Chapter 8
Learning the Lessons of the BSE Crisis

8.1 Introduction

By any standard, the BSE crisis was a most difficult period in the public health of the UK. This period saw a previously unknown TSE emerge in cattle and then transmit to humans, a scenario which by August 2009 had cost 164 people their lives in the UK[1] and which has resulted in an unknown number of other people incubating variant CJD (vCJD).[2] The economic damage caused by this disease has been considerable. In April 2000, the government estimated that by the end of the 2001/2002 financial year, the total net cost of the BSE crisis to the Exchequer would be £3.7 billion (BSE Inquiry Report, Volume 10: 1). Less quantifiable consequences have also stemmed from this crisis.[3] Chief amongst them has been significant damage to the public's ability to trust the pronouncements of government on matters of food safety and risk.[4] The scientific community has suffered inestimable damage to its expertise and to its capacity to provide objective, consistent scientific advice to the public.[5] With such serious consequences emanating from the BSE affair, it is incumbent on all those who were involved in this tragic episode to reflect on the events that took place and to consider how things could have been done better. Such a reflective exercise has, of course, been conducted by Lord Phillips and his inquiry team who examined all the events that took place during the BSE epidemic and drew a wide-ranging set of lessons from these events.[6] A reflective purpose is also a central motivation of the current chapter. However, the focus of this reflection – scientific reasoning in contexts of uncertainty – is altogether narrower than that undertaken during the public inquiry into BSE. Moreover, the question of reasoning in contexts of uncertainty was omitted from Lord Phillips' inquiry into BSE[7] and has also been overlooked within the vast literature that has been written on the topic of BSE both before and after this inquiry was conducted.

The purpose of this chapter will be to bring together the various features that we have identified in the reasoning of scientists during the BSE epidemic. The aim is to arrive at a model that will provide a new conceptual framework for scientists who are charged with managing emerging infectious diseases like BSE in contexts of uncertainty. This model will be informed by the informal logical analysis of arguments used by BSE scientists that was undertaken in Chapters 4, 5, 6, and 7 inclusive. This

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analysis has its roots in philosophical disciplines. However, it is undertaken with a distinctly scientific purpose in mind. That purpose is one of responding to the call from public health scientists and epidemiologists for new modes of reasoning that can cope with uncertainty (see Section 2.2). It is to be expected that philosophy and science should cooperate on the response to this call. Both these intellectual enterprises, after all, must address the concept of uncertainty (science in an altogether more urgent way) and are concerned with the various logical operations that are integral to reasoning (philosophy in an altogether more abstract way). Yet, their cooperation has been stifled through disciplinary boundaries and other obstructions to greater integration. Chief amongst these obstructions is philosophy's failure to give proper consideration to the cognitive agent in matters of reasoning with all the chaos that this entails (e.g. taking cognitive shortcuts, assessing arguments with sub-optimal logical acuity). The scientific reasoner must seem a strange beast indeed to the philosopher or logician who cannot conceive of reasoning in terms other than the preservation of truth relations among propositions. For its part, science must look beyond its technical resources to the conceptual wealth of philosophy if it is to make genuine progress in generating the new ways of thinking that are needed to address increasingly complex public health problems. The model of reasoning that will be proposed in this chapter is an important step on the road to achieving greater integration of these disciplines.

To the extent that philosophy and public health science need to join forces in devising new modes of reasoning that are equipped to cope with uncertainty, I believe that the so-called informal fallacies are the place to begin this venture. These fallacies represent an important logical resource of reasoners that has for too long been treated with suspicion and more than a little contempt. Yet, it is the very feature of these arguments which has traditionally seen them despised by philosophers that puts them in good standing for the theorist who is investigating reasoning under uncertainty. That feature is their ability to exist in conditions where high status epistemic concepts such as knowledge are not to be found. The fallacies occupy a logical place where reasoning occurs against the odds, so few are the epistemic resources that are available to reasoners. But quite apart from being a weak or misguided response to this lack of resources, the fallacies act as guides through the paucity of evidence and knowledge that attends certain contexts. They are thus rational adaptations to the uncertainty of these contexts. This view of the fallacies as strategies or heuristics for tentatively inching forward in a process of reasoning in the absence of even minimal evidence or knowledge is largely an anathema to logicians and philosophers of a traditional bent. Fallacy analysis, these philosophers argue, should resist the type of cognitive characterisation that is integral to this view. Nor should features of context play a role in any determination of the rational standing of these arguments. And, finally, the very fact that fallacies are to be found where knowledge is lacking is proof, if proof were needed, that there are no redeeming features to these arguments. But this response sacrifices too much for some rather high-minded and outdated preconceptions about the logical value of the fallacies.

Most present-day fallacy theorists are not inclined to adhere to the view that the fallacies are of dubious logical worth. But acknowledging, as Douglas Walton and others do, that there are non-fallacious variants of the fallacies or that the fallacies can best be analysed within a pragma-dialectical framework[8] doesn't quite go far enough for our present purposes. For contributions of this type often lack the theoretical power to explain how these arguments function within the rational procedures of different domains such as inquiry in science (as witnessed by the fact that we have not found it useful to employ the Gricean and Searlean communicative insights that are integral to pragma-dialectics in the argument analyses undertaken in Chapters 4–7). If the analyses of earlier chapters have demonstrated anything, it is that the rational merits and weaknesses of arguments are not particularly well characterised in terms of rules, either rules on the performance of speech acts à la pragma-dialectics or any other type of rules (none of the analyses in Chapters 4, 5, 6, and 7 appealed to rules in order to characterise the strength or weakness of arguments). Nor is it even helpful to conceive of a standard list of fallacies which contains arguments that are inherently weak. Some of the weak arguments that we examined in earlier chapters are not to be found in any list of fallacies, and other arguments that have historically been labelled as fallacies were shown to be anything but fallacious. The assumption of a standard list of fallacies has had a particularly constraining effect on the development of theoretical frameworks, as these frameworks are constructed to prohibit certain argument forms while permitting other forms. It emerges that even recent theoretical approaches that take a more positive view of the logical worth of fallacies still have some way to go if they are to shed certain rather unhelpful assumptions about the fallacies.

If philosophical accounts of the fallacies need to make some adjustments in order to accommodate a greater alliance with public health science, then public health science must also facilitate greater disciplinary integration by undertaking some changes to its practice. Chief amongst these changes is a diminution of the preoccupation, in epidemiology in particular, with statistical techniques that are designed to establish correlations. This should be accompanied by an increase in thinking about the informal arguments that epidemiologists must advance in order to give rational weight to the various associations they establish.[9] Battersby (2006: 50) effectively makes this point in the case of correlations, only some of which can qualify as causal claims and only after they are supported by rationally warranted arguments:

> [S]tatistical inference is often not adequate for establishing correlations in most studies. It is never adequate for establishing causal claims. Correlations are necessary but not sufficient for a causal claim. Epidemiologists therefore must use informal arguments to make their case for a causal claim.

Epidemiologists must re-engage with the critical base of their discipline, a critical base in which arguments are advanced about the correlations that satisfy criteria for causal claims, for example.[10] In this way, the epidemiologist's challenge is to become more like an informal logician who reflects on the arguments that must be advanced in order to determine which of the many statistical associations that can be established through the application of techniques warrant rational acceptance. This re-engagement with the critical base of epidemiology will not be easy, even for a discipline that is more aware than most scientific disciplines of the need to reflect on its processes of knowledge generation.[11] After all, if epidemiologists are to start thinking like informal logicians about the arguments in their field, it may be feared that they could come to apply these critical skills of a whole range of argumentative practices. One such practice could be the relationship in epidemiology between argumentation and corporate influences.[12] Notwithstanding the difficulty in overcoming hurdles to greater engagement with the critical base of epidemiology, this engagement must occur if philosophy and public health science are to make progress on areas of joint concern.

As well as becoming an informal logician, the epidemiologist can secure a greater convergence of philosophy and public health science by becoming an epistemologist. An epistemological concept, the concept of presumption, has been integral to the account of the informal fallacies that we have been developing in this book. In this way, informal fallacies have been shown to facilitate scientific inquiry in a context of uncertainty, a capacity which, it has been argued, is directly attributable to the presumptive nature of the arguments in question. Specifically, these arguments have been shown to licence decisions in the practical sphere in the absence of complete deliberation and to respond to shifting evidential considerations during inquiry because the presumptions on which they are based display an orientation to action and context sensitivity, amongst other features (see Section 3.2). A concept that can confer such epistemic gains on inquiry, particularly in a context of uncertainty, has obvious relevance to the discipline of epidemiology and should be firmly embraced by epidemiologists and other public health scientists. Historically, epidemiology has made considerable strides when it has opened itself to the conceptual influences of other disciplines. Krieger (2000) describes epidemiology's long-standing relationship to the social sciences, a relationship that has seen certain social scientific concepts have a substantial impact on the work of epidemiologists.[13] Amongst the many benefits of this relationship for epidemiology have been new ways of conceiving of social inequalities[14] and racial/ethnic disparities[15] in health. In the same way, I believe that it is only when epidemiologists open themselves to epistemological concepts that we will begin to see significant progress on questions of joint interest to philosophy and public health science.[16]

Of course, the question of joint interest to philosophy and public health science that we have been examining in this book is how best to develop a model of scientific reasoning that is adapted to conditions of uncertainty. We argued in Chapter 3 that a model based on presumption was best equipped to address the three aspects of this question: the scientific inquiry within which reasoning about BSE proceeded; the type of uncertainty that beset this inquiry; and the strategies (informal fallacies) that scientists used to facilitate their reasoning in this context. To the extent that we have committed ourselves to a presumptive framework, our model must assume certain features. It must exhibit *defeasibility*: the various structures and processes posited within the model must be capable of being overturned, if conditions dictate that this should occur. The model must display an *orientation to action*: the reasoning that is captured by the model must be the basis of courses of action and decisions in the practical sphere that cannot await the completion of extensive inquiries and other investigations. It must exhibit *rational justification*: the structures and processes within the model are not arbitrary and must possess the minimal degree of rational warrant that is befitting of presumption. The model must display *context sensitivity*: it must be capable of varying its structures and processes in accordance with the conditions that exist at any particular point in time. So what constitutes evidence in support of a thesis or proof of a claim, for example, will be different in knowledge abundant contexts and contexts in which knowledge is lacking. Finally, the model must reflect the *epistemic status* of presumption. Initially at least, presumption has a lowly epistemic status. However, this status can be improved over time. Our model of reasoning will need to accommodate the changes, both positive and negative, that can occur in the epistemic standing of presumptions.

It should be emphasised that these general features of the model may not actually be fulfilled by scientific reasoners in practice. Scientists may operate in inquiry with a standard of evidence that is in excess of that which can be achieved in a particular context. The actual reasoning of scientists may, therefore, not exhibit context sensitivity. Scientists may also fail to give effect to the defeasibility of the model by continuing to adhere to a claim in the face of contrary evidence. But neither of these scientific performances detracts from the fact that it should be possible *in principle* for the structures and processes within the model to vary in accordance with conditions in particular contexts and to be overturned by the emergence of contrary evidence. In not permitting these scientific performances to undermine the features of the model, we are not thereby diminishing the importance of the reasoning practices of scientists to this model. In fact, the need to achieve a model of scientific reasoning that can more closely reflect some of the characteristics of actual scientific reasoning has been one of the main motivations of the current study. But it is a reminder that if our model is to have any normative weight, it must be informed by, rather than reduced to, the reasoning practices of scientists. In placing high value on the role that the fallacies can play in this project, we are not taking the extreme view that there is no such thing as fallacious reasoning. We have seen numerous examples in earlier chapters of very weak scientific reasoning that, if anything, frustrated the aims of inquiry into BSE. If we want to emerge from this undertaking with a model of reasoning that is at once logically respectable and scientifically viable, we need to give this weak reasoning as much of a wide berth as the ideas of a theorist who refuses to engage with the actual reasoning practices of scientists.

8.2 A Model of Reasoning in Scientific Inquiry

In keeping with the significance that we have accorded to the temporal context in which scientific reasoning takes place, we will outline the various aspects of our model in the three time phases that we have identified in the BSE inquiry. Our purpose in identifying these phases was to emphasise the fact that a scientific inquiry can assume different states as it evolves over time. Each of these states is characterised by unique epistemic conditions and other features that have a profound effect on the type of reasoning strategies that are employed by scientists. For each stage of inquiry, these conditions will be laid bare alongside a number of other considerations that impact more or less directly on the reasoning of scientists. We begin by describing the *goals* of each phase of inquiry. Goals in inquiry might include the gathering of evidence to support a particular hypothesis about the origin of an emerging infectious disease, the justification of disease control measures or the simple initiation of inquiry. The *scientific conditions* that characterise each phase of inquiry will also be addressed. These conditions might include technical issues such as the types of experiments that can be conducted or organisational issues such as the establishment of expert advisory committees. The *epistemic conditions* in each phase of inquiry will be discussed. Here we might address not just obvious considerations such as the lack of knowledge in a certain phase of inquiry, but also issues such as the changing epistemic status of theses. Finally, we will consider the *reasoning strategies* that scientists use in each phase of inquiry. Some of these strategies facilitate scientists in achieving the goals of a phase of inquiry. As well as these facilitative strategies, scientists can use non-facilitative strategies that frustrate the attainment of one or more goals in a phase of inquiry. Both types of strategy will be discussed.

8.2.1 A Model of Reasoning in Early Inquiry

Newly emerging infectious diseases such as BSE have a habit of catching the scientific community in a state of less than complete preparedness. An important element in improving the scientific response to these diseases must surely be the development of an explicit model of reasoning that can help guide scientists in their early decision-making. At a minimum, this model should stipulate (i) the goals towards the fulfilment of which the model is contributing, (ii) the conditions under which the model is to be applied and (iii) the reasoning strategies that can address the goals of early inquiry within the conditions that obtain at this point in inquiry. We examine each of these components in turn below.

Goals: Upon identifying a new disease entity, scientific investigators have an overriding goal: to launch a formal process of scientific inquiry within the shortest timescale possible. Where a new disease entity is infectious or a potential zoonosis, there is even greater urgency to embark on inquiry – any delay or inaction could pose considerable risks to animal and human health while the transmission routes of the disease remain unknown to scientists. The pressing demand to launch inquiry assumes precedence over other competing demands on scientific investigators. For example, the concern to avoid incurring error in inquiry is temporarily suspended as scientists forge ahead in an attitude of optimistic exploration. This attitude does not involve throwing all caution to the wind, but it does involve the calculation that the risk of error cannot be allowed to outweigh the altogether more pressing need to initiate inquiry. A further goal in the early phase of scientific inquiry is to arrive at decisions that become the basis of disease control measures in the absence of all but the most preliminary investigations. Of necessity, disease containment actions must be initiated in advance of the facts about a new disease. Ultimately, these actions may be found to be ineffective or based on an incorrect understanding of the transmission properties and other features of the disease in question. Yet, these possible outcomes should not deter scientists from undertaking the type of pre-inquiry decision-making that is an essential part of the early scientific response to a newly emerging infectious disease. The goals of early scientific inquiry are thus twofold: (1) to initiate inquiry, a goal which is only made possible through the temporary suspension of a number of other desiderata in inquiry and (2) to arrive at decisions relating to disease containment in advance of all but the most preliminary investigations.

Scientific Conditions: The results of initial epidemiological investigations become available to scientists during the early weeks and months following the emergence of a new infectious disease. In an effort to identify the new disease entity, scientists also undertake various laboratory analyses that examine the histopathology and molecular properties of the disease in question. However, at this early stage of inquiry, no direct experimentation has yet been undertaken and is still some way off in the future. The scientific community can be in different states of organisational readiness to address the new disease. In the case of pandemic influenza, for example, the global scientific community is particularly well prepared to mount a rapid and effective early response through its organisation via international agencies such as WHO.[17] This reflects more generally WHO's well developed systems for dealing with outbreaks of infectious disease.[18] In the case of little known diseases like the TSEs, the situation is quite different. Although expertise existed in TSEs when BSE first emerged in 1986, this was to be found among small, disparate research groups and individuals across both medical and veterinary fields. This expertise had never been formally organised and had never been collectively called upon to assess the implications of the emergence of a new TSE for human health. Inevitably, this lack of organisation in the scientific community produces delays in the community's response to a new infectious disease and certainly did so in the case of BSE. The result was that it took until June 1988, nearly 2 years after BSE was identified as a new disease entity, before scientific experts in the form of the Southwood Working Party were brought together to consider this bovine disorder (and even then the range of this expertise was questioned; see note 19 in Chapter 7). The early response to a new infectious disease may therefore have to proceed in a less scientifically informed state that would ideally be the case.

Epistemic Conditions: Of the three time phases that we identified in the BSE inquiry, the early phase was undoubtedly the most challenging for scientists in epistemic terms. The only direct knowledge scientists had of BSE was gleaned from John Wilesmith's early epidemiological investigations and from molecular and histopathological studies conducted by Hope et al. (1988) and Wells et al. (1987), respectively. With so few findings about BSE available to investigators, scientists were compelled to bridge gaps in their knowledge by drawing on what was already known about other TSEs. Scrapie was the most extensively investigated TSE by the time BSE emerged and was also believed to be the origin of this new bovine disease. As such, it became a natural template for scientific judgements about how BSE might behave. However, to the extent that this template provided only indirect information about BSE, the various claims which the template was used to justify were at best weakly warranted. The type of epistemic strategy which is exemplified by the case of scientists in the early phase of BSE inquiry can be characterized as follows. Scientists respond to the uncertainty of early inquiry by achieving a downward adjustment in the epistemic standards that must be met in order to advance claims. These lowered epistemic standards allow scientists to seek out possible sources of presumption in inquiry. One such source is the use of analogical templates, which are based on a disease that is related to, and better known than, the newly emergent disease under investigation. The presumptive theses to emerge from these sources are certainly not knowledge claims, although this fact does not preclude them becoming knowledge claims as inquiry proceeds. What these presumptive claims do achieve, however, is the facilitation of inquiry until such times as other theses, which are more strongly warranted, can be obtained.

Reasoning Strategies: Reasoning based on the analogical template that we have just described became a highly productive strategy for scientists during the BSE inquiry, particularly in the early phase of this inquiry. This strategy formed the basis of early risk assessments about BSE and was also used to justify measures that were taken in order to control the spread of the disease. But it was not the only facilitative reasoning strategy that was at the disposal of scientists during the adverse epistemic conditions of early inquiry. The argument from ignorance was used to effectively order questions for investigation in early inquiry. This reasoning strategy sought to prioritise those questions that had a reasonable prospect of being addressed within the epistemic and scientific conditions of early inquiry. Where a question was not consistent with those conditions – the question of the transmissibility of BSE to humans could not be experimentally investigated and, given the long incubation period of TSEs, natural transmission might take many years to be revealed – the argument from ignorance served to exclude that question from further, active consideration in inquiry. Question-begging argument also proved to be a highly valuable reasoning strategy for scientists in the early stage of inquiry. Typically, this argument is associated with the misguided attempt to use in reasoning the conclusion that the arguer is attempting to establish. However, by allowing scientists to use within their reasoning the proposition they were attempting to prove, this argument form permitted investigators to move forward in inquiry and establish lines of evidence that were independent of the conclusion. Question-begging argument thus transformed points in inquiry that were essentially impassable into much needed opportunities for evidence gathering.

The facilitative reasoning strategies that we have just described are not intended to be exhaustive of the strategies that are beneficial to scientists at the outset of inquiry. But they do exemplify an important type of reasoning that has been almost completely overlooked by theorists who are concerned to examine how scientists reason in contexts of uncertainty. Each strategy owes its facilitative capacity to the fact that uncertainty is part of the logical structure (some would say logical flaw) of the argument associated with the strategy. For example, in question-begging argument uncertainty characterises one of the premises of the argument – to the extent that this premise *is* the conclusion, it exhibits the uncertainty of the conclusion and cannot satisfy the epistemic requirement that premises in an argument must be more certain than the conclusion to be proved. But given that this requirement may be held in abeyance as scientists attempt to embark on inquiry, the uncertainty of the premise of a question-begging argument is less a logical anomaly than it is a feature of this argument which makes it particularly well adapted to the adverse epistemic conditions of early inquiry. Non-facilitative forms of reasoning in the early stage of inquiry are those arguments which fail to reflect the wider epistemic conditions under which they are advanced. Deductive arguments which proceed, by definition, from premises that are certain (known to be true) to a conclusion that is uncertain (not known to be true) are poorly suited to the epistemic conditions of early inquiry. So while the circular pattern of reasoning evident in question-begging argument prospers under the conditions of early scientific inquiry, the linear pattern of reasoning that is typical of deductive arguments is altogether less well adapted to the pervasive uncertainty of early inquiry.

8.2.2 A Model of Reasoning in Middle Inquiry

Following early investigations of BSE, inquiry into this new bovine disease entered a phase of intensive scientific activity. The middle stage of inquiry saw the relatively tardy and even disorganised response[19] of the early weeks and months of the BSE crisis yield to a wide-ranging programme of research into BSE that was already producing results by the end of this period. We describe below the goals that motivated scientific reasoning during this middle stage of inquiry, the conditions that characterised this phase of investigation and the reasoning strategies which facilitated and hindered scientists in their attainment of these goals.

Goals: To the extent that measures to control BSE had been implemented in early inquiry on the basis of tentative evidence, an overriding goal of scientists in the middle phase of inquiry was to establish a stronger rational basis for these various courses of action. In this way, the pathogenesis study, which was initiated at the CVL in December 1991, was undertaken with a view to justifying the terms of the human SBO ban (in the event, of course, the results of this study achieved an extension of the ban). The capacity of evidence from studies of this type to validate and revise earlier actions in relation to BSE is related to the fact that this evidence is obtained through experimental investigation. Its probative weight is therefore altogether greater than the evidence of early inquiry, which was established through less direct means such as analogies with other TSEs. Apart from the post-implementation justification of disease containment measures, another important goal of scientists in the middle stage of inquiry was the development of a body of knowledge about BSE. The tentative claims of early inquiry were exposed for the first time in the middle stage of inquiry to results from experimental studies and to findings of natural transmissions of BSE to a range of species. For some of these claims, this exposure marked the end of their journey in inquiry – the force of emerging evidence overturned these claims (or, as we argued in Chapter 5, emerging evidence should have overturned many more claims than actually occurred in the

BSE inquiry). But for those claims that withstood the emergence of evidence in the middle phase of inquiry, integration within a body of knowledge about BSE was for the first time more than a theoretical possibility. This was the stage in inquiry when the prospect of knowledge that is implicit in presumptions looked as if it might actually be realised.

Scientific Conditions: The middle stage of inquiry saw scientists embarking on an organised programme of experimental and other research in relation to BSE. Priorities for research were determined by the Tyrrell Committee,[20] while recommended projects were undertaken at centres such as the Central Veterinary Laboratory and the Neuropathogenesis Unit in accordance with the expertise and facilities of these centres. Epidemiological studies, which had been so prominent in the emergent phase of inquiry, continued to occupy a position of significance during the middle stage of inquiry[21] with epidemiological work an integral part of the Tyrrell recommendations and the basis of early studies of natural transmission of BSE to species that are not susceptible to scrapie (e.g. Kirkwood et al. 1990; Kirkwood and Cunningham 1994). During the same period, scientific advice to government about the risks that BSE posed to human health became the responsibility of a single expert committee, the Spongiform Encephalopathy Advisory Committee. From these various developments we can draw conclusions about the scientific conditions under which investigators were operating in the middle phase of inquiry. Firstly, how the scientific response to BSE should proceed became as much a focus of rational deliberation as BSE itself. In this way, the research that should be undertaken and the use of the results of that research to inform BSE risk assessments and justify disease containment measures became the primary scientific activity of expert committees during this period. Secondly, the ongoing prominence of epidemiological work during this phase of inquiry is indicative of just how long scientists were expecting to wait for BSE experiments to begin producing results. TSEs were known to have lengthy incubation periods, in some cases of many years. Epidemiological work provided a much needed means of characterising BSE while scientists awaited the results of experimental studies.

Epistemic Conditions: As evidence from studies began to emerge in the middle phase of inquiry, the epistemic challenge for scientists was less about bridging gaps in knowledge and more about integrating this evidence within a body of knowledge. Some evidence that emerged during the middle stage of inquiry served to expand this body of knowledge by contributing new propositions to it (the finding of the dose required to achieve oral transmission of BSE to cattle is a case in point). Other evidence called into question the rational bases of disease containment measures and BSE risk assessments. By right, this evidence should have achieved a significant revision of the rational approach to scientific decision-making (specifically, scientists should have relinquished their reliance on analogical reasoning based on scrapie). On a few occasions, contrary evidence did overturn earlier decisions (e.g. the finding of BSE infectivity in calves less than 6 months old led scientists to call for an extension to the human SBO ban). However, the fact that this did not occur more widely, we argued, was an indication that the normal dialectical processes of presumption and burden of proof were subverted in inquiry. From these evidential developments in middle inquiry, several points emerge. Firstly, the development of a knowledge base supersedes the bridging of knowledge gaps as the primary epistemic activity in the middle phase of inquiry. Secondly, a lack of knowledge or evidence is not the only obstruction to progress in inquiry. The progress of inquiry can be frustrated even in the presence of abundant evidence, if this evidence is not permitted to have its full probative weight. Thirdly, although a body of knowledge begins to take shape in the middle phase of inquiry, it is in a state of constant flux as some theses are added to it, other theses are removed from it and still other theses vary their epistemic standing within it.

Reasoning Strategies: In order to be responsive to the emergence of evidence in the middle stage of inquiry, scientists must have access to a set of defeasible, context-sensitive reasoning strategies. These strategies allow scientists to revise their commitments to theses in a proportionate manner to reflect changes in the evidential base of inquiry. In some contexts, a proportionate revision may involve the rejection of a single claim which can no longer be supported by the available evidence. In other contexts, a proportionate revision may involve the rejection of several claims, all of which are indefensible given their shared reliance on an insupportable claim. It has been argued that the so-called informal fallacies are uniquely equipped to respond to changes in the evidential base of inquiry. The defeasibility and context-sensitivity of these argument forms stem from the presumptive theses that constitute these forms. When the presumptive character of these arguments is allowed to stand in inquiry, the reasoning strategies based on these arguments can be seen to facilitate inquiry by enabling scientists to respond to the emergence of evidence. However, when this presumptive character is distorted, as occurred during the middle phase of the BSE inquiry, these same reasoning strategies frustrate the very argumentative purposes for which they are brought forward. In this case, rather than responding to emerging evidence, these strategies serve only to protect a developing body of claims from any evidential challenge. To the extent that emerging evidence is not able to bring about revisions in the epistemic commitments of scientists, these commitments progressively become detached from the evidential base of inquiry. In the BSE inquiry, this detachment found scientists continuing to argue that BSE would not transmit to humans and that beef was safe to eat even when the evidence available to scientists failed to support either of these claims.

If correctly employed, presumptive strategies can guide the reasoning of scientists as they deal with new evidence about an infectious disease in the middle phase of inquiry. However, these same strategies have another important function for scientists during this phase of inquiry. While the defeasibility and context-sensitivity of these strategies equips them to respond to the emergence of new evidence, another feature – the capacity for the theses that are warranted by these strategies to improve their epistemic standing in inquiry – is integral to the knowledge generation function of these strategies. For presumptive theses that withstand the emergence of evidence in middle inquiry, the prospect of these theses improving their epistemic standing in inquiry and, eventually, attaining the status of knowledge claims becomes increasingly real.[22] To the extent that reasoning strategies such as the argument from ignorance and analogical argument are based on presumptive claims, we can expect these strategies to be vehicles of knowledge generation in inquiry. In the early phase of inquiry, the raison d'être of presumptive reasoning strategies is to bridge gaps in scientific knowledge with no guarantee that this will result in any long-term epistemic gains for inquiry. By the middle phase of inquiry, investigators are beginning to see some epistemic return for their initial commitment to these strategies, as a number of the theses that are warranted by means of them are able to contribute for the first time to the knowledge base of inquiry. The capacity of presumptive reasoning strategies to generate knowledge in inquiry is not always evident to investigators at the outset of inquiry. But for those investigators who make an early investment in these strategies, the middle phase of inquiry is where they can begin to see some return for their efforts in terms of the development of a body of knowledge.

8.2.3 A Model of Reasoning in Late Inquiry

As with other infectious disease epidemics, BSE cases have now decreased to an almost negligible level. From a peak of 36,680 cases in 1992, cases of BSE fell to 8,013 in 1996 (the end of the period we are studying) and only 7 cases were recorded in 2009 by the UK's Department for Environment, Food and Rural Affairs. However, unlike other infectious disease epidemics, even as BSE cases were in decline, a related epidemic in humans in the form of variant CJD was emerging. It is not an exaggeration to say that scientists in the late phase of the BSE inquiry appeared to be taken aback by this serious human health development. We explained this response in terms of an unassailable scientific consensus about BSE which had served to reassure scientists and the public alike that BSE would not transmit to humans. This lack of scientific preparedness for the emergence of variant CJD was entirely avoidable and, indeed, could have been avoided if scientists had engaged in a more robust form of reasoning. We examine the main components of that reasoning below within a wider consideration of reasoning in the final stage of scientific inquiry.

Goals: With the attainment of knowledge now well and truly within the grasp of scientists, theory construction becomes the focus of scientific effort in the late stage of inquiry. To this end, a number of priorities or concerns that were temporarily suspended in early inquiry once again assume significance. We described in Section 8.2.1 above how the need to initiate scientific inquiry into an infectious disease is so great that scientists at the outset of inquiry are prepared to suspend their concern for the avoidance of error. However, this suspension is relatively short-lived and by the middle and final stages of inquiry, investigators are positively inclined to ensure that their developing theories of a disease are consistent with the best scientific evidence that is available to them. Error at these later stages of inquiry is much more costly in cognitive and epistemic terms than in the early phase of inquiry. At the outset of inquiry, there are few epistemic commitments resting on presumptions. So if a particular presumption is found to be lacking, it can be rejected without necessitating a more widespread revision of scientific theses. However, a presumption that has been elevated to a knowledge claim in inquiry and integrated within a theory threatens to destabilise that theory should it be shown subsequently to be unwarranted. We also described in Section 8.2.1 how an epistemic priority requirement on argument was held in abeyance at the outset of inquiry. This required that scientists argue from theses that are more certain than, or better known than, the thesis to be proved through argument. In the uncertainty of early inquiry, the satisfaction of this requirement would have seen scientists having to abandon the possibility of even initiating inquiry. This epistemic priority requirement can be more readily satisfied in the late phase of inquiry, when there are many more theses, which can fulfil what it stipulates, at the disposal of investigators.

Scientific Conditions: To the extent that theory construction is the goal of late inquiry, certain scientific conditions must be in place for this goal to be realised. The emergence of evidence during the middle phase of inquiry is certainly essential for theory construction to proceed. But this evidence is inadequate in itself to determine a single, correct theory of an emerging infectious disease and, indeed, may even be consistent with more than one theoretical account of such a disease.[23] This was amply demonstrated in the BSE inquiry when two groups of scientists – government scientists and dissenting scientists – developed two opposing theoretical views of BSE which were based on the same set of evidence from experimental and epidemiological studies. These views contained quite different claims about the origin of BSE, the transmissibility of BSE to humans and much else besides. The key factors in deciding which of these views should be accepted as most likely to be a true account of this new bovine disease were all dialectical in nature.[24] In this way, the failure of government scientists to afford dissenting scientists opportunities in which to present their claims and to bring forth evidence in support of those claims[25] was the type of consideration that we described in Chapter 6 as serving to undermine the consensus view of BSE. Presumption and burden of proof form the dialectical engine of the process of inquiry that has been presented in this book. Through the interplay of these concepts, the rational grounds of a thesis are laid bare. The same dialectical considerations, which are the basis of presumption and burden of proof, can now be seen to guide theory construction in the late phase of scientific inquiry. While the consensus view of BSE enjoyed the support of most scientists who investigated the disease, it was a view that failed by the dialectical standards of inquiry.

The scientific context in which a consensus view of BSE developed was one in which dialectical considerations relating to theory construction were increasingly subordinated to a range of non-scientific interests. These interests motivated government scientists to protect the consensus view from criticism, as this view contained reassuring claims to the effect that BSE had negligible implications for human health. The attempt to suppress the normal dialectical processes of inquiry had concrete consequences for scientists who undertook to challenge the consensus view of BSE. These dissenting scientists found their professional standing undermined, access to data and research materials restricted[26] and the publication and funding of their work challenged.[27] In short, the working conditions of these scientists ensured that they would be unable to mount an effective challenge to the consensus view of government scientists. In the absence of such a challenge, theory construction during the BSE inquiry consisted in the promotion at all costs of a particular position (the consensus view) rather than in a dialectical exercise between competing theoretical views. The lesson to emerge from theoretical developments during the BSE crisis is that any condition which frustrates this dialectical exercise is an obstruction to robust theory construction in inquiry. These conditions may include behaviours such as denying scientists opportunities in which to present their views. Dissenting scientists, for example, wished to discuss their research work with SEAC scientists but were prevented from attending SEAC meetings. However, they may also include a number of more fundamental conditions, the existence of any one of which can make dialectical interventions by scientists all but impossible. For example, dissenting scientists were denied the use of the data and materials that were needed in order to undertake their research.

Epistemic Conditions: Of all stages of inquiry, the late stage has traditionally been the focus of discussion of philosophers of science and logicians.[28] This is because this stage embodies epistemic concepts like certainty and reasoning processes such as deduction that have historically been of interest to these theorists. By late inquiry, scientists are not contending with a lack of knowledge as was the case in early inquiry. However, a knowledge problem of sorts nevertheless confronts investigators in the final phase of inquiry. Warranted theses have to be integrated into a body of knowledge, from within which they can enter into a number of deductive relations with other theses. However, not every deductive consequence of these theses is interesting, relevant or significant enough to form propositions that should undergo further testing in inquiry. Scientists must therefore manage the potentially large number of deductive implications that can be generated by this body of knowledge with a view to pursuing only those implications that are most likely to make a positive contribution to theory construction. But deduction does much more in late inquiry than generate propositions for further scientific testing. Deduction from certain and known theses confers certainty on all derived theses. This is in stark contrast to early inquiry, when scientists attempted to bridge a lack of certainty through the use of presumptive reasoning strategies. Certainty preservation assumes significance in late inquiry, as this is a time in inquiry when substantial epistemic commitments on the part of scientists rest on a small number of foundational theses. Disruption to one of these theses can have adverse consequences for investigators, who must face the prospect of substantial revisions to their other commitments should one of these foundational claims be invalidated.

Of course, these deliberations bore little resemblance to how scientific theorising actually proceeded in the late stage of the BSE inquiry. The theses that government scientists used in theory construction did not emerge from a dialectical process in which claims grew in epistemic stature as they survived successive cycles of challenge during inquiry. Certainly, the theses advanced by these scientists persisted over the course of inquiry. But this persistence was only achieved by shielding these claims from criticism by dissenting scientists. To the extent that these claims entered theory construction in late inquiry in a less than warranted state, no process of deduction based on them would ever produce sound conclusions regardless of the validity of its rules of inference. This scenario demonstrates that the really important epistemic work of inquiry lies in establishing strongly warranted theses that can then participate in deductive reasoning – no deductive process can confer on its premises the type of certainty and warrant that comes from a thoroughgoing dialectical examination of the rational merits of a thesis. This scenario also demonstrates that theorists have been somewhat remiss in attending for the most part to later, deductive stages of scientific inquiry. Clearly, these stages can find scientists engaged in some very weak theory construction if earlier phases in inquiry have failed to deliver strongly warranted theses upon which construction can proceed. The traditional (mainly positivist) characterisation of early inquiry as a non-logical process has seen this important stage of scientific inquiry dismissed as mere creative guesswork. Yet, logical processes are very much in evidence in the formative stage of a scientific inquiry, as we demonstrated in Chapter 4. Moreover, it is these processes that must work well if scientists are to have anything even approximating a strongly warranted thesis for use in theory construction in late inquiry.

Reasoning Strategies: It should be clear from the preceding section that deduction from certain, known premises is the dominant mode of reasoning in the final stage of scientific inquiry. It is not difficult to see why this is the case. It is only in the final stage of inquiry that scientists have access to strongly warranted theses for use as premises in deductive arguments. But even in this deductive phase of inquiry, the strategies that we have identified as facilitating early inquiry can once again be seen to play an important role in scientific reasoning. One such strategy, the argument from ignorance, has the status of a deductively valid argument when certain conditions are satisfied (see note 23 in Chapter 4). These conditions are that an exhaustive search has been conducted of a knowledge base that is closed, i.e. the base must contain all the relevant information pertaining to a particular question. In Chapter 6, we described two uses of the argument from ignorance by SEAC scientists that fulfilled these conditions. These uses were evident during SEAC's deliberations concerning the safety of blood and its further assessment of the risk of BSE transmission through bovine eyeballs. With these conditions fulfilled, it was left for a modus tollens inference to generate deductively valid conclusions to the effect that blood did not pose a risk of CJD transmission and that there was no risk of BSE transmission through bovine eyeballs. As well as prioritising questions for investigation in early inquiry, the argument from ignorance, as these examples demonstrate, is able to contribute to theory construction in late inquiry by extending the knowledge base of inquiry. This argument is able to perform these diverse epistemic functions because it is as much at home in the exacting epistemic conditions of late inquiry as it is in the tentative epistemic circumstances of early inquiry.

The argument from ignorance is particularly well adapted to the late, deductive phase of inquiry on account of its logical structure. Unlike other informal fallacies that we have studied in this book, this argument has a deductive logical structure which it owes to its dependence on modus tollens, a valid rule of deductive inference. Although the deductive operations of late inquiry preclude the use of presumptive reasoning strategies by scientists, these strategies are nevertheless pivotal to reasoning in this phase of inquiry. For it is through these strategies that the premises of deductive arguments are generated. The certain, known theses that constitute the premises of deductions in late inquiry are the epistemic product of reasoning undertaken in earlier stages of inquiry. These theses acquire their rational standing in inquiry through dialectical exchanges between scientists. Accounts of deductive reasoning never interrogate the origin of the theses that form premises in deductive arguments.[29] According to these accounts, deduction proceeds by definition from premises that are true theses with no explanation of the epistemic and other processes that give rise to these theses in the first place. Of course, the deductive logician can easily avoid such an explanatory task by assigning it to the inductive logician. It is not the deductive logician's task, after all, to describe the processes through which premises are established, but to capture deductive relations between established propositions. But this is not a stance that is open to the applied logician who is seeking to characterise the reasoning of public health scientists. In this case, the epistemic course that theses take en route to becoming premises in deductive arguments is relevant in any consideration of the reasoning of these scientists.[30] And to understand this course, we must engage with the presumptive reasoning strategies that were discussed in earlier chapters. This final stage of scientific inquiry completes our model of reasoning, which is shown in its entirety in Diagram 8.1.

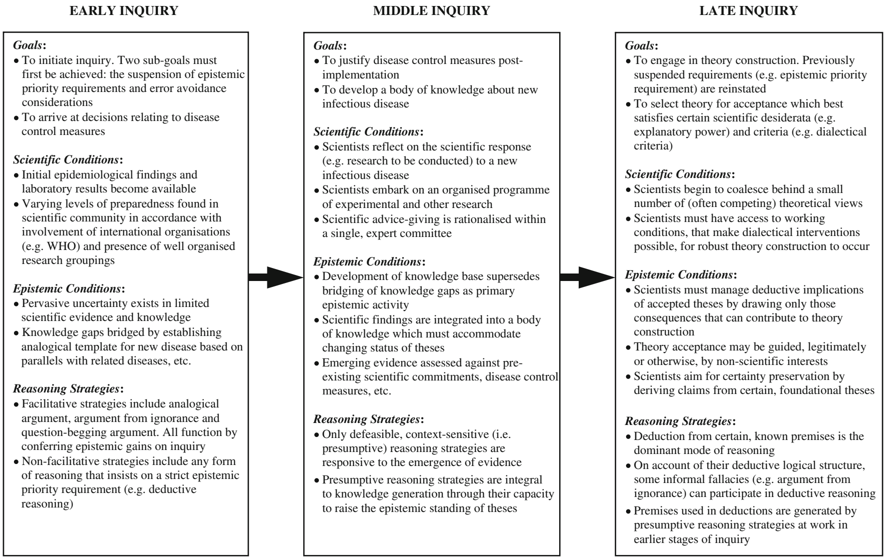

Diagram 8.1 A model of scientific reasoning under uncertainty

8.3 The Model, Risk Analysis and Public Health Science

A number of risk analysis concepts shaped the public health response to BSE. These concepts, which included the precautionary principle and ALARP principle, have yet to be described in any detail. This lack of earlier description is not an oversight. Rather, it reflects part of the argumentative purpose of this book. That purpose is to contend that if the model of reasoning discussed in the last section is to have relevance to the work of public health scientists, then it must be consistent with the concepts that inform the work of these scientists. This includes risk analysis concepts which should be capable of being fully integrated within the proposed model. In this final section, we examine two such concepts both in their own terms and in terms of how they came to be employed by scientists during the BSE crisis. From this examination, we will glean a number of key attributes of these concepts which at a minimum should be accommodated by our reasoning model. To the extent that these attributes are only poorly accommodated by this model, we should be led to consider if our model is truly adequate to address the challenges and issues that confront public health scientists. In such a case, a rational response might be to use the exposure of the model to features of scientific risk analysis to achieve some conceptual fine-tuning of the model. If our model can readily accommodate these attributes, then there is at least a reasonable basis for claiming that it has certain merits for public health science. In any event, an analysis of the conceptual interrelationships between our model of reasoning and the tools of scientific risk analysis can only serve to highlight the features of both of these concerns and bring these two important dimensions of public health science into closer alignment with each other.

8.3.1 The Precautionary Principle

Although the precautionary principle was developed in the field of environmental health, it has been used extensively in a range of circumstances relating to public health (Martuzzi and Bertollini 2004). An important public health application of the principle occurred during the BSE crisis. Throughout the years that the BSE epidemic raged, scientists and government officials repeatedly invoked this principle in order to justify measures that were taken to control the spread of the disease and to limit its risk to human health. In evidence to Lord Phillips and his colleagues, Dr Calman (Chief Medical Officer, 1991–1998) stated that '[t]he Department of Health has always adopted a precautionary approach in relation to public health issues arising from BSE in their deliberations with MAFF' (BSE Inquiry Report, Volume 6: 508). On 9 November 1995, Mr Hogg (Minister of Agriculture, Fisheries and Food, 1995–1997) met with representatives of slaughterhouse operators to discuss the handling of specified bovine offals. A note of the meeting recorded that '[a]lthough there was at present no evidence that BSE might be a threat to public health, we had to take a precautionary approach, basing our controls on the presumption that BSE might be a threat' (BSE Inquiry Report, Volume 6: 599). On some occasions at least, it is clear that the precautionary principle was applied in name only during deliberations relating to BSE.[31] However, the extent to which this principle was successfully applied during the BSE epidemic is more appropriately topic of discussion for another context. In this section, we are concerned to examine the main features of this principle and to consider if these features can be fully integrated within our proposed model of reasoning.

Unsurprisingly, definitions of the precautionary principle vary. But in general, a number of central elements can be identified across all or most of these definitions. The first feature is that the principle is presumed to apply when courses of action must be taken in situations of uncertainty:

> The Precautionary Principle (PP) is a valuable tool for developing adequate courses of action in situations where there is large uncertainty. Such uncertainty can derive from: patchy scientific evidence about the health effects of an agent; sporadic reports of episodical adverse effects, unconfirmed or not reproducible; or limited knowledge of the dynamics of complex systems, resulting in effective ignorance on a series of chain events. Uncertainty can be of different magnitude and degree, but essentially discussion around the PP has focused on elements and criteria that should be addressed when making decisions under this kind of "undetermined" uncertainty, i.e., not easily measured or quantified (Martuzzi and Bertollini 2004: 43).

Moreover, this uncertainty cannot be used as a reason to delay action.[32] Rather, the precautionary principle urges action in advance of possession of scientific evidence and knowledge of scientific facts:

> . . .the PP prescribes that uncertainty cannot be used as a pretext to delay action (Martuzzi and Bertollini 2004: 44).

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[33]

The second noteworthy feature of the precautionary principle relates to burden of proof. Typically in inquiry, the burden is on those who doubt the safety of some proposed activity or agent to demonstrate that it is harmful.[34] The application of the precautionary principle reverses this burden of proof. The burden of proof is no longer on those who seek to demonstrate that an activity or agent is harmful. Rather, the burden is on those who are proposing a new activity or agent to demonstrate that it is safe: 'the burden of proof might be reversed, from "recipients" to prove that an agent or technology is harmful to "proponents", to prove that it is innocuous' (Martuzzi and Bertollini 2004: 44). This reversal of burden of proof is clearly evident in the note of Mr Hogg's meeting with representatives of slaughterhouse operators (see above). In this case, there was a presumption that BSE might be a threat to human health and a burden of proof on those who disagree with this view to show that BSE poses no risk. The third feature frequently discussed in relation to the precautionary principle is proportionality. This requires that any actions or measures that are undertaken under the auspices of the precautionary principle must be proportionate to the risks posed by a certain activity or agent. Specifically, measures should not be in excess of those risks:[35]

> The principle of proportionality has an impact on the choice of possible measures, and in the trade context, this could mean that one adopts measures that would be the least trade-restrictive. In general terms, the normative line of thinking here is that a proportionate application of the precautionary principle involves the least onerous measure while still attaining the legitimate objective (von Schomberg 2006: 27).

So the precautionary principle applies in contexts of uncertainty (which is not, in itself, grounds to delay action), involves a reversal of the burden of proof in inquiry and is intimately connected to a requirement for proportionality. To the extent that the model of reasoning which we outlined in the last section is to have relevance to public health scientists, this model must be able to accommodate features of the risk analysis concepts that these scientists use, including these features of the precautionary principle. This can be easily demonstrated on account of the presumptive nature of this model. We described in Section 3.3 how presumption was able to integrate the disciplines that converge on scientific inquiry (uncertainty, it was claimed, attends the convergence of different disciplines on a scientific inquiry), accommodate the prioritization of uncertainties in inquiry and capture the temporality of uncertainty. To this extent, presumption was able to address the main dimensions and forms of uncertainty that confront scientists in inquiry. A fortiori, a presumptive model of scientific reasoning is able to accommodate an uncertainty-gravitating notion like the precautionary principle. Also, presumption was characterised in Section 3.2 as a 'means of extrication' from deliberation when some action is called for in advance of the completion of deliberation (i.e. before evidence has been fully gathered and considered). A presumptive model of reasoning will, therefore, have little difficulty in handling a precautionary principle that calls for action to be taken in the absence of scientific evidence and certainty. So it can be said that our model of scientific reasoning adequately addresses the first of our three features of the precautionary principle, the capacity of this principle to apply to contexts of uncertainty.

Our presumptive model of reasoning is also equipped to accommodate the precautionary principle's reversal of burden of proof and requirement for proportionality. By definition, presumption is a dialectical notion. Any model of reasoning based on the concept of presumption inevitably assumes the dialectical character of this concept. The reversal of burden of proof demanded by the precautionary principle is a dialectical stipulation about the party in inquiry which should assume responsibility for demonstrating that a particular agent or activity poses no risk to health or to the environment. This dialectical stipulation is readily accommodated within a presumptive model of reasoning that is itself dialectical through and through. Proportionality is a context-sensitive notion. An action or measure that is proportionate to the risks of an agent or activity in one context may be in excess of what is required in another context. For example, it may be proportionate to ban the use of a certain chemical in food products even if there is only minimal evidence of risk to human health if the chemical in question can be readily replaced by a safe alternative. However, if no safe alternative exists, a complete ban may be judged to be a disproportionate response to the risk posed by the chemical.[36] Context sensitivity was one of five features of presumption examined in Section 3.2. Presumption, it was argued, is intimately tied to context along a number of parameters including the evidence that can overturn a presumption and that can bring about its rational validation. A presumptive model of reasoning inherits the context sensitivity of the presumptions that constitute this model. This model is thus ideally equipped to accommodate the context sensitivity of the concept of proportionality that attends the precautionary principle.

8.3.2 As Low As Reasonably Practicable

A further risk analysis concept that was used extensively during the BSE affair was ALARP (as low as reasonably practicable).[37] This concept contains an imperative to reduce risk until such times when further risk reduction activities incur costs (the latter broadly construed[38]) that exceed any gain from these activities:

> The principle of ALARP (As low as reasonably practicable) describes the way in which risk is treated legally and by the HSE (Health and Safety Executive) in the UK. The concept is that all reasonable measures will be taken in respect of risks which lie in the 'tolerable' zone to reduce them further until the cost of further risk reduction is grossly disproportionate to the benefit (Smith 2001: 129).

ALARP had been a familiar risk analysis concept within government since the 1983 publication by the Royal Society of *Risk Assessment: A Study Group Report*. Notwithstanding this fact, the use of this principle was largely implicit in the deliberations that followed the emergence of BSE in 1986.[39] One of the few explicit statements of this principle by a key actor in the BSE story was the following account by the Southwood Working Party which was given in evidence to Lord Phillips and his colleagues:

> Our approach to risk was in accord with the then developing application of analysis to public risk which involved the balancing of the perceived magnitude of the risk against the practicability or achievability of successive steps for its reduction. The magnitude of a risk comprises both its likelihood and the scale of the danger (BSE Inquiry Report, Volume 1: 52).

Despite this explicit statement of adherence to the ALARP principle, it was the opinion of Lord Phillips and his co-investigators that this principle was on occasion inadequately implemented not just by Southwood scientists but also by other central players in the BSE affair.[40] However, as with the precautionary principle of the previous section, we are less concerned with how well scientists implemented the ALARP principle than we are to discover if our model of scientific reasoning can accommodate features of this principle. It is to an examination of this issue that we now turn.

The ALARP principle sets out from a position which acknowledges that complete risk reduction is not attainable and that risk must therefore be managed by bringing it within levels that are as low as reasonably achievable or practicable.[41] The principle achieves this risk reduction through three components: (1) an imperative to undertake *action* to reduce the risks of an agent or activity, (2) an expectation that this action will incur *costs* and (3) a requirement that these costs should be *proportionate* to any benefit derived from the action. I want to argue that the ALARP principle, and the three components which give it effect, have a functional role in the domain of risk management that is similar to the functional role of presumption in uncertainty management. In the same way that ALARP practitioners acknowledge the impossibility of complete risk reduction, proponents of a presumptive model of scientific reasoning recognise that the total eradication of uncertainty is not attainable in inquiry, particularly inquiry in its emergent phase. Uncertainty is an inherent feature of scientific inquiry and, like risk, must be brought within levels that are as low as reasonably achievable. A presumptive model of reasoning also has functional equivalents of each of the three ALARP components described above. We described in Section 3.2 how presumption is an action-oriented concept. The actions that are licensed by presumption include cognitive actions (e.g. decisions) that enable investigators to circumvent uncertainty and advance inquiry. Undertaking these actions incurs costs which extend beyond economic considerations to include cognitive costs such as memory and attention. Finally, no presumption or source of presumptions is sustained in inquiry at any cost. A presumption that fails to pay its way in terms of epistemic gains for inquiry will very quickly be relinquished by investigators. Presumption in the epistemic domain, it emerges, is functionally equivalent to ALARP in the domain of risk. Through its functional equivalence to ALARP, a presumptive model of scientific reasoning can accommodate the defining features of this important risk analysis concept.

8.4 Summary

This chapter has sought to bring together the various strands of the model of reasoning that we have been developing throughout this book. Central to this model are the informal fallacies, an area of logical inquiry which has historically experienced some neglect but which has proved to be particularly valuable in addressing the difficult epistemic conditions in which scientific reasoners are compelled to operate. Several of these so-called fallacies were found to be anything but fallacious when assessed against the uncertain contexts in which they were advanced. In fact, these fallacies were shown to confer certain epistemic benefits on inquiry, particularly in the early stage of inquiry. An equally neglected area of epistemological inquiry, the concept of presumption, provided the framework for our analysis of the fallacies. A presumptive framework brought the logical and rational features of the fallacies into sharp focus, features which had been obscured by more traditional epistemological analyses. As well as supporting an analysis of the fallacies, a presumptive framework was also used to capture the rational methodology of scientific inquiry à la Rescher. Through this framework, we were able to chart the epistemic course of theses in scientific inquiry, the BSE inquiry specifically included. Only some theses improved their epistemic standing during the inquiry into BSE. Many other theses were overturned by contrary evidence and fell by the wayside in inquiry. Still other theses should have been defeated by this evidence but persisted in inquiry on account of the distortion of the dialectical rules of presumption and burden of proof in inquiry. In any event, the combined presumptive analyses of the informal fallacies on the one hand and scientific inquiry on the other hand opened up new possibilities for a model of scientific reasoning that could address uncertainty.

The proposed model of scientific reasoning represents a joint venture between the areas of philosophy and public health science. These areas, it was contended, have not been particularly well integrated to date on account of a number of disciplinary features. Specifically, philosophers have traditionally been concerned to describe reasoning in a formal, abstract manner which is concerned more with deductive, truth relations between propositions than with how individuals cope with issues such as uncertainty in their everyday reasoning practice. For their part, public health scientists and epidemiologists have devoted little effort to the type of conceptual work required to generate the new modes of reasoning that are needed to address the complexities of modern public health problems. A combined effort on the part of philosophers and public health scientists to develop new ways of thinking and reasoning about the public health issues (including emerging infectious diseases) that confront us provides us with a rational basis for further progress in this area. The model of reasoning that has been proposed in this book is a first step in this direction. Ultimately, this model may be found to be lacking in ways that reduce its usefulness to the work of public health scientists or that compromise its conceptual credentials for philosophers. However, even if either (or, indeed, both) of these possibilities comes about, this model still has one overriding merit over investigations that have been conducted to date. This is the merit of initiating a form of inquiry that sees much greater potential for progress to be made on important public health questions through the collaboration of the disciplines of philosophy and public health science. If this is the single, enduring feature of this study, then this book will have made a significant contribution to this new area of intellectual inquiry.

Notes

1. There have also been cases of vCJD outside the UK. Collee et al. (2006) report 28 cases outside the UK by February 2006. This figure breaks down as follows: France (16 cases), Ireland (3), USA (2), Canada, Italy, Japan, The Netherlands, Portugal, Saudi Arabia and Spain (1 case each).
2. It is important to establish the prevalence of vCJD if effective measures are to be taken to prevent the iatrogenic transmission of the disease (e.g. through blood transfusions). To this end, studies have been undertaken to establish the prevalence of disease-related prion protein in tonsil and appendix tissue. Clewley et al. (2009) examined 63,007 tonsil samples and found that none of the samples were unequivocally reactive to both enzyme immunoassays used in the study. No disease-related prion protein was detected using immunohistochemistry or immunoblotting either. Frosh et al. (2004) screened 2,000 anonymous surgical tonsillectomy specimens for disease-associated prion protein and found no positive cases. Hilton et al. (2004) examined tissue from 14,964 appendectomies and 1,739 tonsillectomies. Three appendectomy samples showed lymphoreticular accumulation of prion protein, giving an estimated prevalence of 3/12,674 or 237 per million (95% CI 49–692 per million).
3. Although these consequences are unquantifiable, some interesting qualitative work has been conducted into the public's perceptions of trustworthiness of politicians and scientists on matters of food safety. Green et al. (2005) used focus groups to examine how the public assessed risks associated with food in general, and the BSE problem in particular, in four European countries. These investigators found that 'participants made routine comments about the lack of trustworthiness of politicians, who were seen as acting in terms of vested interests that were unlikely to be those of the consumer. . .the BSE crisis was seen as a key contributor to this lack of faith. To some extent, 'experts' such as scientists were similarly mistrusted. Some

reported frustration with the uncertainties of expert advice on food, but others were sceptical of the neutrality of experts' (2005: 525–26).

4. Lord Phillips and his colleagues stated that '[c]onfidence in government pronouncements about risk was a further casualty of BSE' (BSE Inquiry Report, Volume 1: xviii). Jasanoff (1997: 223) characterises this breakdown in trust and confidence between the public and government in relation to BSE as 'civic dislocation': 'The phenomenon that I call civic dislocation expressed itself as a mismatch between what governmental institutions were supposed to do for the public and what they did in reality. In the dislocated state, trust in government vanished and people looked to other institutions – the high street butcher, the restaurant, the media, the supermarket – for information and advice to restore their security'. Green et al. (2005: 526) also report that the local butcher was trusted by respondents in their study of focus groups in four European countries to provide reliable information on food safety: '[P]articular individuals were seen as reliable sources of both information and safe food. The archetypal embodiment of this kind of trust was the 'local butcher', who was suggested across all countries as someone who could be relied upon to provide good quality, safe food and to know the provenance of that food on behalf of the consumer'.
5. Adam (1998: 167) states that: 'It is my reading of the situation that the public standing of science has been badly damaged by the BSE-CJD episode. Science has suffered a blow to its respectability and its credibility not only through mis/representation by the press but through self-inflicted disastrous 'performances' on television. As the crisis broke, for example, viewers were able to watch Professor John Pattison, the chairman of the Government's BSE advisory committee, change his story from 1 day to the next: on Wednesday 20 March 1996 he stated that the potential number of humans contracting CJD could be anywhere between two-figure numbers and 500,000, thus indicating that the *potential* was there for a major epidemic. Either scenario, he suggested, was possible; science at this point simply did not have an adequate basis upon which to make predictions or calculate risks. The very next day, however, this same scientist insisted that due to the regulations which the UK Government had put in place in 1989, the risk of contracting CJD was very, very small indeed. On the basis of these measures, he was adamant, the public could be assured that, 'in the normal sense of the word', British beef was 'safe' to eat' (italics in original).
6. In fact, Lord Phillips and his co-investigators formulated 73 lessons arranged according to 21 episodes during the BSE affair (e.g. introduction of the ruminant feed ban). A further 52 lessons were arranged according to four topics that were prominent within the inquiry (e.g. use of advisory committees).
7. None of the lessons described by Lord Phillips and his co-investigators relate to the issue of scientific reasoning in contexts of uncertainty. Uncertainty was mentioned in one of the four topics that were considered prominent throughout the inquiry (see note 6 above). The topic in question was 'Dealing with uncertainty and the communication of risk'. However, the discussion of this topic and the 11 lessons advanced by Lord Phillips and his colleagues dwell entirely on risk communication.
8. This framework is elaborated in note 41 in Chapter 3.
9. That the ascendance of statistical techniques in epidemiology has tended to displace the informal arguments that are needed to make sense of the results of these techniques is evident from the following comments by the prominent American epidemiologist George Willis Comstock. In an interview for the journal *Epidemiology* in 2003, Comstock was asked how present-day epidemiology differs from the field in which Comstock started his career. He responded: 'Statistics plays a more prominent role today. Epidemiology back then was based more on logic and whether the results made sense biologically. My early papers don't have a *P* value or significance test. The "biostatisticians" were more like today's project directors. They knew how to carry out studies and how to avoid biases. Technology has improved. We are able to measure more things in different biologic samples. But I don't think the basic principles of epidemiology have changed at all. It's just that we now rely more on statistical significance and less on what makes sense' (Sandler 2003: 624).

10. Battersby (2006) compares three sets of criteria for causal claims: those advanced in 1964 by the US Surgeon General's Committee on Smoking and Health; those advanced a year later by the leading biostatistician Bradford Hill; and those advanced by the informal logician Douglas Walton. He remarks that '[e]pidemiologists are an important example of disciplinary practitioners who develop and apply epistemological criteria. I have argued that epidemiologists would benefit from seeing the justification of a causal claim as making an "argument for the best explanation", which involves not only commonly used criteria for justifying a causal claim, but also consideration of arguments against alternative explanations' (2006: 60). Weed (1995: 915) also sees a need for greater engagement of epidemiology with philosophy on issues relating to causal claims: 'The philosophy of science is another link between the humanities and epidemiology that is partially in place. Causation and causal inference are central issues, providing epidemiologists the opportunity to answer questions regarding the nature of epidemiological knowledge, the role of logic and reasoning, and constraints on scientific discovery'.
11. Battersby (2006: 41–42) captures the same point as follows: 'Epidemiology is a highly successful science and to some extent epistemically self-conscious'.
12. Corporate influences have a significant and growing role in epidemiology, largely through the funding of the research work of epidemiologists. For discussion of the pernicious effects of corporate influences on epidemiology, see Pearce (2007, 2008).
13. Baum (2008: 166) states that '[c]ollaboration of epidemiologists with social scientists can improve the quality of public health research and interventions'.
14. Krieger (2000: 160) states that '[s]tarting in the mid-1990s a new raft of articles – by epidemiologists for epidemiologists – turns critical attention to theoretical frameworks guiding epidemiologic hypotheses and investigations. Challenging the discipline's dominant focus on individual-level biological and behavioral "risk factors", as fostered by biomedical and lifestyle approaches to analyzing disease causation, these epidemiologists call for explicit development of epidemiologic theories of disease *distribution* – informed by relevant social scientific constructs – capable of explaining current and secular trends in social inequalities in health' (italics in original).
15. Krieger (2000: 160) describes how '[r]enewed connections between epidemiology and social sciences in the 1990s also challenge a long-standing epidemiologic practice of conceptualizing and analyzing "race" as an innate biological characteristic. Bringing new insights to unexplained racial/ethnic disparities in health, an emerging body of work examines effects of racial discrimination on somatic health, with measures of exposure extending from individual-level, self-reported experiences of racial discrimination to data on residential segregation and Black political empowerment'.
16. According to Battersby (2006: 41), epidemiology is effectively applied epistemology: 'I invite those who are interested in applied epistemology . . . to look at epidemiology'.
17. The following extract from the Introduction of WHO's document *Pandemic Influenza Preparedness and Response* (2009) reveals the advanced state of readiness of the world's scientific community for the emergence of pandemic influenza. This level of preparedness was only possible because of the huge international organisational effort mounted by WHO: 'WHO previously published pandemic preparedness guidance in 1999 and a revision of their guidance in 2005. Since 2005, there have been advances in many areas of preparedness and response planning. For example, stockpiles of antiviral drugs are now a reality and a WHO guideline has been developed to attempt to stop or delay pandemic influenza at its initial emergence. There is increased understanding of past pandemics, strengthened outbreak communications, greater insight on disease spread and approaches to control, and increasingly sophisticated statistical modeling of various aspects of influenza. Extensive practical experience has been gained from responding to outbreaks of highly pathogenic avian influenza A (H5N1) virus infection in poultry and humans, and from conducting pandemic preparedness and response exercises in many countries. There is greater understanding that pandemic preparedness requires the involvement of not only the health sector, but the whole of society.

In 2007, the International Health Regulations (2005) or IHR (2005) entered into force providing the international community with a framework to address international public heath concerns. In light of these developments, WHO decided to update its guidance to enable countries to be better prepared for the next pandemic. This Guidance serves as the core strategic document in a suite of materials. It is supported by a complement of pandemic preparedness materials and tools. These documents and tools provide detailed information on a broad range of specific recommendations and activities, as well as clear guidance on their implementation' (World Health Organization 2009: 12).

18. The Global Outbreak and Alert Response Network is one such system. Plant (2008: 46) describes the role of this network when she responded to a call for epidemiological assistance to deal with a 'respiratory disease of unknown cause' in Vietnam. The disease in question was subsequently named SARS: 'I belong to the Global Outbreak and Alert Response Network, a World Health Organization (WHO)-sponsored network which facilitates country, institutional and individual response to outbreaks. This means there is a large army of people available to respond, and the individuals function as surge capacity for the WHO. It is an efficient and rapidly available task force from which people can be quickly mobilized to where they are needed, which means that the WHO has access to the most appropriate responders for different outbreaks'.
19. That scientists failed to make timely use of expert resources in making this response is evident from the following comments of Lord Phillips and his co-investigators: 'When BSE was identified as a new disease by the CVL in December 1986, it was at once appreciated that two important questions needed to be answered. Was it indeed a TSE? And did it have implications for human health? It was the greatest good fortune that, as a result of the joint initiatives of the Agricultural and Food Research Council (AFRC) and the Medical Research Council (MRC), there existed in the form of the Neuropathogenesis Unit (NPU) a world-renowned centre of expertise in TSEs. We have criticised the delay in seeking the collaboration of the NPU in answering the first important question. We have also criticised the more substantial delay in involving DH [the Department of Health] in the consideration of the second question' (BSE Inquiry Report, Volume 1: 252).
20. Although the Tyrrell Committee submitted its Interim Report to government in June 1989, it took until January 1990, when the report was finally published, before funding for research projects became available. Lord Phillips and his co-investigators considered if this delay had adverse implications for the projects concerned. Having heard evidence from witnesses that this delay was not detrimental to the scientific work recommended within the report, Lord Phillips and his colleagues concluded: 'It may be that no time was lost as a result of the delay in publishing the *Tyrrell Report*, although we are not convinced of this. Publication of the Report would have acted as a spur to the speedy identification of how the recommended research was to be funded. . .It would also have informed the outside world, and in particular the scientific world, of the likelihood of research opportunities, which could have led to a degree of competition for some of the projects. As it was, the CVL and the NPU proceeded to prepare to implement most of the high-priority projects without the peer review that the Tyrrell Committee had advised they should receive' (BSE Inquiry Report, Volume 11: 37). It is clear from these comments that Lord Phillips and his colleagues did believe there were adverse consequences for scientific research of the delay in publication of the report.
21. In accounts of other infectious disease epidemics, epidemiology has been described as the branch of science that is first to produce a characterisation of a new infectious disease usually in the absence of knowledge. In relation to the AIDS epidemic, Berridge (1996: 23) states that '[i]nitially it was epidemiology, in the absence of almost any knowledge of the etiology of the disease, which appeared to offer a means of arriving at some explanatory framework within which it [AIDS] could be placed'. In a US policy context, an epidemiological characterisation of AIDS then yielded to a biomedical explanation of the disease, while epidemiology continued to shape AIDS policy alongside biomedicine in the UK: 'Gerald Oppenheimer, in his analysis of the relationship between scientific models of AIDS and policy-making in the

USA, has drawn attention to the initial epidemiological constructions of AIDS which determined policy and which were then replaced by perceptions of AIDS as a set of biomedical problems open to chemical resolution in the period after the discovery of the virus in 1984–1985. Epidemiology as the engine of policy was replaced by biomedicine, in the US context at least. But in the UK, the relationship between different forms of science and health policy was different. Epidemiology, the rationale for a redefined public-health medicine since the 1960s, continued to define policy along with biomedicine' (Berridge 1996: 9). In continuing to play a significant role in the characterisation of BSE, even as this disease was increasingly being investigated by other branches of science, epidemiology's part in the BSE crisis was similar to the role of epidemiology that Berridge describes in the context of AIDS in the UK.

22. The idea that presumptions are a transition stage for scientists en route to a particular epistemic destination is succinctly expressed by Fuller and Collier (2004: 301): '[S]cientists are professionally mandated to treat presumptions not as positive accomplishments in their own right, but as way stations to be superseded on the road to inquiry'. However, according to the view of presumption developed in this book, presumptions are not 'superseded on the road to inquiry'. Rather, they are an integral part of inquiry.
23. This is, of course, an expression of the underdetermination thesis in the philosophy of science. Although different versions of this thesis exist, it may be defined in general as follows: 'The underdetermination thesis asserts that no body of data or evidence or observation can determine a scientific theory or hypothesis within a theory. . .underdetermination is explicated as the assured possibility of rival theories that are at least as well confirmed as the original theory by all possible data or evidence' (Norton 2008: 20).
24. To the extent that evidence alone is not sufficient to decide between rival theories, non-empirical factors have been proposed by theorists as a means of singling out a particular theory for acceptance. They include simplicity, breadth of scope, explanatory power, heuristic fecundity and practical success (Magnus 2006).
25. On several occasions during the BSE crisis, dissenting scientists were denied access to information which was needed in order to support their claims. On 21 April 1994, Dr Dealler wrote to John Wilesmith of the CVL to request data that would be used in predicting the number of BSE cases. Mr Wilesmith responded to Dr Dealler on 4 May 1994 by saying that the CVL 'will not be providing you with any data as I have to cover the costs of all our time and, in this case, the time required to provide these data is not justifiable'.
26. This is confirmed by comments made by Dr Dealler to Lord Phillips and his team. On 5 February 1994, a letter by Dr Dealler and Professor Lacey entitled 'Suspected Vertical Transmission of BSE' was published in the *Veterinary Record*. The letter described a case of BSE in a female Friesian-Holstein calf that had been born nearly a year after the ruminant feed ban: 'Dr Dealler told us that he was telephoned at home by the local MAFF veterinary officer after the publication of the letter in the *Veterinary Record* and that MAFF demanded the brain of the animal. Dr Dealler considered that this may have been to make sure that he did not carry out further research' (BSE Inquiry Report, Volume 11: 264).
27. It is difficult to read the following minutes of the fourth BSE research and development progress meeting held on 21 November 1989 without forming the impression that attempts were being made to block the funding and publication of research work prepared by Dr Harash Narang, another dissenting scientist. Dr Narang was a microbiologist who was employed by the Public Health Laboratory Service at Newcastle General Hospital. The minutes state that 'Mr Dawson pointed out that he [Dr Narang] had at present no funding and Mr Bradley said this material would only be required if funding was forthcoming. Dr MacOwan said Narang had applied to the Chief Scientist for minimal funding and that if his request for money was granted any information his work produced would be for the Chief Scientist. While to date it was unheard of for the Chief Scientist to stop work being published this was possible. The contract made with the Chief Scientist when funding was granted was to protect the customer. Dr MacOwan asked the meeting to be more specific in their dismissal of Dr Narang's work as this had a bearing on the result of the request for funding' (BSE Inquiry Report, Volume 11: 280).

28. Positivist philosophers of science in particular treated the late stage of scientific inquiry as the only stage worthy of investigation on account of its logical nature. However, even recent work in argumentation theory has tended to privilege this final stage over earlier, discovery stages of inquiry. It is not uncommon, for example, for argumentation theorists to restrict the use of the term 'inquiry' only to the activities of this final stage, as can be seen in the following remarks by Douglas Walton (2006: 186): 'It seems generally that, at the later stages of scientific research, where results are solidified and presented to colleagues and the public, scientific reasoning does take a form of argument very similar to the inquiry. However at the earlier stages, where a lot of creative guesswork is involved in arguments about scientific hypotheses, the inquiry is probably not a very useful model of scientific argument'. In this book, the term 'inquiry' has been used to describe both main types of scientific activity. Moreover, I would suggest that if any model of inquiry is unable to capture both types of activity, then it is the model that needs to change rather than theorists restrict the use of the term 'inquiry' to the activities of late scientific inquiry.
29. It is as if these theses stand 'in splendid isolation from [their] probative background' (Rescher 1977: 117). The actual course of argumentation that led to the premises is not deemed to be relevant to deduction. Rescher captures this point in terms of the relationship between a conclusion and its premises in deductive arguments (to the extent that premises are conclusions of other, prior arguments, Rescher is effectively characterising in this extract the relationship between premises and their background supporting argumentation): 'To assess the solidity (i.e., *validity*) of a *deductive* argument, we must simply determine that the conclusion is such that IF the premises are true, THEN it must be true as well. The *way* in which the conclusion is linked to the premises – the actual course of argumentation itself – is ultimately irrelevant. In deductive arguments, a thesis can shed its probative antecedents' (1977: 117; italics in original).
30. The 'epistemic course' taken by theses in scientific inquiry – and denied relevance within deduction (see note 29 above) and the deductive sciences (see below) – is at the centre of Rescher's disputational model of science: 'These general considerations regarding the probative structure of dialectical contexts have one particularly significant bearing in the specific setting of a disputational model of natural science. They mean that we can never really assess the probative standing of a scientific thesis outside its historical context – outside the background of the actual course of controversy and discussion from which it has emerged. The real-life sequence of argumentation and debate that has brought us to where we are becomes a crucial factor in the rational assessment of this position. The probative or evidential situation in this domain is context-dependent on the details of the historical background in a way that finds no parallel in the deductive sciences that have often (and mistakenly) been taken as the model of scientific rationality in general' (Rescher 1977: 118).
31. The precautionary principle states that a lack of scientific evidence or certainty should not be used as grounds to delay taking measures which can reduce risks from an activity or agent (see main text). But, as can be seen from the following oral evidence to the BSE Inquiry on 12 June 1998, this central tenet of the principle failed to apply to the government's handling of BSE:

    Mr Walker (Counsel for The BSE Inquiry): When you were describing Government policy in this way, are you meaning to say that the scientific advice must be that there is evidence that such and such occurs before the Government can act to stop it?

    Mr Cruickshank (Animal Health Group, MAFF): Yes, Yes, that was the policy.

    In waiting for evidence of harm to be obtained before action was taken, the British Government could be described as operating on the basis of a principle of reaction rather than precaution in the manner suggested by Kriebel and Tickner (2001: 1354): 'Too often, we believe, public health and environmental policies are based on a principle of *reaction* rather than precaution. Government regulatory agencies are often put in the position of having to wait until evidence of harm is established beyond all reasonable doubt before they can act to prevent harm' (italics in original).

32. Scientists and others often exaggerate the uncertainty of evidence upon which regulatory action is based with a view to postponing actions that could protect public health. Michaels and Monforton (2005: S39) state that '[e]nvironmental activists can be. . .guilty of using the existence of scientific uncertainty to advance policy aims through an overzealous application of what has been labeled "the precautionary principle". If the weighing of potential risks and benefits is transformed into a demand for certainty that a policy or action will result in *no* harm, scientific advances or public health interventions with the potential to genuinely improve the human condition can be disparaged and delayed' (italics in original). Martuzzi and Bertollini (2004: 44) remark that 'there might be the danger that the [precautionary principle] is used, or rather misused, against technological development and scientific advancement'.
33. This extract is Principle 15 of the Rio Declaration on Environment and Development. The full Declaration can be found in Annex I of the Report of the United Nations Conference on Environment and Development. The Conference took place in Rio de Janeiro between 3 and 14 June 1992.
34. 'Characteristically under environmental treaties the burden of proving risk is allocated to those questioning whether a risk-generating activity should proceed. If there is high uncertainty and no likelihood of harm can be established (thus: the threshold is not known to be crossed), activities may proceed' (Nollkaemper 1996: 85).
35. '[T]he proportionate implementation of the precautionary principle is not aimed at categorical bans of products or processes. . .but certainly does not exclude such measures in individual cases' (von Schomberg 2006: 27). Such 'categorical bans' will, in certain cases, be in excess of the risks posed by a product or process.
36. Proportionality was a guiding concept in deliberations concerning the safety of vaccines during the BSE epidemic. The reasoning of scientists on this matter can be characterised as follows. A complete ban on the use of bovine tissues in the production of vaccines was a proportionate response in those cases where non-bovine sources could be readily accessed and there was no risk of disruption to necessary vaccination programmes. However, such a ban was judged to be disproportionate to the perceived risks if non-bovine sources could not be readily established for vaccine production and if disruption to vaccination programmes was threatened. In a letter to Mr Cruickshank (Animal Health Group, MAFF) on 13 January 1989, Mr Scollen (MAFF Animal Health Division) cautioned against action on vaccines that may be judged to be disproportionate: 'While there is potentially a need for radical – and expensive – action, it is, of course, quite possible that in the course of a few years we will be able to demonstrate the effectiveness of the action already taken to eliminate BSE. Extravagant action now to deal with a contingent risk could then seem to be wholly disproportionate' (Scollen 1989: 1). Mr Scollen continued '[i]n my own view the issues involved centre on an assessment of the risks associated with maintaining or disrupting the supply of vaccines for human health purposes' (Scollen 1989: 2).
37. The related concept ALARA (as low as reasonably achievable) originated in the atomic energy field. ALARP and ALARA are largely indistinguishable: 'If there is a substantive difference between the intent of ALARA and ALARP, it's difficult to establish' (Manuele 2003: 283).
38. Cost 'should contain factors relating to time, resource and trouble, not just a financial consideration' (Maguire 2006: 73).
39. When the ALARP principle was used implicitly, policy decisions could be seen to conform to this principle even though no explicit reference had been made to ALARP during the decision-making process. For example, in relation to the two principal policy decisions which were introduced to address the possibility of BSE transmission to humans through food – compulsory slaughter and destruction of cattle with symptoms of BSE and the human SBO ban – Lord Phillips and his colleagues remarked 'we consider that they constituted a proportionate response that satisfied the ALARP principle, albeit that the policy decisions did not result from the application of that principle' (BSE Inquiry Report, Volume 1: 230).

40. The following comments by Lord Phillips and his inquiry team indicate that they believed the ALARP principle was less than successfully implemented on certain occasions: ‘We believe that part of the [Southwood] Working Party’s problem was that they were in no position to reach an informed view of how the ALARP principle should apply’ (BSE Inquiry Report, Volume 1: 53); ‘No reasoned application of the ALARP principle was carried out by MAFF’ (BSE Inquiry Report, Volume 1: 123).
41. ‘If the residual risk for a task or operation is never zero, for what risk level does one strive? At best, we can say that the concept of designing and operating to attain risk levels as low as reasonably achievable or practicable should be applied to the situation being considered’ (Manuele 2003: 282).