



CENTER FOR RENEWABLE ENERGY EDUCATION AND DEMONSTRATION (CREED) PROJECT

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of Minnesota.

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THE FUKUSHIMA STORY

AS RELATED BY NUCLEAR PHYSICIST, JIMMY MCNAUGHTON

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INTRODUCTORY NOTE BY ROGER AIKEN OF THE CREED PROJECT:

I am repeatedly amazed how God predetermines the encounters that take place between people. Some people would call it chance but I prefer to think of it as designed by the Almighty for the purpose of helping us in our understanding of events which we can then pass on to others. Last summer my wife and I were visiting our daughter who currently lives in Vienna, Austria. While there we took a side trip down to a town called Güssing in the southeast corner of the country.

Our purpose in making this trip was to visit the European Centre for Renewable Energy in ökoEnergieland. In 1990 the local authority of Güssing made a decision, which was probably the most important decision in the history of the town: 100% reduction of fossil fuel use! This led to Güssing becoming the European Center of Renewable Energy.

On the bus trip back from Güssing to Vienna, I met a nuclear physicist, Jimmy McNaughton. After exchanging pleasantries, we proceeded into a serious discussion during which he asked me about the rationale for the development and education of people regarding renewable energy resources and I asked him about his work in nuclear physics and specifically what he knew about the fallout from the nuclear disaster that had taken place at Fukushima Dai Ichi in Japan. What follows is his account of the events leading up to, during and after the catastrophic earthquake and tsunami that riveted the attention of the whole world with horror.

With respect to our work here in Minnesota with the CREED Project, Jimmy was kind enough to say that he supports it wholeheartedly - both from an experience in Austria 30 years ago and from his recent ones in Japan.

He said he had read the main texts of both my e-mails, but not yet the attachment, which describes the rationale behind development of renewable energy sources, but "I think I reach the same conclusions anyway. And I am much in favor of what your organization is doing."

He said the Japanese government really needs these things urgently, and he hoped that our organization would be helping them, and that the Japanese government would be open-minded enough to accept help from us.

THE STORY STARTS IN AUSTRIA:

Let me go to the beginning of the story. When I went into nuclear physics it was for the purpose of learning more physics at a very basic level, not really thinking about the possible applications of it. And I was very busy with the challenge of understanding the basic physics of it as well as I could, as well as other basic knowledge of physics that I should acquire. (E.g. electromagnetism is not really nuclear physics, but one should have some minimal understanding of the basic principles of that too.)

Then in 1978 the Austrian chancellor decided to build the first nuclear power plant in Austria, and after it was finished, he held a public referendum on whether or not it should be turned on. (Maybe not the ideal sequence of events, but better than that in other countries, e.g. Japan, the way things turned out.)

At first I did not think much about it because I was not eligible to vote in Austria. But then some people in that very small town in Austria asked me my opinion, realizing correctly that I knew much more about those issues than they did. So then I had to think about the question myself as to whether nuclear power plants were a good idea or not. I guess I had already been hearing something about the arguments pro and con, although I had not yet formed my own opinion.

I advised them to vote against turning on the nuclear power plant even though its construction had been finished. And I had come up with 2 important reasons for that.

First, many from the pro-nuclear power plant lobby had written computer programs proving they were "safe". But, I had my suspicions about that: if some of the input assumptions to those computer programs would turn out to be wrong, and one should not really trust them, then the probability of a serious accident could be much higher than those computer programs predicted, and the consequences of what might then happen could be serious indeed.

In Austria the outcome of the referendum was what I recommended, so the Austrian nuclear power plant was not turned on, and no more of them were ever built in Austria. And today public opinion in Austria against nuclear power is currently much stronger than it was in those days.

But other countries did the experiment of building nuclear power plants to do the experiment of finding out what the errors were in those computer programs predicting an extremely low probability of a serious accident at a nuclear power plant. And indeed in the United States, the Ukraine, and Japan a great deal has been learned about that - Three Mile Island, Chernobyl, Fukushima. (I know some of the details about that, but not all of them.)

There was a second reason also to vote "no" in that 1978 referendum in Austria - nuclear power plants produce waste which will be dangerous for thousands in years, and no one really knows what is going to happen after thousands of years, so better not to produce it in the first place.

So much for that.

But, as a consequence of the outcome of that 1978 referendum in Austria, (where I helped to get what I consider to be the correct outcome), Austria has now become a world leader in renewable energy. Because they also have realized that when refusing to go into nuclear power (a good idea), one should NOT just switch to fossil fuels.

About 10 years ago I heard from the mayor of Stockerau, the city where I live in Austria, that even that town is supporting renewable energy (in this case wind energy) in a big way. I was very happy about that. Now this time I met the new mayor of Stockerau and was able to tell him that due to my Fukushima experiences in Japan I could give him even more support for renewable energy at the local town level.

So much for the Austrian side of the story. (What I am doing is basic research - I am not working on these things myself.)

THE STORY CONTINUES IN JAPAN - FIRST THE POLITICAL BACKGROUND:

On March 11, 2011 at 14:50 I was visiting an accelerator at Tokai Mura, which was built in the same complex as a nuclear power plant. It took us nearly 24 hours to get home after the earthquake, and during that time I was concentrating on getting home again (a 50 km trip), and not on any other issues. In fact at this point we were listening to the radio (in Japanese of course - but the real decision makers were all Japanese - many of whom spoke English and it was also no problem for me to communicate in Japanese with those who did not - however for me to understand by myself everything which was said on the radio in Japanese was not entirely successful). The reports about what was happening in our province were mostly rather minor, although a few people were killed by the earthquake in our province too - the real things going on, as we knew must be the case, were happening in the provinces to the north of us. At this point in time we knew almost nothing about what was going on there.

First I have to make some comments on the current Japanese political situation - because what happened with the Fukushima nuclear disaster after the earthquake is very much connected with this.

For about 50 years after the 1950's there was a single Japanese controlled political party - the LDP in English, or Liberal Democratic Party. This means that essentially all political struggles in Japan were taking place inside the LDP, and most of what was really going on in those terms was essentially all hidden from public view - with various factions inside the party struggling with other factions. I remember reading newspaper accounts about who the leaders of the various factions were, and that was about all that the general public knew about what was really going on. It had in common with communist systems that almost everything of political consequence was taking place within a single ruling party, but it differed from the communist system that elections were real, and that it was theoretically possible that the LDP could lose.

When a single party stays in power so long, there is a general feeling that this gives rise to certain problems. I do not have the complete list of them at my fingertips, but one thing that struck me about that situation was the cozy relationship between the bureaucrats inside the government (it was the bureaucrats who really ran the government - not the politicians) and industrial magnates who wanted the government to pay large prices for very costly public works projects that might not have been really needed (e.g. these magnates were high up in the management of large construction firms), and that is one principal reason why the current Japanese national debt is so large. This is likely a kind of corruption that arises during such a long-term single party rule. The relationship between the government bureaucrats and these industrial magnates was all too cozy. There is the term "descent from heaven" when these government bureaucrats get very lucrative industrial positions once they retire - which makes the industry-government relationship all that much more cozy.

Then, something like 15 years ago, people started to get tired of such a long-term dominance of the LDP. And, for a short time, the unthinkable happened - the LDP lost an election, and the opposition came into power for a short time. But, then the new government quickly fell apart, and the LDP came back. But, the feeling of unease about the long-term dominance of the LDP in Japan continued.

Around 2000 this feeling of general uneasiness led to support for someone calling for reform within the LDP - Koizumi. He managed to come to power and stay there for about 5 years just by talking about reform - repeating over and over that he was going to do it - but in fact what he actually did in terms of real reform was very little.

It is unclear how long this charade could have continued, but after about 5 years of this, Koizumi retired. He was followed by two LDP Prime Ministers both of whom quite quickly became deeply unpopular - Abe and Aso. After the second one of these two, the opposition won again - this time to stay in power longer than 15 years ago. (Just how long that will be remains to be seen.) What seems to be happening is that this shock of losing power for a longer period of time is NOT causing the LDP to finally implement some real reforms, and however disappointed the Japanese are becoming with the opposition now that they have come to power, they do not seem to want the

LDP to return to power again.

The first opposition prime minister in this period was Hatoyama. He was greeted by high hopes, and he really did set up reform commissions who really did try to change things in a reasonable way (e.g. to try for politicians to obtain some control over the bureaucrats), to investigate many government-supported projects to see if they really made sense or not and to cut back on or eliminate those which did not, etc. This was in a situation where under the long LDP reign some things had gotten more or less out of control. But, Hatoyama tripped up finally over the question of the US armed forces base in Okinawa. (Japan has some dangerous neighbors - the worst of which is North Korea, but China too is not always so reasonable.) And after a few months of that, he resigned. The resignation of a Japanese prime minister is not such big a deal as the resigning of a US president is. In Japan there is a tradition that they quite often do it. When it happens in Japan, since it is a party who is elected, not a person, then the resigning prime minister is just replaced by another leading member of the same party. After Hatoyama within a year or two this has happened two or three more times. I do not even remember the names of all of them. In terms of real stumbling block issues after the US military base in Okinawa issue, which still has not been really resolved, there is the scandal in the main opposition party around Ozawa. There are rumors that he got his hand caught in the cookie jar, in terms of industrial magnates in Iwate province giving his party large contributions in exchange for his seeing to it that they received lucrative construction contracts. (This was a specialty of the LDP, but it is a leading member of the opposition party who seems to have been caught nearly red-handed in it - it remains to be seen if he will be sent to prison for it or not.)

What all this meant is that when the massive earthquake happened, the prime minister at the time, Kan (of the opposition party), was in quite a weak political position. And of course he was totally unprepared to deal with a massive nuclear disaster like Fukushima. On the other hand Fukushima, after it happened, was going to go all the way up to the prime minister's office, and dealing with it was going to become his number one priority. E.g. he was the one who would have to decide when to start pumping in sea water to the stricken nuclear plants, which, once done, would make it impossible for them to operate normally again. A prime minister is not generally capable of making such decisions. Especially when they must be made really fast, at a time when a large fraction of the country has just undergone a major disaster.

There is one more aspect of the background to the massive earthquake and subsequent nuclear disaster: that concerns one aspect of Japanese culture: namely for centuries the Japanese have been masters of the art of concealment. In general in Japan you never know what is really going on. This is something those US officials in charge of negotiating trade agreements with Japan are going to become aware of in some detail. Many things in the agreement which one thinks have been really nailed down in reality are not really going to happen. And as to what is going on behind the scenes, that is something that in general you just do not know.

So, with this description of the political situation in Japan at the time of the massive earthquake, and the Japanese expertise in the art of concealment having been mentioned, this is the time to resume the comments on the situation during and just after the earthquake.

THE DAY OF THE EARTHQUAKE – FROM ZERO TO ZERO PLUS 40 MINUTES:

First let me say, that on the afternoon of March 11 a small group of us, 3 Indian physicists, a senior Japanese physicist from our lab and myself were visiting a J-PARC lab at Tokai Mura, where they have a quite new accelerator - aiming mostly for neutrino physics. They also have a nuclear power plant in the same installation. It was at Tokai Mura that they had one of the first nuclear reactors in Japan, if not the very first one. It is about 50 km from our lab, and it is only one km from the coast. This is the first time I had been to J-PARC. I had somehow missed out on earlier opportunities to go there.

I skip the description of the first 90 minutes or so of our visit there. At 14:50 the earthquake started. In Japan we have a noticeable one about once a month, so it seemed just routine at first. But then it started really shaking very strongly - I have been through many earthquakes, but this

was the first one like that for me. I forgot to time just how long it lasted - I think it was about 2 minutes, but obviously much longer than most of them do. About 2/3 of the way through it, the lights went out. We were visiting the hadronic experimental hall and looking down on it from a balcony. Our local Japanese physicist guide, (there were 2 of them) just stayed where he was, clinging to the railing of the balcony (no real challenge there), and so did I. The Indians had edged closer to the entrance to the building (the "common wisdom" is not to leave a building during an earthquake as if it is major, the process of going out of the building is more dangerous than staying inside). Then it was over - but it was obvious that it had been major - not like the many less serious ones we had been through. Very happy of course that the building had not caved in. We had been thoroughly shaken. Nothing obviously broken in the immediate environment, but we were not in the mood to look carefully at that. We had something else on our mind. It is well known that after what seems like a major quake, (which very fortunately is the exception, not the rule) if you are not trapped inside a demolished building, and if there is not something immediately obviously wrong, there are basically 2 things on your mind: fire, and tsunami if you are near the coast. When you are at a big lab, if there is a danger of fire, you are going to find out about it.

So, within a few seconds one of our Japanese physicist guides had turned on a nearby portable radio. These are well in stock at big labs in Japan, as disasters are expected, and when they occur, the electricity may well go off. It was in Japanese, which is not so easy for me to pick up all the details. But it was no problem for him. And within a couple of minutes he told us that there would be a tsunami, it would arrive in our area in 40 min. and would be about 6 meters high near us. (The Japanese are very well organized about these things.) I asked him where the epicenter had been, and he said "Sendai". (I know very well where that is, as I had lived there for 15 months about 20 years ago.) That is 250 km. north of where we were, so I knew it must have been really massive, (9.0) considering how strong it had been 250 km away. (By a couple of days later I also found out the epicenter had been 100 km offshore.)

We did not yet know, but our guides must have, that we were high enough, despite being only 1 km from the coast, that the tsunami was not putting us directly in danger. When nothing special happened about 40 min. later, we were sure of it.

There is a joke too, if one is in the mood for that with such a serious subject.

One of the young Indian physicists with us had never seen the ocean, and asked in advance of our visit if he could spend that night at that lab, and the next morning try to find a way to get to the ocean quickly before going back to our lab by himself. Realizing that for these people to travel around Japan by themselves if they do not speak Japanese is difficult, I had not been very enthusiastic about it. I had given him a few tips just in case, but he had not pushed it too much. Our plans had been to take the bus back to our lab around 6 PM that evening, and we would have been home around 7:30 that evening. (I speak Japanese well enough that travel for me in Japan is no problem - in fact when I am travelling in Japan, I am helping the Japanese find their way around more often than the reverse.)

So, we joked with him after the earthquake that he had caused the earthquake so that he could spend the night at the lab. But we advised him not to go to the beach even if he could, because with all those aftershocks there might be another tsunami. With the really big tsunami, there had been a few people who had been curious to see it - if they did, it was a serious case of "curiosity killed the cat".) This is intended to be just a joke, and everybody knew that. Normally we have an earthquake once a month or so. In the weeks and months after March 11, it would be about once a day. In the first night, it would be about once an hour.

THE DAY OF THE EARTHQUAKE – LATER IN THE DAY:

After the earthquake the rest of that afternoon was actually quite a quiet time. But, around late afternoon - early evening it was decided that the time had not yet come for our return 50 km bus trip home, and we realized that we were going to become refugees for a while. Ever since the time of the earthquake the emergency staff of the J-PARC lab had been doing an excellent job of taking care of us. Natural disasters are so common in Japan that a lot of effort goes into to planning for

them, as it is well known that they are going to happen. (But there is no tradition in Japan in dealing with nuclear disasters.) Just to list some of them: earthquakes, typhoons, floods, landslides, volcanoes. I guess those are the main ones. But, as the bus decided not to start out at the end of the afternoon, that is when we realized that we were likely going to be spending the night sleeping on the floor of the hostel of the lobby of the hostel at J-PARC.

We were a group of about 30 physicists, many Japanese, but some foreigners too. When one knows 10-11 languages as I do, and live outside the United States, it is likely that languages are going to be quite a big part of your life. And, in the post-quake part of that afternoon, having not much else to do, I had been speaking various languages with various foreigners, Japanese with the Japanese, especially those Japanese who did not speak English.

It was in that context that later that evening I heard one of them speaking German, so I went over to him, being curious about that. Turned out that he had succeeded to call his wife in Germany. And he told me that his wife had told him that on German TV it had been announced that there was a nuclear power plant in Japan that had gone out of control after the earthquake (later on I would find out that it was a total loss of cooling). That was the first time that I had heard anything about that. So, I asked him where in Japan it was, but that he had not understood.

Later that evening I heard something about a nuclear reactor problem at Tokai Mura, J-PARC and a nuclear power plant are both there, so I thought it might be where we were. Nothing we could do about that. This came from a news broadcast in Japanese, so I was not so sure what they were really saying.

THE DAY AFTER THE EARTHQUAKE:

Toward the end of the morning that day our bus arrived back home in Tsukuba, and from the lab it was only a 10 min. bike ride home. Almost no traffic lights had been working on that drive, which had taken about 3-4 hours for the 50 km drive - not unusual in Japan when the expressway is closed (as it still was after the earthquake), due to the electricity having been knocked out by the earthquake, and it was still down. But in the center of our town it looked as if the traffic lights were working, so either electric power had not been lost there, or already restored. However, as our part of town was approached, the traffic lights were not working. As to water, which had also mostly gone out due to the earthquake, one could not see just by driving by which places had it and which did not. At the end of the bus trip it was a 10 min. bicycle ride home - no problem with that.

Turns out that just as I arrived home, the electric power came back there. And when it did, as we have our own well, we had water again too. So then life seemed almost normal again. (I would find out later that the city water did not come back until several days later.) On the bus returning home, some of the other clever physicists had pointed out that most likely with electricity being out, it would most likely be impossible to buy gas, so if you ran out, you would just be staying where you were.

First item upon arriving home again, some 20 hours after the earthquake, was to spend perhaps a couple of hours getting something to eat and drink (I had not done either of those in nearly 24 hours, but it had not been too uncomfortable), and then a little bit of sleep - the night after the earthquake I had not slept very much.

So, after feeling somewhat normal a couple of hours later, I took note of the following: the restoration of normal life, in terms of everyday things, electricity, water, food, even buying gas, would likely return to more or less normal within a few hours to days, and those things were not going to be real issues. Already things were much more normal than they had been the previous afternoon. (Having electricity and water as well as being home again, made a big difference.) That it was the middle of March, and it was not very cold or hot either, ameliorated the situation considerably. So, although it would be amusing to take note of just how those things would be restored (Japan is really great at doing that - partially it is due to "practice makes perfect" as there are so many disasters in Japan - with a great deal of forethought being given to just what should

be done when the disasters do occur - and partially it is due to Japan being so well organized with the Japanese all performing their jobs so incredibly well) we were relatively comfortable.

But, there were 3 main questions: -

1. What had happened to the north of us, where things were probably much worse than where we were?
2. What about the tsunami further north - which must have been much bigger than the 6 meters where we were. Rather late the previous evening someone had told me that 300 people had been killed by the tsunami up there - and that had been not really a surprise to me.
3. Where was the nuclear power plant that was out of control?

So, I was hoping to turn on the TV, hoping to find the answers to these questions. It was now early afternoon the day after the earthquake. But, there was a problem doing that - we did have electricity again, but the TV cable had not come back yet. (I guess it took them a few hours to restore that after electricity came back - as to listening to emergency radio in Japanese and seeing what I could understand of that, I had had enough of that on the previous afternoon.

Within another hour or two, the TV cable did come back, and not surprisingly receiving TV again, it was devoted largely to describing the situation post-disaster - just what most of us wanted. I was not the only one curious about what was going on.

The answer to my first question was not easy to find, as that was not talked about much, because up north the disaster of the tsunami far eclipsed everything else. The magnitude of the earthquake, as we had known already a few minutes after it, was somewhere around 9.0 or 8.9, which is enormous.

The answer to my second question was that in the area up north around Miyagi Ken (my wife and I had spent one year living in Sendai about 20 years ago, so the area was very familiar to us) the tsunami had been about 13 meters in height, and something like 10,000 or 20,000 people had been killed by it. All low-lying areas near the coast up there had suffered enormous destruction. The immediate priority was rescuing people still alive, but who were in serious trouble due to it. (E.g. stranded for hours on rooftops - the Japanese rescue teams knew exactly how to do it.) The problems of resuming the ordinary things of normal life and rescuing these people would have been much more difficult in less developed countries (like Haiti) than they were in Japan. This was a great shock (that there were also many people in shelters who would be there much longer than we were, that was something, having been a refugee myself for nearly 24 hours was something I had a better feeling for). But it was something that had happened about 30 min. after the earthquake, had lasted a few minutes, and then was largely over.

It was the third question, the out-of-control nuclear power plants, which would be what would require the most thinking on our part as to how we wanted to deal with that situation. I quickly learned, turning on the TV, about 24 hours after the quake, that that was in Fukushima. And of course I knew where that was. Fukushima is both a province and a city. (Those nuclear power plants are in Fukushima province, but not in Fukushima city.) I had been there many times, as it is on the main route between central and northern Japan, both by rail and by highway. The main connection goes somewhat inland - where most travelers go, but those power plants are on the coast. I am one of the few who also took the local trains on the coast several times, so I have been past those plants, but I did not know they were there. Nor had I thought of tsunamis as I took those coastal rail lines.

The next question was how far were we away from Fukushima (170 km) and how far are the 30 million people in the Tokyo area away from there (230 km).

THE FUKUSHIMA SITUATION:

The Fukushima situation was clearly dire.

With the cable restored, there was now another option - to connect to the Internet and e.g. to consult the Austrian news (in German - no problem for me). They covered what was going on in

Japan very well - it was obviously big news not only in Japan, but also in Austria too - and it seemed that one got a much clearer picture as to what was really going on in Japan - and the danger posed by Fukushima - by reading what the Austrian news posted on the Internet than one did on Japanese TV. That seemed pretty obvious. (After Three Mile Island and Chernobyl the Austrians had become even more convinced that they had voted the "right" way on that referendum back in 1978 - the Austrians, still remembering that 1978 vote, pay special attention to such things, also because Chernobyl had been detectable in Austria.)

The situation at Fukushima was clearly dire.

The news coming out of Fukushima, especially as reported on the Austrian news (Internet) appeared to be increasingly serious.

Almost everybody besides me in our experiment, the Belle experiment, has his own laptop, so I was the only one so dependent on the TV cable, which also connects the PC at home to the Internet, to find out what was going on in this extraordinary situation.

BACK AT THE LAB THE FOLLOWING MONDAY:

The day after that, the Monday after the earthquake, I went to the lab again, telling my wife that I would come home for lunch, expecting the situation at the lab to be not yet "normal". As we have many experts there in various kinds of nuclear physics, I expected to get more insight into the post-earthquake situation, especially w.r.t. Fukushima.

Indeed, the lab was measuring local radiation levels, and not surprisingly was already picking up some effect from the troubles at Fukushima. And this information was not being suppressed, but was being passed on to anyone interested. (Since we work with radiation at our lab, we have our own radiation safety department.) So, we then had a quantitative measure of the effect of Fukushima in our immediate area. (Much of Japan was pretty much in the dark about this - they knew that the situation was out of control, but they did not really know what they should do.)

But, there was no water or electricity at the lab. Being there was OK, if you did not need any water or electricity. Almost nobody could work, and except for the possibility of exchanging information, there was nothing most people could do there under those conditions. The extremely limited electric power at the lab, which would go on for nearly the next 2 months, as it would turn out, was due to enormous loss of electricity generation caused by the earthquake, both due to the going down of normal caloric power plants and the nuclear ones, of which Fukushima was an extreme example. Recovery of the caloric ones would be a much easier task than of the nuclear ones. (With Fukushima it would turn out to be impossible.) The lab would be much more limited in this situation than private homes were.

THE TEPCO COVERUP:

Being home that afternoon and most days that week, one could follow the information that was released about Fukushima. From the very beginning one suspected that Tepco, (Tokyo Electric Power Company, the owner of Fukushima nuclear power company) was covering up a good deal of information about the troubles there, in keeping with the long established Japanese tradition of covering up a great deal of what is really going on.

The Japanese prime minister at the time, Kan, was aware of that, as also were the Japanese TV news networks. (Most of us suspected it too.) So, what the Japanese TV news stations did was to hire helicopters that trained TV cameras on the Fukushima nuclear power plants 30 km away. (Fortunately the weather was generally clear, so they were mostly clearly visible from that distance.) And there was live coverage of white smoke coming out of those plants, black smoke coming out of them, and of them sometimes exploding. It was no surprise that these events were accompanied by large, uncontrolled releases of radiation into the environment. The information as to just how much radiation was generally poor. (How much was reaching our lab, we knew, but in general the information released about that was poor.) Having these events being broadcast live on national TV forced TEPCO to make some kind of statements about what was going on when that

white smoke was coming out of them, and the black smoke, and the plants also exploding. Otherwise, it seems not implausible to me that TEPCO would have covered that up too as long as they could. The Japanese news TV stations knew that they had to witness those events first-hand if they could figure out a way to do it, and they did. For the people waiting in those helicopters, it made their lives easier that they did not have to wait very long for a number of dramatic events to occur. How much radiation they were exposed to themselves while they were doing that, I do not know.

THE PERIOD STARTING ABOUT 3-4 DAYS AFTER THE EARTHQUAKE:

When I arrived at KEK the first Monday after the earthquake, hoping to do something at the lab again, I found out I could not because there was no water or electricity there, and in those circumstances there was a pause of uncertain length dictated by the lack of the most basic utilities. But, there was something else that I gradually became aware of.

It is that KEK has a special contract with TEPCO whereby they use the large amounts of electric power to run our machines (it may be interesting to point out that results of the Belle experiment, along with another one in California, provided the basis for the awarding of the Nobel prize in physics in 2008 - as was explicitly pointed out by the Nobel committee - so our experiment is certainly an important one in fundamental science), but at times when the electricity supply may be limited, we are one of the first to be forced to cut back. And due to the loss of both caloric and nuclear power plants due to the earthquake, there was a very big shortage of electric power in eastern Japan right after the earthquake.

(Building so many power plants on the coast might have certain advantages in terms of cooling, but it also makes them susceptible to enormous tsunamis, and the nuclear ones turn off automatically in earthquakes, and do not resume until after safety checks. Which is a very good idea - and it is - justifiably - becoming much stricter after Fukushima.) And it became obvious, as this became clearer, that this was going to last much longer than the few days it took to restore electricity and water to the city.

So, there was not much that I could do. One thing was to stay home and hear by TV what was being said in Japan particularly about Fukushima and also consult the Austrian news by Internet (in German) to find out what was known about what was going on in Japan, but not being stated very clearly on the Japanese news broadcasts. One of the things which one found there after a few days was that the Austrians living in east Japan were advised to leave the area for a while - either to go somewhere else in Japan or leave the country. (Since it was the Austrian news, it was advised e.g. to go to Austria.)

One had the impression that even TEPCO did not know very well all the details about what was going on, and that they were also not giving the full story about what they did know. One excuse for that was that if all 30 million people living in the Tokyo area should decide that they should all get out quite quickly, this could lead to unimaginable chaos. (A substantial fraction of the foreigners living there did leave within the space of a few days, but that was not unmanageable - the Austrian embassy even organized a special flight to get the Austrians out.) But, although true, that was rather just an excuse. The more real reasons for it was the ancient Japanese custom of concealment of what is really going on, and the fact that TEPCO management is dominated by managers who want to promote nuclear energy at all costs, even when it is obviously unsafe, and these are the guys who have been covering up more minor mishaps for decades. Of course it did lead to unnecessary exposure of the general population to relatively high levels of radiation, especially in Fukushima province. And these guys have close connections to those at high levels in the government.

Nevertheless enough information was released so that one could see 3 mechanisms for radiation being released into the environment: one was the intentional venting of steam which contained some radiation: this was actually the lesser of the evils - otherwise if the pressure gets too large inside, it may perhaps explode, and that would obviously be even worse. Another was not immediately obvious, but one thought it was likely happening, as the radiation was also coming out

due to the holes in the containment vessels - I do not know if they were due to the explosions or the extremely high temperatures inside melting their way through - maybe it was both. And the third mechanism was the explosions of several of them a few days after the earthquake as a result of hydrogen buildup - caused by chemical reactions after the nuclear reactors were seriously misbehaving due to extreme overheating. This mechanism was likely the one leaking the largest amount of radiation into the environment.

That several of the reactors had melted down within hours or days after the earthquake, this was not admitted until some months later - it is generally felt, probably correctly, that TEPCO had known about this long before it was admitted by them. One should also point out that immediately after the earthquake that even TEPCO may not have known so much about what was really going on due to the complete lack of electric power, e.g. for instrumentation which needed it, and also that within hours the radiation increased so much in the control rooms of the reactors that no one could stay there any longer.

So, in those first days, after getting home after the quake, these things were becoming clear from what was said on Japanese TV and on the Austrian news on the Internet. At that time one suspected the partial cover-up in Japan, and much later it was confirmed that this had happened. It was more on the part TEPCO than the Japanese government.

WHAT HAPPENED JUST AFTER THE EARTHQUAKE, REVISITED:

Let's go back to what happened just after the earthquake at Fukushima - as I found out somewhat later.

When the earthquake occurred the nuclear reactors shut off automatically as they were supposed to do. But even when reactors shutdown it is essential to keep cooling them otherwise the temperatures inside them will rise to several thousands of degrees which can lead to all kinds of severe consequences which can lead to large releases of radioactivity into the environment as we were to find out. (That it would actually be the formation of hydrogen after the cores melted down which would then explode, and that that would be the biggest cause of release of radiation into the environment, was probably not immediately obvious to most of us.) And, because of the total loss of electric power to large parts of eastern Japan due to the earthquake, cooling could not be done in the normal way.

But of course this had been foreseen, and they had backup diesel generators that went into action. And that worked OK - for a while. A couple of days or so after the earthquake I found out that where we had been, at the Tokai Mura power plant - but in a different part of that installation, they initially had had problems with their backup diesel generators, but had been able to solve that before the situation got really critical.

The problem at Fukushima started due to 2 circumstances: the failure of all primary electric power in large areas of eastern Japan due to the earthquake, coupled with an enormously large tsunami about 40 minutes later.

Back in 1978, at the time of the nuclear power plant referendum in Austria, I had said that the computer programs calculating that the probability of a serious accident at a nuclear power plant would be extremely small (e.g. once in 100,000 years) suffered from the inputs to those programs being deficient in a number of ways. But I had no idea what would be specifically wrong with them. As Austria then abandoned nuclear power we did not try the unwise experiment of building nuclear power plants to find out what the specifics of those deficiencies might be. At Fukushima we found out that at least one of those errors was building in a place that had the wrong probability distribution for very large tsunamis.

About 40 minutes after the earthquake a very large tsunami struck those power plants in Fukushima knocking out the backup diesel generators, and when that happened there was little or nothing they could do to cool the reactors, and they overheated dramatically, leading to almost complete meltdowns within a few hours or days. (The news of the meltdowns was not released until some months later - I do not know when TEPCO became aware of what had really happened,

but just after the tsunami they were fully aware that they were in serious trouble.)

About one day later they decided to start cooling with seawater and were able to start doing it. This was a dramatic decision, because it meant that they would never be able to use those reactors again. There are a couple of stories about that. One was that the top brass of TEPCO contacted Kan, the Japanese Prime Minister at the time, asking if they should do it - it was the most important decision at a time when much of the country was in total disarray due to the massive disaster - but as it took too long for a decision to be made in that way, one of the engineers on site at Fukushima realized that he could not wait for the Prime Minister to decide that and pass it down through official channels, so he started doing it on his own initiative. If it had turned out to be the wrong thing to do, he would have been in serious trouble, but the way things turned out, it was the correct thing to do, and he became something of a hero. (Maybe that is what prevented all of eastern Japan from becoming uninhabitable. After he resigned a few weeks later, Kan candidly said that he was well aware that all of eastern Japan might have become uninhabitable due to Fukushima, and that if it had become necessary to evacuate all 30 million people from Tokyo quickly, that would have been a real nightmare.)

I think the engineer decided by himself that he had no real alternative, but he also had a lot of guts to do that. (I don't remember who told this story about this guy to some news media, some months after the fact, which is how I heard about it, but it might have been among the candid remarks of ex-prime minister Kan just after he resigned. [Those remarks make very interesting reading.]) Ex-prime minister Kan does not have entirely clean hands, but in my mind he ranks in something like the top 2% of prime ministers for trying to do the right thing in that impossible Fukushima situation, and doing the best he could.

The other thing is that if it had been possible to start cooling with seawater much sooner than they did, and if they had done it, then what happened might have been much less serious. One delaying factor might have been the time it took for this to be passed up to the top management of TEPCO, who were totally unprepared (there is likely to be a parliamentary inquiry in Japan concerning the failures of the TEPCO top management concerning Fukushima just after the earthquake, and if they do find out some details of what those guys really did then and which ones), and then from the TEPCO top brass directly to the prime minister's office. Just when to start the seawater injection had economic implications on the order of billions of dollars, but even more important was the health risk to millions of people. If the seawater injection could have started sooner, if someone could have decided to take that decision more quickly, that I do not know.

One more comment about the period immediately after the earthquake.

Even for TEPCO to know what was really going on in the situation when the electrical power lines and the water lines went down during the earthquake (where we were, the lights went out about 2/3 of the way through it - and I wasn't trying to find out during it just when the water went out), and the emergency backup diesel generators were knocked out 40 min. later by the enormous tsunami. Because those instruments that depended on electric power were then not in service, (I have no idea just which ones of those it might have been) I suppose that flashlights could have been used to look at anything which was showing something. But, in our experiment we use computers to read out our instruments - probably they do the same thing, and all those read-out computers would have been down too.

And, in that situation where the reactors were rising to extremely high temperatures with no cooling, the radiation levels inside the control rooms of the nuclear power plants relatively quickly would have become so high that no one could go inside them. (Just how quickly I do not know.) And, when not even TEPCO was really sure of what was going on, that was a scary situation. However, as TEPCO was forced to admit during the summer, some months later, they were holding back some of the information which they did have. The fear of causing a panic among the 30 million people in the Tokyo area was only a partial excuse for doing that. The other real reasons are that those in favor of nuclear power (those with vested interests in it), even when it is obviously demonstrated to be unsafe would like to "sugar-coat" it when they can, and play down

the seriousness of what the public is told about what is going on, and also the Japanese ancient tradition of not revealing what is really going on.

Kan candidly said some other things just after resigning as prime minister a few weeks ago: one of them was to say that it was really scary for him too at the thought that it was not inconceivable that a large fraction of the Japanese population was living within 200-300 km of Fukushima, and he realized that it was not inconceivable that this area might become uninhabitable. Another was that about 4 days after the earthquake the radiation levels at the nuclear power plants themselves had become so high that TEPCO told the highest levels of the Japanese government that they just wanted to abandon them and just let whatever would happen just happen (it goes without saying that that could have been far worse than what actually did happen).

Kan's answer to that was that you cannot do that - and they kept people working there - hundreds of TEPCO employees working in an uncomfortably high radiation environment for the next weeks or months, being very well aware that there were certain risks connected with that. The modern term is samurai or kamikaze. (The word kamikaze actually means "divine wind" and refers to the time the Mongols tried to invade Japan sometime around 1300, and lacking information from weather satellites, the ships of the invaders were destroyed by a sudden unexpected violent storm - sounds like a typhoon to me, and Japan was saved from the invaders in that way.)

One really has to admire the dedication of those people, sacrificing themselves for months there, saving much of Japan from an even worse fate. In not many countries would one find the people willing to do that. This kind of self-sacrifice is a kind of ancient Japanese tradition. (But the willingness to live in dangerous conditions is also a negative thing in this situation too - causing perhaps the Japanese to take unnecessary risks living in high radiation environments when it would be better to take evasive measures - e.g. to have larger evacuation regions, and to stay away longer.)

Something else that we learned from going through this is that although there is a complicated cocktail of radioactive materials released in such situations, actually a quite simple picture explained what happened. In a nuclear reactor the fuel is radioactive, and also the fission products produced by the reactor are radioactive. Of the latter there are many different substances. The dangers created by such major accidents depends on the concentrations of the various radioactive substances, their half lives, their chemical properties, and the fact that the various substances produce different kinds of radiation. One thing that was said is that plutonium in the environment is particularly noxious. (Plutonium does not occur naturally - all of it that we have is man-made.) But, in the Fukushima case, and maybe others as well, most of it can be explained in terms of only 2 elements - radioactive iodine and radioactive cesium. Radioactive iodine has a half-life of about 8 days, and in the first weeks after March 11 it was the main thing to contend with. But after 3-6 months nearly all of that was gone, and then the main thing to be concerned about is radioactive cesium (maybe it does not then dominate so much as iodine did in the first weeks after the accident), with 2 isotopes - one with a half-life of 2 years and the other 30 years. It is the 30-year isotope that is the main reason that if nothing is done, Fukushima could be a major problem for Japan for centuries.

(Note that Hiroshima was a major problem when it happened, but now it is a thriving city. The consequences of Fukushima 30 years later will likely be considerably bigger than those of Hiroshima were.)

So, so much for these additional comments on what happened at Fukushima in the first few days after March 11.

LIFE IN THE WEEKS AFTER THE EARTHQUAKE:

About 1/2 week after the earthquake, being unable to work at the lab, (I didn't know how long that would continue, but it would turn out to be about 2 months), in addition to trying to follow what was going on both by TV and Internet, I was mainly involved in 2 other activities.

(It was also amusing to watch what was going on concerning recovery of normal life locally. That was

remarkably easy. About the only real shortage of items at the local supermarket - certain items became missing rather quickly as it reopened 2 days after the quake - my wife was quite amused by which items they turned out to be - the only one which took about one month to recover was bottled water - first due to the lack of running city water for a few days, then due to the fear of radioactive contamination of the local water supply. We did not have much gasoline for about at least a week after the electricity was restored, but that did not bother us as we had had nearly a full tank at the time of the earthquake and we did not need to drive much. My bicycle was very helpful - if one did not mind riding through slightly radioactive air. That one might want to keep short.)

One of those 2 activities was to decide what we wanted to do. E.g. in our lab we do work with radiation, and how we deal with that is mostly to do observation from a safe distance. I suggested to my wife that this might be a very good time to go to Austria for a while - if we could figure out how to make the trip. (E.g. if we had decided in time, we might have gotten on that special flight organized by the Austrian embassy.) She seemed to almost agree, but in the end did not. So then I got the idea of going to Miyazaki U. for a while since I had wanted to work with the professor there. It would solve 2 problems: one being that I could do observations from a safe distance for a while, and the other that I would have electric power so I could do some work again.

The other activity, or rather problem, was what to do about e-mail contact. On the PC at home the only e-mail I had been using was an address used to write e-mail in Japanese. It is not so easy for me to do that, and I do not do very much of it. But, I had been doing that with a colleague in Austria (who also has a Japanese wife and also knows some Japanese.) Through him I got the e-mail addresses of many physicists in Belle, and through one of them in Nara I got the e-mail address of the professor in Miyazaki.

This was in the morning of Friday, March 18. Within a couple of hours he agreed that I could come, and then we decided how to make the trip. This my wife did agree to. His first suggestion was to drive, but for a couple of very good reasons I was not so happy about that, and then he found out that a flight from Tokyo was open for the following evening. Mid-afternoon that day we bought the air tickets at the travel agency - we easily still had enough gasoline to get there - and then later that afternoon we made very hasty arrangements to leave for an indefinite period of time. We expected no problem in principle to get to the Tokyo airport - it is in the direction away from Fukushima, which is not bad. On the following day I was more cautious about the time needed to do that than I needed to be, the way things turned out. That trip was surreal, despite the major disaster it all went so normally. The flight turned out to be full, but we had been able to get our seats, and everything else was no problem at all. And with that the short-term consequences of the earthquake were pretty much over for us.

In terms of evacuation the Japanese government issued this for a 20-30 km zone about the plant, but the US said it should have been 80 km. With the Japanese directive, 100,000 were moved out, but if the US recommendation had been followed it would have meant several million - I think the American approach would have been wiser.

Next is to say something about what I was doing in those days, in addition to trying to follow the news. That concerned e-mail and figuring out what we wanted to do.

Except for the problems caused by the Fukushima nuclear reactors getting completely out of control leading to massive releases of radiation into the environment, the recovery where we were went remarkably smoothly. The first 24 hours (when I was not yet home) without any electricity or water were a little tough, but then the electricity was recovered first, (and with it we had water again as we have a well and are not connected to city water). The city water was recovered about 4 days later, and then life was much closer to normalcy for all in our area. (We are about 300 km from the epicenter, so things were generally not all that dramatic locally, but a few people were killed by the earthquake in our province too.) And, it was not hard to live through that, as we knew that within a few days most of the remaining problems would be solved except for the radiation coming from Fukushima, and the severe shortage of electricity at the lab.

About the last problem to be solved was the shortage of bottled water after the earthquake. (Everything else showed up in the shops again sooner than that.) That took about one month to

start to get back to normal again. We drink mostly bottled water because we have the well, not because of the aftereffects of the earthquake. The reason for the shortage of bottled water in the first days after the earthquake was probably due to the city water not yet being restored (that was why the local McDonald's was not open for the first few days - when McDonald's is not open, you know the situation is not really normal yet), after the first 5 days or so, it was due to people being nervous about radioactivity in the water supply. (If that was reasonable or not, I do not know.)

So, that finishes that part of the story.

SOME BACKGROUND ABOUT MY WORK:

I do experimental work in elementary particle physics - also called high-energy physics. We work with large particle accelerators - most recently with machine ranging in size from about 4 kilometers to about 30 kilometers. The discovery of large CP violation in β decay, in 2001 by our experiment, the Belle experiment, also independently by the BaBar experiment in California at the same time, provided the basis for the Nobel prize in physics in 2008 to Kobayashi and Masukawa. That was a very exciting event for our experiment.

Having worked after getting my PhD in the field, I have worked in Japan and Austria (where I still work - in different seasons of the year - but now on a voluntary basis after having retired 6 years ago), and earlier in the Netherlands and also in Soviet Russia - also being there a bit in the post-Soviet period. It goes without saying that my background in languages is a useful thing to have when working in this international environment. English, German, Russian, Hungarian, French, Swedish, Chinese, Dutch, Japanese, Czech, and some Korean. That is the order in which I started them. Some acquaintance with Latin too, but I don't really speak that. And I guess I don't really speak Korean yet either. (I suppose that this kind of background in languages is sort of unusual. Also not so many of us have been through both the Austrian referendum on nuclear power plants in 1978, and the Fukushima disaster and have a background including nuclear physics.)

I thought that these few words about what I am doing might be of some interest to you. Although I have not actually worked in the area of real nuclear physics, my background does contain elements which make it easier for me to understand what has been going on.

THE FUKUSHIMA SITUATION ON A LONGER TIME SCALE:

The next part concerns the story of the Fukushima fight on a somewhat longer time scale. (Namely TEPCO struggling to cope with the situation after the genie had come out of the bottle. It was very unadvisable for that to happen, but it had!)

There were **3 parts** to this story. **One** was the struggle to cool the reactors as best they could in that very unfortunate situation, a struggle that would take weeks at first, then months, we are currently hoping it will not be years - but there are clearly other problems that will last years or decades. The **second** was to reduce the uncontrolled release of massive amounts of radiation into the environment as much as possible. (Obviously connected to the first part.) The **third** part concerned how the affected Japanese people would cope with this situation.

The Japanese have enormous patience concerning the various natural disasters they have always been living with, but large amounts of radiation in the environment, that was something very new to them, and the traditional patience they had was not really the appropriate response in this case, and maybe has negative (or unwise) aspects too. That Tokyo took the whole thing with remarkable calm however, made the situation considerably less difficult than it might have been. (The amount of radiation released in the Tokyo area was never all that large as far as I know - at least not yet. I would not rule out unpleasant surprises though.)

For the first month of this, from March 18 to April 13, I was following the story from Miyasaki U., about 1500 km to the southwest, the opposite direction from Fukushima. Then for the next 5 months from Vienna until returning to Japan on Sept. 16.

I had 3 sources of information: the Japanese TV, the English language newspaper Japan Times and

the professor I was visiting, a physicist of elementary particle physics. The professor was very well informed, being in good contact with the network of such Japanese professors around Japan. The Japanese newspapers seemed to move gingerly when moving on to worst case, but those Japanese professors of elementary particle physics, they had no inhibitions about considering the worst case scenarios (e.g. all of eastern Japan becoming uninhabitable.) The Japan Times, an English language newspaper in Japan, obviously aimed at the foreign community, I thought they gave good coverage of it, and, probably since they were mostly aimed at the foreigners in Japan, also seemed to me to be more open about it than was the case on Japanese TV. And of course I followed also via the Internet what was being said about it in the Austrian news. (That is in German - no problem for me.)

Immediately after the earthquake the government was faced with a myriad of problems. They realized that they were going to be faced with enormous difficulties, after the magnitude of it being assessed at 9.0 within the first few minutes. The most urgent task was going to be to issue the tsunami warning if there was going to be one (we knew within about 5 min after the earthquake that it was going to be 6 meters where we were, which was obviously of significant size, but since we knew also that the epicenter was 300 km north of us that it would be much worse further north). All of this went very rapidly through an already established system, so the central government did not need to worry immediately about that, but could look into a myriad of other problems. The warnings were issued correctly, but 10,000-20,000 people still lost their lives in the tsunami. If the warnings had not come immediately as they should, then the loss of life due to the tsunami would most likely have been even larger, maybe far larger. So, up until the period when the tsunami arrived, the central government could concentrate on the "normal" problems in a major disaster. And that, since there are so many disasters in Japan, is something that the whole country was well set up to do. Those of us who lived through that, as "refugees" as we were for nearly the first 24 hours, in those cases where everything worked out fine, we were very impressed by how well it did work just as planned.

It was however when the tsunami struck about 40 min. after the earthquake, and it knocked out the emergency back-up diesel generators at the Fukushima nuclear power plant, so there was then no cooling there at all for some time - leading inevitably to a major nuclear catastrophe, that the completely unexpected real trouble started. This led to meltdown within a few hours to days, and major releases of radiation within a not much longer time scale. I don't know how long it was after the tsunami caused this before the central government was told - but likely it was a matter of minutes or hours. Just how long it was, I don't know. I do know that within 6 hours or so that it had been broadcast on TV in Germany, and that is how I found out about it.

This then caused 3 novel, serious, unexpected problems for the central government. One of them was how to cool the reactors as best they could after the cat had been let out of the bag, and those reactors had mostly melted down. The second was to reduce the massive releases of radiation as much as they could. The third was to do what could be done to ameliorate the effects of the radiation on the general population as much as possible.

One of my Japanese physicist friends said that they should have started cooling with seawater sooner than they did (even though this would make it impossible to run those nuclear electricity generators again). If this would really have been possible or not, I do not know. Other than that, what was done here was likely to be the best that could have been done. The biggest problem being that much of that work was done in an environment where radiation levels were very high, and they were battling that for weeks or months. By now that situation finally seems to be settling down, but dealing with the radiation levels on-site is still very much non-trivial for those doing it. One must really admire what those very brave people are doing. That is to save as much of eastern Japan as they can.

After the first few days or weeks the next problem they ran into here was the large amount of very radioactive water they were producing in their desperate attempts to cool the reactors. Around June they were then fighting with how to decontaminate very large volumes of very radioactive water, and that was a tough struggle, but they seem to have that pretty much under control now - no recent news of continuing big problems with that. However, before they could fix that, large

volumes of radioactive water, and not only low-level, had found its way into the ocean. Fishing in large regions of the northeastern coast of Japan is something that you would not really want to do now.

As to the second problem, avoiding release of even more radiation, one urgent thing has already been described: how to deal with that large amount of very radioactive water used for cooling after the meltdown, so that things would not get even worse. They also have been taking other measures, which are likely to have been reasonable too.

It is the third area, protection of the general population from radiation already released, that my own personal feeling is that what was really done was not always exactly what should have been done.

RADIATION AVOIDANCE TO THE GENERAL POPULATION:

In this section I want to make some candid comments on the post-Fukushima situation regarding radiation avoidance to the general population. These remarks will include aspects that will be not uncritical.

In the first few days the Japanese government soon recommended that the people living within 20 km or so of the Fukushima plant should take special radiation protective measures. One would be to evacuate the area as soon as they could. (One should remember the situation we faced after the earthquake when it took us 24 hours to make the bus trip home again, which in normal conditions would have taken one hour. And where we are both the earthquake and the tsunami were much less severe than they were in Fukushima. So, even if people wanted to evacuate, with much of the transportation system in Fukushima severely damaged by the earthquake, and also by the tsunami near the coast, it would have been much more difficult to evacuate these people than it would have been in normal conditions.) Those in this region who did not leave were advised to stay indoors and not to use any ventilation of outside air. (This has a few consequences. E.g. if you do not have an infinite supply of food in your house you will eventually starve to death. Also, it means that one could not use electric heaters that draw in outside air, the most widespread method of heating in winter in Japan. And up in Fukushima the winters are colder than they are where we are. Japan has a tradition of having well-ventilated houses - dating much further back than major releases of radiation from out-of-control nuclear power plants.) After a few days the evacuation zone of 20 km became mandatory - and yes, there were some people who couldn't leave or didn't want to leave for a while, and there were even a few who wanted to come back very soon. But, it is not so easy to survive in a zone that has been abandoned - for good reason. Some also complained about wanting to leave, but having transportation problems - details of that I fortunately did not experience myself first-hand.

The Americans though openly disagreed with the Japanese about the size of the evacuation zone. The Americans recommended 80 km, not 20 or 30 km. With the Japanese evacuation zone, about 100,000 people were evacuated. With the American recommendation it would have been several million. Also the main rail and expressway link between the north of Japan and the Tokyo area goes through an inland valley, about 60 km from the east coast. So this was outside the Japanese evacuation zone of 20-30 km, but would have been inside the US evacuation zone. So the US recommendation would have cut off, more or less, the north of the country from the rest of it. One cannot really prove who is really right on this issue as far as I know, but my own feeling is the American recommendation was the wiser one. The US government still, in Sept./Oct., is recommending that US citizens do not stay within 80 km of the Fukushima plant.

Fukushima is both a province and a city. Fukushima City is well away from the plant (it is a city of perhaps one million people), but the radiation levels are still so high there that I think people should not be living there.

One should also make some comments about how Japanese society actually works. The casual foreign visitor to Japan will notice that the Japanese have a long tradition of "honored guests" who are treated with great respect, and most foreign visitors more or less automatically fall into this

category, treated with extreme politeness. But one may also notice, if one lives here for a while and begins to catch on (if one attends courses this may be pointed out by some who understand Japan well and openly express somewhat critical views - the Japanese do have some inhibition about doing that, but on the other hand just the opposite can happen too - Japan is also full of contradictions), that in Japanese society the group structure plays a large role. For many Japanese the interactions within the group are very important, and inside the group people are treated very well, but outside the group, it is not at all easy to make any real relationship at all, and even there are aspects of people outside the group being treated even inhumanely. (Something which casual foreign visitors seldom see, because there the honored guest tradition overrides that.)

It is this group structure in Japan that makes it very difficult for people in Japan to move around, especially the rural population, as if you do move to a new location, you will have lost contact with the group members who had been around you, and you will be isolated in the new location. The US society is very mobile - Japanese society is the exact opposite of that. (Japan is a place of contradictions - there is also the trend of movement into large metropolitan areas, which is the exact opposite of the immobility principle.) Also there is a large scarcity of attractive land in Japan. Both of these make it very difficult to resettle the people in Japan in the event of a nuclear catastrophe. So, it seems likely to me that in the future there is going to be much suffering caused by Fukushima radiation that would have been easily preventable if people had been more mobile.

What the American embassy recommended, and other western embassies as well, within a few days, was that their citizens in eastern Japan, and this includes the Tokyo area as well, should either leave Japan entirely for a while, or move to other parts of Japan. (We did the latter for a while, and later I went early to Austria for the summer.) The Austrian embassy even organized a special flight out of Japan for the Austrians here. Many foreigners did leave, and it was not too difficult for them to do that.

It is very obvious that in a nuclear power plant there are many different radioactive substances. The fuel contains very radioactive elements, and many others of them are produced by the fission reaction. (The power comes mostly from the fission reaction, but a non-negligible fraction also from the radioactive decay of the fission products.) It is very obvious that when there is a massive uncontrolled release of radiation that not only is the total amount of released radiation relevant, but also the properties of the individual (isotope) radioactive components. The half-life and chemical properties of each component are important, and also the amount of each of them at every location outside of the plant. At our lab in Japan the concentrations of each significant isotope was also measured continuously in the post-earthquake period and posted on the web.

In the few days after the earthquake, we heard a lot of about the individual components and their properties. (One does not remember all the details immediately.) We were warned especially that unit number 3 used a plutonium containing fuel, and that plutonium is especially toxic. (Luckily, not such large amounts of it have been detected outside the plant - so it could easily have been far worse than it has been.)

Although there could be many different radioactive substances, and there are to some extent, only 2 seem to dominate. In the first 3-6 months it is iodine 131 with a half-life of 8 days, and after 3-6 months it is largely gone, and the second is cesium 137, with a half-life of 30 years (there is also a second important isotope of cesium with a half-life of 2 years), and it is cesium which Japan may be struggling with for a few centuries.

Now something I learned about during the summer when I was in Austria (but with obviously a great interest in how the nuclear catastrophe was being dealt with back home in Japan.) It was a story passed on to me by old high school friends in the United States. And it was something that did not surprise me - I more or less expected that kind of thing based on my experiences in Japan. I was told that there was a nuclear safety protection agency in Japan. But it had been dominated by people with close connections to the nuclear industry, who for decades had been preaching that the Fukushima kind of accident would happen only once in about 100,000 years (the errors in those computer programs seem to have been demonstrated by Three Mile Island, Chernobyl, and

now Fukushima, the real number seems to be about once in 10 years, not once in 100,000 years, so that number was off by about a factor 10,000, and when such an accident does happen, it can devastate, more or less, a whole province or state, and it can go even beyond that.) And after Fukushima did happen, and dramatically proved them wrong, they were so fixed in their obsession that nuclear power is "safe", even when it has been proven that it is not really, that they were more concerned with minimizing negative impressions of nuclear power than doing their real job of protecting the public from the negative effects of radiation. So, they did have a team measuring radiation levels in Fukushima province, and reporting them to the central agency. But the agency was so dominated by those with close ties to the nuclear industry, who just wanted to play down the justified fears, that instead of using them to warn the general public, they just swallowed them. They knew that there was a radiation cloud headed for a school, but they did not warn the school. We will come back to this point, but former Prime Minister Kan tried to shake up this agency.

The radioactive iodine part is now largely over, but the governor of Fukushima province is doing something I consider reasonable (my opinion is that, especially in Fukushima, the general population was not protected as well against radioactive iodine as it should have been), and he is now passing this on to the medical community, which is not dominated by blind proponents of nuclear power. 100,000 children in Fukushima province are now thought to need to be under long-term observation due to possible excessive exposure to radioactive iodine. A positive effect of this is to wake up the people to the possible dangers of these massive uncontrolled releases of radiation, and that may be a good thing. If it encourages more people to move out of Fukushima-ken, not to avoid iodine, for which it is already too late, but to avoid more negative effects coming from cesium, and perhaps others, that would be a good thing too.

Then there is the question of agriculture in Fukushima-Ken - and in other contaminated areas. It goes against common sense to continue to do agriculture in radioactive contaminated areas. And in a few cases the government has been disallowing it. But the measures do not go far enough in my opinion. And, there has been some testing of food for radiation, and occasionally finding it. But in my opinion there should have been much more of it than there has been.

That agricultural produce from Fukushima-Ken has often been unsellable, that I consider to be a good thing - what I hope they would then do if they cannot make a living doing agriculture in Fukushima-Ken, they should move to a very different location if they want to continue to do agriculture, and the government should help them relocate in this situation. I feel the government is doing far less along these lines than they should be doing.

One not unexpected consequence of this is that some radioactive food is being found. There was a case of imported radioactive tea being found at a French airport when tested on arrival. Particularly noteworthy here is that this tea was grown at an area on the other side of Tokyo from Fukushima. (There are still massive radiation problems in Japan.) Then there was the radioactive beef found accidentally which had come from Fukushima. In this situation I would not recommend importing food from Japan, as the government does not have this situation really under control. (Far more testing should be done than is being done, and the government should take more measures than they are for food being produced in areas where the radiation is too high.) If you live in Japan, as we now do, it is not so clear what one should really do about this.

SOME VIEWS ABOUT JAPANESE HISTORY:

The isolation of Japan for centuries has a very big influence on what Japan is today. Mostly the interaction between Japan and the rest of the world was minimal most of the time until the middle of the 19th century.

The exceptions to that are very significant though. There may be many of them that I do not know very much about. One of the first ones with very large implications for Japan was the interaction with Chinese civilization starting about the 8th century. Called the Heian period in Japan, and I think the T'ang dynasty in China, when Japan imported a number of ideas from China. Two of the important ones were Chinese writing - the Japanese had no writing system up until then - and the Buddhist religion (which had come to China from India). The importation of writing and the

importation of religion may have been connected with each other.

(The Japanese were very lucky that the writing system they were importing was one of the most complicated ones.) That much of the Chinese intellectual imports to Japan came via Korea is something that is emphasized much more by the Koreans than by the Japanese.

Then around the 16th century Europeans started sailing all over the world. Temporarily, it turned out, ending Japan's isolation from the rest of world except for sporadic earlier contacts with China. Notably the Portuguese, Spanish, and then Dutch in that order. The Portuguese being the first of those, and hence there is a special Portuguese influence in Japan still. (E.g. in terms of food.)

After about 100 years of this, the absolute despots in Japan, (the shoguns - the top military warlords) decided that the foreign influences were going in directions undesirable for them, so they then severed contact between Japan and the rest of the world entirely. (Arriving or departing at Narita was then a capital offense.) Before that though they had taken over much of the military technology of the time from abroad, and engaged in one their rare invasions - of Korea - where they caused a lot of destruction in Korea before they lost and abandoned it (for a few centuries). After the shoguns severed all ties between Japan and the rest of the world in the 17th century, only Dutch traders were permitted at Nagasaki. There they were carefully watched. They were supposed to bring in goods, not foreign ideas. In the 8th century when Chinese ideas came into Japan, they did not provoke the strong immune reactions that the western ideas coming into Japan in the 16th and beginning of the 17th centuries did within a few decades.

This situation lasted until the 1860's when the US navy forcefully demanded that it be allowed into Japan and start trading. This led to an intellectual revolution in Japan, between the isolationists who were fighting a losing battle - and both foreigners who wanted to be allowed to start trading, and the other Japanese who had changed their minds. The latter decided they wanted to catch up on technological advances from the outside that had taken place when they had been voluntarily isolated for some 200 years. The technical advances of the greatest interest to them were likely those in military technologies.

In this period both sides played off the military despots, the shoguns, who had de facto ruled the country for the previous 200 years, against the emperors. After a few years the emperor was restored, on the side of opening up intellectual contact with the rest of the world, and the shoguns lost. The new emperor was called the "Meiji" emperor and this period was called the Meiji period, when the country suddenly switched from adamantly opposing all foreign ideas to ardently embracing them and seeking them out. Young intellectuals who had formerly been forbidden from going abroad now did so.

The first people to find out first hand how adroit the Japanese were in assimilating foreign military technology were the Koreans and the Russians (around 1905), and Taiwan too, later the Chinese - I think that started on a big scale in China and Manchuria, around the 1920's and the 1930's.

By the 1930's the Japanese had realized that they then had the military means to take over much of eastern Asia, and the prevailing faction in the leadership thought it would be what they really wanted to do. And they actually went a long way in that direction. Then they seriously overplayed their hand, thinking that the United States might not be very happy with the Japanese overrunning large parts of eastern Asia, and attacked Pearl Harbor. (With your background in New Zealand you may have heard of much of this before.)

Here one would like to point out one aspect of Japanese mentality under the shogunate that has been largely carried down to present times even though the shogunate disappeared in the 1860's - 1870's. It is the sometimes-extreme deference to authority. (Under the shogunate if you wanted to stay alive - not be executed on the spot for even minor breaches in deferring to authority, you had to submit, and in the proper way.) (A lot of things in modern Japan can be easily understood if one thinks that when the shogunate disappeared, much of the mentality did not change. It is still the same as it was in shogun times - e.g. the address system in Japan.)

Pearl Harbor led pretty much inevitably to 2 events in Japan in 1945 - the atomic bombings of

Hiroshima and Nagasaki and Japan losing the Second World War. The Japanese for centuries had been fighting mostly each other, as there had generally been no one else around. (The Koreans had never tried to invade Japan, but they had had the misfortune, due to no fault of their own - as far as I know, to be among the few exceptions.) And they had been generally really fearless as warriors. Even with a tradition of suicide (e.g. harakiri, which obviously means "abdomen cutting"). This was something not recommended to be played around with. E.g. the Mongols defeated almost everybody, but not the Japanese. It was the success of the Japanese against the Mongols that convinced them that they were really great militarily. So, when they lost the Second World War to the United States, they found a great thing to do: they decided that if the United States could defeat the Japanese who considered themselves to be really great warriors, that the US must be really great, and what should one do when one is vanquished by some power even greater than Japan?

Learn from them. Just as the language and religious scholars had done in the 8th century (Hei-an period) when they had taken over Chinese writing and religion, and those young intellectuals of the Meiji restoration period had taken over western academic achievements. So, nearly overnight Japan switched to becoming great allies of the United States (which the Americans preferred to the opposite). And those great achievements of US culture, McDonalds's and Kentucky Fried Chicken became ubiquitous in Japan. So much of modern Japanese culture is very obviously imported from the United States. (What was imported from China in the 8th century is less obvious to western eyes - even the modern Japanese language consists of 3 parts - the original Japanese part, which is obviously related to Mongolian, Hungarian, Finnish, Estonian, Korean, Kirghizian.) - the Chinese part, which was much more than just the writing, and the much more recent English words which have been taken over in very modern Japanese. I have my own personal vendetta for the Japanese to minimize the use of those when speaking Japanese.

When I lived in the United States, "Kirghiz" was not exactly a common household word as far as I know. The only time it came up back then was in Hungarian class, emphasizing what an exotic language Hungarian is, being a non-European language, and being related to Finnish, Estonian and Kirghizian. (Somehow they omitted Japanese, Korean and also Mongolian from that list. At the time of my Hungarian class at Berkeley in the 1960's I had had no idea that I would ever be learning Japanese.) Kirghizia had also come up one time in my undergrad years at Duke, because my Russian prof, from Leningrad, had also spent some months teaching, early in her career, in Kirghizia. So, when I was told in Hungarian class at Berkeley that I had now started to learn a language related to Kirghizian, Hungarian, the word Kirghizia rang a bell. I already knew that Alma Ata was the capital of Kirghizia. (The word "alma" means "apple" in Hungarian. If that has any relation to the "Alma" in "Alma Ata" or not, I do not know. If the precursors of the modern Hungarians ever went to drop in on their language cousins in Kirghizia or not, that I do not know, but if so, it would have been millennia before the Hungarian people I met.

It is with this background that the nuclear power plants were introduced to Japan. Like McDonald's and Kentucky Fried Chicken, they came into Japan as the result of the American influence and the Japanese post-World War 2 enthusiasm for emulating the United States. The Americans were very happy when World War 2 was over, but they too were shocked by the atomic bomb. So, when in the 1950's ideas came for the peaceful use of nuclear energy, to generate electricity, controlled fission, there was a certain enthusiasm for beneficial (supposedly) applications of nuclear science. (My own interest in nuclear physics is for the intellectual understanding of very basic things, not in either destructive or supposedly constructive applications). And, being US allies at the time, Japan also took over the idea of nuclear power plants from the US and found in Japanese industry ardent proponents of it, who really believed those computer programs that told them that a really serious accident would happen only every 100,000 years (much longer than any of them expected to live) and were not unduly worried about rather minor incidents either.

So that is how in pre-Fukushima days Japan grew to depend on nuclear power for about 30% of its electricity, with plans even for a big increase in it.

THE GOVERNMENTAL SYSTEM THAT THE US SET UP IN JAPAN POST-1945:

Just as the shogunate disappeared in the 1860's - 1870's, the military leaders in Japan in the 1930's and first half of the 1940's just disappeared too. The emperor became a figurehead, but a much respected one. The government became a parliamentary system, like in much of Europe, but unlike the United States. The real head of government is the Prime Minister, who is elected by a majority in parliament. The resignation of the US president rarely happens, and when it does, it is a really big event. (Richard Nixon being a famous example.) Resignation of a Prime Minister in Japan is a relatively routine occurrence, and especially lately it has been happening often.

In the US the president heads the executive branch but in Japan that is done by the bureaucracy who have become very entrenched. Politicians, who at the national level are in parliament, have little control over the bureaucracy.

There is a very strong collaboration between leaders in industry and the government bureaucrats. (The term "descent from heaven" - "amakudari" in Japanese - refers to the common practice of government bureaucrats landing lucrative jobs in industry when they retire, making such contacts even closer). So, in this way the relations between the leaders of the nuclear power industry and the government bureaucrats are too close - and moreover the nuclear power industry magnates have "bought off" many of the leading politicians at the national level especially.

It is in this context that Fukushima, once the Japanese people began to understand what was really happening, really has been shaking up Japan.

SUMMER 2011:

Over the summer, in terms of fighting continued large radiation releases at Fukushima, most of the attention was focused on what countermeasures to take on the large volumes of very radioactive water being produced there. A large amount of cooling water was needed to prevent new overheating of the largely already melted down reactor cores, and in their damaged condition this water was becoming very radioactive. These countermeasures were very difficult to carry out, and one would often read about a new setback (with the high radiation level at the plants, it was difficult to do anything there), but as the summer progressed, there did seem to be some progress - a very tedious process, also dangerous for the people working in those high radiation areas. There seemed to be 2 main issues getting the most attention: first to build new cooling systems, which would function more normally - that is to do a better job of cooling, and maybe produce less radioactive water as the cooling was done. The second issue was treatment of the large amount of radioactive water that had been produced.

Also in the summer patterns in the political aspects became clearer. It became obvious that at the national level the proponents of nuclear power, who could not change their minds even when events had proven that nuclear power is far more dangerous than they had always been claiming (just bringing a Geiger counter to Fukushima is all that you need to prove that - even some areas outside the province have substantial contamination issues too), had far closer relations to both the politicians and the bureaucrats than they should have had. So it is here that you find more reluctance to move away from nuclear power. (At one point there was even some talk about building more nuclear power plants close by the damaged ones in Fukushima - which provoked enough uproar that it was not talked about for very long.)

But, it was at the local levels where the opposition to the nuclear power plants in the post-Fukushima area was growing very strong in many places. It was along about July or August when then prime minister Kan announced that 2 things were going to happen: Japan was going to reduce its dependence on nuclear power as being too dangerous and the national radiation safety council was going to have its top leadership changed. The reason for the change was that the previous leadership of the national radiation safety council had ties too close to advocates of nuclear power, and after Fukushima had proven, very dramatically, that nuclear power is obviously unsafe, with a major fraction of an entire province, and even more, seriously contaminated by radiation, what the council had sometimes been doing was to play down the seriousness of the situation rather than

doing its job of protecting people against radiation, when there was an obvious urgent need to do so. When Kan made these 2 announcements, a member of his own party publically announced that one of these was not going to happen. (It was one high-ranking party member with ties too close to the nuclear power industry.) This was even more shocking, because in a parliamentary system, unlike the US system, all party members vote in parliament in favor of the laws put forth by the governing party or coalition.) The LDP party leaders had long ago been bought off by the nuclear power industry, but the opposition Democratic Party, now in power for while, obviously had had some of its members bought off too.

As to restoring the National Nuclear Safety council to its real function, it seems that Kan really succeeded in doing this, as now the advice we are getting seems to be much better. Also, as we thought likely to happen in the first few days of the crisis, the iodine part was important for the first few weeks but by now has largely disappeared. (Due to its half-life of 8 days, this part is largely over after 3-6 months.) The damage has now already been done, with probably inadequate measures having been taken in those weeks when they should have been. The consequences of that are likely to become clearer in subsequent decades. The people directly affected, mostly in Fukushima province, will likely be closely watching how this develops over coming decades. (The damage is mostly over now, but the consequences of it may take a while to become clear.) But it is the cesium with its half-life of 30 years which will be around with us for a few centuries unless the decontamination efforts really succeed, which is what is being struggled with mostly now.

Over the summer attention was mostly focused on the continued problems with cooling and what to do with the large volumes of highly radioactive water being produced by the cooling. But now that that situation seems to be somewhat improved, the government is being forced to face more clearly its claims that they are going to decontaminate large parts of Fukushima Ken, and maybe other areas as well. Those really concerned about radiation safety issues will then be asking just how effective this decontamination will really be. It seems to me that to decontaminate a large fraction of an entire province is an enormous task. Hopefully if they really want to do it, they will do something effective, not just a few token measures. My own feeling matches well with what the US is officially saying, that the evacuation areas should have been much larger than they were.

A few weeks ago the government said that the Fukushima plants have now quietened down enough that some evacuated people could begin to think about going back since there was now only a small danger of massive new releases of radiation. But some of these people said that the decontamination should be done before they go back. I agree with that view, and might also add that if it turns out that decontamination does not really succeed, that maybe they should not go back at all.

As the cesium issue will continue for many months, decades, years and even centuries, the Japanese people are rather slowly coming to realize what they really face, and the general public anger against nuclear power is quite slowly, but steadily growing. Despite the connections between the nuclear power industry and the highest levels of national government, both parliament and the bureaucracy, the local governments are much more open to opposition to nuclear power, and the general public opinion against it is rising too. So, there is a struggle there - hard to predict its outcome.

There are a couple of ways that the public outrage can shut down nuclear power. One is that the reactors need to be shut down periodically (something like general maintenance, but not of the same kind as happens for most other devices). And it is now becoming nearly impossible to restart them again due to local opposition. So, the number of reactors in operation is decreasing, and this could go on for a while. The other issue is that at the power plants nuclear waste is building up. The assumption had been that it would eventually be removed and put somewhere else. But, I have also read that no location will now be willing to accept it as the antinuclear feelings in the general population is now growing, so it will have to stay inside the plants, and they will have to shut down before all too long for this reason. (If this is really correct or not, I do not know.)

Finally, as I reach the end of all that I want to say about this, I must add that I know very little myself about the biological effects of radiation. The number of measurements of radiation

nowadays is greatly increasing, but, as is true for much of the population I guess, I don't really know all that much about the biological consequences of these numbers.

I hope that you are happy with receiving these candid comments on the things one hears, as we are closer to this nuclear crisis in Japan than we would like to be.

FOOTNOTE:

On that bus trip last summer in Austria I met 2 people with a special interest in the nuclear situation in Fukushima. You were one of them - I should still look into it more, but I realize why you have that special interest in those events, which is why I tried to write down to you some summaries of what I know about that or think I know about that.

The other person on that bus with that special interest was Helge Braun. Our discussion was in English, because you would rather have it in English than in German. I think that with Helge Braun the discussion was in German. He is an Austrian who happens to live near that thermal bath complex in Austria that I was returning from. He is now retired, but he was formerly with one of those atomic energy agencies in Austria who oversee nuclear applications throughout the world, although Austria itself has opted not to have any nuclear industry. And for that reason he has a special interest in the Fukushima related events in Japan too.

So, when I started to write about this, I think it was after I arrived back in Japan on Sept. 16, I had to decide who to write the descriptions to first, to you or to him. And I wrote to you first.