the medical risks and financial outlay, often with only anecdotal information to guide the decisions. This provokes important questions about how these experiments in free will might be managed and what might be learned from them.

The phenomenon of 'stem cell tourism' seems unlikely to subside in the short term. As such, we argue there is an ethical duty to provide individuals who are considering such options with the best available information about the risks and benefits of the procedures. Even so, in most cases a dearth of scientific and medical information exists on the specific 'treatments' being offered. Acquiring as much such information as we can about the interventions and their consequences—beneficial, harmful or inconclusive—leads to better healthcare decisions by patients, caregivers and clinicians. If there are benefits, we want to know. If there is harm, we need to know. If there are no effects, we still need to know so that patients can conserve their energy and funds until more effective applications become available.

The best way to produce reliable information is through controlled clinical trials, which are subject to the rigors of peer review. But without a trial, at a minimum it would be useful to obtain objective data about the consequences of these stem cell transplants by careful evaluation of patients before and after the procedures and by documenting confounding factors and co-variables. Regardless of the transplant, reliable data about any significant changes would be of value and might serve as pilot data for more rigorous trials in the future. In the field of spinal cord injury—a well-publicized target for stem cell treatments—there is considerable interest in defining better outcome measures to evaluate changes in impairment and function, not only of paralyzed limbs but also of bladder, bowel and sexual function and other physiological and psychological parameters that may affect quality of life.

We would like to alert readers to the Spinal Cord Outcomes Partnership Endeavor (http://scope-sci.org/), an international collaboration between academic, medical, government, industrial and consumer organizations to develop improved clinical trial and clinical practice protocols and define reliable, accurate, sensitive and specific measures of clinically meaningful outcomes. The Stanford Spinal Cord Injury and Repair Program is pursuing an initiative to apply some of these assessments to patients who have decided to pursue stem cell interventions overseas. Agreement on outcome measures would allow collaboration on such an initiative by multiple research groups in different countries, pooling data to increase the likelihood of statistical significance and early conclusions. Such a project would also provide the opportunity to inform patients about risks and benefits, at least in general terms, and to educate them about the types of questions that would be reasonable to ask of any clinic offering novel treatments. An example of guidelines about experimental treatments for spinal cord injuries is available on the website of the International Collaboration on Repair Discoveries (http://www.icord.org), in association with the International Campaign for Cures of spinal cord injury paralysis (http://www.campaignforcure.org/iccp).

Because of the controversial nature of some stem cell transplants, it is critical to design these studies with careful attention to ethical issues. These include scientific impartiality and the avoidance of implied endorsement or disapproval of unproved treatments. There may be a duty to warn of known fraud, especially risky procedures, or patient abuse. A distinction should be drawn between the informed consent to an intervention and the informed consent to evaluate the intervention. These processes must be separate, even if the clinicians doing the evaluation cannot be truly blinded to the intervention. Other ethical questions emerge, too. At what point should there be contact between the evaluators and providers of transplants? Should governments get involved? If so, how do we reconcile the ethical norms of one country with another?

Patients who pursue unconventional and untested transplants usually find clinics and health information using a variety of peer-to-peer channels. Some websites are sponsored by patient community and advocacy organizations such as PatientsLikeMe (http://www.patientslikeme.com). Sites, like MySpace and personal blogs, link other patients. And, some are managed and paid for by for-profit stem cell providers. Information across channels can range from accurate to misleading and possibly dangerous. No one can deny the power of the Internet to enable patient-driven healthcare. It is our view that engaging reliable peer-to-peer networks early and often can uncover misinformation, provide some real-time results and aid in the logistical dimensions of observational studies like ours. It is necessary for clinicians and researchers to work more closely with advocacy organizations and patient networks to provide information about these evaluations, to educate patients about their healthcare options, and in the process, educate ourselves about new models of providing clinical care, education and research.

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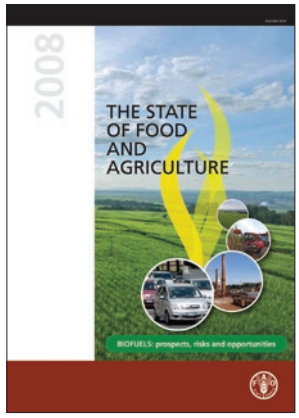
1. Anonymous. *Nat. Biotechnol.* **26**, 971 (2008).

Is FAO selling biotech short on biofuels?

To the Editor:

The Food and Agriculture Organization (FAO; Rome) has just released a report *The State of Food and Agriculture; Biofuels: Prospects, Risks and Opportunities*[1]. This report demonstrates how the FAO has marginalized itself by its thinking and lack of foresight. The words GMO (genetically modified organism) or transgenic are not mentioned as rapid ways to domesticate crops



for biofuels; even breeding is not mentioned as such in the text. The FAO-given role for biotech in biofuel crop development is crop genomics, but they fail to say how genomics might be used. There is also a general statement that "Apart from genomics, other biotechnologies that can be applied include marker-assisted selection and genetic modification." The only things they discuss

in particular that should be "genetically modified" are the organisms producing the enzymes for lignocellulose degradation. Algae as a source of liquid biofuels or hydrogen are not mentioned anywhere, yet their culture in seawater has considerable potential to solve the fuel versus food debate discussed at length in the report[2].

Worse yet they ignore the toxicological and environmental dangers of some of these crops. Castor bean and *Jatropha curcas* (common name: vomit nut), sources of the closely related, exceedingly potent ricin and curcin are widely discussed, and *Jatropha* has an entire box dedicated to its culture ("Jatropha—a 'miracle' crop?"), where the answer on balance is "yes." Nowhere in the report do curcin or ricin appear, nor is there a mention of the cancer potentiators and allergens in *Jatropha.* Unlike soybeans, the protein of the seed of both crops is poisonous (but can be partially detoxified by autoclaving), so there is no possibility of feeding the protein to livestock. No environmental impact or worker toxicological studies have been published that deal with the implications of applying the residues to farmers' fields, as they suggest. The toxins could be eliminated by antisense or RNAi technology, and the residues used as feed. Where is the FAO in dealing with farmer safety? Imagine releasing a transgenic crop with such properties. They do not even cite those who have analyzed and questioned the economics of *Jatropha*[3]. Is the FAO really interested in keeping poor farmers poor? Alas transgenics could rapidly solve many of these problems in domestication that the FAO so glibly ignores[4,5]. So many of the troublesome genes are known, the crops have been previously transformed, but if organizations, such as the FAO, do not recognize the problems, who will deal with the biotechnological solutions?

COMPETING INTERESTS STATEMENT
The author declares competing financial interests: details accompany the full-text HTML version of the paper at http://www.nature.com/naturebiotechnology/.

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1. FAO. *The State of Food and Agriculture; Biofuels: Prospects, Risks and Opportunities* (Food and Agriculture Organization of the United Nations, Rome, 2008). <ftp://ftp.fao.org/docrep/fao/011/i0100e/i0100e.pdf>
2. Chisti, Y. *Biotechnol. Adv.* **25**, 294–306 (2007).
3. Achten, W.M.J. *et al. Biorefin.* **1**, 283–291 (2007).
4. Gressel, J. *Plant Sci.* **174**, 246–263 (2008).
5. Gressel, J. *Genetic Glass Ceilings-Transgenics for Crop Biodiversity* (Johns Hopkins University Press, Baltimore, MD, USA, 2008).

Terri Raney replies on behalf of the FAO: Jonathan Gressel claims that our report[1] inadequately addresses the potential of genetic modification to support the development of biofuels. The aim of the report is to examine the economic and policy drivers behind the recent rapid expansion in the production of first-generation liquid biofuels and the implications of this expansion for agricultural markets, food security and the environment. The report discusses the need for research and the importance of improved technologies, both in feedstock production and conversion to biofuels, to enhance the environmental and economic performance of biofuels. It also dedicates a short box to the application of biotechnologies (including genetic modification) to biofuels. Even so, technology is not the central focus of the report. (Readers may be interested in knowing that FAO published a comprehensive assessment of agricultural biotechnology, including transgenic crops, in a previous edition of *The State of Food and Agriculture*[2].)

The present FAO report[1] finds that the recent rapid expansion in liquid biofuel production offers both risks and opportunities for the global food and agriculture system primarily through its impact on commodity prices. The immediate risk is that higher prices hurt poor consumers in the developing world, who often spend more than half their total household income on food. The opportunities derive from the fact that agriculture is the engine of economic growth in many parts of the developing world, and higher commodity prices can provide the incentives and stimulate the investments needed to revitalize the sector. Most of the world's poorest people depend on agriculture for their livelihoods, so higher prices may translate into higher incomes for them. Minimizing the food security and environmental risks associated with first-generation biofuels and maximizing the potential opportunities for agricultural development would require a shift away from current policies that subsidize the production of first-generation liquid biofuels, toward a more balanced package of policies that consider environmental, food security, energy and agricultural development needs in a more integrated way.

Gressel is particularly critical of a short box in the report which he interprets as giving a positive assessment of the potential of *Jatropha curcas* as a biofuel feedstock. The box reports that *Jatropha* is receiving considerable attention in many developing countries as a drought-tolerant plant that can grow under marginal conditions with limited external inputs. The box notes, however, that many of the positive claims for *Jatropha* are not supported by current evidence, the crop has not been fully domesticated and thus is subject to wide variations in agronomic performance; furthermore, it has not been produced on a large scale and thus may have unknown environmental and economic implications. The box concludes that these risks warrant a cautious approach to *Jatropha* development. Gressel emphasizes toxicity as an additional risk associated with the crop, but it and other naturally toxic plants have a long history of safe use in the agricultural sector.

We would like to note that FAO conducts broader programs of work on bioenergy and biotech than could be covered in *The State of Food and Agriculture* biofuels report. Last month, for example, FAO hosted an electronic conference on biotechnologies for bioenergy production in developing countries[3]. This conference may address Gressel's concerns more directly. FAO is also considering bioenergy production systems that may be important in the future, such as those involving production of biodiesel from microalgae or of second-generation biofuels from lignocellulosic biomass. For their development, research and technology are fundamental. If second-generation biofuels are to become a reality in the future, technological breakthroughs will be needed, although they alone will not be sufficient. Second-generation biofuels will also have to be economically viable and environmentally sustainable.

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1. FAO. *The State of Food and Agriculture; Biofuels: Prospects, Risks and Opportunities* (Food and Agriculture Organization of the United Nations, Rome, 2008). <ftp://ftp.fao.org/docrep/fao/011/i0100e/i0100e.pdf>.
2. FAO. *The State of Food and Agriculture 2003–04; Agricultural Biotechnology: Meeting the Needs of the Poor* (Food and Agriculture Organization of the United Nations, Rome, 2004). <http://www.fao.org/docrep/006/Y5160E/Y5160E00.htm>
3. FAO. *The Role of Agricultural Biotechnologies for Production of Bioenergy in Developing Countries. Background document to Conference 15 of the FAO Electronic Forum on Biotechnology in Food and Agriculture, November 10 to December 7* (Food and Agriculture Organization of the United Nations, Rome, 2008). <http://www.fao.org/biotech/C15doc.htm>