17. Conclusions

The case studies reviewed in this book show that there is much that can be learnt from history. Such learning begins with two basic observations:

- Regulatory appraisal and control of technologies and economic development involves balancing the costs of being too restrictive on innovation with the hazards and costs of being too permissive, in situations of scientific uncertainty and ignorance. The case studies provide many examples where regulatory inaction led to costly consequences that were not — and sometimes could not have been — foreseen.
- The case studies also provide many examples where 'early warnings', and even 'loud and late' warnings, were clearly ignored; where the scope of hazard appraisal was too narrow; and where regulatory actions were taken without sufficient consideration of alternatives, or of the conditions necessary for their successful implementation in the real world.

If more account, scientifically, politically and economically, is taken of a richer body of information from more diverse sources, then society may do substantially better in the future at achieving a better balance between innovations and their hazards. Discussion of the case studies led to the distillation of twelve late lessons which, if applied to future decision-making, could help achieve this better balance.

The precautionary principle is an overarching framework of thinking that governs the use of foresight in situations characterised by uncertainty and ignorance and where there are potentially large costs to both regulatory action and inaction.

However, the intrinsic difficulties of applying the precautionary principle to issues of complexity, uncertainty and controversy are compounded by a lack of agreement on the definition and meanings of key terms.

The table below is a contribution to clarifying the meaning of six basic concepts that lie at the heart of this debate. What is sometimes loosely referred to as 'uncertainty' mixes up the analytically distinct concepts of 'risk', 'uncertainty' and 'ignorance'. The public action concepts of 'prevention', 'precautionary prevention', and 'precaution' can then be usefully related to these three states of knowledge, as in Table 17.1.

Table 17.1. **Uncertainty and precaution — towards a clarification of terms**

Source: EEA

Situation	State and dates of knowledge	Examples of action
Risk	'Known' impacts; 'known' probabilities e.g. asbestos causing respiratory disease, lung and mesothelioma cancer, 1965–present	**Prevention**: action taken to reduce known risks e.g. eliminate exposure to asbestos dust
Uncertainty	'Known' impacts; 'unknown' probabilities e.g. antibiotics in animal feed and associated human resistance to those antibiotics, 1969–present	**Precautionary prevention**: action taken to reduce potential hazards e.g. reduce/eliminate human exposure to antibiotics in animal feed
Ignorance	'Unknown' impacts and therefore 'unknown' probabilities e.g. the 'surprises' of chlorofluorocarbons (CFCs) and ozone layer damage prior to 1974; asbestos mesothelioma cancer prior to 1959	**Precaution**: action taken to anticipate, identify and reduce the impact of 'surprises' e.g. use of properties of chemicals such as persistence or bioaccumulation as 'predictors' of potential harm; use of the broadest possible sources of information, including long term monitoring; promotion of robust, diverse and adaptable technologies and social arrangements to meet needs, with fewer technological 'monopolies' such as asbestos and CFCs

The procedures for dealing with the situations of risk, uncertainty and ignorance need to be fair, transparent and accountable, key elements of the 'good governance' which is needed to regain public confidence in policy-making on technologies, their benefits and potential hazards.

Most of the cases in this book involved costly impacts on both public health and the environment, two fields of science and policy-making that have become specialised and somewhat polarised during the last 100 years. Individuals experience their health and their environment as one, interconnected reality: science, regulatory appraisal and policy-making need to be similarly integrated. *Late lessons* should make some contribution to this integration of health and environment.

The scope of regulatory appraisal needs to be broadened to include adequate consideration of relevant social issues alongside the physical, chemical, biological and medical aspects of technologies.

Involving a wide range of stakeholders, and taking account of their values and interests at the earliest stage of the appraisal and choice of technological and social options for meeting human needs, brings two key benefits. It not only augments the information available to policy-making, but may also improve public trust in society's capacity to control hazards, without necessarily stifling innovation or compromising science.

Recent controversies over emerging technologies such as genetically modified organisms and oil-rig disposal have much to do with public values and scientific uncertainties, in contrast to the previously low emphasis on values and to the demand for unequivocal scientific proof before action to reduce hazards. An open recognition of this changing context for such controversies is a first step towards their improved governance.

However, the inclusion of different socio-political perspectives in regulatory appraisal becomes not just a matter of better policy-making: it can make for better science as well.

For example, reductionist science and linear causality are useful approaches, but they are limited. They do not cope well with the dynamics of complex and sometimes chaotic systems, characterised by feed-back loops, synergisms, thresholds, and equilibria/instability issues, and linked by multi-factoral and interdependent causal chains. Such complex reality demands better science, characterised by more humility and less hubris, with a focus on 'what we don't know' as well as on 'what we do know'.

One important consequence of acknowledging both scientific uncertainties (including ignorance) and the urgency of hazard reduction in situations of high stakes is the need for agreement on the sufficiency of evidence of harmful effects that is required to justify action. Such 'levels of proof' can vary from the 'reasonable grounds for concern' of the European Commission's Communication on the Precautionary Principle, to the 'beyond reasonable doubt' of criminal law. Choosing which level to use in particular situations involves a decision that can radically shift the size, nature and distribution of the costs of being wrong. This is a key political decision with profound ethical implications. The level of proof that is appropriate for particular issues depends upon the size and nature of the potential harm, the claimed benefits, the available alternatives, and the potential costs of being wrong in both directions, ie of acting or not acting in the context of uncertainty, ignorance and high stakes. This type of public decision-making is not unknown: military intelligence has long adopted similarly precautionary approaches to uncertainty and high stakes, where the costs of being wrong can be catastrophic.

17.1. Late lessons from early warnings

The case studies in this book both support and illustrate the need for the twelve late lessons derived from the century of history reviewed.

1. Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policy-making.
2. Provide adequate long-term environmental and health monitoring and research into early warnings.
3. Identify and work to reduce 'blind spots' and gaps in scientific knowledge.
4. Identify and reduce interdisciplinary obstacles to learning.
5. Ensure that real world conditions are adequately accounted for in regulatory appraisal.
6. Systematically scrutinise the claimed justifications and benefits alongside the potential risks.
7. Evaluate a range of alternative options for meeting needs alongside the option

under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation.
8. Ensure use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal.
9. Take full account of the assumptions and values of different social groups.
10. Maintain the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering.
11. Identify and reduce institutional obstacles to learning and action.
12. Avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable grounds for concern.

Most of these lessons involve improvements in the quality, availability, utilisation and processing of information in public policy-making on environment and health. However, none of the lessons would themselves remove the dilemmas of decision-making under situations of uncertainty and high stakes. They cannot eradicate uncertainties or avoid the consequences of ignorance. However, they would at least increase the chances of anticipating costly impacts, of achieving a better balance between the pros and cons of technological innovations, and of minimising the costs of unpleasant surprises. The use of the precautionary principle can also bring benefits beyond the reduction of health and environmental impacts, stimulating both more innovation, via technological diversity and flexibility, and better science.

The 'late lessons' may also help to achieve a better balance between proportionate and precautionary public policies, recognising that over-precaution can also be expensive, in terms of lost opportunities for innovation and lost lines of scientific inquiry.

It is the central conclusion of this report that the very difficult task of maximising innovation whilst minimising hazards to people and their environments, which is ultimately a matter of political discourse, could be more successful if it embraced the twelve late lessons from the histories of hazards reviewed.

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Index: Late lessons from early warnings: the precautionary principle 1896–2000

Note: Page references in **bold** refer to figures; those in *italics* to tables or boxed material

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