24 Protecting early warners and late victims

Carl Cranor

Many *Late lessons from early warnings* chapters provide examples of early warning scientists who were harassed for bringing inconvenient truths about impending harm to the attention of the public and regulators. There is also some evidence that young scientists are being discouraged from entering controversial fields for fear of such harassment. In addition, where warnings have been ignored and damage has ensued, it has often proven difficult in the past to achieve prompt and fair compensation for the victims. Some ideas for reform, building on some current institutional models are explored here.

This chapter first explores the idea of extending whistleblowing laws to help encourage and protect early-warning scientists and others who identify evidence of impending harm. Complementary measures, such as greater involvement of professional societies and the use of recognition awards, as for example in Germany, could also be helpful.

Next, the chapter explores improved mechanisms for compensating victims of pollution and contamination. The chapter on the Minamata Bay disaster provides an extreme example of long delays in getting adequate compensation for the victims of methylmercury poisoning. It was almost fifty years, between 1956 and 2004, before the victims attained equitable levels of compensation and legal recognition of responsibility. Other case studies illustrate similar examples of long delays in receiving adequate compensation.

Options are examined for providing justice to any future victims of those emerging technologies such as nanotechnology, genetically modified crops and mobile phone use, which currently can provide broad public benefits but potentially at a cost to small groups of victims. The potential for widespread exposure and uncertain science could justify 'no-fault' administrative schemes that provide more efficient and equitable redress in situations where the benefit of scientific doubt would be given to victims. The use of anticipatory assurance bonds to help minimise and meet the costs of future environmental damage from large scale technologies is also explored.

A supplementary panel text describes cases of asbestos and mesothelioma, where the senior courts in the United Kingdom have developed innovative ways of dealing with both joint and several liability, and the foreseeability of subsequent asbestos cancers, after the initial recognition of the respiratory disease, asbestosis. Such legal developments in the field of personal injury could illustrate the future direction of long-tail liability in both environmental damage and personal injury.

Implementing a precautionary approach to managing new technologies requires, first and foremost, administrative laws aimed at detecting and addressing risks before they materialise into harms. But in addition to precautionary policies towards chemical, genetic and other technologies, additional legal tools can support the precautionary approach, better protecting public health and environment.

Since most statements of the precautionary principle emphasise acting on the basis of early warnings of threats to health and the environment and to minimise harm, at least two significant kinds of supporting laws should be considered.

First, in order to encourage the identification of impending threats to health or environment as early as possible, current whistleblowing laws could be extended to protect early warning scientists and others from harassment. Such people should feel free, and be free, to research and report early warnings without the threat of adverse actions that would discourage them.

Second, for those foreseeable and surprise events that cause future harm despite precautionary actions, measures could be taken to provide prompt and fair compensation without having to prove negligence by specific parties.

These two issues are explored below.

24.1 Encouraging and protecting early warning scientists and others

It is not hard to imagine situations where rules or personal risks could prevent potential 'whistleblowers' from sharing important information. Employees in academia, business or government might become aware of serious risks to health and the environment, but internal policies might pose threats of retaliation to those who report these early warnings. Private company employees in particular might be at risk of being fired, demoted, denied raises and so on for bringing environmental risks to the attention of appropriate authorities. Government employees could be at a similar risk for bringing threats to health or the environment to public attention, although perhaps this is less likely ([1]).

Several democracies in the developed world have implemented whistleblower laws and policies to foster and protect those who call attention to legal wrongs, often but not only regarding corruption. Such laws provide models for how to think about whistleblower protections in a precautionary world.

> 'Whistleblower protection laws are intended to make it safe for employees to disclose misconduct that they discover during the course of their employment. Indeed, when accompanied by other initiatives, such laws can actually help foster an environment that rewards and encourages whistleblowing' (Kaplan, 2001).

Countries that have constitutional guarantees of free speech can also assist in protecting public employees, in particular those who call attention to issues of public concern.

While some may praise whistleblowers for taking on their own companies or misconduct in government, others may regard them as disloyal, malcontents, grumpy employees, even bitter individuals who have been passed over for merits or promotions and are seeking to create problems. When they are regarded in this negative light, it becomes clear why there might be a need to foster and protect whistleblowing in order to encourage the revelation of misconduct, wrongdoing and harm, along with warnings that actions have occurred or are about to occur.

Some whistleblower protections in the United States

In the United States, the Civil Service Reform Act of 1978, as amended by the Whistleblower Protection Act of 1989 (WPA), provides some of these protections. As Kaplan (2001) explains:

1. The WPA 'makes it illegal to take or threaten to take a 'personnel action' against a federal employee because the employee has made a protected disclosure' where 'personnel action' is broadly defined.

2. This prohibition should be backed by sanctions for taking or threatening a 'personnel action' against a federal employee because the employee has a made a protected disclosure. This would be information that the employee 'reasonably believes evidences a violation of the

([1]) The US Union of Concerned Scientists has recently reported cases of government employees in food and other areas who have been restricted from speaking out in the past. There are now attempts to restore the integrity of science across the US government following an initiative from the administration (UCS, 2012).

law, rule or regulation, a gross waste of funds, gross mismanagement, an abuse of authority, or a significant and specific danger to public health or safety.' Moreover, such a disclosure 'need not prove ultimately accurate in order to be protected — it is enough if the person making it is acting in good faith and with an objectively reasonable belief in its accuracy.'

3. In the US, the Office of Special Counsel (OSC) enforces the whistleblower protection provisions of the WPA and has a great deal of independence from other government and private sector bodies to carry out its work.

4. The OSC has authority to correct an adverse personnel action or to prosecute any retaliation.

5. It also operates a 'secure channel', which government employees can use to report misconduct.

6. It is comparatively easy for a whistleblower to make a 'prima facie case of retaliation'. It is sufficient that an employee's public disclosure be a 'contributing factor' to an adverse personnel action.

Following the recent financial crisis, the US Congress passed financial reform legislation that included protections for whistleblowers in order to improve early warnings of violations of securities laws (Harvard Law Review, 2011). The new law provides substantial bounties to people reporting information that the Securities and Exchange Commission (SEC) finds useful in identifying securities law violations, enhances protections for those providing the information, and establishes a two-tiered system for whistleblowers reporting to the SEC. The bounties can be 10–30 % of sanctions exceeding USD 1 million.

The law 'prohibits employers from discharging, demoting, suspending, threatening, harassing, or in any other manner discriminating against a whistleblower "because of any lawful act done by the whistleblower"' (Harvard Law Review, 2011). Protections for whistleblowers are greater for those who report directly to the SEC, but somewhat lesser for those who report to the company. These two tiers strongly encourage a person to report to the SEC rather than going to the company that has committed the violation. This could be a strength — boosting the hand of SEC enforcers, but discouraging local corrections for abuses — or a weakness, undermining internal compliance systems within companies.

Some whistleblower protections in the United Kingdom and South Africa

The United Kingdom's Public Interest Disclosure Act (PIDA) differs in some respects from the US approach (House of Commons, 1998). In the United Kingdom the PIDA governs both public and private employees, providing that 'a worker has the right not to be subjected to any detriment by any act, or any deliberate failure to act, done on the ground that the worker has made a protected disclosure.'

Based on 'reasonable belief', whistleblowers are protected if reporting criminal offenses, miscarriages of justice or that 'the health or safety or an individual, is being or is likely to be endangered.' There are defined channels by which a whistleblower may disclose violations but in the United Kingdom there is a preference for disclosing to the private employer or some public agency identified by the Secretary of State to hear such reports. Whistleblowers are at some risk if they go outside the recognised reporting channels (Kaplan, 2001).

In contrast to the US approach, the UK law encourages employers to specify internal procedures for disclosures and responses to them, but employees are not restricted to these. Moreover, there is no 'independent agency of the State to investigate or prosecute whistleblower complaints' as there is in the US (Kaplan, 2001).

In 2000, South Africa passed 'the Protected Disclosures Act', largely modelled on the UK's PIDA and covering both private and public employees. In addition to covering dismissals, demotions, involuntary transfers and suspensions, it goes beyond the US laws by 'explicitly including harassment and intimidation, as well as the refusal to provide an employment reference, or provision of an adverse reference as "occupational detriments"'. Reports of misconduct may be made to employers or a specified public agency, but there is no independent agency of the State to conduct investigations. The whistleblower has to invoke a court or tribunal for protection (Kaplan, 2001).

Whistleblower provisions have been enacted in some established democracies but many emerging democracies have been slow to institute them. In addition, countries with constitutional or other free speech protections appear to have a wider range of protections for those who identify and report wrongdoing (Kaplan, 2001).

In order for whistleblower provisions to function well employees must be aware of both statutory protections and the variety of channels through which disclosures or wrongdoing may be reported. The protections must be sufficiently effective to overcome employee reluctance to use them. In addition, government agencies and private entities must 'change their cultures, to make them receptive, rather than hostile, to employees who "rock the boat"' and this must be communicated from the top (Kaplan, 2001).

Desirable features of whistleblower laws
Whistleblower protections for those who report threats to the environment or public health from genetic, chemical or other technologies can supplement laws implementing the precautionary principle. Existing models suggest that such laws should protect public and private employees from adverse personnel actions, broadly construed.

Employees should be protected as long as they have a reasonable belief that private or government actions are a violation of the law or pose threats to the environment or public health. There should be a secure channel by which misconduct can be reported and it should be fairly easy for an employee to make a prima facie case that he or she has suffered retaliation. There should be an office with considerable independence from private or government bodies to provide protection and prosecute any retaliation. Finally, if a country desires to encourage whistleblowing more strongly, it could offer bounties amounting to some percentage of the fines issued against wrongdoers.

Panel 24.1 Better scientific support for early warning scientists?

David Gee

An early warning scientist is not the same as a whistleblower who reports on wrongdoing. However, the *Late lessons from early warnings* case studies have provided several examples of early warning scientists who, like whistleblowers, were harassed after issuing or publishing their views. Examples include Snow (in relation to his work on cholera); Selikoff (regarding asbestos); Henderson, Byers, Patterson and Needleman (regarding leaded petrol); Osakawa (regarding mercury); Putzai and Chapella (regarding GMOs); Schneider (regarding climate change); and several scientists in the French bees story. In addition there are others who wish to remain anonymous.

Other examples from beyond the *Late lessons* case studies include public servants who have been prevented from speaking out on environment or health issues (UCS, 2012; Martin 1999 and 2008).

Generally, recognition that scientists were harassed seems to increase over time, alongside acceptance that the early warning has been vindicated by unfolding science. The luxury of such hindsight is of little use to harassed early warning scientists, however, who, unlike Nobel prize winners, need fairly immediate recognition for their 'inconvenient truth' and resulting personal difficulties.

The price of providing early peer group support to harassed early warning scientists could be that some warnings turn out to be false alarms. However, this may be seen as an acceptable price to pay for defending the rights of scientists to issue an early warning based on reasonably plausible evidence.

As we have seen, there are some legal precedents from the field of whistleblowing that could be used to help characterise the situations in which responsible early warning scientists would be encouraged and protected by their scientific peers. Relevant considerations include the following:

- the scientists have acted in good faith in drawing attention to threats to health and/or the environment based on evidence that they reasonably believe;
- the belief need not necessarily prove 'ultimately accurate' in order for them to be protected, (Kaplan, 2001);
- the early warning scientist suffers from some form of serious harassment, including personal attacks (distinct from scientific criticism) in the scientific literature and elsewhere; being preventing from speaking out, or publishing; removal from their scientific work; loss of contracts or funding; unreasonable difficulties in getting their science in the relevant literature; accusations of scientific misconduct; being by-passed for promotion; loss of their facilities or staff; and threats of legal action.

Panel 24.1 Better scientific support for early warning scientists? (cont.)

In contrast to whistleblowers, where the law is the main measure used in their protection, it would be more constructive if early warning scientists were encouraged from the outset by a culture within science that explicitly supported challenges to conventional scientific ideas and paradigms and the scientists who may suffer as a result of producing the challenges. There is a long history of scientific and other dissenters, which illustrates their frequent value to societies (Sunstein, 2005; Mercer, 2010).

It may be asking too much of individual scientists, whose lifelong work is challenged by an early warning scientist, to respond positively to the challenge. It would be reasonable, however, to expect more independent professional associations of scientists, who have the integrity of science as a whole to uphold, to produce explicit policies that encourage early warning scientists and defend them if they are harassed.

Early warning scientists would be further encouraged if there were a European award to an early warning scientist who had produced a reasonably credible challenge to conventional science and who subsequently suffered harassment.

Such an award would follow the precedent of rewards to successful whistleblowers, which began with a law against lead in alcohol production in the USA in the 18th century (see Chapter 3) and which continue today under US financial regulations.

The award would need to be made by an authoritative and independent scientific body of scientists, free from direct bias (i.e. their own scientific work would not be challenged by affording credibility to the early warning science).

An interesting legal view of such 'intellectual bias' comes from a World Trade Organization case in which scientists acting as expert witnesses were asked to review science that was critical of their own work. The WTO Appellate Body considered that as 'coauthors' of the JECFA reports that were being criticised, they 'cannot be considered to be independent and impartial in these circumstances, because this would amount to asking them to review and criticise reports that are their own doing' (WTO, 2008).

An appropriate title for such an award could be 'The Henrik Ibsen award for early warning scientists' in recognition of Ibsen's play, 'An enemy of the people' which concerns the harassment of an early warning public health doctor. The harassed Chisso company doctor in the Minamata chapter of the present volume of *Late lessons from early warnings*, like many others in similar situations drew support from reading that Ibsen play.

An existing award that could provide some relevant lessons is the German Whistleblower Award, which honours individuals who have exposed grave abuses, dangers or aberrations in their professional field for the public good. It is awarded by The Federation of German Scientists (VDW/FGS) and the German section of the International Association of Lawyers Against Nuclear Arms (IALANA). info@vdw-ev.de / info@ialana.de.

In addition to possible legal remedies, early warning scientists could receive greater support from scientific communities (see Panel 24.1).

24.2 Providing compensation in a precautionary world

If we have precaution, do we need compensation? How necessary are compensation policies in a legal system committed to precaution in protecting health and the environment? Compensation might seem unnecessary in a world guided by precautionary approaches. Effective precautionary approaches would result in fewer wrongs to right; wholly successful policies might not leave any.

In reality, of course, flawless implementation of precautionary approaches is unattainable. Compensatory schemes are needed to address harms that occur despite precautionary efforts.

Harms can also arise because society accepts certain risks, which benefit society as a whole but may result in harm to individuals. For example, we use lead or cadmium in batteries and other electronic devices despite the hazards to people and the environment. Alternatively, accepting one risk of

harm potentially mitigates other, more serious dangers to human or environmental health. The use of some pesticides is an example of such a risk-risk trade-offs. Even if such harms do not involve wrongful acts by individuals or companies, justice arguably demands that society compensate those adversely affected

In addition, there may continue to be less visible threats to health and the environment. For instance, substances that contribute to disease during early human development can trigger subtle diseases or dysfunctions that can be difficult to detect via human studies. Some will have extremely long causal tails, delaying the manifestation of disease by decades. Some will be comparatively rare. For example, early or mid-life exposures to substances such as the pesticide paraquat or the industrial degreaser trichloroethylene (TCE) may hasten the early onset of Parkinson's disease, as shown by animal and human studies (Cranor, 2011). Other substances may pose long-delayed risks to wildlife or the broader environment, as has been seen in the Arctic (Cone, 2005).

Genetically modified plants may cause subtle genetic or other changes in vegetation or the environment that may not be immediately perceptible, or that will only be revealed over a longer period of time. For example, there have been proposals to use transgenic plants to extract organic mercury from the soil and volatilise it into elemental mercury (National Research Council, 2002). While this might be of some benefit at a local level, on a larger scale this proposal could easily have long-term adverse environmental and health consequences. Concentrations of atmospheric mercury would probably increase in local areas and then be deposited further away into aquatic or terrestrial ecosystems via precipitation and condensation. Once there, it would again be converted into more toxic organic mercury, although in a different location. This would add to organic mercury from other sources, exacerbating existing effects (National Research Council, 2002). Decision-makers must clearly be alert to such long-term, subtle environmental consequences of new technologies.

Finally, it is worth noting that imposing an obligation to compensate those harmed by technological hazards can also help deter firms from undertaking harmful activities.

Compensation systems

There are different rationales for compensation. One comes from the tort law. As Priest (2003) explains: 'Tort law is designed to deal with harms inflicted by some identifiable person who was in a position to have prevented the harm'. The tort system shifts the costs of injuries to parties judged to be responsible, sometimes 'at fault' for the harm, 'in order to create incentives to reduce the level of harm suffered in the society'. It awards full damages to injured parties in order to ensure that the full costs of the legal violation are paid by the tortfeasor and to provide some degree of deterrence.

In contrast, **insurance** addresses 'losses that cannot realistically be prevented'. Typically private insurance is funded by parties seeking to protect themselves from future costs and placed into 'self-supporting risk pools in ways that serve to reduce effective risks while amassing resources to compensate those who ultimately suffer losses'. **Government insurance**, another form of risk sharing, is ordinarily 'provided for more generalised societal risks for which no, or less of a, market exists, such as the risks of unemployment or disaster' (Priest, 2003).

Contrasted with all of these, but somewhat similar to tort law, are systems of **compensatory reparations**. Reparations presuppose that one person has acted wrongly, causing harm to another person who deserves compensation as a consequence (Boxill, 2011). The best reparations would also include an acknowledgement by the wrongdoer of the wrongdoing in order to help restore relationships severed by the wrongful act ([2]). Institutionalising acceptance of wrongdoing presents difficulties, however, and there is likely to be greater success in securing compensation for injured parties if it is not required.

The existing institutions discussed below do not always carefully distinguish these different dimensions of restitution. The central idea, however, is to provide some substantial degree of recompense to those who have suffered losses as a result of new technologies.

One ideal would be to ensure that the full social costs of a technology are incorporated into the costs of the activity (removing negative externalities), or at least to ensure that the costs are not left to fall on innocent bystanders or the environment. However,

([2]) As noted in Chapter 5, victims of methylmercury poisoning in Minamata, Japan, have sought such acknowledgement but have not secured it.

not all compensatory approaches accomplish the first goal. For example, the creator of a technology that causes harm may not be have acted wrongfully according to the requirements of tort law or compensatory reparation systems.

Guidance for compensation in a precautionary world

The above discussion suggests the outline for compensatory approaches in a precautionary world:

1. Successful precautionary policies should reduce the need for compensation.

2. Compensatory approaches should seek to minimise any harm as quickly as is institutionally reasonable and to shorten its duration, if possible.

3. Some past environmental, health and new technological issues suggest that compensation is needed to address difficult situations such as long-tailed, less visible, low probability, and subtle consequences of a technology. These could be long-tailed in two senses: both highly unlikely and possibly years into the future.

4. Any reasonable compensation should also be combined with an adequate deterrence mechanism to discourage firms from negligence or recklessness toward public health or the environment.

5. Finally, in some countries with single-payer health systems that provide medical care to all citizens, compensation for injured people would be less than under medical systems with private insurance. Nonetheless, there would still be a need to compensate for income loss, personal suffering, losses of loved ones, and other non-medical losses.

What compensatory 'institutions' or policies might be adopted for a precautionary world to set matters right, once people or the environment have been harmed? Of those compensatory approaches, which might be most compatible with a precautionary approach towards people and environmental resources?

With these questions in mind, the strengths and weaknesses of several compensatory approaches are assessed below: traditional personal injury law, workers' compensation, and individual compensatory schemes tailored to particular classes of potential harms such as the US Vaccine Injury Compensation Program and the UK's radiation compensation programme. In addition, general no fault compensatory arrangements like those used in New Zealand are considered, and flexible assurance bonds instituted upfront to provide compensation if technological risks materialise.

24.2.1 Tort or personal injury law

Tort or personal injury law is a major institution in the US and the United Kingdom (with analogues in other countries). It aims to provide compensation for injuries that people suffer because of the conduct of others. In bringing a tort action, a party (the plaintiff), who believes another party (the defendant) has caused him or her harm, must show that defendant breached a legal duty, that the plaintiff suffered a legally compensable injury, and that defendant's breach was the cause in fact and the legally proximate cause of the injury. Each element of the cause of action must be established by the preponderance of the evidence — the balance of the quality and quantity of evidence must favour the plaintiff.

The duty that the defendant breached in most cases is a duty in negligence — to take reasonable care that one's actions do not cause legally compensable injuries to others. In the US, tort duties in strict liability (liability without fault) exist for products, ultra-hazardous activities and trespass. Under strict liability a plaintiff need only show that the defendant's action caused and was the proximate cause of a plaintiff's injuries. A plaintiff need not show lack of reasonable care by the defendant.

When torts came into prominence in the 19th century, it was quite cramped and restricted in principle at the outset and quite limited in application in achieving compensation goals. Nineteenth century courts never considered holding defendants accountable in strict liability, instead basing liability on 'moral fault,' interpreted as negligence. Defendants were also provided a number of defences that greatly limited many tort actions for harm caused by railroads or factories during the industrial age, reducing the number of injuries entitled to compensation. Courts were concerned that more extensive tort liability would too greatly burden enterprises; and they had a suspicion of juries, who might be overly sympathetic to injured parties. Both continue in current debates (Friedman, 1985).

As the tort law developed, some of these liability-limiting features were moderated. Strict

liability became the basis for some legal actions: for harm caused by ultra-hazardous activities and for products liability. Proximate causation rules were liberalised. In the early 20th century workplace torts largely disappeared in favour of a government-managed workers' compensation programme designed to expedite compensation, remove long, costly disputes, and provide a more consistent legal framework for addressing workplace injuries (Friedman, 1985).

Doctrines more favourable to plaintiffs continued to develop until about 1980. Various cause-in-fact rules were adopted to ease the burden on plaintiffs in establishing causal claims, recognising the multifactorial nature of causation (Anderson v. Minneapolis, St. Paul & S. St. M.R.R. Co., 1920; Summers v. Tice, 1948; Sindell v. Abbott Laboratories, 1980). Doctrines of joint and several liability better ensured that plaintiffs received compensation from some defendant to an action.

About this time, firms required to defend tort suits, with support from some legal scholars, began efforts to roll back doctrines that had eased the burden on plaintiffs. At the same time, other scholars argued that the tort law had never served well to express moral outrage about wrongs (likely never its aim), poorly compensated plaintiffs and did not function especially well to deter harmful conduct (Abel, 1988).

Defence arguments yielded some success in the United States during the late-1980s and early-1990s. Some jurisdictions limited compensation, especially for pain and suffering. Some sought to limit joint liability. And, there was considerable pressure to ensure high standards for scientific evidence in cases requiring it.

As a consequence, the US Supreme Court intervened, ultimately invalidating a long-standing rule concerning the admissibility of scientific testimony. The Court had initially seemed to liberalise admissibility rules for experts in Daubert v. Merrell-Dow Pharmaceuticals (1993). However, as that decision was implemented by lower courts and expanded by two later Supreme Court decisions (General Electric v. Joiner (1997) and Kumho Tire v. Carmichael (1999)), in many jurisdictions it substantially burdened experts, especially those for plaintiffs (Cranor, 2006). Some state and federal circuits are especially onerous (Merrell Dow Pharmaceuticals, Inc. v. Havner, 1997). Although in principle these rules impartially apply to both plaintiffs and defendants, in reality they asymmetrically hamper plaintiffs, who bear the burden of proof to establish the key elements of a tort.

This series of decisions reduced plaintiffs' access to the law because lawyers must invest greater resources upfront to ensure experts have good scientific foundations for testimony, which in turn means they only take cases they are more certain to win. This development likely reduces somewhat any deterrent effect of tort law (Cranor, 2006).

Too often judicial interpretations of the admissibility of scientists erected unscientific barriers against expert testimony (Cranor, 2007 and 2008b). Recently, however, a decision from the US First Circuit Court of Appeals has marked a change. In that circuit, with jurisdiction over about one-twelfth of the US, scientists may now use in the courtroom the same kinds of arguments that they would use in the lab to draw scientific conclusions. In addition, there is no priority of evidence for cancer causation, such as human epidemiological evidence (Milward v. Acuity Specialty Products, Inc., 2011). This decision removes some judicially created unscientific barriers to expert testimony.

In large measure current US tort law does not compensate injured parties well or quickly. They bear the initial burden of proof to establish legal violations, injuries and causation. When scientific or technical evidence is needed, this increases the hurdles. In some US federal jurisdictions plaintiffs must have human epidemiological evidence showing that toxic exposures double the relative risk of disease from which a plaintiff suffers, a further barrier because of the insensitivity of epidemiological research. In some jurisdictions compensation is capped at a sufficiently low level that it is inadequate for some injuries. Even when plaintiffs are successful, resolution can take considerable time.

Milward v. Acuity Specialty Products was filed in 2007 and stopped by the trial judge for inadequate scientific testimony in 2010. It was reinstated by the First Circuit Court of appeals in 2011 with many of the original twenty-two defendants settling. As of 2012 one defendant continued to seek a jury trial to conclude the issues. This case involves a single plaintiff (but many defendants) and in this respect may be typical of many tort cases.

Class actions involving many plaintiffs and sometimes many defendants are more difficult and can take longer to resolve. However, once there is a sufficient record of injury types, as with asbestos, and a long history of litigation,

subsequent compensation disputes will generally be settled much more quickly, often without trial. In addition, class action cases can reach a point at which the issues are clear and there is no need to litigate compensation for each plaintiff. At that time, defence and plaintiff attorneys, perhaps with encouragement from the judge, agree to a 'settlement matrix' — a classification system for groups of plaintiffs with similar exposures, adverse health outcomes and possible confounding factors, e.g. health status or smoking. The matrix enables comparatively easy classification of each plaintiff to receive greater or lesser compensation depending on the circumstances for the injuries suffered. In this respect, some tort law settlements can resemble the classification of injured parties under the compensation schemes described below, such as worker compensation or vaccine injury compensation.

In addition to the shortcomings of the tort system outlined above, it is essential to note that when there is clear harm to people, injured parties rarely bring legal cases to set matters right. For instance, Saks (2000) observes that in cases of clear medical malpractice just 4 % or fewer of injured parties even approach a lawyer to consider redress.

Based on the above, existing US tort law appears to be a poor legal model for providing rapid and adequate compensation for those who have been wrongly injured by the actions or products of others. Tort law persists but its achievements fall far short of its goals.

Battery and trespass are two other causes of action in the US tort system that could provide some compensation for citizens, short of people being actually harmed. Battery is the 'foundational tort cause of action. It protects bodily integrity and individual autonomy, creating the essential status and space for social interactions' (Lyndon, 2012). The idea is that by giving citizens a cause of action for offense against them or for violation of bodily integrity without their consent, this lessens the chances of retaliatory harm needing criminal intervention; historically it was a means of helping to keep the King's peace in the United Kingdom.

To establish a battery a plaintiff must show that 'the defendant committed a voluntary act with the intent to cause a wrongful [offensive or harmful] contact and the contact occurred.' Intent is widely construed for this purpose and it applies to the contact only; one need not intend offensiveness or harm (Lyndon, 2012; Cranor, 2011). For intentional invasions of one's body by potentially harmful chemical substances without consent that one would reasonably regard as offensive, one could bring a battery cause of action. A special advantage of battery compared with the main body of tort law is that one need not show harm as the result of the invasion, offensive contact is sufficient. Consequently, if one's bodily integrity has been invaded by potentially harmful substances in a manner one would reasonably regard as offensive, whether or not one has been harmed and before one could even show harm, one potentially has a cause of action in battery.

Trespass is also a vindication of a legal right against invasion. What remains of early trespass law largely concerns property but also applies to invasions of individuals. If someone enters property or causes molecules, particles, or toxic substances to enter property without 'authorization' or without permission, the person has trespassed on the property. Trespass also applies to violations of the integrity of persons, e.g. as when blasting trees injure a party on a public highway (Cranor, 2011). Both battery and trespass are founded on deep considerations concerning the integrity of one's person (or property) and 'rights over aspects of one's life'. Without doing harm one can be accountable for either battery or trespass and merit compensation. Compensation for battery would consist of 'Proof of the technical invasion of the integrity of the plaintiff's person by even an entirely harmless, but offensive, contact [which] entitles him to vindication of his legal right by an award of nominal damages, and the establishment of the tort cause of action entitles him also to compensation for the mental disturbance inflicted upon him' (Cranor, 2011).

A larger number of citizens could potentially bring battery or trespass causes of action than could bring actions in torts for harm caused by toxicants. This might better facilitate safety testing and better deter invasions by potentially harmful substances than would successful tort suits alleging (and even proving) harm. Battery and trespass would likely be much quicker and easier to resolve than would tort suits for harm. Compensation for each individual invaded in a battery/trespass action would likely be much less than for each individual harmed in a typical tort action, but total compensation paid out by a company that caused the invasion (or harm, respectively) could be substantial.

One aspect of the tort law, whether for actions for harm or battery/trespass, is quite important both in supporting health protections and providing compensation for plaintiffs. This is a pre-trial stage called 'discovery'. During discovery each litigant in

the dispute can interrogate the other party about information it may have about the background of the dispute, try to determine what legal issues are or could be easily agreed upon, request documents related to the issue, and conduct depositions (questioning of witnesses on the issues). This process can reveal a good deal of information about a case that might expedite settlement or narrow issues. It can also serve the wider public good, by revealing hidden data about adverse health effects, decisions made by responsible people that contributed to harm, policies that might have exacerbated problems and so on. If information unearthed during discovery is publicised, as it has been for asbestos, lead, and vinyl chloride in the US, it can alert public health officials to other problems, issues meriting further investigation, scientists who have acted without integrity, or even other serious legal wrongdoings (Brodeur, 1983; Markowitz and Rosner, 2002).

In a legal system that greatly emphasised precautionary policies toward risks and harms, tort law with its emphasis on showing harm would be a poor compensatory model simply because bringing a successful tort action is normally burdensome and slow. This would greatly slow efforts to reduce harm and clean up environmental contamination. Tort actions for battery/trespass would be less burdensome and slow, but lesser compensation for each individual would result; total compensation paid out could be substantial.

Of course, tort law can be modified; it is not set in stone. For instance, there are some developments in the tort system of the United Kingdom that merit attention because they may expand the range of compensation available to plaintiffs for injuries suffered from some kinds of environmental exposures. For asbestos-caused mesothelioma possibly resulting from exposures due to the activities of two or more defendants, a plaintiff need not rule out other possible causes (because all or virtually all mesothelioma is caused by asbestos exposure). Also, once liability has been established for particular defendants, all defendants must pay full compensation for the mesothelioma-related injuries. Other court decisions have applied the same principle to dermatitis caused by coal dust (discussed below).

Just because medical science cannot determine which of several liable defendants' asbestos fibres caused plaintiff's injuries does not bar recovery for mesothelioma. In short, 'where there are multiple potential tortfeasors ... in the case of an 'indivisible injury' such as mesothelioma, **any tortfeasor** could be liable for the whole of the injury once liability has been established' (McIntyre, 2004 (emphasis added)). UK courts treat asbestosis (which also results from asbestos exposures) differently: each liable defendant in a group need not pay for the full costs of the disease but only for the portion of time plaintiff had asbestos exposures at their facilities (McIntyre, 2004).

A second UK innovation concerns foreseeability for harm from an asbestos facility to those outside the plant boundaries. Where a defendant should have reasonably foreseen a risk of pulmonary injury, not necessarily mesothelioma, it has been found liable for mesothelioma in people who reside near to asbestos plants (see Panel 24.2.). Generalising from this, it suggests that companies might be liable not merely for known toxic injuries to employees but also for other types of harm to local residents of a type that emerged after the initial exposure (McIntyre, 2004).

24.2.2 Alternatives to the tort system

Workers' compensation

The tort system's shortcomings in addressing compensation for **occupational** injuries and illnesses led to the development of an alternative compensatory arrangement. Under tort law, employees seeking compensation historically bore the burden of proof to show that employment caused an injury and that the employer was negligent. Employers had an incentive to delay legal proceedings because injured employees probably had more limited means to support themselves, to secure medical care and to bring legal actions. Such suits were slow to resolve and unpredictable, and damages were often inadequate. Employees were often afraid to sue their employers, and witnesses among fellow workers were often difficult to find (Franklin, 1979).

Workers' compensation programmes were implemented as an alternative to torts for employees. They hold employers liable without fault for injuries suffered by employees in the course of and arising out of their employment. Employees 'exchange their common law damage actions for smaller but more reliable recoveries whenever they [are] hurt on the job even if they [are] at fault and the employer [is] not' (Franklin, 1979). The discussion that follows provides the general outlines of workers' compensation within various states in the United States, since this is a state, not a federal issue.

Panel 24.2 Liability for asbestos-related illness: redefining the rules on 'toxic torts'

Owen McIntyre

In recent years litigation over diseases resulting from exposure to asbestos has led to the progressive development of UK common law principles as they apply to two issues that have traditionally proven very onerous for plaintiffs claiming for 'toxic torts' (Cranor, 2006). These are the burdens of establishing the necessary causal link between an activity and disease and of establishing that harm that only becomes apparent long after the period of exposure, when scientific understanding of the risks may have been less developed, ought to have been reasonably foreseeable. Considerations of justice and injustice played a major role in each of these innovative developments in tort cases on asbestos-induced mesothelioma.

The UK House of Lords has recently ruled that the traditional 'but for' test for causation need not apply in mesothelioma ([3]) claims entered by employees who suffered periods of exposure to asbestos with more than one employer and where medical science cannot prove who among a number of employers caused the condition ([4]). This decision effectively creates joint and several liability whereby the claimant will be entitled to recover damages in full against each defendant.

In addition, and with strong implications for the precautionary principle, the English Court of Appeal ruled in 1996 that liability **arose in respect of exposure to asbestos resulting in mesothelioma despite the fact that the disease was not known to medical science at any time** during the relevant period of exposure ([5]). The Court reached this decision by employing a broad concept of injury for the purposes of establishing reasonable **foreseeability**. This development is significant in light of the emphasis placed on the requirement of foreseeability in environmental claims by the House of Lords decision in Cambridge Water Co. v. Eastern Counties Leather ([6]).

Causation

Establishing causation in toxic tort actions has long proven a difficult and even insurmountable task. The Scottish case of Graham and Graham v. ReChem ([7]) provides an extreme example of the practical problems which can be involved in establishing causation in such cases, involving an action in negligence and nuisance against the operator of a hazardous waste incinerator by local farmers for alleged damage to their cattle. The case lasted for 896 hours in court, spread over 198 days, and involved 80 lay witnesses and 21 expert witnesses on such issues as veterinary toxicology, agricultural accountancy, incinerator design, dioxin formation, pollution dispersion, analysis of trace organics and meteorology. The defendant's costs were estimated at GBP 4.5 million and the cost to the Legal Aid Board at GBP 1.5 million (see Wooley et al., 2000). Ultimately, the case failed on the issue of causation as there were other possible explanations of the cattle's injuries.

The cancer mesothelioma is classified by the UK courts as an 'indivisible' disease, as distinct from the respiratory disease, asbestosis, which is 'divisible' or cumulative. In the case of asbestosis, once the threshold for exposure is exceeded, all inhaled fibres are considered to contribute proportionately and progressively to lung dysfunction. The 'indivisibility' of mesothelioma creates obvious difficulty for a plaintiff mesothelioma victim who has been negligently exposed to asbestos by a number of defendants, usually successive employers, in terms of establishing causation.

In Fairchild, Curtis J. refused recovery at first instance to the estate of a mesothelioma victim suing two former owners of buildings containing asbestos in which he had worked ([8]). The Court found that there was no evidence of significant differences between the respective levels of exposure and was 'unable to establish on the balance of probabilities that the breaches of duty by either defendant were a cause or a material contribution to the deceased's mesothelioma'.

([3]) Mesothelioma is cancer of the lining of the lung or stomach. See the chapter on asbestos in Volume 1 of *Late lessons from early warnings* (EEA, 2001).
([4]) Joined cases Fairchild v. Glenhaven Funeral Services Ltd, Fox v. Spousal (Midlands) Ltd, and Matthews v. Associated Portland Cement Manufacturers (1978) Ltd and others, (2002), UKHL 22, NLJ Law Reports, 28 June 2002. See also, Morgan (2002).
([5]) Unrep. 17 April 1996. See further, McIntyre (2004).
([6]) (1994) 1 All ER 53 (H.L.)
([7]) (1996) EnvLR.
([8]) QBD, 1 February 2001.

Panel 24.2 Liability for asbestos-related illness: redefining the rules on 'toxic torts' (cont.)

However, a mere five months after Curtis J.'s decision in Fairchild, the English High Court reached a very different conclusion on very similar facts ([9]). Where a mesothelioma victim sued two of 15 employers who had exposed him to asbestos during the course of his working life, Mitting J., relying on the 1972 decision of the House of Lords in McGhee ([10]), justified his award of full damages against both defendants stating: 'The claimant was exposed by each defendant and by both defendants, to asbestos fibres, in quantities sufficient greatly to increase his risk of contracting mesothelioma.'

This followed the earlier ruling of Philips J. in a 1987 case ([11]) where he stated:

'Whether the defendants' breaches of duty merely added to the number of possible initiators of mesothelioma within the lungs of Mr Bryce, or whether they also produced a cumulative effect on the reduction of his body's defence mechanism, they increase the risk of his developing mesothelioma. He developed mesothelioma. Each of the defendants must accordingly be taken to have caused the mesothelioma by its breach of duty.'

The House of Lords later judgment in Fairchild relaxed the traditional test for establishing causation where there are multiple potential tortfeasors, holding that, in the case of an 'indivisible injury' such as mesothelioma, any tortfeasor could be liable for the whole of the injury once liability has been established. The House of Lords relied on its earlier decision in McGhee where it held that an employer who causes an indivisible disease such as dermatitis through exposure, only some of which is negligent, shall be liable in full for that injury.

The Lords stressed in McGhee that theirs was a 'common sense' understanding of causation having regard to the circumstances of such cases. According to Lord Reid:

' … it has often been said that the legal concept of causation is not based on logic or philosophy. It is based on the practical way in which the ordinary man's mind works in the everyday affairs of life. From a broad and practical viewpoint I can see no substantial difference between saying that what the respondents did materially increased the *risk* of injury to the appellant and saying that what the respondents did made a material *contribution* to his injury' (emphasis added).

Lord Hoffman stated that 'I think it would be both inconsistent with the policy of the law imposing the duty and morally wrong for your Lordships to impose causal requirements which exclude liability'.

Lord Hoffman approved the test for causation proposed by the Supreme Court of California in Rutherford v. Owens-Illinois Inc., stating that 'the causal requirements of the tort were satisfied by proving that exposure to a particular product was a substantial factor contributing to the … risk of developing cancer'.

Lord Bingham stated that '… such injustice as may be involved in imposing liability on a duty-breaking employer in these circumstances is heavily outweighed by the injustice of denying redress to a victim'.

Foreseeability of the 'surprise' disease of mesothelioma

The unique characteristics associated with the disease of mesothelioma have also resulted in the English courts taking an innovative approach to the issue of foreseeability of damage for the purposes of liability. The disease can develop from a very short period of exposure, even from a single instance of exposure but only manifests itself many years after exposure. According to statistics published by the insurer Munich Re, the average latency period (i.e. from first exposure to diagnosis of the cancer) for asbestos-related mesothelioma is 34 years ([12]) and epidemiology suggests that it is so rare for the latency period to be less than ten years that exposures within ten years of diagnosis may be excluded as causal (see Miller, 2002).

([9]) Matthews v. Associated Portland Cement and British Uralite PLC, QBD, 11 July 2001. Indeed, Dr Rudd, the principle expert witness in Fairchild, also acted in Matthews giving substantially similar evidence. See Miller (2002).
([10]) McGhee v. National Coal Board (1972) 3 All ER 1008, where it held that an employer who causes an indivisible disease such as dermatitis through exposure, only some of which is negligent, shall be liable in full for that injury.
([11]) Bryce v. Swan Hunter Group plc and others (1988), 1 All ER 658.
([12]) Munich Re, Employers Liability Handbook. See further, Buckley, supra, n. 1, at 192.

Panel 24.2 Liability for asbestos-related illness: redefining the rules on 'toxic torts' (cont)

In the joined cases Margereson v. JW Roberts Ltd and Hancock v. JW Roberts Ltd, ([13]) the plaintiffs sued an asbestos manufacturer after having contracted mesothelioma due to the defendant's extensive asbestos contamination of the district of Armley in Leeds where both plaintiffs had lived as children. Both sued in negligence and strict liability ([14]) and/or nuisance, though only liability in negligence was considered by the court. It was never disputed by the defendant that the steps taken by them to mitigate the problems of asbestos dust contamination were woefully inadequate. At trial, Holland J. found for the plaintiffs despite the fact that at no material time was mesothelioma a concept known to medical science.

The defendant appealed on the ground that there was no culpable lack of foresight on their part as they did not know and had no reason to believe that the risk of mesothelioma existed.

The Court of Appeal rejected the appeal stating that liability would arise where the applicant should reasonably have foreseen a risk of some pulmonary injury, not necessarily mesothelioma, and, that the damage occurred at a time when the applicant was on actual or constructive notice as to the potential pulmonary damage that exposure to asbestos could cause.

The Court also considered whether any distinction could sensibly be made between employees working within the factory and local residents. It asked 'did the factory wall pose such a barrier that risk of injury to persons on the other side … amount at worst to no more than a "mere possibility which would never occur to the mind of a reasonable man"?' and agreed with the trial judge that if the conditions outside the factory are not materially different to those giving rise to a duty of care within, there is 'no reason not to extend to that extramural neighbour a comparable duty of care'.

Lady Justice Hale has elsewhere ([15]) stated:

'The point which impressed the [trial] judge was the certain knowledge that asbestos dust was dangerous and the absence of any knowledge, and indeed any means of knowledge, about what constituted a safe level of exposure. … But just as courts must beware using such later developments to inflate the knowledge which should have been available earlier, they must beware using it to the contrary effect. The fact that other and graver risks emerged later does not detract from the power of what was already known …'

It remains to be seen whether this decision has implications beyond personal injury actions ([16]) and whether the courts are prepared to apply a less onerous test of foreseeability in cases of environmental damage generally. Where any particular class of environmental damage was foreseeable, liability might arise for any other type of damage in that class which arises much later. Several of the case studies in volume 1 of *Late lessons from early warnings* and the present report demonstrate that much harm arises after the first wave of harm, e.g. with PCS, mercury, CFCs, benzene and radiations. If the courts were to examine foreseeability in the context of broad classes of damage, the test of foreseeability (seen by many commentators as one of the factors responsible for tort's failure to compensate for historic pollution), would effectively be relaxed. The test may now relate to the foreseeability of some relevant damage.

([13]) *The Times,* 17 April 1996.
([14]) Rylands v. Fletcher (1868), L.R. 3 H.L. 330.
([15]) Shell Tankers UK Ltd. v. Betty Irene Jeromson (2001), EWCA Civ 101, 2 February 2001.
([16]) Following the House of Lords decision in Page v. Smith (1996) AC 155, it is sufficient if any personal injury to a 'primary' victim is foreseeable.

Part of the rationale is that the since the 'employment of labor involves the risk of disability, by social policy the employer must defray its costs.' Expressed succinctly: 'The cost of the product should bear the blood of the workingman' (Franklin, 1979). When employees are harmed, there are costs; workers' compensation seeks to internalise those costs to the commercial activity that produces profits and harms employees.

Workers' compensation is financed by employers' contributions based on the hazards of particular kinds of employment ranging from quite hazardous jobs to office work. General tax revenues could fund such a system but this would likely disconnect compensation from current modest incentives for employers to provide a safer work environment. Moreover, since funding is largely employer based, it could and often does reflect a particular employer's safety record (Franklin, 1979). In addition, like tort law, workers' compensation laws in some jurisdictions permit discovery — but with a twist. Some jurisdictions only permit an impartial adjudicator to conduct discovery concerning injuries, while others allow the injured party to conduct discovery much like under tort law. While either option provides some of the same information benefits of tort, it slows the process, thus interfering to some extent with one of the strengths of workers' compensation: quick compensation and resolution of issues.

Initially workers' compensation only covered injuries resulting from the workplace, not diseases. Coverage has subsequently been extended, however, to include at least some diseases resulting from workplace exposures. Sometimes particular diseases resulting from particular working conditions are dealt with by separate legislation, e.g. black lung from coal mining. Many but not quite all workers are covered in the US. Domestic service employees, agricultural workers, casual employees, and possibly employees of small businesses tend to be excluded by statute (Franklin, 1979).

Injuries or diseases for which employees are authorised to receive compensation must fall within prescribed legislative categories. The injuries must be both explicitly authorised by the legislation or enabling regulations and attributable to a person's employment (Franklin, 1979). A back injury for which compensation is sought must be due to a workplace event, not weekend soccer.

Compensation typically consists of cash payments to an employee or his/her survivors, reflecting lost income, costs of medical care, and rehabilitative services. Lost income payments tend to be some percentage of the worker's weekly earnings at the time injuries were suffered, usually with a maximum payout, for example up to two thirds of the total earnings. This can vary depending upon marital status and whether the person has dependent children. Moreover, compensation is based on the generic kind of injury suffered, whether it was a temporary but partial disability, a temporary total disability, a permanent total disability, or death resulting from the workplace.

Payment amounts can be quite specific for a lost arm, leg, or particular finger, for example. When an employee dies as a result of a workplace injury, typically his or her survivors receive compensation based on the levels of earnings at the time and the number of his or her dependents. Medical and rehabilitative services provided by workers' compensation 'are generally considered to be the most effective single part of the system'. This is typically provided at once following an injury or disease (Franklin, 1979). Rehabilitative services can avoid other long-term costs that would otherwise result.

Finally, if the workers' compensation law in question does not cover a person or an injury or disease, remedies in tort law may be available. Ordinarily, workers' compensation is the exclusive remedy for workplace-caused diseases but if employees for some reason are not covered or poorly compensated for injuries, in some instances they may have recourse to the tort law.

In the US there are additional variations on workers' compensation. A federal version covers federal non-military employees. The Black-Lung Benefits Act 'provides compensation for [coal] miners suffering from 'black lung' (pneumoconiosis)'. Other laws provide compensation for employees injured by railroads, those working on ships, and those working for private maritime employers, but most of these provide compensation only if employers were negligent (Cornell University Law School, 2010). Some shortcomings of workers' compensation are considered at the end of the next section.

Analogues to workers compensation for a precautionary world

How well might generic strict liability analogues to workers' compensation laws function within a legal system oriented toward a precautionary approach to environmental health and environmental protection?

Imagine a generic compensation scheme that could compensate workers or citizens for injuries, diseases, dysfunctions or death as a result of an

environmental hazard, such as a chemical or other exposure. Imagine also that it provided compensation for environmental damage caused by products whose causal consequences were missed by prior review. How well would such a system function?

A well functioning system analogous to workers' compensation could have aspects consistent with a more precautionary approach to environmental and occupational health harms. It could provide compensation quickly to repair and rehabilitate people from injuries suffered. Once harms were identified, this would shorten their duration. But could analogues for environmental damages be devised? This more difficult issue would need to be addressed.

There is one major limitation. Workers' compensation laws function as well as they do is because many injuries tend to be immediately cognisable and causally traceable to a source, e.g. a worker cuts off a finger or is in a car accident. Obvious and immediate traumatic injuries are easy to identify under workers' compensation programmes. Provisions for other injuries, such as diseases associated with workplace exposures, would need to be created as understanding of disease processes develops and as diseases can be causally attributed to exposures, e.g. how coke oven emissions can contribute to lung cancer (very easy) or bisphenol A can contribute to metabolic syndrome, breast cancer or adverse reproductive effects (extremely difficult). In a precautionary world creating categories of identifiable injuries, diseases or dysfunctions from many chemical exposures becomes more difficult when harms are not obvious, are not obviously traceable to a particular exposure or are not causally proximate to the time of exposure.

As a first step for comparatively new or poorly understood exposures to technologies, decision-makers could assess potential causes of harm from what is known about the technologies and any plausible adverse effects that might result. These could be used together with background information and analogies to the same adverse effect caused by other exposures or sources to create presumptive categories of adverse outcomes and appropriate compensation. For example, at present the evidence may or may not be sufficient to identify various forms of electromagnetic waves as contributors to brain cancer. However, there is surely considerable knowledge about the costs of treating different brain cancers and how much these forms of cancer disrupt people's lives so that if it turns out that cell phones do contribute to some forms of brain cancer, compensation tables could begin to be developed even before the causal evidence is fully sufficient to support a case for compensation.

In addition, decision-makers could 'learn as they go', and assess and evaluate kinds of diseases and dysfunction based on the causal properties of the substance as they are revealed over time. It would take some time to build up categories of injuries that would be more or less automatically compensable. For known hazardous but socially important chemical products whose toxicity was better understood, compensation tables could be developed somewhat quicker.

Another amendment might be a procedure for monitoring for any potential adverse health or environmental effects from risky but socially important products or activities, such as lead. This is highly toxic product with no known safe level of exposure but it is likely to have continued use in batteries (Wigle and Lanphear, 2005). Lead companies would need to continue monitoring the health status of their employees for known adverse effects of lead exposure. Neighbourhoods or communities downwind or downstream from lead battery factories or recycling plants would need to be monitored in order quickly to detect health or environmental effects from fugitive lead exposures for compensation and to expedite its delivery.

For environmental harms there would need to be categories of plausible or even remote harms for which there would be compensation based on liability without fault. There would also need to be monitoring programmes in place to identify long-tailed risks as early as possible so that harm could be minimised and its duration shortened. Such efforts could probably be expedited by experts giving careful thought to potential adverse effects, where these estimates would be made on the basis of existing information and analogies to similar outcomes caused by other sources. For instance, for a genetically modified weed killer new to the market, there might well be recent historical examples of other weed killers, genetically modified or not, that when released into the environment posed problems of killing beneficial plants from which decision-makers could learn. For genetically modified plants with in-built pesticides that are close relatives to wild types that could pose problems, decision-makers could learn from analogies.

Despite the appearance that workers' compensation is more efficient, faster and without many of the transaction costs of tort law, over time it appears that this system's apparent attractiveness has been reduced in practice. Compensation rarely appears to

be adequate, some employees engage in fraud, and companies resist workers' compensation provisions. The public perceives that system as substantially flawed at present. An additional worry for long-tailed risks would be whether companies that caused harms continued to exist long enough for the results of their activities to appear.

Analogues to the US Vaccine Injury Compensation System

The Vaccine Injury Compensation System, a hybrid of the regulatory and tort systems in the US, constitutes another model. Pharmaceutical manufacturers at one time argued that they could no longer manufacture vaccines because there was too little profit margin and even that could quickly disappear if the few people who suffered adverse reactions to vaccines were permitted to sue. Congress created the Vaccine Injury Compensation Program to encourage the production of needed vaccines by providing a streamlined procedure to compensate those who, in rare instances, experienced a vaccine-related injury. This was an alternative to traditional tort actions concerning injuries caused by vaccines and companies were immunised from suits by the legislation.

The Program has two main parts: compensation for so-called 'on table' injuries from vaccines, and compensation for 'off-table' injuries. On-table injuries are identifiable and have typical adverse effects from particular vaccinations. These receive fairly automatic compensation with minimal evidentiary showings.

Off-table injuries are those that might be causally attributable to a vaccine but the injury is atypical. People using this remedy may file a petition 'against the Department of Health and Human Services in the US Court of Federal Claims seeking compensation from the Vaccine Trust Fund'. They must specify who was injured, the vaccine that caused it, when and where it was given, the type of injury, when the first symptoms appeared and how long any adverse effects lasted (USHRSA, 2010).

For off-table injuries, tort law standards of proof apply, but the requirements on expert testimony set out in Daubert v. Merrell-Dow Pharmaceuticals (1993) do not because the magistrate hearing the case is both judge and juror. There is no need to screen a jury from experts; judges simply assess such testimony and give it appropriate weight. In addition, there are fewer formal procedures than in a typical tort case and the magistrates in this system appear to have a much more sophisticated grasp of scientific evidence than the general federal district judges that hear tort cases (Stevens v. the Secretary of Health and Human Services, 2001).

Successful petitioners may receive compensation for past and future non-reimbursable medical, custodial care, and rehabilitation costs, as well as up to USD 250 000 for pain and suffering, lost earnings and/or reasonable lawyer expenses. Death benefits of up to USD 250 000 plus reasonable legal fees are also permitted (USHRSA, 2010).

The Program is funded by an excise tax of USD 0.75 on each dose of vaccine (USHRSA, 2010). Thus, the costs of VICP seem likely to be paid by patients, their insurance companies or the government (in the case of those with government aid). During the 12 years of its existence it has provided 'a less adversarial, less expensive and less time-consuming system of recovery than the traditional tort system that governs medical malpractice, personal injury and product liability cases. More than 1 500 people have been paid in excess of USD 1.18 billion' since its inception. This averages to about USD 78 000 per plaintiff (US Department of Justice, 2010).

In principle, an analogue to the VICP appears to be a superior compensation system to torts and might function well in a legal system that emphasised the importance of precautionary policies. How might it work?

If a potentially hazardous product has been tested and subject to pre-market review (for example under Europe's Registration, Authorisation and Restriction of Chemicals (REACH) system) or is subject to post-market health regulations, neither might be sufficient to protect all those contaminated by the substance. Some will be more susceptible, some less so, because of life-stage, genetic heterogeneity, variation in detoxifying enzymes, age, pre-existing illnesses and so on. Some provisions need to be provided for citizens who are harmed because health standards failed to protect them (Cranor, 2008a).

For injuries that are typical of such exposures — analogous to 'on-table' injuries — there should be virtually automatic compensation. (The list of such injuries would obviously need to be developed and revised over time.) For injuries that were not typical but were suspected of being causally traceable to the toxic exposure subject to regulation, injured parties could make an argument that the compensation system should recognise such injuries with a standard of evidence similar to those employed in the VICP.

How well might such a system function? First, there would need to be a table of expected or not atypical injuries to people or damage to the environment from exposures in order to create the equivalent of 'on-table' injuries subject to compensation. This is a necessary element to expedite compensation. How difficult it might be to create such tables for more subtle diseases and dysfunctions is difficult to know but it should be addressed.

Second, there would need to be some showing that appropriate exposure had occurred that would support the connection between the technology and the adverse effects. Unlike vaccines where exposures are typically known with some degree of confidence, for environmental and even some workplace exposures, this critical element would likely be subject to numerous disputes.

Third, explicit provisions would be needed for long-tailed, subtle, adverse consequences of the technology, making it possible, with reduced procedural requirements, to argue that people or the environment had been damaged as a consequence. One might think of these as something like the off-table injuries if they were more atypical adverse effects.

A possible shortcoming of analogues to VICP is that tort law's preponderance of evidence standard is needed for off-table injuries. This attenuates the chances of compensation for those whose injuries that may have been caused by exposures — at least compared to the United Kingdom's Compensation Scheme for Radiation-Linked Diseases (discussed below).

September 11 Victim Compensation Fund

This fund was created by a separate law passed following the 11 September 2001 terrorist attack on New York city. Its aim was 'to provide compensation to any individual (or relatives of a deceased individual) who was physically injured or killed as a result of [the 11 September attacks].' Congress sought 'in part, to establish a mechanism that would provide financial security and assistance to the victims of the attacks without the uncertainties, delays and costs of traditional litigation' (Feinberg, 2004).

The legislation creates an administrative alternative to traditional tort litigation for the victims of the terrorist attacks. Injured parties were permitted to seek tort compensation instead but with substantial limitations. The law created a 'Special Master' with substantial powers to issue any 'procedural and substantive rules' and to determine eligibility under them. The Special Master had authority to determine the amount of compensation for harms suffered by those making the claims where this includes both economic and non-economic damages. Neither liability nor punitive damages could be considered. Congress authorised the funds necessary to pay compensation costs, but placed no aggregate limit on the total fund or on individual claimants (Feinberg, 2004).

The result was a hybrid system utilising some aspects of tort law but precluding liability and punitive damages. It authorised reduction of compensatory awards 'by payments that the claimant received from certain collateral sources'. Congress tried to create a comparatively quick and fair system for the victims. This was enforced by imposition of 'strict time limits' during which claims could be evaluated. Not everyone harmed by the attacks was eligible — only those 'individuals physically harmed or killed at the sites and in the immediate aftermath of the attacks.' Congress sought to ensure awards that were individualised between parties but not overly disparate between them. The details of these regulations and how they were implemented are described in the final report (Feinberg, 2004).

The Compensation Fund was created following a major tragedy and the enabling legislation passed in less than one week. There was no debate about the need or justification for compensation, which is likely to be quite different from analogous legislation that might cover environmental or environmental health harms. Moreover, there is a critical feature of this law that differs from traditional tort law. It was enacted and implemented in a manner similar to administrative or regulatory law: the Justice Department and Special Master had to implement regulations that would guide the award of compensation and considerations the Special Master had to take into account. The Master also had considerable discretion in deciding on individual amounts of compensation. There was provision for one to appeal these decisions, but appeals were considered within the same organisation that made the initial compensation decision instead of a separate appellate court. Once an appellate decision was issued, no further appeals were available. Thus, unlike the tort law or US administrative law, appeals were quite limited and were heard by lawyers within the structure created by the legislation (Feinberg, 2004).

This example does suggest that a compensation fund might be created under administrative procedures

rather than procedures more closely analogous to tort law. There could be rules issued for guiding an administrator or administrative agency in awarding damages and damage awards would be upheld on appeal as long as the administrative agency did not act to violate administrative procedures for adjudicating compensation under the rules.

In the US, an agency awarding compensation would probably be reviewed to determine whether it had 'substantial evidence' for its conclusion, assuming it had otherwise followed proper procedures. Thus, a reviewing court would consider whether, on the record established by the agency, it 'could reasonably make the finding'. Substantial evidence is 'such relevant evidence as a reasonable mind might accept as adequate to support a conclusion . . . [or provides] a substantial basis of fact from which the fact in issue can be reasonably inferred' (Davis, 1972). While this is somewhat vague, it conveys the idea that such decisions are reviewable, and acknowledges deference to the decisionmaker, but is not so strict as to force frequent second-guessing.

UK Compensation Scheme for Radiation-Linked Diseases

In 1965 the United Kingdom passed the Nuclear Installations Act to provide for civil liability for injuries from nuclear installations. This imposed strict or absolute liability for such injuries, rather than requiring proof of negligence. Despite this, subsequent litigation concerning such damages was complex, contentious and slow.

Consequently, this led to a voluntary Compensation Scheme for Radiation-Linked Diseases (CSRLD) in 1982. This was a joint agreement between British Nuclear Fuels Ltd (BNFL) and trade unions that worked within it. The aim was to create a quicker, more generous alternative to the normal litigation process, and reduce stressful and expensive litigation for complainants and expensive litigation for BNFL. Ultimately this was expanded to include other employers using radiation, and their unions. The Compensation Scheme initially permitted only compensation for mortality but later expanded to include morbidity. This agreement was possible because the causes of radiation-induced cancers were well understood as a result of past experience (CSRLD, 2010).

In order to make a claim under this programme, an employee must have worked for one of the companies that is a party to the agreement and have received a radiation dose during employment with one of the signatory companies. He or she must also be a member of a union that was party to the agreement, with some exceptions. The person must have been diagnosed with a disease that is typical of radiation exposure. Most cancers are considered eligible.

Compensation is determined by a person's radiation dose record from signatory employers, which is then used to assess the likelihood that a disease was caused by the exposure in question. Signatories have guidelines for determining the dose to which a person was exposed. The methodology to determine probabilities of causation and interpretation of uncertainties are generous toward claimants.

If a claimant is found to have radiation-induced cancer as a result of workplace exposure, the full value of a settlement is agreed by the parties and then discounted by the probability that it was the result of workplace exposure. Minimal compensation is awarded if the causation probability is 20 %, whereas in tort litigation the requirement for compensation would be at least 50 % (more likely than not).

If the odds of radiation-caused cancer are between 20 and 29.9 %, a quarter of the full value of a settlement is provided. If it is between 30 and 39.9 %, half is compensated, and from 40 to 49.9 %, 75 % of the full value is paid. If the probability of cancer is greater than 50 % then the full value of the disease is compensated. Most compensation that has been dispensed is for probabilities of causation below 50 %. One hundred and six people have received compensation for radiation-induced injuries, with payments totalling GBP 5.3 million or about GBP 50 000 per person on average.

Claimants have been much more likely to be successful than if their cases had been considered under tort law. They have received some compensation for their diseases based on the best information available, which was probably much quicker and more generous than civil litigation would have provided. The Scheme had therefore achieved its goals (CSRLD, 2010).

The United Kingdom also has a single-payer health system, the National Health Service (NHS), under which all citizens, including those suffering from illnesses caused by radiation, would receive essentially free health care for any diseases. Consequently, it would be difficult to compare compensation received under the CSRLD with compensation received in a country such as the US with myriad private health care providers and insurers.

In the United Kingdom, radiation-exposed employees would receive diagnosis and treatment for their diseases as quickly as the NHS provides it; this seems independent of the timeliness of compensation under the CSRLD. CSRLD compensation assists in setting right other matters beyond health care and rehabilitation for radiation-caused diseases. Clearly, countries with a single-payer system have quite important institutional resources that permit harm to be minimised and shortened as much as can be achieved through medical care and the rate at which patients are considered by the medical system.

Compensation under the CSRLD is possible because there is a substantial medical and exposure history with radiation. Well-designed, scientifically based compensation tables can be provided based on past injuries to earlier employees. Such a scheme could not be instituted quickly because creating the compensation tables depends so critically on a history of previous diseases. For new and subtle diseases, more likely to be typical of contemporary technological risks, this would be a limitation.

There appear to be modest incentives for companies to control exposures to radiation and reduce diseases and death as a result of this programme. If employees contract radiation-caused diseases, the company responsible must pay the required compensation, which is considered 'generous', and some packages are awarded based on probabilities well short of the preponderance of evidence. How successful this is likely to be in deterring dangerous exposure is difficult to judge. Will compensation packages in at least some cases be much less than the costs of preventing the diseases in the first place, especially when they involve substantial capital commitments? If so, the compensatory payouts by themselves would lack deterrence value. Of course, there could be other protective mechanisms, such as regulatory rules, inspections and so on.

New Zealand's no-fault compensation law

In 1972 New Zealand abolished almost all of its existing tort system and moved toward expanding a no-fault injury compensation scheme for compensating workers for personal injuries under the Accident Compensation Corporation (ACC). Initially covering workplace and automobile injuries, this was later expanded 'to cover virtually all accidental injuries and to confer very broad benefits on victims' (Schuck, 2008). Covered categories include motor vehicle accidents, work-related injuries both to employees and self-employed people, employees injured outside the workplace, medical treatment injuries, and coverage for those outside the workforce, such as children and the elderly.

Compensation is provided for injuries suffered, medical and rehabilitation costs associated with treating injuries, replacement of wages up to 80 % of average weekly earnings, impairment of earning capacity, loss of bodily function, possibly lump sum payments for permanent injuries, and benefits for surviving spouses and children, as well as funeral expenses. Injured people 'receive free hospital care and subsidized pharmaceuticals' (Bismark and Paterson, 2006). Compensation comes from different accounts corresponding to accident types and the category of victim involved. Peter Schuck observes that 'New Zealanders today generally regard their system … as a mainstay of their social policy' (Schuck, 2008). Others note that the 'ACC system is one of the simplest in the world for patients to navigate' (Bismark and Paterson, 2006).

Compensating all medical treatment injuries led to substantial costs and, consequently, for medical injuries subsequent legislation reduced 'the scope of covered injuries, shortened the time within which claims could be brought, and eliminated lump sum payments for pain and suffering' (Schuck, 2008). The programme reintroduced the notion of fault, similar to the US requirement of negligence for medical malpractice. In this New Zealand reverted to the previous standard of care that had been used in tort medical malpractice suits before instituting the ACC. There do not appear to be such restrictions for other 'accidents' in the workplace — from automobiles, and so on.

Illnesses not caused by accidents and wilful self-inflicted injuries are excluded from compensation, creating tensions within the system (Henderson, 1981). Injured parties who are not employed, such as children and the elderly, may not be similarly compensated, since they receive no earnings equivalent (Bismark and Paterson, 2006).

Aspects of the New Zealand system in large part seem consistent with a precautionary view of the world. It is relatively simple to navigate and claims are dealt with expeditiously, minimising the time before injuries are addressed. This in turn should shorten the duration of harm that must be endured. It appears that all accidents (with minor exceptions) are eligible for compensation.

A serious shortcoming appears to be the ineligibility of illnesses, at least with respect to the

medical compensation system. Moreover, the focus on 'accidents' might suggest that it is traceable to earlier views in which illnesses were seen as resulting from 'natural' processes, not induced by human activities. The result is that the system might underemphasise illnesses, dysfunctions or death traceable to toxic and other environmental exposures. In addition, the system appears to lack deterrents discouraging activities that lead to accidents (or illnesses).

Precautionary assurance bonds for environmental damage

Liability regimes for environmental damage are helpful but apply after the damage is done (EC, 2008, 2009 and 2010). A more precautionary approach to future environmental damage could involve the use of assurance bonds.

An assurance bonding system is an arrangement in which commercial entities whose activities might have adverse impacts on the environment must 'pay in advance for the costs they might inflict on society if they adopted the most harmful method of disposal, [it] reverses the usual presumption of 'innocence' over 'guilt' as applied to environmental damages' (Costanza and Perrings, 1990). A simple example is a refundable deposit on glass bottles. This encourages users to dispose of the bottles by returning them to a location where they would be recycled instead of their becoming litter, thus providing incentives for better disposal.

Because it is difficult or impossible to calculate the costs of future damage, it is unlikely that a private insurance market could encourage similar behaviour. There are therefore two alternatives: costs from future damage could be imposed on public agencies or privately injured parties when damage occurs, or they could be imposed on the party engaging in an activity that could have possible adverse future consequences.

Assurance bonds impose responsibility and costs on the entity undertaking the activity that might adversely affect health or the environment. A government body would estimate potential future costs of adverse environmental consequences and impose a fee for those on any party whose activities threatened environmental resources.

Under the scheme, each resource user would be required to post bonds, refundable at specified dates if the intertemporal external costs of the activity turned out to be less than those assessed by the environmental authority. The value of the bond at the date of posting would be a function of the environmental authority's [best] estimate of the costs of environmental repair or rehabilitation if the worst happened between the date of posting and the refund date. The value of the bond would be higher, the greater the estimate of the worst case costs (Costanza and Perrings, 1990**).**

The bond would be refundable in whole or part if the resource users could demonstrate lower damages than those assumed by the agency setting the bond. The burden of proof that the estimate of the agency was incorrect would lie with the user of the resource**.** The system should therefore provide a strong economic incentive to firms to research the future environmental costs of their activities, and so to improve their environmental performance. If the environmental authority's estimate of the worst case costs were revised downwards during the life of the bond it would be reduced; if revised upwards it would be increased. This feature of the scheme provides the incentive to resource users to research the future environmental effects of their activities (Costanza and Perrings, 1990).

Such bonds provide a means for addressing ignorance and uncertainty associated with possible future environmental hazards, as well as deterring undesirable behaviour. When businesses are required to post bonds, if harm from their activities occurs, there are resources that can assist in whole (the preferred alternative) or in part (less preferred) in compensating those whose property or person have been harmed and assist in repairing damage to the environment. The greater the upfront bond, the more likely adequate resources would be available to address adverse consequences. Of course, a bonding scheme would need to be supported by an appropriately quick and adequate compensation system similar to the best ones we have considered above.

Assurance bonds have a number of virtues. They provide incentives for private parties and government agencies to conduct research and improve estimates of adverse environmental impacts before the activities are instituted. They also internalise these calculations into the procedures of a commercial enterprise with nudging from environmental agencies. They help correct underinvestment in research on such adverse effects. The funding of environmental protection through the bonds would be proportionate to the size of the problem insofar as this could be determined. And the inducement for research would also be approximately proportional to the assessed social costs of permitting the activity to proceed in ignorance (Costanza and Perrings, 1990).

If companies cannot afford the upfront bonds, they would not be permitted to engage in the activity; in short, no bond, no market.

Importantly, bonds help protect against economically marginal firms whose activities might turn out to be especially environmentally damaging. If they are marginal, they would likely lack resources to address the problems after they occurred and simply go out of business or declare bankruptcy rather than provide compensation for damage caused. Bonds required for activities prior to instituting a potentially hazardous activity would provide funds when firms are optimistic about their activities to ensure that there will be resources to address problems when they arise, even if the firms are no longer in business (provided funding is held in trust). This resembles a common rationale for administrative regulation of risks rather than post-market injury suits to repair damage when risks materialise into harm (Cranor, 1993).

Assurance bonds promote a precautionary approach, placing approximate upfront costs on commercial activities insofar as these can be determined. They do not require testing or estimates of adverse effects of products or activities as does REACH, but they provide incentives for it. If in fact harm occurs, there is then a fund, hopefully adequate, to begin to repair, minimise and shorten damage.

Moreover, because bonds provide incentives to conduct research to discover future harms, they might assist in discovering long-tailed, less visible adverse consequences of technology earlier. They might provide some incentives for businesses to reveal risks earlier in order to increase funds that might be returned should harms be minimised. While there is no explicit deterrence in the form of punishments or penalties, the equivalent of some deterrence exists because firms have resources at stake, which they would lose if there were adverse consequences, but which would be refunded if there were not.

A possible downside is that assurance bonds might overly burden new technologies, possibly discouraging investment in new but potentially risky activities. This concern might be addressed by requiring upfront bonds commensurate with the extent of risks. For low probability, relatively contained risks when enterprises are small, lesser bonds could be required, but as commercial activities grow and the range of risks increases, bonds should probably be increased appropriate to potential costs of risks. The size of commercial activities would need to be monitored in order for the bond fund to keep pace with potential risks. Governmental agencies may or may not be up to the task of on-going monitoring. An illustration of how an assurance bond scheme could have been applied to the Deepwater Horizon disaster is provided in Panel 24.3.

24.2.3 Desirable features of compensation systems

Comparatively quick measures to identify diseases and environmental damage due to poorly understood technologies and quickly minimise and shorten them would promote precautionary approaches better than slower systems. There are tensions between the rationales of the different compensatory systems reviewed above. Different ones might be more appropriate for the varying circumstances and institutions of individual countries, e.g. the presence of universal health care or existing compensation systems like New Zealand's.

The best compensation systems appear to have nearly automatic provisions for many classes of injuries (ideally all). It may be difficult to provide tables for automatically compensable health injuries and illnesses, and for environmental damage from less well understood technologies, but decision-makers must do the best they can. This might be more difficult for subtle, long-tailed risks. Some of these problems would be eased in countries with single-payer, universal health care such as many countries in Europe have, and in New Zealand's no-fault compensation system for accidents, with extensions to diseases and the environment.

A compensation arrangement with some similarities to administrative law and some features of the September 11 Fund in the US might be desirable. In this an administrator would have considerable discretion to award compensation and it would likely be more efficient in quickly providing resources to repair damages suffered. There would, however, need to be some constraints on decision-maker discretion to ensure justice between applicants and to utilise funds efficiently.

The generous compensation system of the UK's Compensation Scheme for Radiation-Linked Diseases, with allowances for compensating for cancers with probabilities less than 50 % is notable. It could be difficult to duplicate, however, because it rests on a long, well understood history of radiation-caused diseases with prior victims. It is nevertheless worth considering.

Panel 24.3 Precautionary assurance bonds for potentially serious environmental risks

Robert Costanza has long advocated anticipatory assurance bonds on corporations as a means of internalising and helping to minimise future environmental costs from their large scale, potentially hazardous technologies (Costanza and Perrins, 1990). His argument is summarised below, based on lessons from the Deepwater Horizon oil spill (Costanza et al., 2010).

The spill from the *Deepwater Horizon* is causing enormous economic and ecological damage. The spill has directly and indirectly affected at least 20 categories of valuable ecosystem services in and around the Gulf of Mexico. The USD 2.5 billion per year Louisiana commercial fishery has been almost completely shut down. As the oil extends to popular Gulf Coast beaches, the loss of tourism revenue will also be enormous. In addition, the spill has damaged several important natural capital assets whose value in supporting human well-being is both huge and largely outside the market system. These non-marketed ecosystem services include climate regulation via the sequestration of carbon by coastal marshes and open water systems, hurricane protection by coastal wetlands, and cultural, recreational, and aesthetic values.

A recent study estimated the total value of these ecosystem services for the Mississippi River Delta to be in the range of USD 12–47 billion per year (Batker et al., 2010). Based on the flow of these services into the future, the value of the Delta as a natural asset was estimated to be in the range of USD 330 billion to USD 1.3 trillion, far more than the total market value of BP (USD 189 billion) before the spill. Unlike BP, ecosystem service values are outside the market. They continue to produce benefits unless an action like the spill damages them.

One major lesson is that our natural capital assets and other public goods are far too valuable to continue to put them at such high risk from private interests. We need better (not necessarily more) regulation and strong incentives to protect these assets against actions that put them at risk. Our current approach to dealing with the risk of private interests damaging public environmental assets is to assign liability to the private interests, but with the burden of proof on the public. The public must demonstrate damages after the fact, claim compensation, endure a lengthy judicial process, and finally hope to recover just reparations. In addition, the total liability is often limited, as with oil spill and nuclear accident cots. This gives private interests strong incentives to take large risks with public assets — far larger than they should from society's point of view.

The long-term solutions to these problems require fundamental changes to business-as-usual practices, including assessment and incorporation of the full value of public natural capital assets into both corporate and public accounting and decision-making, a reversal of the burden of proof from public to private interest, and a requirement of corporations and other private interests to internalise and monetise their risks to public goods.

One way to internalise and monetise these risks would be to require private interests to post an 'assurance bond' large enough to cover the worst-case damages. Portions of the bond (plus interest) would be returned if and when the private interests could demonstrate that the suspected worst-case damages had not occurred or would be less than was originally assessed. If damages did occur, portions of the bond would be used to rehabilitate or repair the environment and to compensate injured parties. The critical feature is that the risk to the public asset is apparent to the private interests in financial terms before the fact, not as a liability that may or may not be enforced after the damage occurs.

Imagine how this system might have worked had it been in place prior to the Deepwater Horizon incident. What actually occurred is pretty close to the 'worst-case' scenario that might have been envisioned before the fact. Our best guess of the potential damages would thus be in the range of USD 34–670 billion. Let's say that a scientific review panel, after assessing the risk in more detail, settled on an estimate of USD 50 billion. This immediately makes it very apparent to BP and others drilling in deep water in the Gulf of Mexico that they are engaged in a *very* risky business — several orders of magnitude riskier than the USD 50 million liability limit previously in force. What could they do? Either not drill at all or find ways to reduce the size of the risk and the bond. They might be able to do this very cost-effectively if they spent some money on risk-reduction procedures or technology, such as the acoustic blowout preventer costing a mere USD 500 000 which they failed to install on Deepwater Horizon. These

Panel 24.3 Precautionary assurance bonds for potentially serious environmental risks (cont.)

measures might convince the scientific review panel to change its assessment of the worst-case scenario and reduce the bond. There would be very strong economic incentives for BP to find creative ways to reduce the risks rather than ignoring the risks and cutting corners.

The *Deepwater Horizon* incident offers a strong lesson in risk management. Our entire society is taking far too many risks with public assets whose real value we are only now beginning to recognise. By shifting the financial burden of those risks onto the private interests who benefit from them, we can establish the right incentives, shift investment to less risky, more productive pursuits, and create a more sustainable and desirable future.

Source: Costanza et al., 2010.

Funding for some of the systems suggests useful features of a model. Workers' compensation and the Vaccine Injury Compensation Program in the US all institute a fee on the covered activities to create a monetary source from which compensation can be paid. This is likely to be attractive to government agencies facing tightened budgets or long-term budgetary concerns. Moreover, if contributions to a compensation fund are based to some extent on a company's safety record with regard to the activity, this may provide some modest deterrence feedback to the company to modify its safety practices toward the new technology. Workers' compensation funds do this explicitly; there is no 'deterrence surcharge' in the VICP and it is not clear that there is such a surcharge in the UK's radiation compensation programme.

Health care and rehabilitation services, likely to be part of some but not all health care systems do not exhaust compensatory needs. People's loss of earning capacity and long-term care, as well as compensation for families left poorly supported, must be addressed.

Assurance bonds or insurance if it is available in the markets, paid for upfront by companies whose technologies appear to pose health or environmental risks, provides important resources to help fund anticipatory research into risks and to provide compensation so that society does not have to pay for any future damage. When companies put up their own money, this provides incentives for better research on risks associated with their technologies and deters carelessness or recklessness in creating such risks.

24.3 Conclusion

Early warning scientists and others who identify potential impending harm have sometimes been discouraged in the past or actually lost positions or suffered various kinds of losses. However. they often bring forth useful and timely knowledge and therefore need to be encouraged and not harmed for their efforts. Good public policy suggests laws should discourage such actions in the first place and justice requires rectification if they are the subjects of retaliation. And if warnings are not heeded and damage results, or if damage results even when there were not warnings, it has often proved difficult in the past to achieve prompt and fair compensation for the victims.

This chapter has explored some ideas for reform, building on some current institutional models in the hope that this will raise awareness of these issues among the wider public and suggest plausible improvements in current law and practices.

References

Abel, R., 1988, 'Torts', in Kairys, D. (ed.), *The Politics of Law: A Progressive Critique*, Basic Books, New York, pp. 445–470.

Ad-hoc Industry Natural Resource Damage Group, 2010, *Survey of industrial companies insurance and other financial security instruments and remediation of environmental damages under the EU Environmental Liability Directive*, February 2010, Brussels.

Anderson v. Minneapolis, St. Paul & S. St. M.R.R. Co., 1920, 146 Minn. 432, 179 N.W. 45.

Batker, D., de la Torre, I., Costanza, R., Swedeen, P., Day, J. and Boumans, R, 2010, *Gaining Ground—Wetlands, Hurricanes and the Economy: The Value of Restoring the Mississippi River Delta*, Earth Economics Tacoma, WA.

Bismark, M. and Paterson, R., 2006, 'No-Fault compensation in New Zealand: harmonizing injury compensation, provider accountability, and patient safety', *Health Affairs*, (25/1) 278–283.

Berger, M., 1997, 'Eliminating General Causation: Notes Towards a New Theory of Justice and Toxic Torts, *Columbia Law Review*, (97) 2 117–2 152.

Boxill, B., 2011, 'Black Reparations' in: Zalta, E. N., (ed.), *The Stanford Encyclopedia of Philosophy* (Spring 2011 Edition).

Brodeur, D., 1985, *Outrageous misconduct: the asbestos industry on trial*, Pantheon, New York.

Cambridge Water Co. v. Eastern Counties Leather, 1994, 1 All ER 53 (H.L.)

CEA, 2007, *CEA white paper on insurability of environmental liability*, Confederation of European Insurers (http://www.insuranceeurope.eu/uploads/Modules/Publications/Mail%20-%20CEA%20White%20Paper%20on%20Insurability%20of%20Environmental%20Liability.pdf) accessed 30 May 2012.

CEA, 2008, *The Environmental Liability Directive — enhancing sustainable insurance solutions*, Confederation of European Insurers (http://www.insuranceeurope.eu/uploads/Modules/Publications/environmental-liability-report.pdf) accessed 30 May 2012.

CEA, 2009, *Navigating the Environmental Liability Directive — A practical guide for insurance underwriters and claims handlers*, Confederation of European Insurers (http://www.insuranceeurope.eu/uploads/Modules/Publications/1240585425_eld-best-practice-guide-update.pdf) accessed 30 May 2012.

Cornell University Law School, 2010, 'Workers' Compensation' (http://topics.law.cornell.edu/wex/workers_compensation) accessed 4 June 2010.

Cone, C., 2005, *Silent Snow*, Grove Press, New York.

Costanza, R. and Perrings, C., 1990, 'A Flexible Assurance Bonding System for Improved Environmental Management', *Ecological Economics*, (2) 57–75.

Costanza, R., Batker, D., Day, J., Feagin, R.A., Martinez, M.L. and Roman, J., 2010, 'The perfect spill: solutions for averting the next Deepwater Horizon', *Solutions*, June 2010 (http://www.thesolutionsjournal.com/node/629).

Cranor, C.F., 1993, *Regulating toxic substances: a philosophy of science and the law*, Oxford University Press, New York.

Cranor, C.F., 2006, *Toxic torts: Science, Law, and the Possibility of Justice*, Cambridge University Press.

Cranor, C.F., 2007, 'A framework of assessing scientific arguments: gaps, relevance and integrated evidence', *Journal of Law and Policy*, 15:7–57.

Cranor, C.F., 2008a, '(Almost) equal protection for genetically susceptible subpopulations: a hybrid regulatory-compensation proposal', in: Marchant, G. (ed.), *Genomics and Environmental Policy*, Johns Hopkins University Press, Baltimore, MD, pp. 267–289.

Cranor, C., 2008b, 'The dual legacy of *Daubert v. Merrell-Dow Pharmaceutical, Inc.*: trading junk science for insidious science', in: Wagner, W. and Steinzor, R. (eds), *Rescuing science from politics: regulation and the distortion of scientific research*, Cambridge University Press, New York, pp. 130–142.

Cranor, C.F., 2011, *Legally Poisoned: How the Law Puts Us at Risk from Toxicants*, Harvard University Press, Cambridge, MA.

CSRLD, 2010, 'The Compensation Scheme for Radiation Linked Diseases, scheme history' (http://www.csrld.org.uk/html/scheme_history.php) accessed 30 May 2012.

Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579 (1993).

Davis, K. C., 1972, *Administrative Law Text*, West Publishing Co., St. Paul, Minnesota.

EBTP, 2009, 'European Business Test Panel consultations 2009' (http://ec.europa.eu/yourvoice/ebtp/consultations/2009_en.htm) accessed 30 May 2012.

EC, 2008, *Financial security in Environmental Liability Directive —* final *report*, August 2008, European Commission, Brussels (http://ec.europa.eu/environment/legal/liability/pdf/eld_report.pdf) accessed 30 May 2012.

EC, 2009, *Study on the implementation and effectiveness of the Environmental Liability Directive (ELD) and related financial security issues — final report*, November 2009, European Commission, Brussels (http://ec.europa.eu/environment/legal/liability/pdf/

ELD%20Study%20November%202009.pdf) accessed 30 May 2012.

EC, 2010, *Report from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions under Article 14(2) of Directive 2004/35/CE on the environmental liability with regard to the prevention and remedying of environmental damage*, European Commission, Brussels, 12.10.2010 COM(2010) 581 final.

EEA, 2001, *Late lessons from early warnings: the precautionary principle 1896–2000*, Environmental issue report No 22, European Environment Agency.

EU, 1992, Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22.7.1992, p. 7.

EU, 2006, Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, December 18, 2006, no. 1907/2006 (UK) (hereafter, REACH).

EU, 2009, Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (codified version), OJ L 20/7, 26.1.2010.

Feinberg, K., 2004, *Final Report of the Special Master of the September 11 Victim Compensation Fund* (http://www.justice.gov/final_report.pdf) accessed 31 May 2012.

FERMA, 2010, *Survey on Environmental Liability Directive Report*, Federation of European Risk Management Associations.

Franklin, M.A., 1979. *Injuries and remedies: cases and materials on tort law and alternatives*, The Foundation Press, Inc, Mineola, NY.

Friedman, F., 1985, *History of American Law*, Touchstone, New York.

General Electric v. Joiner, 1997, 522 U.S. 136.

Gillette C.P. and Krier, J. E., 1999, 'Risk, courts and agencies', *University of Pennsylvania Law Review*, vol. 38, pp. 1077–1209.

Guth, J., 2009, 'Law for the ecological age', *Vermont Journal of Environmental*, vol. 9, pp. 431–512 (www.vjel.org/journal/pdf/VJEL10068.pdf) accessed 29 May 2012.

HLR, 2011, 'Corporate law — securities regulation — Congress expands incentives for whistleblowers to report suspected violations to the SEC', *Harvard Law Review* Vol. 124, pp. 1 829–1 836 (http://www.harvardlawreview.org/media/pdf/vol124_recentlegislation05152011.pdf) accessed 30 May 2012.

Henderson, J. A., Jr., 1981, 'Review: rhe New Zealand Accident Compensation Reform', *The University of Chicago Law Review*, (48) 781–801.

Honore, T., 1995, 'The morality of tort law — questions and answers', in: *The Philosophical Foundations of Tort Law*, Clarendon Press, Oxford.

House of Commons, 2009, *Whistleblowing: 'The Public Interest Disclosure Act of 1998*, House of Commons Library

Kaplan, E., 2001, 'The international emergency of legal protections for whistleblowers', *The Journal of Public Inquiry*, Fall/Winter 2001, pp. 37–-45.

Kumho Tire v. Firestone, 1999, 526 U.S. 137.

Leigh, W. J. and Wakeford, R., 2001. 'Radiation litigation and the nuclear industry — the experience in the united kingdom', *Health Physics, (*81) 646–664.

Lyndon, M. L. 'the toxicity of low-dose chemical exposures: a status report and a proposal,' book review of legally poisoned: how the law puts us at risk from toxicants, *Jurimeterics: Journal of Law, Science and Technology*, (52) 457–500.

Markowitz, G. and Rosner, D., 2002, *Deceit and denial: the deadly politics of industrial pollution*, University of California Press, Berkeley.

McIntyre, O., 2004, 'Liability for asbestos-related illness: redefining the rules on 'toxic torts', *Judicial Studies Institute Journal, (*180).

Mercer, J., 2010, *In Praise of Dissent* , Ode , 1 August, http://odewire.com/50372/in-praise-of-dissent.html

Merrell Dow Pharmaceuticals Inc. v. Havner, 1997, 953 S.W.2d 706 at 718 (Supreme Court of Texas).

Miller, C., 2002, 'Judicial approaches to contested causation: Fairchild v. Glenhaven Funeral Services in context', 1 *Law, Probability and Risk*, 119–139.

Milward v. Acuity Specialty Products, Inc., 2011, 639 F.3d 11 (First Circuit Court of Appeals).

Morgan, A., 2002, 'Inference, principle and the proof of causation', *NLJ*, 12 July 2002.

National Research Council, 2002, *Environmental effects of transgenic plants: the scope and adequacy of regulation*, National Academy Press, Washington, D.C.

Prosser, W. and Keeton, P., 1984, *On the law of torts*, 5th ed., West Publishing Co., St. Paul, Minn.

Priest, G.L., 2003, 'The Problematic Structure of the September 11th Victim Compensation Fund', *DePaul Law Review*, (53) 527–545.

Saks, M. J., 2000, 'Do we really know anything about the behavior of the tort litigation system – and why not?, *Pennsylvania Law Review*, (140) 1 147–1 289.

Schuck, P. H., 2008, 'Tort reform kiwi-style', *Yale Law and Policy Review*, (27) 187–203.

Sindell v. Abbott Laboratories, 1980. 26 Cal. 3d 588, 607 P. 2d 924.

Stevens v. Secretary of Health and Human Services, 2001, WL 387418 (Fed. CI).

Summers v. Tice, 1948, 33 Cal. 2d 80,109 P.2d 1.

Sunstein, C., 2005, Why Societies need Dissent, Harvard University Press.

UCS, 2012, *Heads they win, tails we lose — How corporations corrupt science at the nation's expense*, Scientific Integrity Program of the Union of Concerned Scientists.

US Department of Justice, 'Vaccine Injury Compensation Program' (http://www.justice.gov/civil/common/vicp.html) accessed 30 May 2012.

USHRSA, 2010, 'US Department of Health and Human Services, Health Resources and Services Administration, National Vaccine Injury Compensation Program', (http://www.hrsa.gov/vaccinecompensation/index.html) accessed 30 May 2012.

Wigle, D. T. and Lanphear, B. P., 2005, 'Human health risks from low-level environmental exposures: no apparent safety thresholds', *PLoS Medicine,* (2) 1–3.

Woolley, D., Pugh-Smith, J., Langham, R and Upton, W. (eds), 2000, *Environmental Law*, Oxford University Press.

WTO, 2008, *'United States-Continued Suspension of Obligations in the EC-Hormones Dispute', Appellate Body, p 27, para 65,* World Trade Organization, WT/DS320/AB/R, 16 October.