

Epilogue: Science, Technology, and Risk

Physicists generally investigate nature for the sheer enjoyment of learning. While it is rewarding when discoveries lead to tools for archeologists, medical diagnostic procedures, techniques to aid criminologists, and laser cash registers, these technologies have not generally been the motivations for their research. What motivates and guides basic research is a desire to build more comprehensive models of nature. Yet applications do evolve, regardless of the motivations of the discoverers. Our dual nature as explorers of nature and shapers of the landscape is undeniable. One activity is science; the other, technology.

Today, one of the most controversial technologies is the use of nuclear fission to generate electricity. What began as accidental discoveries, first by Becquerel and later by Fermi, has become an issue that spawns strong emotions. The arguments are not about scientific knowledge; they are about how science should be applied to our current energy dilemma. The question is no longer one of basic science, but rather a discussion of philosophies, of beliefs, and of social concerns.

The debate currently centers on the risks and benefits of nuclear power generation. Benefits include abundant energy, increased economic stability, anticipated growth in the quality of life and decreased chemical pollution. Risks include the introduction of significant amounts of radiation and radioactive waste products into our environment and the increased probability of severe nuclear accidents or sabotage. The unanswered—and perhaps unanswerable—question is whether the benefits outweigh the risks.

Every action we take involves weighing the benefits against the risks. Every time we cross a street, we run a risk of being struck by a car. By exercising proper caution, we can minimize that risk. The risk is relatively small; the benefit gained from freedom of movement is large. So we cross the street without thinking much about the risk involved.

Other situations involve more complex risk-benefit analyses. For example, our study of Newton's first law showed that the use of automobile seat belts is well founded in physical principles. The risk of not wearing one is a

crippling or possibly fatal injury. The benefits of not using seat belts are the saving of a few seconds in buckling and unbuckling, a slight increase in the freedom of movement inside a car, and some psychological or emotional benefits that are difficult to define. The benefits and the belief that the probability of an accident is small convince most people to sit on top of their seat belts.

When individuals decide that the benefits of not using seat belts outweigh the risks, they are, for the most part, accepting a risk for themselves. Should an accident occur, they will receive the injuries. The rest of society is "injured" by having to share hospital and medical costs through increased insurance premiums and taxes. However, the societal injury is small compared to the individual's injury or loss of life.

As technology has advanced, the nature of the risks involved has changed. The pilots of commercial airliners realize that their actions can affect not only themselves, but hundreds of other people. The risk from an untrained airplane pilot is far greater than that from an untrained automobile driver. Risks from nuclear power plants are substantially greater than from coal-burning plants. An accident in a coal plant (or coal mine supplying it) can injure or kill hundreds. However, a nuclear power accident could affect millions and render huge areas of land uninhabitable.

Further, nuclear accidents introduce a new dimension—time—into the risk-benefit picture. The crash of an airplane produces problems that linger for only a few. The meltdown of a nuclear reactor could leave a radiation trail extending hundreds of years into the future. A single accident could affect our children, grandchildren, perhaps even our great-grandchildren, in addition to ourselves. Thus, the risk extends over time and space in a way that most other risks do not.

Who decides to assume the risks associated with a nuclear power plant? Is it the stockholders who decide to build it? Or should it be the regulatory agency charged with protecting society at large? Certainly the local residents who will shoulder a larger-than-average part of the risk need to be consulted. How about the coal miners and oil refinery workers who will be put out of work as nuclear fuels replace conventional fossil fuels? Cost-benefit analyses become increasingly complex as more people become involved, as technology becomes more complex, and as the decisions we make spread so far over space and time.

The risks from nuclear power are high, so the precautions must be great. If we can minimize the risks sufficiently, we can enjoy the benefits. Advocates of widespread implementation of nuclear power plants believe that the risks have already been minimized adequately—or can be soon. Opponents feel the risks are still too great. Some feel the risks will always be too great.

What is the role of science in all this? Scientific knowledge was used to develop the technology and, to a large extent, scientific knowledge can assist us in making the risk-benefit comparisons. Scientists can try to provide as much information as possible about the risks and benefits of nuclear power, and they can analyze this information statistically. As caring members of society, they share in the dilemma we face. But scientists cannot decide for society as a whole whether the risks are acceptable—that is a question of values. Knowledge brings us so far—we must take the last step ourselves.