inappropriate, and they are similar to the 'case reports' that have in the past led to more formal epidemiological investigations of other disease entities. What is now needed is to develop epidemiologic methods that can effectively address the problems generated by the peculiar circumstances that increase the long term likelihood of an accident or, just as important, trigger it. An important development in this direction was the introduction of the case-crossover design that has been effectively used in cardiovascular epidemiology to identify and quantify the importance of triggering factors for acute events. The potential of this method in injury epidemiology is being increasingly recognized, and several injury investigators have already used it. Other promising developments are those that focus on more reliable exposure ascertainment and the creation of large databases that can highlight the problems and set the stage for their solutions.

Injury epidemiology is a young discipline that must borrow from its core methodologies while exploring alternatives and refinements. As the discipline matures, so will its methodology. The basic concepts and principles of epidemiology, however, are already established, as is its potential to document causality in health and disease. Injuries are no exception.

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Injury and entropy

As one jumble of molecules to another, I would quite likely the answers to some questions. Why do unintentional injuries occur? Are they intrinsically probable in some biological or chemical sense? I can partly understand infectious disease, intentional injury, and even genetic variations, as the results of biological competition. But why did I slice the end of my finger off when opening the oil can? I knew it was hilarious fun ferreting around in the grass to find it, wash the oil off, and conduct a full thickness skin graft without anaesthetic—but all the same, nothing and nobody gained from it. If it has no obvious biological purpose, perhaps unintentional injury has a more fundamental aspect—a common property we share with the wider jumble of molecules we call our environment.

The physical and chemical fabric in which we live suffers from an overriding probability of increased molecular disorder over time and a related tendency towards the dispersal of concentrations of energy (entropy). I would like to extend this concept of entropy to serve as a simile for a process that appears to occur throughout the physical and social environment.

The construction and maintenance of these environments requires investment of resources for which there is competition—that is, there is a trade off between the repair of cracked paving, the provision of child care, and the provision of cycle helmets, as well as other potentially foregone benefits. Furthermore, this investment of resources is unequally distributed, such that those in socially deprived communities are a priori likely to be living in situations of high entropy. A litmus test for this dissociation and decay of the fabric might be the frequency of injury (that is entropy of the people as a result of entropy of the fabric).

Learners, explorers, and survivors

New personal situations may be imposed by developing (or deteriorating) faculties, may be sought for pleasure, or may be suffered during unwanted changes in circumstances. Injuries are particularly common in immature children (including adolescents), among those who climb mountains, and among the socially marginalised. In the past, there has been a view that children and adolescents are the only 'learners' in our society. When the environment was relatively fixed for human lifespans, this may have been appropriate. Now, in many cases, adults are also forced to adapt to new environments, both social and physical, throughout their lives. This process of spontaneous disorder and the rebuilding of the social and physical fabric, therefore, has a dimension of speed relative to biological time.

Injury might be partly a product of the novelty of such encounters with entropy and of the stresses that accompany human adaptation. The particular individuals likely to be injured may be difficult to identify in advance as this adaptability and skill in learning is not necessarily on the same dimension as risk aversion. For instance, people in risky circumstances may have little insight into their capacities and especially into the capacities of others who are in their care or upon whom they may have an impact.

Testing the model

INJURY AS A RESULT OF SOCIAL ENTROPY

The processes by which social disintegration might be manifest as individual injury could be because the physical environment is not maintained in a safe state through lack of corporate investment, because individuals in the com-

community do not protect their vulnerable members, or because there is inefficient transmission of 'safety' culture (J Moller. Paper presented at the Third International Conference on Injury Prevention and Control; Melbourne, Australia, February 1996). There are a variety of ways in which these alternative scenarios might be tested and some of them might even be inter-related.

For instance, with respect to decay of corporate commitment, records of expenditure on environmental repair related to safety, and of investment in safety features, perhaps complemented by a safety related environmental audit, could be compared with the ecological frequency of injuries. As far as the protection of vulnerable members is concerned, one might approach this by a similar examination of the social network and support mechanisms within communities and relate these to injury patterns. Alternatively, an individual model might be adopted (perhaps using case-control methodology) where parents, neighbours, or even drivers involved with injury incidents to children are compared for their attitudes to corporate responsibility with similar adults related to control children. As far as decay in the transmission of 'safety' culture is concerned, one might make a comparison of the knowledge, attitudes, and skills of child/parent pairs from different social backgrounds in relation to safe environments and practices. Lastly, it may be that certain types of dysfunctional environments, even those that are relatively new, may predispose whole communities to social disintegration or unsafe behaviour. For example, the physical features of blocks of flats may make it impossible to supervise children or to contribute to communal support and social interaction. This, in turn, may lead to high rates of psychiatric morbidity and family disintegration.

INJURY AS A RESULT OF PHYSICAL ENTROPY
At its simplest level, the contribution of environmental disorder might be assessed by experimental alterations of the environment, possibly using animal models. An important dimension to examine is the influence of environmental complexity, especially where there are large concentrations of potential or kinetic energy. In this sense the 'environment' will include a complete spectrum from the smallest consumer product to whole towns. An 'entropy' question that needs to be addressed here is the extent to which individuals who may be held responsible for the use of such 'dangerous' bits of the environment are actually able to control them, particularly when the potential victim is someone other than themselves. One might examine the properties of this sort of model by checking among drivers involved in fatal crashes, the contrast between their perceived and actual driving skill in comparison with drivers not so involved. Equally, one might wish to look at the properties of particular types of vehicles, such as heavy goods vehicles, in terms of their propensity to be involved in injury events, irrespective of the individual skills of their drivers. What constitutes 'danger' in these small or large environments is not only the fact that they have large stores of energy, or that they are particularly complex, but that their tendency to disorder or entropy is 'out of control' in a way that is not recognised by the usual legal concept of responsibility. It is difficult to see how else one can explain the relative dangers in the use of railway trains versus heavy goods vehicles for transporting people or goods.

INJURY AS A RESULT OF BIOLOGICAL ENTROPY
Here, the underlying thesis is that the less mature a child (or post mature an elderly adult), the greater the degree of entropy. Although relatively ordered at a cellular level within their body, this disorder of children is expressed at a variety of points in the integrative hierarchy. For instance, they may have poor perceptual skills or difficulties in managing a number of conflicting, simultaneous messages. They may have little command over their personal environment or physical capacity to escape commonplace hazards. Furthermore, their attempts to develop skills and explore their environment may create dangers of inhalation, drowning, scalds and burns, etc. These are very difficult areas to research and are closely bound up with adult appreciation of the need for protection. One key issue, however, is the utility, or otherwise, of education and training in safety at various points during a child's development. A question that could be examined empirically is whether a subgroup of children can be identified who are at higher risk through relatively high entropy and amenable to specific changes in the characteristics that make them so. So far, this has proved largely impossible, and instead the assumption is that all children are equally at risk through immaturity, and should be offered generic training to improve their skills. The fact that these skills will be acquired more or less automatically through development, and indeed, that the necessary skills for the same task may change depending on the level of physical and psychosocial development of the child, is largely ignored.

A SIMPLER MODEL OF INJURY FREQUENCY BASED ON ENTROPY
Perhaps a three dimensional model could be contrived where social entropy is one dimension, physical entropy is another, and biological entropy a third. One could envisage a cube, along one axis being social deprivation, including issues such as lack of social networks and protection for children, on another dimension might be 'uncontrolled' physical danger, perhaps most easily represented by exposure to motor vehicle traffic, and on a third, relative immaturity (or decay), including lack of appreciation of this by adults, either as parents or perpetrators.

On the other hand—perhaps I shouldn't have stuck my finger into that oil can!

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Injury and entropy.

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Updated information and services can be found at:
http://injuryprevention.bmj.com/content/3/2/76.citation

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