

# 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
<b>Risk</b>	‘Known’ impacts; ‘known’ probabilities e.g. asbestos causing respiratory disease, lung and mesothelioma cancer, 1965–present	<b>Prevention:</b> action taken to reduce known risks e.g. eliminate exposure to asbestos dust
<b>Uncertainty</b>	‘Known’ impacts; ‘unknown’ probabilities e.g. antibiotics in animal feed and associated human resistance to those antibiotics, 1969–present	<b>Precautionary prevention:</b> action taken to reduce potential hazards e.g. reduce/eliminate human exposure to antibiotics in animal feed
<b>Ignorance</b>	‘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	<b>Precaution:</b> 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.

# Author biographies<sup>(14)</sup>

## Jim W. Bridges

Dean for International Strategy  
Vice Chancellor's Offices  
University of Surrey  
Guildford GU2 5XH  
United Kingdom  
Tel: (44) (0)1483 873802  
e-mail: j.bridges@surrey.ac.uk

Jim Bridges has been Professor of Toxicology and Environmental Health at the University of Surrey since 1979. He is a member of the EU Scientific Steering Committee (since 1997) and Chairman of the UK Veterinary Residues Committee (since 2001). He was previously a member of the EU Scientific Committee on Animal Nutrition (1991–97) and the UK Veterinary Products Committee (1982–97). He acted as a scientific adviser to the European Union (World Trade Organization hearing in Geneva) on the legitimacy of the EU ban on the use of hormones as growth promoters. He is author/joint author of more than 300 research papers and reviews.

## Olga Bridges

European Institute of Health and Medical Sciences  
University of Surrey  
Guildford GU2 5XH  
United Kingdom  
Tel: (44) (0)1483 873802  
e-mail: o.bridges@surrey.ac.uk

Dr. Olga Bridges is a lecturer in Environmental and Public Health at the University of Surrey. Her research interests are the impact of chemicals in the environment and the diet, public perception of environmental risks and application of HACCP (hazard analysis critical control point). She has participated in a number of public enquiries, and has recently been involved in the training programmes of environmental health officers abroad.

## Lars-Erik Edqvist

Swedish National Veterinary Institute  
Ulls vag 2A–C  
Box 7073  
750 07 Uppsala  
Sweden  
Tel: (46) 018 67 40 00  
e-mail: Lars-Erik.Edqvist@sva.se

Professor Lars-Erik Edqvist DVM, Ph.D. is Director General of the National Veterinary Institute (SVA), Uppsala, Sweden. The antibiotics department at SVA has been involved in research for many years and has advocated prudent use of antimicrobials in veterinary medicine. In 1995 the Swedish government appointed Professor Edqvist chairman of the Commission on Antimicrobial Feed Additives. The commission gathered and evaluated scientific information on the use of antimicrobials as feed additives in relation to the temporary derogation from Community legislation that Sweden had when it became a member of the EU. The commission completed its task in 1997.

## Joe Farman

European Ozone Research  
Coordinating Unit  
Cambridge  
United Kingdom  
e-mail: general@ozone-sec.ch.cam.ac.uk

Dr. J. C. Farman, CBE and Polar Medal, is currently a consultant to the European Ozone Research Coordinating Unit in Cambridge, and is a member of the Science Panel on Stratospheric Ozone Research of the European Commission. From 1956 to 1990 he worked for the British Antarctic Survey. He is on the UNEP Global 500 Roll of Honour, and has received the UNEP Global Ozone Award, the Environment Medal of the Society of Chemical Industry and the Charles Chree Medal of the Institute of Physics. He is an Honorary Fellow of Corpus Christi College, Cambridge.

(14) The views expressed in the chapters are those of the authors and do not necessarily reflect those of the institutions where they work.

**David Gee**

Information Needs Analysis and  
Scientific Liaison  
European Environment Agency  
Kongens Nytorv 6  
1050 Copenhagen K  
Denmark  
Tel: (45) 33 36 71 42  
e-mail: david.gee@eea.eu.int

David Gee graduated in economics and politics but has been working at the interface of science, economics, production and policy-making, within occupational and environmental health, since 1974, for trade unions and non-governmental organisations (he is a former Director of Friends of the Earth, England, Wales and Northern Ireland). Since 1995 he has worked with the European Environment Agency on emerging issues and scientific liaison.

**Michael Gilbertson**

International Joint Commission  
100 Ouellette Avenue, 8<sup>th</sup> Floor  
Windsor  
Ontario N9A 6T3  
Canada  
Tel: (1) 519 257 6706  
e-mail: GilbertsonM@Windsor.IJC.Org

Dr. Michael Gilbertson has worked with the Canadian federal government since 1969, when he initiated research on the outbreaks of reproductive and developmental disorders in fish-eating birds in the lower Great Lakes. He has been at the interface between forensic environmental science and regulatory action since 1975. His interest is in the social processes involved in moving from use of inappropriate technologies that require causal demonstrations of injury for their control to appropriate technologies based on sound ecological principles.

**Morris Greenberg**

74 End Road  
London NW11 7SY  
United Kingdom  
Tel: (44) (0)20 8458 2376  
e-mail: GillMorris.Greenberg@talk21.com

Dr Morris Greenberg is a former Medical Inspector of Factories, Health and Safety

Executive, United Kingdom, and a former member of the Environmental Toxicology Unit, UK Department of Health. He helped in setting up the first asbestos mesothelioma register in the United Kingdom and is an expert in the medical aspects of inhaled fibres.

**Poul Harremoës**

Department of Environment and Resources  
Technical University of Denmark  
e-mail: ph@er.dtu.dk

Poul Harremoës has been a full Professor at the Technical University of Denmark in Environmental Science and Engineering since 1972. He has carried out research in urban water issues, water pollution and purification, and environmental management. He is a member of the Scientific Committee of the European Environment Agency and former president of the International Water Association. He has the following international awards: the Stockholm Water Prize (1992) and the Heineken prize for environmental science (2000). He has published five textbooks and some 350 further publications (see www.er.dtu.dk).

**Dolores Ibarreta**

IPTS Institute for Prospective Technological  
Studies (Joint Research Centre)  
European Commission  
Edificio Expo-WTC  
C/ Inca Garcilaso, s/n  
E-41092 Seville  
Spain  
Tel: (34) 95 448 84 45  
e-mail: dolores.ibarreta@jrc.es

Dr. Dolores Ibarreta is a biologist with a Ph.D. in genetics from the Universidad Complutense, Madrid, Spain. She has worked as a researcher at the Centro de Investigaciones Biológicas (CIB–CSIC) in Madrid and Georgetown University Medical Center in the United States. She is currently a scientific officer at IPTS (Joint Research Centre, European Commission), where her main focus has been the risk assessment of endocrine disrupters (DES being one the main references), specifically hormonally active substances in the diet.

**Peter Infante**

Health Standards Programs  
Occupational Safety and Health  
Administration  
US Department of Labor  
Washington DC  
United States  
e-mail: Peter.Infante@osha.gov

For the past 25 years Dr. Peter F. Infante D.D.S., Dr.P.H. has evaluated and regulated toxic substances found in US workplaces for the Department of Labor. He is the author of more than 100 scientific publications. He has a doctorate in public health from the Department of Epidemiology, University of Michigan and is a Fellow of the American College of Epidemiology. He has served on numerous panels and advisory committees related to the US National Cancer Institute, the President's Cancer Panel, the Office of Technology Assessment of the US Congress and the National Academy of Sciences, and most recently as an expert consultant to the World Trade Organization in its deliberations on the banning of products containing asbestos in the European Union countries.

**Paul Johnston**

Greenpeace Research Laboratories  
Department of Biological Sciences  
University of Exeter  
Exeter EX4 4PS  
United Kingdom  
e-mail: p.johnston@exeter.ac.uk

Dr. Paul Johnston is an aquatic toxicologist who established the Greenpeace Research Laboratories in 1987 and continues as its principal scientist. He has more than 15 years research experience in the field of marine pollution.

**Jane Keys**

22 Brook End  
Potton, Bedfordshire  
SG19 2QS  
United Kingdom  
Tel: (44) (0)1767 261834  
e-mail: Jane.Keys@btinternet.com

Jane Keys is a freelance researcher. Since the late 1980s she has researched environmental issues for industry, environmental non-governmental organisations and the European Environment Agency. Recent work includes, on behalf of the UK Forestry Commission and others, the identification of feasible and sustainable economic activities to fund and support the United Kingdom's

semi-natural ancient woodlands and urban street trees.

**Janna G. Koppe**

Emeritus Professor of Neonatology  
University of Amsterdam  
Hollandstraat 6  
3634 AT Loenersloot  
The Netherlands  
Tel: (31) 294 291589  
e-mail: Janna.Koppe@inter.NL.net

After studying medicine in Amsterdam Professor Koppe specialised in paediatrics and neonatology, also at the University of Amsterdam. She became an assistant professor in neonatology in 1969 and a full professor in 1986, becoming head of the neonatology department in 1977, and retiring in 1998. Her contribution to this book was written as part of her role as Emeritus Professor of Neonatology, University of Amsterdam and Chair of the Ecobaby society. Studies on the effects of dioxins and PCBs on the unborn and newborn human baby were started in 1985 and are still ongoing.

**Barrie Lambert**

St Bartholomew's and the Royal London  
School of Medicine  
Charterhouse Square  
London EC1M 6BQ  
United Kingdom  
Tel: (44) (0)1273 471973  
e-mail: barrie.lambert@which.net

Dr. Barrie Lambert is an independent radiation biologist. He has researched and taught the subject for more than 30 years, with particular reference to the comparative long-term risk of radiation exposure. He is a consultant to environmental groups, the nuclear industry and government.

**William J. Langston**

Plymouth Marine Laboratory Citadel Hill  
Plymouth PL1 2PB  
United Kingdom

Dr. Bill Langston is a research scientist at the Plymouth Marine Laboratory and has been engaged in studies of tributyltin behaviour and impact in the marine environment since the early 1980s.

**Malcolm MacGarvin**

modus vivendi  
Ballantruan, Glenlivet  
Ballindalloch AB37 9AQ

Scotland  
Tel: (44) (0)1807 590396  
e-mail: macgarvin@modus-vivendi.co.uk

Dr. Malcolm MacGarvin has a Ph.D. in ecology. Since the mid-1980s he has worked as a consultant on environmental issues for industry, environmental non-governmental organisations, the European Commission and the European Environment Agency. In addition to the precautionary principle, recent work includes that on marine eutrophication and on marine fisheries.

**Erik Millstone**  
SPRU – Science and Technology Policy  
Research  
University of Sussex  
Brighton BN1 9RF  
United Kingdom  
Tel: (44) (0)1273 877380  
e-mail: e.p.millstone@sussex.ac.uk

Dr. Erik Millstone trained initially in physics and philosophy. Since 1974 he has been researching the causes, consequences and regulation of technological change in the food industry. Since 1998 he has been investigating the links between the science and politics of bovine spongiform encephalopathy for projects funded by the European Commission.

**Knud Børge Pedersen**  
Danish Veterinary Laboratory  
27 Bülowsvej  
DK-1790 Copenhagen V  
Denmark  
Tel: (45) 35 30 01 23  
e-mail: Kbp@svs.dk

Dr. Knud Børge Pedersen DVM, Ph.D., DVSc. has been Director of the Danish Veterinary Laboratory (DVL) since 1985, and of the Danish Veterinary Institute for Virus Research since October 2000. His doctoral thesis was on infectious keratoconjunctivitis in cattle, and he is author/joint author of a number of scientific articles on microbiology and infection pathology. During recent years, DVL has established research groups on antimicrobial resistance mechanisms and epidemiology, particularly concerning antimicrobial growth promoters. Dr Pedersen has initiated the formulation of a veterinary antibiotic policy and guidelines for

prudent use of antimicrobials in veterinary medicine.

**David Santillo**  
Greenpeace Research Laboratories  
Department of Biological Sciences  
University of Exeter  
Exeter EX4 4PS  
United Kingdom  
e-mail: D.Santillo@exeter.ac.uk

Dr. David Santillo is a marine and freshwater biologist and a senior scientist with the Greenpeace Research Laboratories. He represents Greenpeace International at various international conventions addressing marine environmental protection.

**Arne Semb**  
Norwegian Institute for Air Research (NILU)  
P.O. Box 100  
N-2027 Kjeller  
Norway  
Tel: (47) 63 89 80 00  
e-mail: arne.semb@nilu.no

Dr. Arne Semb graduated in chemistry from the University of Oslo and has worked on a number of different air pollution problems at NILU since 1971. His major involvements include the OECD long-range transport of air pollutants programme 1972–77, the Norwegian SNSF project on acid precipitation and its effects on forests and fish 1972–80, and the EMEP programme for monitoring and evaluation of long-range transmission of airborne pollutants in Europe from 1977 to the present.

**Andrew Stirling**  
SPRU – Science and Technology Policy  
Research  
University of Sussex  
Brighton BN1 9RF  
United Kingdom  
Tel: (44) (0)1273 877118  
e-mail: A.C.Stirling@sussex.ac.uk

Dr. Andrew Stirling is a Senior Lecturer at SPRU. He has researched and published widely on issues relating to technology assessment, environmental appraisal and risk analysis. He has worked with a variety of academic, public interest, industry and government organisations and served on a number of Advisory Committees.

**Shanna H. Swan**

Research Professor  
University of Missouri, Columbia  
Department of Family and Community  
Medicine  
Medical Sciences Building MA306L  
Columbia MO 65212  
United States  
Tel: (1) 573 884 4534  
e-mail: swans@health.missouri.edu

Professor Shanna H. Swan Ph.D. is an epidemiologist and statistician who studies the reproductive risks of DES, other hormones and environmental exposures. She is currently Research Professor at the University of Missouri, Columbia and directed the Reproductive Epidemiology Section of the California Department of Health Services 1981–98. Her approach to public health, particularly in relation to risks to the unborn foetus, has always been precautionary.

**Patrick van Zwanenberg**

SPRU – Science and Technology Policy  
Research  
University of Sussex  
Brighton BN1 9RF  
United Kingdom  
Tel: (44) (0)1273 877141  
e-mail: p.f.van-zwanenberg@sussex.ac.uk

Dr. Paddy van Zwanenberg trained initially in environmental science before taking postgraduate degrees in science and technology policy. His research focuses on issues of science and governance, with a particular emphasis on the role of scientific expertise in public and environmental health policy-making. He has worked on two European Commission funded projects on the science and politics of bovine spongiform encephalopathy.

**Sofia Guedes Vaz**

Integrated Assessment and Reporting  
European Environment Agency  
Kongens Nytorv 6  
1050 Copenhagen K  
Denmark  
Tel: (45) 33 36 72 02  
e-mail: Sofia.Vaz@eea.eu.int

Sofia Guedes Vaz is an environmental engineer who has worked at the European Environment Agency since 1997, specialising in data, reporting, targets and environmental emerging issues. She has an MSc in Environmental Technology from the Imperial College and before working at EEA did environmental consultancy.

**Martin Kraye von Krauss**

Ph.D. student  
Department of Environment and Resources  
Technical University of Denmark  
e-mail: mkvk9@yahoo.com

Martin Kraye von Krauss has a BEng from the Royal Military College of Canada and has worked as project engineer on petrol-contaminated site investigations. He has an MSc in environmental engineering from the Technical University of Denmark. His Ph.D. study is on 'Incertitude and its implications for environmental engineering'.

**Brian Wynne**

Centre for the Study of Environmental  
Change  
Institute for Environment, Philosophy  
and Public Policy  
Furness College  
Lancaster University  
Lancaster LA1 4YG  
United Kingdom  
Tel: (44) (0)1524 592653  
e-mail: b.wynne@lancaster.ac.uk

Brian Wynne is Professor of Science Studies at the Institute for Environment, Philosophy and Public Policy. He was a member of the European Environment Agency's management board and Scientific Committee from 1995 to 2000. He has completed extensive research and publications on risk, environmental and science studies issues and on public understanding of science and risk.

# 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

## A

abortion, spontaneous 84, 86–7, 176  
 acid rain 102–8  
 aerosols 12, 79, 80  
 Agriculture, Fisheries and Foods, Ministry, UK (MAFF) 157, 161–2, 180, 181  
 air quality standards 101–2  
 Airborne Antarctic Ozone Experiment, US (AAOE) 80  
 aircraft, supersonic stratospheric 79  
 Aksoy, M 39  
 Albers-Schonberg, HE 32  
 aldrin 127  
*Alice, a Fight for Life* 57  
 Alkali Act 101  
 alternatives, evaluation 177  
 Alverson Report 21, 27  
 American Conference of Governmental Industrial Hygienists (ACGIH) 39, 43, 47  
 American mud-snail 136  
 American Petroleum Institute 39, 47  
 amosite **52**, 56  
 androgens 149  
 animal feeds  
   PCB contamination 71  
   slaughterhouse wastes 157, 158, 160  
 Antarctica, ozone hole 76, 80, 82, 172, 173  
 antibiotics 93  
 antifouling paints, *see* TBT (tributyltin)  
   antifoulants  
 antimicrobial growth promoters 173, 177  
   advantages/disadvantages of use 97–8, 99  
   alternatives 177, 178  
   ban of avoparcin 96  
   delays in research 172  
   early warnings and actions 99  
   introduction of 93  
   lessons from 98  
   research and uncertainty 204  
   scientific reports and recommendations on 97  
   secondary benefits of precaution 202  
   Swann Report 94–5, 98, 99, 170, 171, 172, 173, 174, 181  
   Swedish ban 95–6  
 antimicrobial resistance 93–4, 98  
 antimicrobials 93  
 aplastic anaemia 38–9, 42  
 Arcachon Bay, France 136–7, 138, 139  
*Archives of Environmental Health* 112

Arvin, Professor Erik 114  
 asbestos  
   substitution 57, 58, 61, 173–4  
   types of 52, 56–7  
   uses 58  
 asbestos exposure 3, 11, 15  
   actions and inactions 56–8, 59–60, 61, 172, 173, 179  
   and asbestosis 53–4  
   compensation claims 52, 57, 58, 60–1  
   cost-benefits of action/inaction 58–9  
   economic factors 59  
   ‘healthy survivors’ fallacy 60, 178  
   and insurance companies 54, 58, 179  
   latency of disease appearance 55, 60  
   lessons from 59–61, 179  
   and lung cancer 54–5  
   and mesothelioma **52**, 55–6  
 asbestosis 52, 53–4  
 assumptions 174–5  
 asthma 112–13  
 atmosphere, structure of 78–9  
 Atomic Energy Agency, International (IAEA) 35  
 avilamycin 97  
 avoparcin 94, 96, 97

## B

bacitracin zinc 96  
 bald eagle 126  
 Baltic Sea fauna 65, 72  
 Barcelona Convention for the Protection of the Mediterranean Sea against Pollution 69  
 BBC (British Broadcasting Corporation) 56  
 Beaver Report 101  
 Becquerel, Henri 32  
 Beijing Declaration 81, 83  
 Belgium 71  
 Benedick, Richard 80  
 benzene  
   actions and inactions 39–42  
   causes of inaction 42–5  
   costs of inaction 41  
   in gasoline 45, 46, 175  
   industrial uses 38  
   risk assessment debate 40–1  
   substitutes 42–3  
   toxicity and carcinogenicity 38–9, 39–40, 41–2, 42–3, 179  
   US controls 40–1  
 Benzene Decision (US) 40–1  
 Bertram, James 17, 18  
 bioaccumulation 170–1, 175

- organochlorines 64–5, 66, 67, 70, 126–7
- organotins 140
- birds 64, 126, 127, 152
- ‘blind spots’ 173–4
- Blue Ribbon Panel, Oxygenates in Gasoline 114–15
- Blum, Theodore 32–3, 36
- bone sarcoma 32–3
- bovine spongiform encephalopathy, *see* BSE
- breast cancer 151, 153
- breast milk 67, 70
- Bridges, Professor Jim W 149, 195
- Bridges, Dr Olga 149, 195
- bromine, tropospheric 77, 78
- bromochloromethane 81
- Brown, Sandford 64
- BSE (bovine spongiform encephalopathy)
  - costs of 164
  - early warnings and actions 166
  - European response 163
  - first cases 157
  - government policy options 158–9
  - government reassurances and inactions 161–4, 176
  - Phillips enquiry 159, 165
  - potential of precautionary approach 164–6, 196
  - public reaction 178
  - rendering of animal wastes 157, 158, 180
  - research 163–4
  - slaughterhouse controls 160–1, 162, 178
  - Southwood Committee 159–61, 179
  - transmission 157, 158, 160–1, 172, 174
  - US precautions 12, 158, 202
- Buccinum undatum* 139
- burden of proof 107, 199–200
- Bureau of Fisheries (US) 20, 180
- Byers, Elsen 33
- C**
- California
  - MTBE pollution 114
  - sardine fisheries 19–20, 27, 180
- Canada
  - appeal against French asbestos ban 53, 57–8
  - CFCs 80
  - cod fisheries 20–3, 24–5, 27
  - Department of Fisheries and Oceans (DFO) 20–2
- cancer
  - and asbestos exposure 52, 54–6, 58
  - and benzene exposure 38–40, 41–2, 42–3, 179
  - and ionising radiation 36
  - latency periods 55, 56, 60
  - and oestrogenic compounds 84, 85–8, 151, 153
  - and UV radiation 76
- Cape Asbestos Company 54
- Cape’s Acre Mill asbestos plant 56, 57
- carbon monoxide 111
- carbon tetrachloride 78
- Carson, Rachel 116, 126, 127–8
- Cartagena Protocol on Biosafety 14
- Carter, President Jimmy 127
- case studies
  - authors 11, 12, 195–199
  - structure of 11
- catfish 152
- cattle offal 160–1, 162, 178
- causal relationships 129–30, 131
- Center for Health, Environment and Justice (US) 127
- Central Veterinary Laboratory (UK) 159
- cetaceans 140
- CFC-11 77, 78, 79, 80
- CFC-12 77, 78, 79, 80
- CFCs (chlorofluorocarbons) 3
  - actions on releases 79–81
  - atmospheric persistence 77, 170–1
  - essential uses 77
  - late lessons 82–3
  - Montreal Protocol 80–1
  - production and release 76, 77, 79, 82
  - stratospheric ozone depletion 76, 78, 79, 82, 173
  - substitutes 81, 177
  - use of precaution 12
- Chant, Professor Donald 128
- Chemical Manufacturers Association 80
- chemotherapeutics 93
- chickens
  - antimicrobial growth promoters 93
  - PCB contamination of feeds 71
- child development
  - maternal oestrogenic compounds 86, 88, 151, 152–3
  - maternal PCB exposure 67, 69, 70, 72, 127
- childhood asthma 112–13
- childhood leukaemia 34
- China 81
- Chinese Academy of Preventative Medicine 44
- chloracne 64, 66
- chlorine
  - atmospheric 76, 77, 78
  - industrial use 79
- chlorofluorocarbons, *see* CFCs
- cholera 14–15
- chrysotile 52, 56
- cigarette smoking 55
- cities, air pollution 101, 106, 111, 112
- CJD (Creutzfeldt-Jakob disease) 157, 158, 174
- Clean Air Act (US) 80, 102, 110–11
- clear-cell carcinoma, vaginal 84, 85–8
- CLRTAP (Convention on Long-range Transboundary Air Pollution) 104, 105–6
- coal burning 101, 104, 105
- cod fisheries 20–3, 24–5, 27
- cognitive development 69, 127

- Collins Report (1989) 152  
 Common Fisheries Policy (EC) 24, 27  
 communication, professional 189  
 compensation 60–1  
   asbestos damage 52, 57, 58  
 consensus organisations 43  
 Conservative Government (UK) 158  
 constructive technology assessment (CTA) 186–7  
 contraceptives 89, 151  
 Convention on Long-range Transboundary Air Pollution (CLRTAP) 104, 105–6  
 Convention for the Protection of the Marine Environment of the Northeast Atlantic (OSPAR) 140, 143  
 Cooke, Dr W 54  
 cost-benefit analyses 175–7, 187  
 Creutzfeldt-Jakob disease (CJD) 157, 158, 174  
 criminal law 184  
 critical load concept 106, 107  
 ‘critical path’ issues 172  
 crocidolite 52, 56  
 Curie, Marie 32, 33  
 Curie, Pierre 32  
 Czechoslovakia 104, 105
- D**  
 Dally, Clarence 31  
 Daly, Dr Helen 129  
 DDT (dichlorodiphenyl trichloroethane) 126, 152  
 de Bort, Teisserene 78  
 Deane, Lucy 11, 53, 60  
 Delaney Clause 12, 149  
 Denmark 96, 114, 115, 118  
 Dennis, John 31, 36  
 Department of Agriculture (US) 128, 158, 181  
 Department of Fisheries and Oceans (Canada) 20–3  
 Department of Labor (US) 40  
*Der Spiegel* 104  
 DES (diethylstilboestrol)  
   as livestock growth promoter 149–53  
   EU actions 149, 150, 153  
   human health concerns 149–51, 152–3  
   illegal use 151  
   US actions 12, 149–50, 153  
   therapeutic use 84–90  
   carcinogenicity and teratogenicity 84, 85–6, 88  
   economic interests 88–9  
   extent of 87–8, 89  
   inefficacy in miscarriage 86–7, 88, 176  
   lessons from 88–90  
 detergents 116  
 Detroit Wastewater Treatment Plant 130  
 dibenzo-p-dioxin 68  
 dibenzofuran 68  
 dichlorodiphenyl trichloroethane, *see* DDT  
 dieldrin 126, 127, 128  
 diethylstilboestrol, *see* DES  
 dioxins 68, 127  
 Dodds, Charles 84–5  
 dogwhelks 136, 137, 139  
 Doll, Sir Richard 54, 57  
 dolphins 140  
 Drinker, Cecil K 64  
 drinking water 112, 114  
 drug assessment 89–90  
 Du Pont 79, 80
- E**  
 eagle, bald 126  
 Eastern Europe 104, 105, 107  
 Economic Commission for Europe (ECE) 104, 107  
 economic interest groups 59, 88–9, 178–9  
 ecosystem approach 25–6  
 Ecosystem Principles Advisory Panel (US) 25  
 Edison, Thomas 31  
 Edqvist, Professor Lars-Erik 93, 195  
 eels 66  
 Egnér, Hans 102  
 Eli Lilly 89  
 ‘emantoria’ 33  
 endocrine disruption 67, 88, 113, 152  
 endrin 128  
*An Enemy of the People* 55–6  
 energy consumption 102  
 engine technology 118  
*Enhydra lutris nereis* 140  
 Environmental Defense Fund 128  
 Environmental Health Officers, Institute (UK) 162  
 Environmental Protection Agency (Denmark) 114, 115  
 Environmental Protection Agency (Finland) 113, 115  
 Environmental Protection Agency (US) 113, 114–15, 128, 130  
 Erie, Lake 126, 128  
 ethanol 118  
 ethers 115  
 ethics 188–9  
 European Chemicals Bureau 112  
 European Commission  
   Common Fisheries Policy 24, 27  
   *Communication on the precautionary principle* 13, 24  
   scientific advisory system 163, 180  
   Scientific Steering Committee 97  
   Scientific, Technical and Economic Committee 24  
 European Court of Justice 96  
 European Environment Agency (EEA) 3, 11  
 European Scientific Technology Observatory (ESTO), Technological Risk and the Management of Uncertainty project 168–9

- European Union 3  
 action on MTBE 111, 112, 116  
 action on PCBs 69  
 antimicrobial growth promoters 97  
 fisheries policies 23–4  
 hormone growth promoters 149, 153  
 ionising radiation directive 35, 36  
 Maastricht Treaty 14  
 PCBs/PCTs directive 69  
 response to BSE crisis 163  
 Scientific Committee on Animal Nutrition 96  
 Scientific Committee on Veterinary Measures Relating to Public Health 152  
 everninomycin 97  
 ‘evidence of no harm’ 172  
 ‘expert’ opinions 61
- F**
- Factory Department (UK) 54, 56  
*Facts versus fears* 12  
 ‘false negatives’ 12, 53, 60, 184  
 ‘false positives’ 12–13, 60, 184  
 Farman, Dr Joe 12, 207  
 FDA, *see* Food and Drug Administration  
 Federation of Swedish Farmers 95  
 Feedingstuffs Act (Sweden) 95  
 fetotoxicity 67, 69, 70, 84, 86, 88  
 Finnish Environmental Institute 116  
 Finnish Environmental Protection Agency 113  
 fish  
 and acid deposition 102–4  
 organochlorine contamination 126–9, 131–2  
 fisheries 176  
 Californian sardine 19–20, 27  
 cost-benefits of actions 19, 20, 176  
 ecosystem approach 25–6  
 FAO Code of Conduct 23, 24, 25  
 international agreements 23  
 late lessons 26  
 lay knowledge 17–18, 177–8  
 Newfoundland cod 20–3, 24–5, 27  
 precautionary action 23–5  
 research and models 172, 175, 204  
 Scottish herring 17–18  
 steam trawling 18–19  
 UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks 23  
 fishing mortality 24–5  
 fishing nets 17  
*Fishing for truth* 22  
 flame shell 138  
 Fleming, Alexander 93  
 flue gas desulphurisation 105  
 Food and Agriculture Organization (FAO) 175  
 Code of Conduct for Responsible Fisheries 23, 24, 25  
 Joint Expert Committee on Food (JECFA) 150, 152, 153  
 Food and Drug Administration, US (FDA) 84, 86, 89, 149–50, 154  
 Food Standards Agency (UK) 165, 166  
 forest decline 104–6  
 Framework Convention on Climate Change 14  
 France  
 asbestos ban 53, 57  
 marine antifoulants 136–7  
 freshwaters  
 acidification 102, 106  
 detergents in 116  
 PCB pollution 66, 70  
*see also* groundwater  
 fuel desulphurisation 104  
 furans 68, 69
- G**
- gasoline  
 benzene 45, 46  
 lead 110  
 MTBE 111, 112  
 gasoline direct injection (GDI) 118  
 Gee, David 208  
 genetically modified organisms (GMOs) 185  
 Geological Survey (US) 111  
 Germany 96  
 Advisory Council on Global Change 182–3  
 Clean Air Act (1974) 13  
 Council of Environmental Advisers 105, 107  
 Green Party 107  
 sulphur dioxide emissions 104–5  
 Gibbs, Lois 126–7  
 Gilbertson, Dr Michael 12, 126, 196  
 glass fibre 57, 61  
 GMOs (genetically modified organisms) 185  
 governance 187–9  
 governments 180–1  
 Great Lakes contamination  
 actions/inactions 127–8  
 causal relationships 129–30, 131  
 costs and benefits of actions 130–1  
 early warnings and actions 132  
 effects on wildlife 67, 126–7  
 human health 127, 129, 131–2  
 research 172–3, 181  
 water quality improvements 129–30  
 Great Lakes Science Advisory Board 130–1  
 Great Lakes Water Quality Agreement 128, 129  
 Great Lakes Water Quality Guidance 130  
 Green Party, Germany 107  
 Greenberg, Dr Morris 12, 208  
 Greenpeace 25  
 groundwater pollution 111–12

growth promoters, *see* antimicrobial growth promoters; hormone growth promoters

## H

haemopathy 38

halocarbons

actions on releases 79–81, 83

atmospheric persistence 77, 170–1

early warnings and actions 83

essential uses 77

late lessons 82–3

Montreal Protocol 80–1

production and release 76, 77, 79, 82

stratospheric ozone depletion 76, 78, 79, 82, 173, 195

Halowax Corporation 64

Hamilton Harbour 131

Harremoës, Professor Poul 208

Harris Report 21–2

hazardous waste sites 130–1

HCFCs (hydrochlorofluorocarbons) 76, 81

health monitoring 203

Health and Safety Commission (UK) 58

Health and Safety Executive (UK) 61

healthy survivors fallacy 60, 178

heavy fuel oil 101

heptachlor 127

herring fisheries 17–19

Hickey, Dr Joseph 126

Hooker Chemical Company 127

*Horizon* 56

hormone growth promoters

early warnings and actions 154

effects on wildlife 151–2

EU actions 149, 150

human health concerns 149–51, 152–3

illegal use 151

US actions 149–50, 153

Huxley, Thomas 18

hydrochlorofluorocarbons (HCFCs) 76, 81

hydrogen fuel cell 118

hyperactivity 70

hypersusceptibility 38

## I

IAEA (International Atomic Energy Agency) 35

Ibarreta, Dr Dolores 84, 196

Ibsen, HJ 55–6

ICES (International Council for the Exploration of the Sea) 24, 25

ICNAF (International Commission for the Northwest Atlantic Fishery) 20

ICRP (International Committee on Radiological Protection) 33, 34, 35, 36

ignorance 3

defined 192

responding to 169–71

and uncertainty 185

IJC (International Joint Commission) 128, 130–1

IMO (International Maritime Organization) 138, 181

imposex 135, 136, 137, 138–40

India 81

*Industrial Maladies* 52

Infante, Dr Peter 12, 209

innovation 182, 186–7

Institute of Environmental Health Officers (UK) 162

institutional obstacles 180–1

insurance companies 54, 58, 179

integrated environmental assessment 188

Intergovernmental Panel on Climate Change (IPCC) 184, 199

International X-ray and Radium Protection Committee (IXRPC) 33

International Atomic Energy Agency (IAEA) 35

International Commission for the Northwest Atlantic Fishery (ICNAF) 20

International Committee on Radiological Protection (ICRP) 33, 34, 35, 36

International Council for the Exploration of the Sea (ICES) 24, 25

International Joint Commission (IJC) 128, 130–1

International Maritime Organization (IMO) 138, 181

International Programme on Chemical Safety (IPCS) 113

Invitational EU Conference on The Microbial Threat 97

ionising radiation, *see* radiation, ionising

Ionising Radiation Regulations (UK) 34, 35

IPCC (Intergovernmental Panel on Climate Change) 184

IQ scores 69, 127

Irgarol 1051 141

irreversibility 170–1

Italy 39

IXRPC (International X-ray and Radium Protection Committee) 33

## J

Japan 65, 66, 69

Jefferson, Alice 57

Jensen, Søren 64, 68, 71

Johns Manville company 56

Johnston, Dr Paul 135, 197

Joint Expert Committee on Food (JECFA) 150, 152, 153

## K

Karnaky, KJ 84

Keats Report 21, 27

Kershaw, Nellie 54

Keys, Jane 64, 197

knowledge 4–5

- 'blind spots' 173–4
- lay/local 17–18, 177–8
- paralysis by analysis 181–2
- Koppe, Professor Janna G. 64, 197
- Kyoto Protocol on Climate Change 82
- L**
- Lambert, Dr Barrie 31, 197
- Lamming Committee 150, 154
- Lancet* 58
- landfill sites 130–1
- Langston, Dr William J 135, 197
- Laplan, Bernard 88
- 'late haemorrhagic disease of the newborn' 70
- late lessons 16, 168–9, 193–4
  - alternatives, evaluation 177
  - gaps in scientific knowledge 173–4
  - ignorance and uncertainty 169–71
  - institutional obstacles 180–1
  - interdisciplinary obstacles to learning 174
  - lay knowledge 177–8
  - paralysis by analysis 181–2
  - pros and cons 175–7
  - 'real world' conditions 174–5
  - regulatory independence 178–80
  - research and monitoring 171–3
  - social interests and values 178
- 'latency lacuna' 55, 56, 60
- latency periods 55, 56, 60, 195–6
- Lawther, Professor 102
- lay knowledge 17–18, 177–8
- lead 110
- Lear, Linda 127
- learning
  - institutional obstacles to 180–1
  - interdisciplinary obstacles to 174
- Legge, Dr Thomas 52, 59
- leukaemia
  - and benzene exposure 38–44
  - childhood 34
  - defined 38
- life cycle analysis (LCA) 187
- Lima hiams* 138
- lives, valuation of 58
- Lloyd's of London 58
- London
  - cholera outbreak 14–15
  - smogs 101
- loud and late warnings 205
- Love Canal, Niagara Falls 126–7
- luminous paint 32–3
- lung cancer 52, 54–5
- Lykke, Erik 103
- M**
- Maastricht Treaty 14
- MacGarvin, Dr Malcolm 17, 197–198
- MacGregor, John 159
- macrolide antibiotics 94
- 'mad cow disease', *see* BSE
- Madden, Max 56
- MAFF (Ministry of Agriculture, Fisheries and Foods) 157, 161–2, 180, 181
- Marine Environmental Protection Committee (MEPC) 140
- marine gastropods 135, 136, 137, 138–40
- marine mammals 65, 140
- Marine Pollution Bulletin* 13, 137
- Martland, Harris 33, 36
- Massachusetts General Hospital 86
- meat
  - hormone residues 152
  - risk of BSE 159, 160–2
- meat industry 150, 152, 159, 163, 164
- mechanically recovered meat 162
- media 56, 57, 189
- Meldrum, Keith 160
- melengestrol acetate 150
- Merewether, Dr E. R. A. 54
- mesothelioma, compensation payments 52, 55–6, 58
- methyl chloroform 77, 78
- methyl tert-butyl ether, *see* MTBE
- Michigan, Lake 69, 126, 127, 129
- Midgely, Thomas 79
- Millstone, Dr Erik 157, 198
- mineral wool 61
- mink 67, 126
- mirex 126, 128
- miscarriage 84, 86–7, 88, 176
- Mississippi River 128
- monitoring 181
  - long-term 171–3
- Monsanto 64, 65, 66, 71, 128
- Montreal Protocol 14, 77, 80–1, 83
  - Beijing meeting 81, 83
  - Multilateral Fund for Implementation (MFMP) 81
- MTBE (methyl tert-butyl ether)
  - alternatives 117–18, 119, 177
  - and asthma 112–13, 119
  - benefits of 110, 111
  - commercial production 110–11
  - cost-benefit analysis 118–19
  - in drinking water 114
  - early warnings and actions 121
  - endocrine disruption 113
  - groundwater contamination 112, 119, 174, 176
  - national and government recommendations on 114–15
  - persistence 111–12, 116–17, 120, 170–1
  - potential carcinogenicity 112, 113
  - potential use of precaution 115–20
  - present trends in use 115
- multi-criteria mapping 187
- Multilateral Fund for the Implementation of the Montreal Protocol (MFMP) 81
- multiple myeloma 38, 41, 42, 44

- Murray, Dr Montague 53  
 mussels, blue 139  
 Mutscheller, Arthur 33  
 myelodysplastic syndrome 42  
 myelofibrosis 45  
 myeloproliferative disorders 42  
*Mytilus edulis* 139
- N**  
 NAFO Northwest Atlantic Fisheries Organization) 20  
 NASA (North American Space Agency) 82  
*Nassarius obsoletus* 136  
 National Agricultural Chemicals Association (US) 127–8  
 National Cancer Institute (US) 44, 87  
 National Institute for Occupational Safety and Health (NIOSH) 41, 43, 44  
 National Institutes of Health (US) 86  
 National Oceanic and Atmospheric Administration, US (NOAA) 138  
 National Ozone Expedition, US (NOZE) 80  
 National Radiation Protection Board, UK (NRPB) 32, 36  
 National Research Council (US) 182, 186  
 National Toxicology Program (US) 113  
*Nature* 80, 103, 173  
 Netherlands 58, 67, 88  
 neutropenia 45  
*New York Times* 80, 93  
*New Yorker* 127  
 New Zealand 188  
 Newhouse, Dr M 56  
 Niagara river 130–1  
 Nice Decision 13  
 NIOSH (National Institute for Occupational Safety and Health) 41, 43, 44  
 nitrogen oxides 111  
 Nixon, President R 128  
 NOAA (National Oceanic and Atmospheric Administration) US 138  
 ‘no evidence of harm’ 172  
 non-governmental organisations 79–80  
 non-Hodgkin’s lymphoma 41, 42, 44, 45  
 North American natives 17  
 North Sea  
   fisheries 17–19, 24–5  
   and PCBs 69, 72  
   TBT antifoulants 139–40  
 North Sea Conference 14  
 Northwest Atlantic Fisheries Organization (NAFO) 20  
 Norway 80, 96, 103, 180  
 Norwegian Institute for Air Research 103  
 NOZE (National Ozone Expedition) US 80  
 NRPB (National Radiation Protection Board) UK 32, 36
- Nucella lapillus* 136  
 nuclear industry 34, 61  
 null hypothesis 183–4
- O**  
 Occidental Chemical Corporation 131  
 Occidental Petroleum 127  
 Occupational Health and Safety Administration (US) 40  
*Ocenebra erinacea* 136  
 Odén, Svante 102  
 oestradiol-17 $\beta$  149, 150, 152, 153  
 oestrogens  
   biological role 84, 149  
   synthetic, *see* DES (diethylstilboestrol)  
 Ontario, Lake 126, 128, 129  
 Organisation for Economic Co-operation and Development (OECD) 66, 72, 116  
   Air Management Sector Group 101, 103  
 organochlorines  
   bioaccumulation 126, 127  
   Great Lakes contamination 126–32  
   and human health 126–7  
   *see also named compounds*  
 OSPAR Convention (Protection of the Marine Environment of the Northeast Atlantic) 140, 143  
 Outboard Marine Corporation 131  
 overfishing  
   Californian sardines 19–20, 27, 180  
   early recognition of 17  
   fishing mortalities 24–5  
   Newfoundland cod 20–3, 24–5, 27  
   Scottish herring 17–18  
 oyster drill 136  
 oysters fisheries 136–7, 138  
 ozone, industrial uses 78  
 ozone layer  
   depletion 76, 79–80, 82, 172, 173  
   discovery 78–9
- P**  
 ‘paralysis by analysis’ 181–2  
 Paris Commission (PARCOM) 138  
 participatory approaches 186, 188–9  
 PCBs (polychlorinated biphenyls) 64, 72, 152  
   chemistry and toxicity 68, 68  
   chicken feed contamination 71  
   congeners of 66, 70  
   early warnings and actions 73  
   environmental distribution and persistence 64–5, 66, 72, 170–1, 174  
   government and industry actions 66, 69, 71–2  
   Great Lakes contamination 126–32  
   human health effects 64, 65, 67, 69, 70, 127, 129  
   rice oil contamination 65, 66, 67, 69  
   routes of environmental exposure 70–1  
   uses of 64, 70  
 pedascopes 34

- Pedersen, Dr Knud Børge 93, 198  
 pelvimetry 32, 34  
 penicillin 93, 95  
 ‘pensioners’ party’ fallacy 60, 178  
 peregrine falcon 127  
 persistency 111–12, 116–17, 120, 170–1  
   organochlorines 131–2  
   or organotins 142  
 Peto, Julian 56  
 petrol, *see* gasoline  
 pharmaceutical companies 88–9  
 phenobarbital 70  
 Phillips Inquiry 159, 165  
 pigs 160  
 Pimenta Report 151  
 Plymouth Sound 137  
 Poland 104, 105  
 policy-making 4–5, 195  
   integration of science 15–16  
   levels of proof required 197–8  
   public participation 188–9  
 political administrations 180  
 political interests 178–9  
 politicians 15, 16  
 ‘polluter pays’ principle 59, 176–7  
 Pollution Probe 128  
 polychlorinated dibenzofurans **68**  
 poultry 71, 93, 160  
 power generation plants 101, 104, 105  
 precaution  
   cost-benefit analyses 175–7, 187  
   and governance 187–9  
   and innovation 186–7  
   justification 197–8  
   and science 183–6  
   wider implications 182–3  
 precautionary prevention, defined 192  
 precautionary principle 3  
   clarification of terms 192  
   example of early use 14–15  
   examples from US 12  
   in international agreements 13, 14  
   meaning of 12, 13  
   proportionality and time 60  
   US/EU disputes 12  
 pregnancy  
   X-rays 32  
   oestrogenic compounds 84, 85–8  
   PCB exposure 67, 69, 70  
 prevention, defined 192  
 Price, C. W. 54  
 progesterone 150  
 proof  
   levels required for precaution 184, 193  
 proportionality principle 60, 196  
 ‘pros’ and ‘cons’ 175–7  
 prostate cancer 153  
 public  
   trust in politicians and scientists 16  
   understanding of scientific uncertainty  
   185–6  
 public awareness 188–9  
 Public Health Laboratory Service, UK  
   (PHLS) 163  
 public interests 178, 181–2  
 public values 178, 181–2, 193
- R**  
 radiation, ionising  
   contemporary risk estimates 34–5, 36  
   early warnings and actions 36  
   first controls on exposure 33  
   first reported injuries 31–3  
   liability for injury 35–6  
   medical examinations 35, 36, 175, 176  
   medical treatments 31, 33  
   misuse 34  
 radiation protection  
   first measures 32, 33  
   post-war development 34–5  
 radiation, ultraviolet **76**  
 Radiation Workers Compensation Scheme 36  
 radiodermatitis 31  
 Radiothor 33  
 radium, discovery 32–3  
 ‘radium jaw’ 32–3, 36  
 radium standard 33  
 radon 33  
 raincoat manufacture 42, 46  
 RCEP (Royal Commission on Environmental  
 Pollution) 158, 182, 186  
 ‘real world’ conditions 174–5  
 reformulated gasoline (RFG) 111  
 Registry of Clear-Cell Adenocarcinoma of the  
 Genital Tract in Young Females 87  
 rendered animal wastes 157, 158, 160  
 reproductive tract abnormalities 86  
 research  
   lack of baseline 171–3  
   paralysis by analysis 181–2  
 Rhine, River 66  
 rice oil contamination 65, 66, 67, 69  
 Rio Declaration on Environment and  
 Development 13, 14  
 risk  
   acceptability of 72  
   clarification of term 192  
   significant 40–1  
 risk appraisal  
   approaches 187–8  
   interested parties 179–80  
 Rochdale, asbestos-related disease 54  
 Roentgen Society 33  
 Roentgen, Wilhelm Conrad 31  
 Rollins, William 32, 36  
 Rossby, C. G. 102  
 Rotheim, Eric 79  
 Royal Commission on Environmental  
 Pollution (UK) 158, 182, 186

rubber industry 38, 42  
 rubella infection 67

## S

St Bartholomew's Hospital 101, 102  
 salmon farming cages 137, 138  
 Santa Monica, California 114  
 Santillo, Dr David 135, 198  
 sardine fisheries, California 19–20, 27, 180  
 Scandanavia, acid deposition 102–4  
 Schweitzer, Albert 13  
 science  
   and precautionary principle 183–6  
   public trust in 16  
   sociology of 184–6  
   refutation of evidence 55–6, 179  
 scientific uncertainty 4, 15  
   benzene toxicity 43–5  
   and ignorance 185  
   public understanding of 185–6  
   and research 203–5  
 Scottish herring fisheries 17–19  
 scrapie 157, 174, 181  
 sea birds 64  
 sea otter 140  
 SEAC (Spongiform Encephalopathy Advisory Committee) 161, 165–6  
 seals 65, 140  
 Selikoff, Dr I. 55–6  
 Semb, Dr Arne 101, 198  
 sensitivity and scenario analysis 187–8  
 sex hormones 84  
 Shell Chemical Company 127, 128  
 shoe manufacture 39, 43, 46  
 'shooting the messenger' 55–6, 179  
 'significant risk' 40–1  
*Silent spring* 116, 126, 127–8  
 Simpson Committee 56–7  
 skin cancer **76**  
 slaughterhouses, specified bovine  
   offal 160–1, 178  
 Sleggs, Dr C. A. 55  
 smog 101  
 smokestacks 101, 105, 107, 174, 176  
 Snow, Dr John 14–15  
 social interests 178, 181–2  
 Socrates 4  
 soil acidification 106  
 Southwood (BSE) Committee 159–61, 179  
 specified bovine offal (SBO) ban 160–1,  
   162, 178  
 spiramycin 94, 96  
 Spongiform Encephalopathy Advisory  
   Committee (SEAC) 161, 165–6  
 stakeholder involvement 186, 193  
 statistical proof 183–4  
 steam trawlers 18–19  
 Stewart, Alice 32, 34, 36  
 stilboestrol, *see* DES (diethylstilboestrol)  
 Stirling, Dr Andrew 198

Stockholm Convention on Persistent Organic  
 Pollutants 14

stratospheric ozone, *see* ozone layer  
 subsidiarity 188  
 substitutes, evaluation 177  
 Sullom Voe 138, 139  
 sulphur dioxide emissions  
   CLRTAP Protocol 104, 105–6  
   cost/benefits of control 104–5, 176, 202  
   critical load concept 106, 107  
   European trends 1880–1990 103  
   forest decline 104–5, 105–6  
   freshwater acidification 102–4  
   from fuel oils 101  
   role of precaution 106–7, 180  
   tall smokestack solution 101, 105, 107,  
   174, 176  
   urban air quality 101–2, 106, 111, 174, 176  
 supersonic stratospheric transport (SST) 79  
 surprises 169–71  
 survivors, fallacy of healthy 60, 178  
 Sutherland, Ian 17  
 Swan, Professor Shanna H 84, 199  
 Swann Committee 94–5, 98, 99, 170, 171,  
   172, 173, 174, 181  
 Sweden  
   acid deposition 102–4  
   action on PCBs 66  
   actions on antimicrobial growth  
   promoters 95–6, 99, 180  
   benzene poisoning 38, 42, 46, 47  
 Swedish chemical law 183, 184  
 Swedish Farmers, Federation 95

## T

Tage, Ronald 54, 55  
 Tait, Nancy 57  
 Taiwan, rice oil contamination 67  
 TBT (tributyltin) antifoulants  
   alternatives 141, 142, 177  
   bioaccumulation 140, 141  
   control in small vessels 138–9  
   development and use 135–6  
   early warnings and actions 143  
   effects on marine molluscs 136, 139–40  
   environmental quality standards 137,  
   138, 141  
   human intake 140  
   impacts in Arcachon Bay, France 136–7,  
   138, 139  
   impacts in United Kingdom 137–8  
   lessons from 141–2  
   prohibition of 138, 140–1  
   use in seagoing vessels 139–40, 181  
 TCDD (tetrachlorodibenzoparadiioxin)  
   68, 70  
 technological options analysis (TOA) 187  
 technology assessment 175–7, 186–7  
 testosterone 150

- tetrachlorodibenzoparadioxin (TCDD)  
68, 70
- tetracycline 93, 95
- Thomson, Elihu 31
- trade disputes 57–8, 153, 175
- transport systems 118
- trawlers 18–19
- trenbelone acetate 150
- triazine herbicide 141
- trout 152
- Trudeau, Prime Minister 128
- Turkey, benzene poisoning 39, 43, 46
- Turner Brothers' asbestos plant 54, 56, 57, 58
- tylosin 94, 96
- U**
- uncertainty 169, 170, 192  
*see also* scientific uncertainty
- United Kingdom  
asbestos and mesothelioma 52, 58  
fisheries 17–19, 27  
Ionising Radiation Regulations 34, 35  
sulphur dioxide emissions 105, 106  
TBT antifoulants 137–9
- United Nations  
Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks 23  
Convention on the Law of the Sea 20  
Food and Agriculture Organization, *see* Food and Agriculture Organization (FAO)  
Rio Declaration on Environment and Development 13, 14
- United Nations Environment Programme (UNEP)  
Coordinating Committee on the Ozone Layer 79  
Vienna Convention 80, 83  
Washington Declaration 69, 72
- United States  
antimicrobial feed additives 95  
benzene 40–1  
CFCs 79–80  
hormone growth promoters 149–50, 153  
scrapie precautions 12, 158  
uses of precautionary principle 12  
United States Supreme Court 40, 181  
University of California, Davis 112–13, 114  
urban air pollution 101, 106, 111, 174, 176  
UV (ultraviolet) radiation 76
- V**
- vaginal clear-cell adenocarcinoma 84, 85–8  
values 178, 181–2, 186, 193
- van Zwanenberg, Dr Patrick 157, 199
- vancomycin 94
- vancomycin-resistant enterococci 96, 97
- Vaz, Sofia Guedes 199
- Velsicol Chemical Company 127, 128
- Vienna Convention for the Protection of the Ozone Layer 80, 83
- virginiamycin 94, 96
- VOCs (volatile organic compounds) 111
- von Krauss, Martin Krayer 211
- Vorsorgeprinzip* 13, 186
- W**
- Wagner, Dr J. C. 55
- Walton, J. R. 94
- Washington Declaration 69, 72  
*Washington Post* 80
- whelk, common 139
- White House National Science and Technology Council 113
- Women Inspectors of Factories (UK) 53
- World Health Organization (WHO)  
air quality 102  
antimicrobial growth promoters 97, 99  
dioxins 71  
FAO Joint Expert Committee 175  
International Agency for Research on Cancer (IARC) 57, 113  
Joint Expert Committee on Food 150
- World Meteorological Organization (WMO) 76
- World Trade Organization (WTO)  
French asbestos ban 53, 57–8, 175  
hormone growth promoters 153  
Sanitary and Phytosanitary Agreement 199
- Wynne, Professor Brian 199
- X**
- X-rays  
discovery 31  
injuries from 31–2  
medical examination 35, 67, 176  
*see also* radiation, ionising
- Y**
- Yell Sound 138–9
- Yorkshire TV 57
- Yucheng accident 67
- Yusho accident, Japan 65, 66, 69
- Z**
- zeranol 150



European Environment Agency

**Late lessons from early warnings: the precautionary principle 1896–2000**  
**Environmental issue report No 22**

Luxembourg: Office for Official Publications of the European Communities

2001 – 210 pp. – 21 x 29.7 cm

ISBN 92-9167-323-4