Editorial

Health and the environment*

The old problem of the relations between health and environment is often based nowadays on philosophies challenging not only science but also common sense. The aim of this commentary is to come up with an interpretation of this problem and to suggest some changes to the current practices used to understand health environment relations.

Deep and widespread concern about the quality of the environment has increased over the years leading most of the population, including that of developing countries, to prefer having lower standards of living but a lower risk to health. Although public interest in the environment as a threat to human health is something new, the history of environmentally induced diseases is obviously not; neither is the origin of what is now referred to as environmentalism—their origins lie far back in time. For example, Grove reports that in 1838 over 800 surgeons were employed in different possessions of the East India Company. As time passed increasing demands were made upon these highly educated employees because of the need to understand unfamiliar environments and to counter associated health risks. Consulting and state employment on environmental problems were therefore comparatively common elsewhere long before such a phenomenon existed in Europe.

In modern society considerable efforts are devoted to analysing the magnitude of the risk of environmental damage to establish appropriate regulations. Whether these efforts pay off is controversial, considering that so far as health is concerned, improvements in mortality and morbidity have come primarily from scientific and technological progress and a higher standard of living, not from government regulation. Furthermore, research on perception of environmental risk in the general population has shown that “difficulty in understanding probabilistic processes, biased media coverage, misleading personal experiences, and the anxiety generated by life’s gambles cause uncertainty to be denied, risk to be misjudged, and judgements of fact to be held with unwarranted confidence. Experts’ judgement appears to be prone to many of the same biases as those of the general public, particularly when the experts are forced to go beyond the limits of available data and rely on intuition.”

A legitimate question therefore arises as to whether the understanding of these problems and the approach to their solutions can be improved.

The phenomenon of the “strange loops”

The problem of the relation between environment and health that we are now so much concerned with has existed throughout the history of man even though in different forms and different degrees of severity, understanding, and consciousness. The struggle of man in adapting the environment to his needs, among which health is fundamental, will continue for ever; epidemics of infectious diseases, for instance, have occurred over the centuries and we are now facing AIDS. It is also clear that any action taken to improve our environment and health will have consequences on both environment and health. The origin of environmental diseases has often been understood by mankind but sometimes in the past a malicious deity has been invoked. This also seems to be the case nowadays when certain emotional reactions to chemical pollution are observed.

How can we represent the perception of an endless problem in a finite way and resolve this strong sense of conflict between the finite and the infinite that allows emotional shortcomings? Perhaps the answer comes from a fascinating book by Hofstadter that illuminates one of the greatest mysteries of modern science; the nature of human thought processes. I suggest that our understanding of the relation between environment and diseases should be framed within the original links made by Hofstadter of the music of Bach, the graphic art of Escher, and the mathematical theories of Gödel, as well as ideas drawn from logic, biology, psychology, physics, and linguistics. All these complex intellectual constructions of the human mind can be explained by the phenomenon of the “strange loops” that occurs whenever, moving upwards (or downwards) through the levels of some hierarchical system, we unexpectedly find ourselves back where we started. Three examples taken from Hofstadter’s book will clarify this concept.

J S Bach wrote several canons in his “musical offering” that illustrate the “strange loop” as found in music. A canon is a single theme played against itself. This is done by having copies of the theme sung by various participating voices. After successive

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modulations all the voices are exactly one octave higher than they were at the beginning, and here the piece may be broken off in a musically agreeable way. This process, however, could go on for ever. Straightforward canons are the familiar “row, row, row your boat” and “Frère Jacques.”

The “strange loop” is also one of the most recurrent themes in the work of the Dutch graphic artist M C Escher. His “drawing hands” is one of the best visual realisations; each of the two hands draws the other.

In logic, the ancient philosophical paradox of Epimenides shows the phenomenon. Epimenides was a Cretan who made the immortal statement “all Cretans are liars.”

Environmentally induced diseases: a “strange loop”?
How does the concept of the “strange loop” apply to the intellectual construction of our understanding of the relation between environment and disease?

EXAMPLE 1
Human health is thought to be a fundamental tracer of the quality of the environment. Because life expectancy has increased over the past few decades, we shall conclude that the quality of environment has improved in parallel. Improvements in standard of living together with medical treatment and other measures such as the control of nutritional and infectious factors has led to the present situation. Paradoxically, however, because of our longer lives other environmental diseases are now frightening our society. The incidence of cancer, for example, increases exponentially with age and the current view is that cancer is the result of multiple mutations occurring throughout life. Therefore the development of cancer is likely to be due to a number of environmental factors to which man is exposed during a longer life leading to mutation. This “strange loop” may be linked to several others forming the “eternal golden braid” of our understanding of the relation between health and environment; for instance, to the “strange loop” formed by nutritional factors and mutagens as brought about by the hypothesis that mutations are involved in cancer production. The flourishing studies on binding of foreign chemicals to genetic materials led to the development of mutagenicity tests that have gained some relevance in the assessment of risk of cancer. Whether such tests are of any help, however, in identifying or understanding the cause of human cancer is unclear. Therefore discussion has developed over the years among scientists, administrators, and the general public on the risk assessment of low levels of exposure to man made chemicals based on such tests. A contribution on this point was made by Ames who indicated that the current level of certain man made mutagens to which the general population is exposed is far below the background concentrations of naturally occurring mutagens in our food. Whether such natural exposures are likely to be of importance is unknown. Nevertheless mutagenicity studies now indicate that food is another possible cause of mutations in man. It seems therefore that nutrition, although contributing to an increased life expectancy, might now be endangering it, at least to the same degree as several man made contaminants.

EXAMPLE 2
Several vector borne diseases, including malaria, filariasis, and onchocerciasis affect man. Among other measures to control such diseases, an important achievement has been the development of pesticides—namely, man made chemicals interfering with the biological cycle of vectors of diseases. Following World Health Organisation guidelines, for example, Indian authorities instituted a programme of medical treatment and pesticide application in 1952 that within a single decade reduced cases of malaria from over 100 million to 50 000. In the past few years, however, it has become clear that eradication of malaria has run into severe difficulties and the disease has made a comeback. Estimations indicate that one to two million malaria related deaths occur each year and 107 million new cases a year are reported in 103 countries where the disease is endemic and the population at risk accounts for 2·1 billion. A few cases have also occurred in malaria free countries. Among reasons for the resurgence is the development of resistance of insects to pesticides. In certain areas of the world this resurgence seems to have paralleled the increased use of pesticides. Their widespread use, both in vector control and agriculture, imposed such strong selection pressures on insects that it resulted in the development of resistance to such pesticides. This is an example of a “strange loop”, in which use of the same chemicals leads to both control and resurgence of the same disease.

With the concept of the “strange loop” in mind, it becomes clear that all changes in the environment, even those made to improve our health, should have some consequences. Furthermore, changes in our health—for instance, the longer life expectancy—might also influence the environment, simply because more natural resources will be necessary.

Science, technology, and the prediction of health risks
Research on environmental health over the years has focused mainly on the recognition of adverse effects caused by changes in the environment but a new approach has emerged and consists of tackling the question a priori rather than a posteriori. It is not clear, however, whether and how environmental and
health consequences of ingenious human activities such as science and technology are predictable. Therefore it might be useful to distinguish between science and technology.18

It has been stated that the purpose of science is to surprise people. Good science surprises; not only does it argue against previous common assumptions but it triggers a cascade of unpredictable events. Thus, when x rays were discovered nobody could have predicted their carcinogenicity; or when penicillin was discovered, that some penicillin resistant bacteria would develop. But technological development is fundamentally different; it is done to avoid surprise. The risks derived from new technology should be forecast and this is usually done by means of probabilistic calculations.8,19

How effective is such a forecast when, for instance, it is performed to assess health risks of new man made chemicals? It is the common practice of regulatory bodies to require batteries of toxicological tests of chemicals in animals to estimate risk.20 Risk assessment requires a precise knowledge of the hazard, particularly when no historical data exist, or the risk is likely to be small, or both. In some circumstances, however, it seems that understanding of the hazard is of little relevance in risk assessment and management, simply because the toxicological significance of certain tests is unknown. What is the meaning, for example, of some mutagenicity and teratogenicity tests, of the test for organophosphate delayed polyneuropathy as applied to pyrethroid pesticides, or of some neurobehavioural tests? It appears that when these tests are used to set rules, the whole process of risk assessment and management lacks criteria for a demarcation of the absurd. It has been stated that Popper’s criterion of falsifiability demarcates between empirical and metaphysical statements, but it is so wide that it allows for non-metaphysical nonsense.21 A number of tests seem to belong to toxicological nonsense and they can be identified only with the criterion of understanding the mechanisms of toxicity of chemicals. For the science of toxicology the current testing procedures at best provide rules for systematic collection of data. At worst they inhibit the development of new approaches in understanding the mechanisms of biological action of such chemicals. Also, as a practical consequence of such procedures, some potentially useful chemicals may have been discarded for no reason. An example is given by the assessment of the teratogenicity potential of chemicals when mechanisms are almost completely unknown; it is not even clear whether teratogenicity is initiated by an action on the fetus or the placenta. The catastrophic episode of thalidomide urged certain teratogenicity tests to be included in the toxicology data base for drugs and chemicals. Uses of chemicals that are positive in such tests are now usually restricted. If such tests had been applied to acetylsalicylic acid, however, which has been proven over the years not to be a human teratogen, it would not have reached the market.

Therefore, it is becoming clear that the current approach as based on an increasing number of tests of dubious significance is no longer tenable for several reasons and more understanding of the mechanisms of toxicity is required.22-24 The better we know about mechanisms of biological action of chemicals the better we are prepared to assess risks and to make rational decisions. This does not imply that we need to understand the mechanisms of toxicity of all chemicals to be regulated, but rather whether such an approach should be implemented in toxicological research and throughout the regulatory process.

Another example arises from risk assessment based on a vague or anecdotal assessment of exposure. This is the case when certain epidemiological data are used for such a purpose. A distinguished expert committee recently concluded that “spraying and application of insecticides entail exposures that are probably carcinogenic to humans.”25 Beyond the strict purport of wording used by this committee what is the meaning of such a statement? Hundreds of chemicals are applied differently, in varied environments, and using several mixtures. How can the general statement be derived from a handful of studies performed in one country only?

What research for environmental health?
As stated by several scientists, only by pursuing knowledge itself have exploitable discoveries been produced. This concept was beautifully illustrated when Sir George Porter highlighted an episode of Michael Faraday’s life.26 Faraday was asked by the Royal Society to try to improve the optical qualities of glass and he accepted the task because he thought that the money he was offered was essential for his laboratory. After several years of fruitless work he asked to “lay the glass work aside for a while, that I may enjoy the pleasure of working out my own thoughts on other subjects.” Within two months he discovered electromagnetic induction. When Faraday showed the effect of his discovery to the Chancellor of the Exchequer he was immediately asked “But what is the use of your discovery?” His reply was “I know not Sir, but I’ll warrant one day you’ll tax it.” They did and a few months later the first small dynamos were made.

Faraday started his research on glass because a highly qualified committee considered that this was an important problem. He was persuaded by them, although aware that he was not a “manufacturer.”

How much will the enormous worldwide efforts for environmental research pay off bringing about the camouflage of many scientists aimed at obtaining ad hoc grants? Certainly there is no answer but it has
been historically shown that knowledge itself and its inevitable practical exploitations have formed a golden braid of "strange loops!" According to the definition of a "strange loop," this will continue for ever.

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Health and the environment.

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