head through the curved lens of space-time". One can ponder the parallels between the significance of the title of the book and the concept of 'angle of repose' in the theory of Per Bak and collaborators describing the self-organized critical state of complex systems.

As an illustration of Benford's assertion that fiction informs science, Peter Atkins's *The Periodic Kingdom* is required reading in my honours chemistry class, as is a creative writing assignment based on this book's format (necessarily fiction). Although it is initially perceived as an odd assignment, I hope to infect web-surfing, computer-gaming students with an appreciation for literary science and fiction.

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Standardizing chemical risk assessment, at last

Sir — Industry is continually synthesizing new chemicals, the regulation of which requires evaluation of the potential danger for human health and the environment. Risk assessment is nowadays considered essential for making these decisions on a scientifically sound basis. Yet there are large data and conceptual gaps, which a new European Union (EU) white paper (policy document), *Strategies for a Future Chemicals Policy* (http://europa.eu.int/eur-lex/en/com/wpr/2001/com2001_0088en01.pdf) is attempting to redress.

The white paper is intended to clarify the definition and quantification of 'risk'; the margins of safety for description as 'low risk' (which currently show large differences for pesticides, veterinary drugs and industrial chemicals); and acceptability criteria (currently, the same concentration of the same chemical in soil or food items can be regarded as low or high risk depending on the EU guideline applied!).

Terrestrial ecosystems are of particular concern. In the past, ecotoxicologists have for various reasons focused on aquatic systems, so terrestrial risk assessments have been forced simply to apply the aquatic model to soils, or have focused on specific targets such as risk posed by agrochemical pesticides to birds, bees and beneficial arthropods.

An example of this confusion is demonstrated by the risk assessment of an insecticide that has an acute earthworm toxicity of 1 mg per kg (earthworm toxicity is a widely used measure, as earthworms are among the most sensitive soil-dwelling organisms). As things stand, such assessments can simultaneously conclude that:

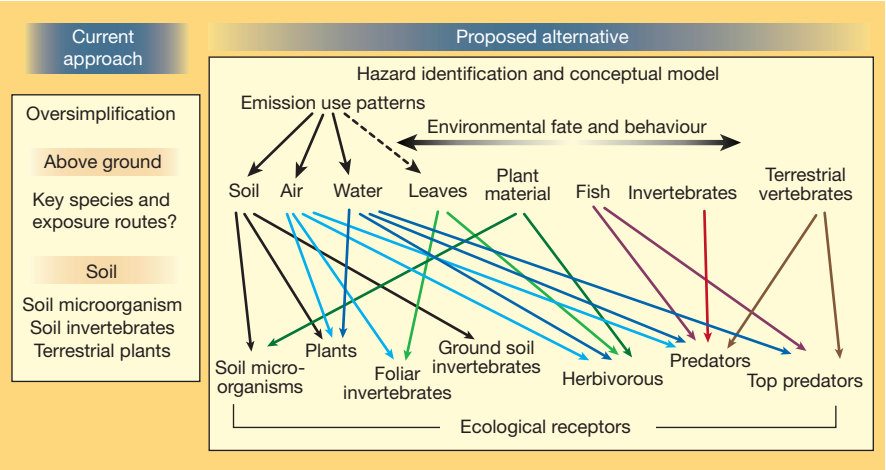
(1) A farmer can use the insecticide as a plant-protection product without risk for soil organisms if the concentration in the soil does not reach 0.1 mg per kg.

(2) The same farmer cannot use the insecticide as a veterinary medicine on farm animals if this use could produce concentrations in the same soil higher than 0.01 mg per kg.

(3) Industry-related processes (for example, use of sludge for fertilizer) giving concentrations higher than 0.001 mg per kg in the same agricultural soil are classified as unacceptable risk, requiring risk refinement or risk reduction.

It is not clear whether confusing inconsistencies such as these originate from uncertainty, cost/benefit considerations, or the lack of scientific knowledge when the guidelines were set. Nevertheless, this inconsistency does not occur for aquatic risk assessment, where the rule is that a concentration 10 times below the chronic NOEC (highest concentration that does not produce effects) for the most sensitive aquatic species is acceptable. Any value above this trigger-point represents a potential risk.

Last year, the EU's Scientific Committee on Toxicology, Ecotoxicology and the Environment (CSTEE) reviewed the scientific basis of proper risk assessment on terrestrial ecosystems (http://europa.eu. int/comm/food/fs/sc/sct/out83_en.pdf). The main weak points requiring further attention are the validation of model estimations with real monitoring data, and the development of a holistic approach for risk characterization. The new white paper requires much-needed simplified alternatives to speed up the assessment process. (At the current rate of progress, a comprehensive risk assessment of all chemicals currently on the market would take more than 1,000 years!). But, of course, simplifications should not jeopardize the best use of science. Now that the main research required to explore these alternatives has been identified by CSTEE, work can start, through the new EU chemicals strategy, while the Organisation for Economic Co-operation and Development and the United Nations Environment Programme can coordinate the extension of the approach beyond Europe.



Comparison of the current and proposed approaches for the terrestrial ecological risk assessment of chemical substances.

We have compared the compartment-based approach developed in the 1980s and 1990s with the more holistic view now proposed by the CSTEE (see figure). Instead of the traditional two-compartment approach, each covering three taxonomic groups, the new proposal is to select key route-receptor interactions for each assessment. Targeted protocols can be referred to specific emission or use patterns, particular exposure routes or specific ecological receptors, all of which offer a large potential for covering regulatory needs.

The conceptual model for terrestrial ecosystems proposed in the figure can be used to assess the risks to humans and other species of exposure to chemicals on agricultural and other managed systems, for biological agents such as foot-and-mouth disease and bovine spongiform encephalopathy, and even radiation.

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