Science, Terrorism, and Natural Disasters

Since the September 11 terror attacks, scientists and the policy community have focused on ways in which science might be applied toward reducing the risks or consequences of future attacks. The U.S. National Academy of Sciences has appointed a committee under the co-chairmanship of Lewis Branscomb and Richard Klausner to explore the vulnerability of the United States and other Western nations. The committee will do well to consider how mitigating threats from terrorism could also serve to reduce the consequences of natural hazards, for the two are linked in some unexpected ways.

Other efforts have explored vulnerability in less alarming contexts, and there is much to be learned from them. Modern industrial societies, because they are complex arrangements optimized for efficiency, tend to be quite resistant to random failure; but careful studies of various networks, including subsystems of our own efficient industrial economy, reveal a troublesome feature. The Internet exemplifies the pattern: It consists of multiple nodes that interact through links. Some nodes are highly connected to other nodes; some are linked to only a few. The organization is scale-free, because added nodes connect preferentially to others that are already well connected. Such networks are robust with respect to random failure. But they are highly vulnerable to targeted disruption of the most highly connected nodes. Terrorists rely on knowing where these vulnerabilities lie.

Mitigating terrorism threats could also reduce the consequences of natural disasters.

Like these creations of modern societies, genomes are highly buffered in ways that protect cell function against random mutation. But mutations in the few genes encoding proteins that play critical nodal roles in metabolism or structure are likely to be lethal. Mutation can't pick these genes out; unlike terrorists, who look for the weak spots in social infrastructures. We tend to assume that natural disasters attack targets randomly, just as mutations do.

But the way we have arranged our society geographically has distributed its potential targets nonrandomly with respect to natural hazards. In a conference called "Crowding the Rim" at Stanford University last summer, geologists, disaster mitigation and relief experts, and others assessed the consequences of earthquakes, tsunamis, extreme weather events, volcanic eruptions, and other natural occurrences. An extraordinary array of transportation, communication, and economic nodes occupies the "ring of fire"—that is, the Pacific Rim, from Lima through Los Angeles, Seattle, Anchorage, Tokyo, and Taipei. These nodes, rapidly growing along with the human population of the Rim, lie on a map that features high seismic and volcanic activity, along with coastal mountains that are vulnerable to landslides and the heavy precipitation that causes them.

The consequences of a major event in this area have been foreshadowed by recent occurrences. The 1999 earthquake in Taiwan was not only costly in terms of life and property there, it disrupted economies as distant as San Jose, California, where electronic industries stalled for lack of the components made in that country. The linkages we have built to connect the U.S. West Coast and Asia are all vulnerable to "echo" disruption of this kind, and much larger and more devastating earthquakes are in prospect for Seattle and San Francisco.

Because our societies have been made vulnerable both to natural disasters and to human attack, we can obtain a double dividend from successful planning; but prevention alone will not accomplish both ends. Terror attacks can be predicted and prevented or turned aside if we can apply our science effectively. Natural disasters, even where we can identify likely targets, as along the Rim, can be predicted only statistically and not prevented at all. Solutions that will work for earthquakes and extreme weather events must therefore be focused on redesign and/or recovery. Redesign would require retrofitting society to create a more diffuse and distributed infrastructure. Recovery, which is more doable, entails plans for relief, development of redundant and backup systems, and incorporation of disaster resistance into the design of new installations.

Science can play a role in helping with prevention and mitigation as well as recovery and repair. It will make its greatest contribution if we consider our vulnerability to terror attacks and to natural disasters jointly rather than separately. Because our social and economic arrangements have made us vulnerable to both, we can gain from working on them together with a program that involves the social sciences as deeply and as actively as the natural sciences.

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