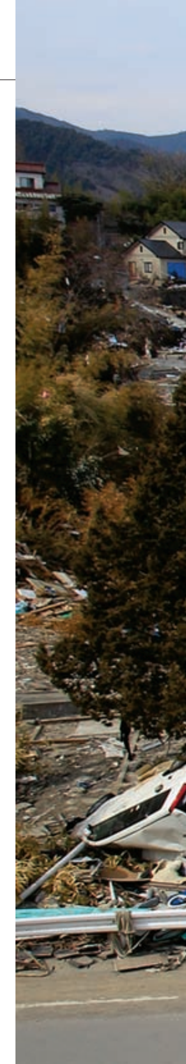

BRIEFING BOOK

Earthquake Readings

We ask Rochester experts to share some reflections and background on the March earthquake in Japan.

By Kathleen McGarvey

Radiation Risks?

A research professor in the Department of Radiation Oncology, **Jacqueline Williams** is the principal investigator of the University's Center for Medical Countermeasures against Radiation.

The most fundamental effect of radiation is that it kills cells. Ionizing radiation has enough energy that when it comes into contact with an atom, it can remove an electron from its orbit, forming an ion. If that ion is in the DNA, you now have damaged DNA. If too many atoms within the DNA have been damaged, the cell will die. If only a few atoms have been damaged, then the cell can repair itself. In between—with damaged DNA that isn't fully repaired but isn't sufficient to kill the cell—you have a mutated cell. And if that mutation is in a tumor suppressor gene or an oncogene, then that cell can become a cancer cell. There's a huge spectrum there of damage.

The most sensitive organ in the body is the bone marrow, although over time, other organs like the kidneys and lungs will show effects of radiation. Among survivors of the atomic bombs in Japan, the earliest major effect was that a lot of people developed leukemia—that was from DNA mutations in their bone marrow. In the 50-plus years since, we've also seen increases in lung and kidney diseases. Interestingly, the biggest increase is in heart disease and stroke. This is probably because of the sensitivity of the cells lining the blood vessels. There are still many unanswered questions about radiation. A hundred years plus since we first realized what radiation is, we're still arguing about how much radiation it takes to cause a cancer. And we still don't have any drugs that will prevent the later diseases.

We're being bombarded by radiation all the time—from the sun, from the ground. You eat it. If you are a smoker, or you live with a smoker, you're further exposed—one of the highest sources of radiation to a person who doesn't work with radiation is cigarettes. Radioactive material in tobacco leaves is inhaled by smokers when they draw on a cigarette or by nonsmokers when they inhale secondhand smoke, and that radiation builds up in the body. Therefore when considering the risks from radiation from events such as Fukushima, you need to understand how much you are normally exposed to.

The hazards posed by radioactive materials vary according to the types of radiation they release. Some radioactive contaminants only release electrons; others release alpha particles. Plutonium is mostly an alpha particle emitter, and an alpha emitter is really bad—but only close up. Plutonium is only a danger if you eat it, breathe it in, or inject it into your bloodstream. Other radioactive isotopes release gamma or x-rays. And this is the problem when we're told that the water near the Japanese reactors is contaminated. We need to know, what with? You can't just say it's radioactive because radioactivity takes different forms—and how dangerous it is depends on the form.

The mantra with radiation is, the farther away you are from the source, the less radiation you get. They've been really good in Japan. I cannot believe that in the midst of the chaos caused by an earthquake and tsunami they managed to get the population to go back 12 miles and then to move farther back a week or so later. The 50 people who stayed behind at the plant, they're heroes.

Economic Effects?

Mark Zupan, dean of the Simon School, is a professor of economics and public policy.

We've discovered that nuclear power is less safe than we thought it was. This hasn't been the case near term, but it's going to put upward pressure on energy costs. We're seeing China, Japan, and other countries rethink to what extent they can rely on nuclear power. So it'll drive up natural gas and petroleum costs. It may not be bad because it will spur a greater search for substitutes over the long haul, but we'll feel it at the pump in the interim.

What's been holding down prices is just decreased demand right now from Japan. Once they start rebuilding and gear up automobile production and other industries, that will change.

The Japanese have been leaders in single-sourcing, "just in time" systems. You get better production, you develop stronger relationships, you take inventory out of the system—but the downside is when you have a major event like this, it can really throw a wrench into the works. How do we rethink the supply-chain side, organizing production? How do companies in other earthquake-prone areas, whether it's New Zealand or California, have to restructure their sourcing? It'll be interesting to see how it plays out.

We have about 150 Simon alumni in Japan. All are safe, thankfully. The number two person at Prudential Insurance is a Simon alumnus, and they have major operations in Sendai. They reported that the Monday after the earthquake, 70 percent of the people were back to work—so even in the most hard hit areas, the resiliency was pretty impressive.

The quake hit a pretty broad swath of the Japanese economy. You can point to fishing and tourism as areas that are particularly affected, but otherwise it seems to be a pretty wide variety of operations in the earthquake area.

The effect on the world economy will be fairly minor in the grand scheme of things. Japan is the third largest economy, and there will be less demand for American products coming from Japan in the short term. But most important, it's a horrible human tragedy.

Geological Guidance?

Cindy Ebinger is a professor of geophysics and editor of *Geophysical Journal International*. Her research focuses on geological hazards along continental margins, espe-

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cially earthquakes and volcanic activity.

Japan has invested heavily in infrastructure and hazard mitigation. Over the past 20 years, Japan installed GPS sensors every 5 to 10 kilometers. We're using real-time data, telemetered from these kinds of instruments—GPS, seismometers—to understand and better predict earthquakes. We generally are able to predict what will happen during an earthquake of a particular magnitude and whether a tsunami will be generated, but what happens afterward depends on the way that the rocks deep down in the earth respond to the forces, and we can't replicate that in laboratories.

The destruction created by the Japanese earthquake and the resulting tsunami, despite all the precautions the Japanese people took, is a massive wake-up call for the United States. We haven't had a major tsunami on the West Coast in historic memory—that's obviously a good thing, but it's also a problem, in the sense that we don't think of it as a possibility. We don't have the building codes that Japan has, we don't have the earthquake and tsunami education, and we don't have the density of observation devices.

▲ **RECOVERY: As Japan, which has invested heavily in earthquake readiness, recovers, its experience offers lessons to other countries, say Rochester experts.**

In the global seismological community, we've been encouraged to act as a team, to work across political boundaries, and we've been doing that for 30 years now. But further collaboration and expansion of global networks seems essential, and the expansion needs to engage developing countries as equal partners, wherever possible. Those most at risk, the most vulnerable, live in developing countries.

To make progress in understanding earthquakes, it's going to take teams of collaborative research across disciplines. For example, we'll need collaborative studies to understand the physical processes that are happening in the locked fault zones between two plates. The plate slipping beneath Japan is carrying down sediments that have a lot of fluids in them. As they move deeper, they heat up and release water, causing chemical reactions in the surrounding rocks. The exchanges may facilitate or impede earthquakes, depending on the reactions and the rocks involved.

In just the past five years, we've documented a new kind of earthquake—it's not a short, sharp earthquake, but a slower earthquake called "slow slip." And we discovered it because of the development and regular use of broadband seismometers. Before, we could only detect a strong motion—we'd see the "short sharp," a peak, but we didn't realize there were these longer period slips going on. They're equally important for the release of energy and earthquake predictions, but their detection required better instrumentation and new methods.

We're discovering new phenomena all the time, and it's because of the increasingly global nature of these instruments and our ability to telemeter information that we're able to then correlate it to surface processes in real time.

We will learn a huge amount over the next 20 years about what and why and how the earth responds.

Earth's processes are slow, and we haven't seen all that can happen. Ⓡ