.

Now comes a shocking reality check, revealed this week in the *British Medical Journal* (*BMJ*). As we report on page 15, a London-based team has scrutinized reports of all the randomized trials of bone-marrow stem-cell treatments for heart disease they could find.

The authors searched for discrepancies that might undermine the results and found plenty — errors such as numbers not adding up, or individual patients reported variously as male and female, dead and alive. In fact, the researchers found a linear relationship between the number of discrepancies and the claimed effect size. The small number of trials that they identified as unflawed showed an effect size of zero. In other words, the scientists declare this stem-cell emperor to have no clothes.

The multitude of discrepancies may not necessarily invalidate the conclusions of an individual trial — the authors point out that all too often the clinical data are not available, leaving them unable to check whether the discrepancies are real errors or just the result of sloppy reporting.

But, at the very least, the *BMJ* report should raise the question of whether the data are really strong enough to support the big step of moving to a phase III trial, particularly given that in the case of adult stem cells the results of animal studies have been ambiguous. Initially, researchers suggested that these cells became specialized to the target organ and replaced damaged tissue, but this idea has since been rejected. Many clinicians now think that the cells instead act to heal the surrounding tissue, releasing molecules that cause inflammation and the growth of oxygen-bearing small blood vessels, processes important to repair.

The findings of the *BMJ* study raise another worrying question: why did the clinical journals concerned fail to notice the discrepancies, given that many of the errors seem, in hindsight at least, to be startlingly visible? If a table claims to describe n clinical events, for example, but in its columns refers to $n + 2$ events, is that really so hard to catch?

This, in turn, raises more queries about the process. Who should take responsibility for fact-checking a paper for internal consistency? Is it the notoriously busy clinical experts who act as referees? Or the editors, many of whom also have a full schedule of clinical duties? Few of the journals that published the papers scrutinized in this case have professional editors or significant numbers of in-house editing staff. Pressure to review and publish quickly is high. The two sides of the equation don't balance, and the problems identified in the study suggest something of a crisis.

“The small number of trials identified as unflawed showed an effect size of zero.”

To address this, the publishers of clinical journals must do more to ensure that someone takes responsibility for the fact-checking. That could involve asking authors to guarantee that they have checked figures, tables, text and abstracts for internal consistency. Publishers could require authors to make available suitably anonymized data on each patient as metadata to the study, so that readers can trace the source of any discrepancy that might creep through. Or the publishers could reach into their pockets and provide more in-house resources to perform the necessary checking. What is not acceptable is for the situation to continue as it is, with responsibilities undefined and inexact publishing distorting clinical messages.

The problem seems to run deeper than the heart and stem-cell studies checked in this case. For years, analyses have highlighted a bias towards publishing clinical trials that show a positive outcome. (A similar trend has also been found with scientific results.)

Translational medicine is one of the buzz-phrases of the twenty-first century. In a way, it should be a surprise that it has taken so long for the idea to catch on. What use is medicine that is stuck in the scientific laboratory? But as the curious case of adult stem cells demonstrates, the right checks and balances are not brakes on progress, but an essential foundation for that progress. Fools rush in. So do those who have not done their homework. ■

Agency for change

Japan's proposed reforms to science monitoring are welcome but long overdue.

Scientific misconduct is a universal problem. Policies to investigate and prevent it, however, are patchy. Japan is now taking welcome steps to address the issue.

Japan has certainly produced some of the more bizarre cases of scientific fraud identified in recent years. In 2000, an amateur archaeologist was caught on film burying stone tools that he later unearthed as evidence of human civilization — his ‘discoveries’ over two decades falsely pushed back Japanese history by 650,000 years and corrupted a generation of history textbooks (see *Nature* **408**, 280; 2000).

In 2009, a University of Tokyo professor, Serkan Anilir, was found to have lied about several of his career achievements, including his claim to be the first Turk in a NASA programme: an image of him wearing a spacesuit was uncovered as a fake. And in 2012, the 20-year career of an anaesthesiologist came under question amid the record retraction of more than 100 of his papers (see *Nature* **489**, 346–347; 2012).

There is more to these cases than embarrassing tales of individuals gone off the rails. They indicate a lack of oversight in research and the common cultural reluctance of colleagues to act on suspicions for fear of challenging their peers. They highlight how misconduct is not reported enough in Japan, partly because the country has lacked a high-level agency to deal with it.

Japan is now preparing to clean up its scientific act. At a 14 April meeting of the Council for Science and Technology Policy (CSTP),

the nation's highest science-policy organization, an eight-person subcommittee called for the cultivation of research integrity in individual researchers, and for the setting up of fraud prevention and response measures at the institutional level to restore public faith in science.

The council's chair, Japanese Prime Minister Shinzo Abe, expressed concern that “the recent rash of cases involving scientific misconduct threatens to erode the foundation of our research.” He noted that an approach to misconduct based purely on the experience of individual cases is inadequate; instead, he has asked the CSTP to develop measures “from a broad perspective”.

In its call for action, the CSTP cited the ongoing case of Haruko Obokata of the RIKEN Center for Developmental Biology in Kobe. In January, she published research in this journal that suggested adult cells can be reprogrammed into stem cells through stress. Within weeks, allegations emerged that the work contained errors. On 1 April, RIKEN charged Obokata with misconduct. She is appealing the decision.

It is unclear how Japan will act on the CSTP call for action, but the country should take this opportunity to create an agency, akin to the US Office for Research Integrity, that can handle allegations of fraud and misconduct in a systematic way and encourage whistleblowers to come forward. The need for such an agency has been noted often, including in these pages (see *Nature* **437**, 595–596; 2005).

Researchers now deal with more data than ever before, and the evaluation of misconduct allegations often comes down to distinguishing sloppiness from deception in the presentation of data. For this reason,

Japanese institutions should be given funding to educate their researchers in the responsibilities of data management. Whatever the outcome of the CSTP's proposals, the high level of attention given to the issue is long overdue. ■

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