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SECOND INTERDISCIPLINARY CONFERENCE ON SELECTED EFFECTS OF A GENERAL WAR

VOLUME II

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SUMMARY

The Second Interdisciplinary Conference on Selected Effects of a General War was held at Princeton, New Jersey from 4-7 October 1967, under the auspices of the New York Academy of Sciences Interdisciplinary Communications Program, with the support of the Defense Atomic Support Agency. The first of this series of conferences was held from 18-21 January 1967 and dealt chiefly with the effects of the atomic bombing of Hiroshima and Nagasaki.

This second conference was concerned mainly with the effects of fallout or other release of radioactive materials from subsequent tests or accidents involving nuclear weapons. The specific effects discussed extensively included the effects of the 1954 H-bomb test in the Pacific ocean which resulted in radioactive fallout contamination of Marshall Island natives and of the Japanese fishermen on the vessel Fukuryu Maru (Lucky Dragon); the ecological effects of bomb tests in the Pacific ocean test regions; and the effects of the "Spanish incident," which involved the accidental dropping of four nuclear weapons, without detonation but with release of radioactive material (plutonium) onto Spanish soil as a result of accidental destruction of an airborne bomber.

Representatives of many disciplines engaged in vigorous and free-wheeling discussion and debate of all aspects of these incidents. The disciplines represented included, among others, physics, weapons technology, military science, ecology, epidemiology, radiation biology, toxicology, pathology, psychiatry, genetics, other biologic and medical specialties, and pertinent administrative and cultural specialties.

In addition to discussion of the physical characteristics and extent of the radioactive contamination, the radiation doses, the monitoring and decontamination procedures, the biological, medical, psychological and sociological effects of the radioactive contamination upon the people and locales immediately involved, the discussions extended to broader and farther reaching psychosocial aspects, i.e., to the chains

of circumstances and events leading from these localized incidents through the news media and diplomatic channels to the reactions of the more complex social structures, such as the economic, political, and diplomatic repercussions of national and international scope.

There was much discussion of possible reasons for differences in reaction to incidents of these kinds among different nations; the importance of seeking answers to such questions in the differences in culture, as well as in politics, was stressed.

On the basis of the discussion of the specific incidents and their consequences, the conferees roamed the whole field of psychosocial and biomedical implications of nuclear warfare in an attempt to project the consequences of nuclear warfare under a variety of conditions with respect to magnitude of the warfare, anticipation of onset, preparedness, and civil and military defense policies. Interest was focussed upon policies and means which might help to prevent or to mitigate nuclear warfare, upon the nature, scope and consequences of nuclear warfare should it occur, and upon the problems of national recovery after nuclear warfare.

The participants of this conference included Dr. Frank Fremont-Smith, director of the New York Academy of Sciences Interdisciplinary Communications Program; the two co-chairmen of the conference, Dr. Austin M. Brues, and Dr. Arthur C. Upton; the discussion initiators for the five major subjects on the agenda, Dr. Charles L. Dunham (the 1954 thermonuclear test), Dr. Robert A. Conard (the effects of fallout on populations), Dr. Lauren R. Donaldson (ecological aspects of weapon testing), Dr. Wright H. Langham (the Spanish incident), and Dr. Merril Eisenbud (discussion of psychosocial reactions); and others listed on the following pages.

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TABLE OF CONTENTS

TABLE OF
CONTENTS (Continued)

SESSION II
THE 1954 THERMONUCLEAR TEST

INTRODUCTION

BRUES: To introduce the subject which will occupy us today we have asked Dr. Dunham to say something about the 1954 thermonuclear test, its background and nature and anything else he wishes to say.

DUNHAM: My guidance has been rather loose, I would say, and not having attended the previous meeting, you are going to have to put up with my playing it very much by ear. I have taken our leaders literally in that I haven't prepared a half-hour lecture on any particular topic and I gather that my function is that of an initiator in the sense that one talks about initiators in atomic weapons; the problem is whether I can generate enough neutrons to produce a chain reaction with this, our critical assembly here. [Laughter]

FREMONT-SMITH: Critical mass.

DUNHAM: Critical mass. I've been thinking about this off and on ever since Austin persuaded me to take this assignment last June, and I'm still having very great difficulty in trying to relate this event to the avowed purposes of these meetings, which are to consider the long-range effects, psychological and biomedical, of a nuclear war. The more I think about it the more difficult I find this, other than the medical. You will find that Dr. Conard and Dr. Donaldson will have a great deal to say on what the fallout aftermath is for plants, animals and people in a hypothetical or real nuclear war.

To relate the way people behave—and this is one of the more fascinating things about this whole story—to the way people might behave or react during a war, I find very, very difficult, and I think of a proposed experiment that was concocted back around 1949, in relation to the old NEPA Project, to find out how pilots would behave if they realized, when they were flying a plane near where a nuclear device let go, that they had received a lethal dose of radiation. This flight project

373-782 O - 70 - 4

was to take a bunch of Air Force personnel to the reactor at Oak Ridge and have them visit it, and while they were within the building and looking at the outside of the reactor, a lot of lights would flash and bells would ring and so on and so forth, and the loudspeaker would go on the air, "Evacuate the building immediately. Everybody has received a lethal dose of radiation." Then a group of psychologists would stand around and see how these people behaved. Of course, it was absolutely unrealistic in terms of the person who was motivated.

FREMONT-SMITH: This was just an idea? It was never done?

DUNHAM: It was never done, but it was very seriously proposed.

FREMONT-SMITH: Especially that "You have just received a lethal dose." Therefore, you may be used in any way we see fit.

DUNHAM: Right. Anyway, I though it might be useful to try to review the context within which these events took place. I think one has to go back to the fact that there was a war, that two atomic bombs were dropped on Japan, and that the Japanese were the only people who have ever experienced bona fide mass effects of nuclear weapons, admittedly small ones. One also has to object. . .

FREMONT-SMITH: It was not bona fide in Spain?

DUNHAM: That's a little different. Wright will tell you what his definition of the effects there is, I'm sure, later on.

FREMONT-SMITH: I just had to throw that in.

DUNHAM: Yes. Anyway, in 1949 the U.S.S.R. did detonate an A-bomb, and I can remember a meeting called hurriedly about getting on with our program. Shortly after that there was this tremendous debate, which is all available on the public record, a large part of it in the Oppenheimer hearings, as to whether or not we should develop the H-bomb. As you recall, both Oppenheimer and Conant had looked at what had happened at Hiroshima and Nagasaki; they then imagined what an H-bomb would do and they were totally incapable of doing anything except sort of turning the other way and saying "We must have nothing to do with it," and "Well, maybe the Russians will build one, but hopefully they won't use it." You know the decision was made to go ahead with the H-bomb program and at the Ivy Mike shot there was the first detonation of a thermonuclear device. It wasn't a weapon but it showed that the whole thing was a reality and possible, and

information that this thing was happening became more or less public around the world. So, when on March 1st there was a detonation at Bikini of something of the order of 10 to 15 megatons, the stage was really set for people to react. People had begun to be aware that there is such a thing as fallout, but they didn't have any real feel for it, and I don't think the military did either. Certainly I didn't.

In the first edition of The Effects of Atomic Weapons (Reference 1), fallout is discussed and not badly, actually, but still I don't think it meant very much to anybody because nobody could really see the problem.

I think one should keep in mind the kinds of people one is dealing with in this episode. On the one hand, one is dealing with Marshall Islanders, a small group of native people who are quite literate but who weren't well educated, and I think this is the distinction to make. They had been a possession first of the Germans, then the Japanese, and then the United States. I think they do not really love the United States. Bob may contradict me on this, but I think he would agree that their attitude had been, "Well, somebody is always going to be poking his nose into our business. We're going to be wards of somebody. The U.S. has been pretty good." So, when something had to be done and they were moved, they took it all very quietly and were totally cooperative. I never ran into a group of people who tried to be more helpful. Just to give you an idea of the kind of people they are—I don't have any slides because I think slides tend to slow up discussions —I'll pass around some pictures of the natives, and you can take a look at them.

In contrast, of course, are the Japanese, a highly sophisticated people, just as sophisticated as we, who had this extra sensitivity to the whole phenomenon of radiation, and who had been a beaten people who were very worried about their relations with the United States and with the world as a whole, but who were just beginning to sort of feel their oats a little bit.

It was within this general framework that these events occurred. I think that one way to set the stage here is simply to read the preface from a special issuance (Reference 2) of the Institute of Chemical Research at Kyoto, which came out in November 1954, six months after the event, and which shows how they set the stage as far as they were concerned. This is all physics and chemistry. There is no medical business in this report because none of the fishermen actually got to Kyoto, but much of the material did.

"On March 1, 1954, at three-forty a.m., twenty-three Japanese fishermen on board the fishing boat No. 5, Fukuryu Maru, were engaged in fishing in the Middle Pacific about ninety miles northeast of Bikini Atoll when a reddish-white flash was seen on the horizon in a west-southwesterly direction, and seven or eight minutes later a loud explosion was heard. Afterwards it was learned that the flash and explosion had been caused by the hydrogen bomb test at Bikini Atoll.

"About three hours after the explosion, fine dust began to fall on the boat. The falling of dust lasted for several hours and ceased towards noon. The boat as well as the fishermen and the fishes caught by them were covered with a white sheet of fine dust. After a two weeks' voyage, on March 14 the No. 5 Fukuryu Maru, contaminated by radioactive dust, returned to Yaizu Harbor, Japan."

It was at this point that the world really began to learn what had happened, although the U.S. had announced that there had been a test on the first of March, and that 236 residents of the Marshall Islands had been exposed to radiation and evacuated to Kwajalein.

Just to give you a visual picture . . .

FREMONT-SMITH: Had there been a sort of a warning to ships and so forth?

RADIOACTIVE FALLOUT AND RADIATION EXPOSURE

DUNHAM: There had been an exclusion zone within which ships were warned not to come, and there has been argument back and forth as to whether the Fukuryu Maru was within that zone. As you recall, the U.S. officials insisted that it must have been within it. It's obvious that it didn't have to be, because in Rongelap, which is way outside the exclusion zone, the doses on the northern part of the atoll were even higher than anything on the ship, and they would have been fatal.

Bikini is about eighty or ninety miles away from Rongelap; the Fukuryu Maru was up to the north, the other side of the lethal zone. At Rongerik, there were fifty air-weather personnel, and 300 miles from Bikini is Utirik. The doses here were roughly 10r-plus.

UPTON: Excuse me, Chuck. What do you mean by 10r? Is this over infinity or a week or a day?

DUNHAM: Infinity dose.

UPTON: Is this a surface air beta primarily?

DUNHAM: No, air gamma.

EISENBUD: Wasn't this up to the time of evacuation, Chuck? I think it was fifty-six hours actually.

DUNHAM: Here, yes. You're perfectly right. These are doses up to the time of evacuation. I'm sorry. The 800r line is an infinity dose. Thank you, Merril. These are estimates of actual doses received.

The air-weather people at Rongerik got 50. These are external. The dose for Rongelap was 150, and some of the Rongelap people who were on the small atoll fishing probably got about 75.

UPTON: Would this be whole-body or to the skin? What sort of penetration?

DUNHAM: This is an estimate of the whole-body dose. It's no better than an estimate, but a great deal has been based on this in terms of what the human blood response to ionizing radiation is.

As you know, there is a great deal of argument centered around that point, which I think is not particularly germane to the discussion today.

BUSTAD: Of course, on your exclusion zone, Chuck, isn't it true that this was related somewhat to the predicted wind direction, and that the wind direction did change so that Rongelap really appeared in the preliminary stages to have been safer than it was because of the wind shift?

DUNHAM: I think the following happened. The original exclusion zone for the test site didn't include Bikini. It went about two-thirds of the way between Eniwetok and Bikini. When they began testing at Bikini, they extended it beyond Bikini, but only what looks like about 50 miles. The exclusion zone was not big enough for what happened.

EISENBUD: Chuck, could I say something relative to this? In fact, might this be a good time to augment some of the background that you have given, which I think might be helpful in setting the stage?

DUNHAM: Yes.

EISENBUD: First let me say with respect to Leo's comment, in which he tacitly assumed that there was a windshift, I'm not sure of that.

DUNHAM: I believe the wind was already changing.

EISENBUD: This is a matter that hasn't yet been documented. It's a strange business.

I was then Director of the Health and Safety Laboratory and was in direct communication with one of our teams stationed in the Marshall Islands. The only wind information I have ever seen came in an official dispatch, at H - 6 hours, which arrived in New York just a few hours before shot time. From my recollection I would say that it would not have required a wind shift to dump the fallout on Rongelap. Unfortunately, the situation has never been documented in a manner that would make it available to many of us who were interested in the exact meteorological circumstances.

DUNHAM: But your comments are predicated on the only hazard being on those two atolls. It had nothing to do with ships out of the exclusion zone.

EISENBUD: That's right, yes.

For many of us, our first exposure to the possibility of massive fallout came in 1951 with two Nevada explosions of the Jangle series. One small surface explosion and one underground explosion took place in the fall of that year. Prior to that time the military doctrine as it was translated to us on the civilian side was that there would never be any point in exploding bombs close enough to the ground so as to get fallout; they wanted to maximize blast, as was done at Hiroshima and Nagasaki. So, only the airburst needed to be considered. Of course, obvious questions were raised, like "Well, suppose one drops to the surface inadvertantly and explodes on the ground, what kind of fallout are you going to get?" or, "Why not put it on the ground if you can make a big crater?"

I suppose that within the military there must have already been a discussion of a military demand for surface and underground shots. Until Jangle we had not really thought about the consequences of a surface or underground explosion. It was widely recognized that the Jangle explosions would produce more radioactive dust than any of the previous detonations including the Tower Shot during World War II. However, it was thought to be unnecessary to monitor the radioactivity beyond 50 miles from the explosion. HASL arranged to make measurements in the annulus of 50 to 500 miles, despite the fact that people thought we would be wasting time. To the contrary, we obtained a good deal of useful information and, in fact, we found that even as far away as Salt Lake City doses were higher than 100 mr. This was certainly revealing, considering that the two Jangle devices were very small. Following these tests several groups took the Jangle data and extrapolated to the multi-megaton device which was then being planned for Eniwetok.

FREMONT-SMITH: What is Jangle?

EISENBUD: Jangle was the Nevada test. It was a code name. This was in November 1951, and a year later they were planning to explode the first large thermonuclear device at Eniwetok.

There was an Air Force officer known to most of you who came up with a rather pessimistic estimate of what the fallout would be like, and he, I think, was probably the first to have predicted that there might be hundreds or maybe thousands of rads hundreds of miles away. Our group in New York came up with somewhat the same conclusion although not quite so pessimistic. However, it certainly did seem that much more extensive monitoring of the Pacific would be necessary than was then being contemplated. The task force saw no need to monitor beyond the atoll of Eniwetok, where Mike, the first large thermonuclear detonation, would take place. A fallout research program was included as part of the test program but it was limited to about 50 miles from Ground Zero. The AEC, however, did agree that a monitoring program beyond Eniwetok proper could be mounted if support could be found outside the task force. We succeeded in convincing CINCPAC, Commander-in-Chief of the Pacific, who had responsibility for security of the natives in the Marshall Islands, that the fallout should be tracked throughout the Southwest Pacific Ocean.

Then we were given the job of doing it, and after the Mike shot, found there was no fallout. As we reconstructed it later on, based

on water samples, we realized that there was fallout that went into the ocean. The probabilities of hitting those atolls are pretty small. They were a very small fraction of the total water surface exposed.

Well, there was about two years of wrangling over what should be done to Castle, the series we're concerned with here. There was a very, very influential group of people, both among the military and civilians, who insisted that there never was any Mike fallout, that it all went up into the stratosphere and that probably most of it was in outer space, and there even were calculations to prove it. But once again we felt that this had to be looked into. However, because of a very low probability that there would be fallout on these atolls, since they were so small, and a greater probability that it would all go into the ocean, we began to devise schemes for laying artificial islands. This has never been reported, largely because the information got lost in what happened afterwards, but on the day of the shot we actually were off the Florida coast in a Navy-supported operation, in which drums of viscous oil were being dumped from aircraft in such a way that it was hoped that an oil raft would lay on the surface long enough so that fallout would lay on the top and then a plane with suitable instrumentation could swoop down and make measurements.

This worked. The test fallout material was some iron filings that were irradiated in the Brookhaven reactor and dropped on these oil rafts. Plans were under way for shipping large amounts of oil out to the Pacific to lay down these rafts so that we could find out whether or not there was fallout. The idea was to wait until the shot was fired, find out the direction in which the fallout was likely to occur, send aircraft out to drop the oil rafts, then wait a few hours and send the aircraft in again with instruments to see if there was anything on them.

Well, actually, in parallel with that there were instruments put on that island, but those . . .

UPTON: That island?

EISENBUD: On those islands. The nearest one to Rongelap was the instrument put on Rongerik. I think this is revealing because it simply serves to illustrate the tremendous tenacity with which certain people just refuse to accept facts.

DUNHAM: I think that one of the problems is that you see people around Bikini all the time. They stayed there even when the thing was

detonated, and yet in one sense they were exposed to more or less lethal radiation.

EISENBUD: Yes. I think one of the things, in retrospect, was. . .

DUNHAM: Of course, they were in bunkers and that sort of thing.

EISENBUD: But in the Mike Shot the whole task force was exposed and we could have lost 10, 000 men. It could have been awful.

DUNHAM: I think that the fact that we were there gave a sense of security. You see, if you looked at the original weapons handbook at a pattern of fallout, and, as Admiral Schyler used to say, "Scale it up," why, you had something. But I don't think anybody took it as seriously as it should have been.

CONARD: I remember that during the Greenhouse Operation, we actually did have quite a substantial fallout.

TAYLOR: Also, after the first shot, the Dog Shot. That is one I've never understood. There was serious enough fallout so that people got a few r, at least.

CONARD: Yes.

TAYLOR: And this was known to a lot of people but somehow it never seemed to have had much of an effect on what happened at Castle. They were tower shots, I guess. At least the Dog Shot was a tower shot. And the fact that that produced quite heavy local fallout was certainly a material indication of what would happen later.

BUSTAD: But isn't it true that the March 1st shot was considerably larger than predicted?

EISENBUD: Well, it's true in part but I don't think the difference is significant.

BUSTAD: Isn't it a factor of two or three or four?

EISENBUD: I think my recollection is that it was considerably less than two. Let me make the point I wanted to make, which was that the instrument on Rongerik, which was an automatic instrument, went off scale at H plus seven hours. This was an instrument which was not part of the Task Force. It was being operated by what was

basically a CINCPAC-supported civilian organization based with the Task Force but not operating as part of it. When the instrument went off scale, the operating procedure called for the aerial confirmation of this and there was not enough interest in the Task Force to authorize sending a plane over the island to see if, in fact, the instrument was working properly. As I recall it, this was delayed about 36 hours. No information beyond the initial dispatches came into the States for about two days. In other words, there was just a complete breakdown as far as information was concerned, in taking the steps that were necessary in order to evaluate the situation, and to take the necessary palliative measures.

UPTON: You say it was delayed?

EISENBUD: I cite this simply to illustrate that right up to the last minute, with the fallout lying on the ground, the people just didn't go up to investigate.

UPTON: You say 36 hours, Merril? Was something done then, and if so, why?

EISENBUD: This is also interesting. The Commission had recommended an evacuation capability up there and this was denied on the basis that it wasn't necessary; that there would not be any fallout; that there just couldn't be enough fallout to warrant keeping ships on station so that they could evacuate natives on short notice. Finally, a plane went up. I was never clear as to why it went up there, but it was up there with a radiation instrument; it flew over Rongerik and found that the radiation levels were high. It was a PBM-1, of that series. It put down into the lagoon and took the American personnel off and then sent information back to headquarters which resulted in an LST, I believe, being dispatched to Rongelap to take natives off of Rongelap, so that the natives were there, I think, 56 hours.

DUNHAM: Fifty-two hours.

CONARD: A plane evacuated 16 older people from Rongelap at 50 hours and the remaining 48 people were evacuated by ship at 51 hours.

EISENBUD: I thought I would give this as background, because it illustrates the incredible disbelief of the subject of fallout that persisted not only up to this point but later on, as you will probably see.

DUNHAM: This was an analogous situation to what was seen in the Army with malaria. They had little malaria units. Every military group had a team, but the commanding officers had had no experience with malaria. They didn't see anything and this poor little malaria unit would cool its heels until they had a great many cases of malaria. Then they would be told to scurry around. I think it's just human nature.

Langham, you seem to be restless there. Would you have anything to add? You're the authority on Dog Shot, by the way, because some of your dogs were there, weren't they?

LANGHAM: Yes, they were. Merril's story to me is almost incredible.

FREMONT-SMITH: That's like life! [Laughter]

LANGHAM: Fallout was predicted for the Trinity test in 1944 by the bomb phenologists, Hershfelder and McGee. Stafford Warren mounted evacuation teams and monitoring teams to cover the potential fallout area. We didn't have to evacuate anybody; we almost did. The arbitrary limit chosen for evacuation was an infinite life-time dose of 50 r. One family approached this limit, and there was much debate as to whether we should evacuate them or not. They weren't evacuated.

WYCKOFF: What happened to the cattle?

LANGHAM: Cattle were burned by fallout at Trinity, and we had experience with fallout at Bikini where there was fallout on ships. I can't imagine anyone thinking that there wouldn't be fallout involved with weapons tests. I still to this day want to attribute the 1954 accident to just a little bit of misconception on the part of the meteorologists. I can't imagine at that time that one would think there wouldn't be a fallout problem with that device if a populated area was downwind from the detonation. So they had trouble, and I can't understand why anyone would have expected otherwise.

FREMONT-SMITH: You know what happens on misunderstanding. It seems to me this is one of the things we have to face. I will give you a little episode. During World War I we had shell shock, a considerable amount of it. It was so reported, and anybody who studied the thing at all knew that we were going to have some kind of equivalent

to this in World War II. So as soon as the first report came out in the Lancet by Sargeant and Slater of the war neuroses of the men evacuated from across the Channel, I came down to Washington to see Lou Weed of the National Research Council about what we were doing in anticipation of the emotional problems we would be facing when we got into this war. He sent me over to the Army Surgeon General's office where I was met by a colonel who said, "Now, Doctor, what are you worried about?" I said, "Well, I'm worried about what preparations we are going to make because we're going to be in this war and we'll probably have a considerable number of emotional problems as a result of the war, and we know from World War I what happened. In World War II, the British have already had it." And he said, "Doctor, you don't need to worry; we'll have no neuroses in the U.S. Army!" [Laughter]

Now, I just want you to know that this is the kind of extraordinary aspect of human nature one has to face, and I suspect that the true story really didn't come out that it wasn't a radiological but a human factor that went wrong. But maybe I'm wrong.

EISENBUD: I can understand why you feel that way. The fact of the matter is that Joe Herschfelder by then was probably back in Wisconsin.

WARREN: Jim Cooney was my deputy at Bikini. Jim, like many others, was not convinced that there was anything to do. He would leave at four o'clock and go to the BOQ and have a beer just about the time the boys were returning with contaminated clothes and hands on the gangplank, and then about dark the algae would begin to rise and we would have troubles with radiation through the hull all night. He thought it was unimportant. He thought we were foolish for staying up all night wondering where the stuff was going in the deep part of the lagoon. When Frank came back with this radioactive sodium, there was a big haw-haw on his part and they almost court-martialed me for exposing Frank's ships to this radiation hazard. And, yet, on the other hand, Jim pooh-poohed the whole operation and thought it foolish to send a destroyer on this crazy downwind trip in the hope of getting some rain-out.

If I may just continue. He was the RADEF for the preceding operation and was the adviser to the Army, and many of the times that I described in the last session, when I was up before the Fleet for explanation in a pseudo-court-martial, they couldn't taste it, they couldn't hear it, they couldn't see it, they couldn't feel it. There were

just these RADEF boys, with their instruments which showed something or other, who claimed it was hazardous and that they were losing their ships and equipment and their gear and their laundry and their possessions. You could understand some of the objections. It was a lot of trouble and it was costly. How do you get a station to stand out in the ocean in the right place? The waves come along in a little while and the fallout which hits the water is gone. Even the SARAR left an awful lot of oil when she sank, and this went on over the reef. It was traced downwind about 60 miles but in ten hours it was gone and anybody going out there then could show that there wasn't anything there and could ask why you were worrying. It was costing an awful lot of money and time. The meteorology was expensive, too, to cover this vast area where there wasn't anything to sit on, and it was very chancy. But they didn't really have the concept of how vast this phenomenon was and what the quantities were. You'll find people, not all of them in the military, who were unwilling to face what might have happened at Alamogordo. Oppy protested our surveys after the war until the white-backed cattle appeared in the Albuquerque slaughterhouse. It took a lot to overcome the resistance to our purchasing of cattle. I don't know if Dunham remembers this because it was partly before his time.

Such antagonism to the concept of the meteorological mechanisms and the vastness of the fallout problems, together with all of the expense and trouble and manpower required for instrumentation and the many safeguards like evacuation plans and public relations complications from excluding ships from this vast area, all combined to make this episode possible.

Then I feel that this was a very fortunate thing to have happened with so little real tragedy involved because actually nobody was really hurt seriously by the fallout.

DUNHAM: I think the most dramatic thing of all is where that 800-rad line landed.

WARREN: Yes.

DUNHAM: It was squarely between the Japanese fishing boat and the Rongelap people.

WARREN: If you had planned it that way you couldn't have gotten it better.

DUNHAM: If it had happened on their own home island they probably would have had a lethal exposure within the 48 hours between the time of the fallout and the time they were evacuated. These were studies that were made by Pete Scoville, * I think (see Dunning, Reference 3), who was one of the principal people involved in actually taking the measurements. They went in there at 36 and 48 hours; they took readings at different places on different parts of the atoll, then went back later, took more readings, and then extrapolated back along the K-constants, and so forth, as to what it would be originally and what the infinity dose would be.

Merril, do you want to comment on this?

EISENBUD: I think it was very difficult to estimate the doses, obviously.

DUNHAM: Yes.

EISENBUD: I've often had a feeling that the doses may have been very much higher than had been estimated, particularly in the case of the Japanese ship.

DUNHAM: Of course, that's a different proposition, because nobody measured them until two weeks later.

EISENBUD: That's right.

DUNHAM: And the ship had been hosed some.

EISENBUD: That's right. I saw that ship March 22, 22 days later, and by that time it was still reading generally about 110 mr per hour, and the Japanese and our own people had had enough of the debris. We knew what the decay-characteristics were, and if we extrapolated from that 150 mr per hour to H plus four hours, the integrated dose was something better than 100 r.

DUNHAM: Yes.

EISENBUD: By this time the ship had been hosed, as you say, and scrubbed and people had gone on with vacuum cleaners to take off as

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* Scoville, H., Jr. At that time Scientific Director, Armed Forces Special Weapons Project.

much of the dust as possible because they wanted the dust for study. So it could very easily have been in excess of 500 or maybe even 1,000 r.

DUNHAM: So it's possible, with this line that I've drawn—and you called my attention to it this morning—on the map, that I've come much closer to the ship than is indicated there; the 800-r line might have been quite close, not 20 miles away.

EISENBUD: The fallout on the ship was estimated to have been 50 curies per square meter, which is going to make some of you wince, but I think it's a pretty good estimate. It was made by the Japanese in a very interesting way. They took surfaces and sprinkled sugar on the surfaces and then asked the fishermen, independently of each other, to pick a surface which looked like the ship at the time of the fallout. The opinions clustered around a certain couple of slabs, and since they had samples of the fallout, they could estimate what the activity was. The best estimate is around 50 curies per square meter, which is quite a heavy dose.

BUSTAD: Wasn't one of the difficulties that some of the crew members swept up the fallout and put it under their pillow?

EISENBUD: I don't know that.

DUNHAM: One of them put some in his pocket, I believe, to take home as a souvenir.

MILLET: Thus far, we have heard that those in charge thought they knew, but they did not. Whether or not the fault lay with meteorologists, admirals, generals or scientists may not be important except to those who want to define history in its greatest detail.

No information reached the United States for 36 hours. There was incredible disbelief that the event had occurred. And disbelief was true not only for this episode, but as Dr. Dunham has mentioned, for malaria, and as Dr. Fremont-Smith said, it was true also for psychoneuroses. It happened subsequently with respect to radiation exposure, as we will hear later in this meeting.

I wonder if there are not really two kinds of psychological features with which we should be concerned: one is the fear of radiation effects among exposed persons, and the other pertains to the psychology that

leads to underestimation or miscalculation of the magnitude of the nuclear event and its psychosocial consequences.

BRUES: This is because we've been brought up to have a two-valued way of looking at things, isn't it? That either we're frightened or we're not frightened. Actually, there are degrees of being frightened.

MILLET: I think one of the very interesting things is what motivates so many people to deny the facts when they are so readily demonstrable. If the data are clear and are presented and they are denied by intelligent people, otherwise intelligent people, there must be some motivation known to them or unknown to them which makes it impossible for them to change their position. This brings us to the question of when is a delusion not a delusion.

FREMONT-SMITH: Right.

LANGHAM: I think it's a matter of biased values. There isn't a man in the field that isn't anxious to get on with his part of the job, and in dealing with these people you find that to them the highest priority, consciously or subconsciously, is to get on with the job; isn't that right, Dr. Warren?

WARREN: Yes.

LANGHAM: Invariably you'll find this conflict. The protection man is obstinate in his way. He wants to do a job right, too. And this is a conflict that's brought about by the bias. The bias is brought about by the position in which the man finds himself.

MILLET: One wonders if there isn't something in our national culture which makes us prefer getting on and moving rather than waiting and listening and finding out. I heard a comment last night from my neighbor here that the American psychiatrists don't bother to read foreign literature, for example.

LANGHAM: We have hawks and doves right now. I think probably insofar as radiation protection and nuclear devices are concerned I might be classified as a hawk. I still think one has to make haste, but with caution. I think in some cases people who want to be cautious may lose and in some cases they may win. At Greenhouse we had a trick played on us which may amuse you. During Dog Shot, at which

we were recovering animals from the shot island, we dressed in complete protective clothing including respirators. We looked like men from Mars. We invaded the shot island to get our animals, and the plan was that when we came back to our home island with the animals we would strip off all our clothes and throw them into a box on the beach and walk up to the quarters in the nude. On the shot island, we could hardly get a meter reading anywhere. In the meantime, a sheer in the wind had brought the fallout right over our home island. When we returned to base camp with our animals, we took off all our clothes and walked in the nude through a hundred times as much radioactivity as occurred on the shot island! [Laughter]

FREMONT-SMITH: That's a wonderful story.

TAYLOR: I would like to interject something that you challenged, Staff. You said a moment ago, you can't hear it. Apropos of the Dog Shot, fallout was clearly audible. There were little beads of steel from the tower that condensed, and one heard this constant tinkle, tinkle of steel from the tower hitting the aluminum roofs and then rolling down the gutters and piling up in little piles on the ground. The thing which I've never understood, which has some psychological significance, I suppose, is that the radiation monitoring teams, pairs of people with a Zeuss meter, would find one of these little piles and you just heard from them lots of expressions of various kinds of bad language about 10 r per hour, 40 r per hour, a few r per hour and a sort of disbelief. The upshot was that everybody kept wandering around. According to a Zeuss meter that Herb York* had set up in one of the buildings just to have people file past to see what their reading was, my own hair was reading 2 r per hour after a shower. Well, I got worried, along with a number of other people. But somehow there was an air of unreality about the whole thing. There was a big discussion about whether we would have a movie that night or not, and somehow they, and no one seemed to know who "they" were, had decided that the movie was all right.

Somehow I've never understood how that could have happened, in view of all the literature that was available for years before Greenhouse on fallout and on how large areas could be covered with very intense radiation. No one seemed to want to believe what was happening.

* Herbert F. York, then at the University of California.

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FREMONT-SMITH: Isn't there a lesson for the whole purpose and goal of these series of conferences in this discussion that's taking place this morning? Human nature is not going to change that fast and we're going to have a variety of conflicts and attitudes, and hawks and doves, with respect to a, b, c, and d, in preparation for the possibility of atomic war. Also, if there ever is a nuclear war, there will be this same kind of confusion and reaction all over the world. So it seems to me that this aspect of human nature, which we're probably going to have to face in one way or another as long as there's human nature around, is one of the central lessons for this whole business. If we're going to get anything out of this, part of it is going to come by the fact that human nature is this way and that there are conflicts in authority, the highest level of authority. You're going to get denial of facts, as Jack brought out; clearly evident facts will be denied up and down and proved not to be so by other authority.

I attended a conference that the Civil Defense put on in which the problem faced by the group in this 3-day meeting was that a bomb has been dropped. This was the assumption, and we were to focus attention on two counties in northern New York State bordering on the of the Great Lakes. According to the assumption, the wind has blown the fallout over these counties and the question is what do you do? Well, the report of this meeting was never published, not, I think, so much because it was classified, but because it was unbearable to have a group of intelligent people about as confused as we were. We ended up with a terrible wrangle as to who was to milk the cows! [Laughter]

So, I think that among the lessons is that there's a lack of a logical approach to the realities of the problem that can be counted upon no matter where we stand. I would throw in one little touch, and that is that we are all aware of the fact that the weather every once in a while turns out differently from what is predicted.

LANGHAM: I would like to refer back again to the conflict of interest on the part of scientists trying to work together. Each man's ego is tied up with his job.

FREMONT-SMITH: You are right. Our multi-disciplined conferences are bringing this out every day.

LANGHAM: I have a rather amusing story that illustrates this. I don't know whether I ever told Dr. Warren, but he kept getting messages from the colonel on Eniwetok who was in charge of putting the droned B-17s through the clouds at Bikini.

WARREN: Yes.

LANGHAM: Under remote control these B-17s had been flown through the bomb cloud. They were not destroyed but were slightly radioactive. The colonel wanted to take the remote control equipment out and use the B-17s to fly his crew back to Honolulu. He asked Staff to send a man over to clear the planes as radiologically safe.

Staff sent over two people and before the monitor would get back, this man would be on the radio again asking Staff for a decision. Dr. Warren finally came to me and said, "I don't know what's happening with that guy. I sent two men over and he's still bothering me. Will you go over and find out what's bothering him and get this thing straightened out?"

I went, and as I came down the ramp at Eniwetok, standing at the bottom of the stairs was the young colonel who looked about 25 years old; he wasn't as old as I by 10 years or so. When I came down the stairs, these were his words, "Are you that radiological man?" When I said I was, he pointed to the B-17s and continued with, "Well, sonny, they're there. Don't give me any of this crap about milli-roentgens. Do I fly them home, or do I push them in the ocean?"

The highest readings were in the cockpit where there were several radium dials and on the engine intake and exhaust manifolds. I came back to the colonel and, in my most efficient manner, announced, "Fly them home." With that he said, "Come with me. We're closing out the club." I stayed there four days and wasn't sober a minute! [Laughter] It never cost me a dime!

Here is a specialist, good at his job. So you've got a psychological conflict right here that, I'm sure, stems back to the ego and the fact that the man doing the job satisfies that ego by filling it well.

FREMONT-SMITH: And you satisfy yours and therefore went to the club! [Laughter]

LANGHAM: That's right.

WARREN: After 20 years I've got an explanation why he was so long gone! [Laughter] This is why I made such a tremendous effort to save the Independence. The Navy had towed her to Mare Island. She was seriously contaminated by the underwater blast. The Navy

had been unable to clean her enough to get the radiation down below our 24-hour level. Twice I went to the 12th Naval District where she was berthed to persuade the commanding officer to delay her sinking temporarily. She was a fine example of general contamination inside and out, and would have been a fine training resource.

The first time an inexperienced person walks into a situation where he's surrounded by contamination and the meters show it, he can hear the buzz on the Geiger counter, he realizes he's in a hazardous situation and he's either prepared or not prepared to deal with it. But he should be prepared and he can be prepared to deal with it and conduct himself with some safety. We needed a place like that, a real situation as this ship represented. But they finally took it out and sank it. I think part of it was to get it out of sight, out of mind.

FREMONT-SMITH: "Let's forget about it."

WARREN: It was a hazard they wanted to forget.

DUNHAM: Maybe we should move on from this background as to why the Task people behaved as they did. They behaved in some ways very much like the Command in Hawaii, when the little fellow running the radar at the ack-ack installation at Pearl Harbor reported he saw some planes coming in.

FREMONT-SMITH: Exactly.

DUNHAM: I think as far as the Rongelap people go—and if anybody wants to disagree, they can take this up right here—that until one comes to the end of the line almost, there's no particular psychological problem. They were dealt with, I think, well. They were put in good barracks and taken care of. They were probably given too much to eat and had good medical care and there was very little protesting. Isn't this generally the situation, Bob, as far as the people are concerned? They were not enthusiastic about having to leave their atoll but they bore with it. They were not having any aberrant psychological responses.

CONARD: This is generally true. There were a few psychological reactions resulting from the fallout situation on Rongelap after they were moved back to the island. I will refer to these later.

DUNHAM: They still didn't really know what happened. They were told that something happened. They were told that they had to

have their hair washed and that they had to stay away from home for a while.

LANGHAM: How did they respond to this?

DUNHAM: This is all second-hand from talking with them. One of them, the "doctor," what was his name?

CONARD: Jabwe.

DUNHAM: Jabwe, the "doctor," who had some training, decided the water maybe was getting contaminated, and I think he forbade them to drink water after the first few hours.

CONARD: But they did anyway.

DUNHAM: They did anyway. Some of them went swimming to get the stuff off. Again I don't think it was a panic reaction. There was nobody to tell them this was radioactivity; there was nobody to get them excited, and it had happened. I think one of them who had been in Japan somewhere along the time of the Japanese occupation, recollected that it looked like snow but, of course, wasn't cold. I don't want to steal your thunder for your afternoon session, Bob.

CONARD: They had seen previous shots.

DUNHAM: They had seen the light.

CONARD: And this was nothing unusual except it was much larger than anything they had previously seen, and they described it as the sun rising in the West, I think.

EISENBUD: They wouldn't have seen the Eniwetok shot in 1952.

CONARD: They saw others.

EISENBUD: Yes. It was my recollection that the Eniwetok shot certainly was about the same size as Bravo, wasn't it?

DUNHAM: In 1952?

DONALDSON: No, no. A little less than one-fifth.

THE FUKURYU MARU (LUCKY DRAGON) AND THE PROBLEMS IN JAPAN

DUNHAM: I think we should go on to the Japanese fishing boat. Ralph Lapp, you know, has written a book (Reference 4) on this subject and there are some pictures in it of the boat and the crew. I'll pass this around for anybody who hasn't seen it. It was an old tub, not up to modern Japanese fishing boat standards, but I think it did have a radio aboard and that the radio was in constant communication with Japan throughout this whole two-week period. It's not at all clear that anything was ever said about this episode in conversing back and forth.

FREMONT-SMITH: You mean they didn't report it to Japan at all?

DUNHAM: No.

FREMONT-SMITH: Not until they got in?

DUNHAM: Not until they got in. Anyway, the Japanese fishermen actually developed skin lesions, which Bob will describe quite vividly for you with pictures, as appeared in the Rongelap people, perhaps a little more severe and the distribution somewhat different, particularly along the belt line because they were all wearing trousers and apparently collected a lot of the stuff right where the trousers were tied. The people are described as looking black, and you can almost sense—Ralph tells a good story of this part of it—how the almost panic situation developed over a period of 48 hours.

FREMONT-SMITH: After they got the fallout.

DUNHAM: After they got the fallout.

UPTON: Were they unaware until then that they had been exposed? Is it clear from the log when they first became aware that they had been exposed?

DUNHAM: They saw the flash. They had the fallout.

UPTON: Did they know at the time?

DUNHAM: Yes. There was no question that they had a general idea exactly what the whole story was and they hot-footed it straight home. They made a bee line home, which in itself is significant.

FREMONT-SMITH: Did they know they were in danger?

DUNHAM: I don't know if they knew how much danger. There were various degrees of concern, and what they were thinking at that time, I don't think we know. Ralph interviewed a lot before he wrote the book and he was there three years or two years later, which is an after-the-fact recollection.

UPTON: You speak of panic, you mean among the crew or among everyone concerned?

DUNHAM: No. This was a broad panic almost involving Japan as a whole. I want Merril to make a real contribution now because he was right there. When they monitored the ship, they found radioactivity. They found that the fish, at least the top fish on the catch, were contaminated. They began throwing the fish away. Then the next thing anybody knew was that within a week or so they had thrown away a million tons of fish; almost anything that came from anywhere. They would monitor the run and they would say, "Oh, boy, it's reading," and right into the sea it went. Merril, you were right there and you saw what happened.

EISENBUD: This whole story has the same element of the Rongelap fallout. For example, there's no official report of it, which is surprising. I don't think there is one of the Rongelap fallout; at least I've never seen an over-all comprehensive report covering the thing from beginning to end.

FREMONT-SMITH: This is extraordinary, isn't it?

EISENBUD: Yes.

DUNHAM: What kind of a report do you mean?

EISENBUD: Well, I mean that ordinarily you would expect that an incident of this magnitude would involve setting up an investigating team and putting out a report which would be available to the people who are involved. For example, I never wrote a report on my own experience in Japan beyond the first two weeks because I just waited and waited, presuming I was going to be able to fit it into some sort of over-all report.

DUNHAM: You mean a report on the episode, how and why?

DUNHAM: This document here is an after-the-fact one.

EISENBUD: That's right. Normally you would expect, for example, that the meteorology would be described, including the development of wind patterns starting a day or two before and running right up to shot time. This is not available. I asked for it before I came down here and it's still classified. So I couldn't bring it with me.

FREMONT-SMITH: You mean it's available but classified?

EISENBUD: Yes, right. This would simply mean that nobody has taken the time to declassify it, which takes work.

DUNHAM: I think Merril has a feel for the way this thing built up in the Japanese press that nobody else in this room can have. I hope that he will just devote a few minutes to this, starting with, say, throwing away the fish from the Fukuryu Maru.

I have a few more visual aids which I will pass around. You can look at them at your leisure. There is a record by Holmes & Narver* of the repatriation of the Rongelap people, and it has nice pictures of them and their habitats.

The only thing really wrong about it is that the pictures of the original houses were taken after two years of total neglect and they are not nice, well-kept-up homes such as Bob Conard and Cronkite put in their report, which were pictures taken immediately after the event. But otherwise I think you'll find these interesting.

The other things I want to pass around are pictures of Mr. Eisenbud and some of his Japanese friends. This is the July 17, 1954 issue of the Saturday Evening Post, with an article (Reference 5) entitled "The Grim Facts of the H-bomb Accident." This was out at about the height of the fever both in this country and in Japan. It starts: "Shortly before noon of a sunny day last January began the most famous voyage any Japanese ship has made since the battleship YAMOTO undertook the dramatic suicidal sortie from the Inland Sea." It shows pictures of Dr. John Morton examining the fisherman. It shows pictures of Merril wandering around on the deck of the Fukuryu Maru. Please treat it gently because it's my only copy.

*The Holmes & Narver Co. was contractor to the Joint Task Force and rehabilitated the islands of Rongelap and Eniwetok on the Rongelap Atoll. The document referred to was never published.

It may not be apparent from articles like this or from Ralph Lapp's book how much rapport developed between the Japanese scientists and people like Merril, John Harley, Lauren Donaldson and others who worked closely with them and tried to help them sort facts from fiction. It was a very close working relationship, and as evidence of this, in the special issuance (Reference 2) of the Institute of Chemical Research at Kyoto, which is a special issue on the dosimetry, radiochemistry, and so forth, it says, "Furthermore, we should like to acknowledge with deep appreciation the kindness of Dr. John H. Harley, Chief of the Analytical Branch, Health and Safety Division, New York Operations Office, U.S. Atomic Energy Commission, who provided us with much valid literature concerning the metabolism and internal dose determination of fission products." Many of their articles have a similar acknowledgement at the end of the article. I think this is important to keep in mind; in spite of all the public panic, hoopla, newspaper reporting, personal accusations and unpleasant things that may have occurred on the streets, there was, among the disciplined, thinking scientific community, a great deal of wholesome and constructive exchange.

With that as sort of an introduction, I'm going to ask Merril first to tell us a little about his experiences in the development of the problem over there. Then Lauren can tell us something of his experiences. He was sent over at the request of the Japanese as an expert on fisheries and radiation. Finally, I hope we will have time for a little bit from two people, Dr. Schull and Dr. Miller, who were at the time with ABCC, which was peripherally involved, and that they will give us a little picture of how they got dragged into the thing.

Keep to the same ground rules. Everybody interrupt, if you want to.

WOLFE: Before you start I would like to know just what the date was that the U.S. society found out about this fishing vessel.

EISENBUD: Well, it's a good place for me to start. They found out the way the world found out, when the ship put into port.

WOLFE: That was two weeks after?

EISENBUD: Yes. It was the 18th, I think.

DONALDSON: The 17th.

EISENBUD: The 17th here, the 18th there, I think.

DUNHAM: March 14th, precisely two weeks.

EISENBUD: Then I'm wrong.

WOLFE: You mean our people didn't know that ship was out there?

EISENBUD: That's right. If you've ever been on any of these sweeps, you could understand why. It's a big ocean and the radar isn't very effective on a small wooden vessel.

DUNHAM: Remember how long it took to find Eddie Rickenbacher.

EISENBUD: Yes.

WOLFE: He had the winds blow in two directions.

EISENBUD: The boat put in, I thought it was the 17th but you say it was the 14th, and I think the first newspaper accounts were on the 16th, as I recall.

DUNHAM: Right.

EISENBUD: Now it comes back to me.

FREMONT-SMITH: The Japanese?

EISENBUD: The Japanese newspaper accounts were, of course, picked up all over the world. Consistent with the pattern right from H plus 7 hours, the initial reaction here was disbelief, that this was just a propaganda stunt, that there would be nothing to it. Dr. John Morton, who was then director of ABCC, was dispatched pronto up to Tokyo to help out and telephoned me in the middle of the night.

FREMONT-SMITH: Where were you at this point?

EISENBUD: In New York. He told me that he would need somebody who could evaluate the physical facts. There was no one there at the time. I tried to catch John Harley, who had just left Japan, but I couldn't intercept him, and it was finally decided that I should go there myself.

FREMONT-SMITH: How long did it take you to get there?

EISENBUD: Well, apparently I'm not too good on the dates. I flew straight through. In those days it was about 40 hours. I think I got there around the 19th or 20th, 48 hours later. There was a lot of confusion everywhere. You've got to remember that 1954 was the end of a very bad time for the Japanese. It was nine years post-war but the upturn really hadn't begun. They were two years past the Peace Treaty. The scientific community wasn't organized. The Japanese had no instruments, not even Geiger counters. Also, there was a lot of jockeying for position among the Japanese.

Well, I went very innocently myself. Actually I was all packed for going into Eniwetok anyway, and within an hour I changed my plans and left for Japan and had no contact with anybody until I got there. When I got there, there must have been a thousand people with signs at the airport, and I wondered who the big shot aboard was; I found out it was I! [Laughter] Somehow or other, through this telegram, they had word that I was coming and were picketing. Some American MPs had been permitted to come to escort me into a limousine, which was right at the foot of the ramp.

Well, this of itself was very bad. A number of Japanese had come out to the airport to meet me, some of whom I knew quite well, but I wasn't permitted to see them. They had waited for hours, and I was put into the limousine and whisked out to the Embassy so that I could brief the staff. So that was the beginning.

The Japanese had no way of getting the basic information that they needed. They knew nothing about bombs; there was no way in which they could get, for example, information on the fission products that you would expect, the debris, and what kind of activation products would be present. On the other hand, the next morning one of the first people I saw was Doctor Kimura, who was one of the first radiochemists who actually had been a student of radioactivity, and who in 1945 was the one who had taken soil samples from Nagasaki and Hiroshima and concluded that there was plutonium in the Nagasaki bomb, based on his analysis and what he read in the newspapers.

By the time I talked with Kimura the next morning, he had already analyzed the debris and had detected uranium-237, which led him to the conclusion that there must have been an n2n reaction which involved the fast fission of uranium-238. I mention this because at that time this was a very sensitive fact in our weaponeering and here I was sitting with a man who had deduced something in a couple of days that was known to very few people in the United States. So you

see the situation I was in, trying to be helpful and at the same time trying to protect information that other people thought should be held secure.

I think that at that particular point in time the whole difficulty with the Japanese, as far as the public relations problem was concerned, could have been solved. The main thing that the Japanese wanted was a statement that our government was sorry.

DUNHAM: Didn't one of the fellows get involved with the accusation as to whether or not they were within the exclusion area, so that it was a long time before the powers in Washington would agree that it was perfectly possible that it wasn't within the exclusion area?

EISENBUD: That's right. I think it was clear, and this was reported, that they really couldn't tell, and that the navigation equipment they had wasn't very sophisticated. The log looked authentic but they could have been five or ten miles on one side or the other.

One thing that impressed me through this stage, which I've often remembered as other crises developed and as I think about our people that were participating, is how tired you get. I flew straight through in 40 hours in a very excited condition wondering what it was going to be like when I got there. I arrived at two o'clock in the morning of, I guess, the end of the second day. I was whisked to the Embassy at two in the morning and stayed in conference for about 2 hours. I went home and got into bed for the first time in 3 nights; I had 2 hours sleep and then went off for the first conference with the Japanese, and met all day. I made a point of getting to bed early that night, but with the 12-hour difference in time, John Bugher was just about ready to telephone me along about ten o'clock at night, and this pattern kept up for 4 or 5 days. I was really at the verge of exhaustion, but I had to make a decision.

FREMONT-SMITH: Yes, which is very difficult to do in that state.

EISENBUD: Yes. And I don't know whether or not I made the right decision; I mean, somebody else would have to evaluate this. But when I think of the Cuban crisis and the Berlin crisis, and of the very few people who were at the center of this thing and who had to think despite the fact that they couldn't get their rest. I think it's a problem that someday the government is going to have to deal with. Chuck, you may have been in the middle of this many times.

DUNHAM: It's not uncommon.

EISENBUD: The relationships with the Japanese were . . .

FREMONT-SMITH: The safety of all the world can rest upon the judgment of somebody who is exhausted, who has to made a decision.

EISENBUD: Yes. There were some obvious snafus of a very minor nature which seem amusing, but might not be. Maybe there are some that I don't know about that were not so amusing. For example, on the third night Tsuzuki who was down at Yaizu—there were a few fisherman down there—passed word, through one of the others, that I should call on him immediately on his arrival that night. He was coming in at eleven o'clock that night. This seemed like a strange time to be asking me to call on him, but I checked with this fellow who seemed to speak good English and he said, "No, Dr. Tsuzuki wants you to call on him at his home." So the Embassy provided a car and at eleven o'clock I was up at Tsuzuki's house and, of course, he came to the door in pajamas. He was expecting a telephone call! [Laughter] This illustrates another problem, that is, that the fact that a man thinks he can speak English can be very dangerous. The difference between "call Dr. Tsuzuki," which I would take as meaning that he wants me to telephone him, and "call on him," which means that you visit, is a subtle one which you can't expect all Japanese to understand. So I emphasize this as another thing that complicates a situation which is already complicated. He was very gracious; he had a bottle of Scotch and we sat up and had a fine chat.

I would say that the political situation was stalemated by the fact that the Japanese Government was very anxious to settle the thing amicably and were willing to cooperate in any way. They were willing to enter into an official agreement with the United States that would relieve us of any further financial responsibility. But they insisted that we had to say we were sorry. So while this was going on, John Morton and I were concerned with the more technical aspects, and it is commonly said that we weren't allowed to see the fishermen. This is not so. They didn't want the American doctors to examine the fishermen, primarily because of what was being said in the American press and by some Americans in Japan, including a couple of Congressmen, to the effect that there was nothing wrong with these fishermen and that it was all a hoax. There were two members of the Joint Committee on Atomic Energy that came through Japan, saw these men a few days after they arrived, saw the burns, decided that these were superficial and made a public statement to the effect

that the whole episode was being exaggerated, despite the fact that at that time the blood counts were dropping at an alarming rate.

So, the Japanese understandably were reluctant to have Americans publicly come in and check up on what they were doing. On the other hand, John Morton and his staff were given every courtesy. They looked at the blood; they stood there while the blood was being sampled. They could poke the fishermen and talk with them. I myself got involved in this in a peculiar way. I think you'll find it on the front page of that Saturday Evening Post article (Reference 5) where it says that I wasn't allowed to see the fishermen because I wasn't a doctor. Quite the reverse is true. I went to Yaizu to see the ship and had no idea of seeing the fishermen because it was almost an impossible situation. I had been told that the hospital was a small hospital, that the patients were sitting on mats on the first floor, that there were hundreds of people milling around and that there must have been 40 or 50 reporters, and I didn't see how it could be useful for me to go to see the fishermen even on a courtesy basis, although I was anxious to make some physical measurements on them.

Well, at lunch that day the Mayor of Yaizu indicated quite strongly that the fishermen would be hurt, knowing I was in town, if I didn't come to see them. So, I did go there and I made enough very superficial measurements to ascertain that their thyroids were very hot. I took samples of their hair and asked for some skin scrapings, which I took with me. These were sent to New York and analyzed subsequently.

DUNHAM: I'm interested in what you said about the relations with Morton and yourself because a lot of Americans got very upset with the idea that the Japanese didn't invite you to take over.

EISENBUD: That's right.

DUNHAM: You weren't invited; there's no reason why you should have been. As George Le Roy* said, how would we feel if the situation had been reversed and a couple of so-called experts from Japan came over and were to demand total access and taking over of the

* Dr. George LeRoy was then on the faculty of the University of Chicago and was consultant to the AEC and to the medical team that was responsible for the care of the Rongelapese.

treatment, and so forth. But this was the way it was played up in the press.

EISENBUD: I got samples of urine and blood, for example.

DUNHAM: Surely.

EISENBUD: Well, we made a considerable amount of progress in the first week. I had set up a sort of formal organization for investigating this. There was a Japanese committee established and Morton and I were invited to all the meetings, and then something happened which was heartbreaking and which is a matter of public record. Of course, the American press at that time was very much involved. There was a furor at home. So, it was decided that the President would go on television and make a statement to the public. He did this with Admiral Strauss and there were two things in that statement which were very offensive to the Japanese and that caused things to deteriorate so far as Morton and myself were concerned. One was the statement that the burns that the men had—if I'm not giving this in correct context, Chuck, say so—were not due to radiation but were due to lye produced when the coral was calcined in the fireball and then fell out on the fishermen.

DUNHAM: I can remember when this hit us. We were at Kwajalein. I could see the expression on Cronkite's* face when he read this.

EISENBUD: Yes. This hit the Japanese papers with the full knowledge . . .

FREMONT-SMITH: Where did the idea come from?

EISENBUD: It certainly didn't come from me, but everybody else thought it did.

CONARD: The fallout material was indeed caustic, though this did not cause the "beta burns" that later developed.

FREMONT-SMITH: You just made a nice excuse.

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* Commander Eugene P. Cronkite, of the Naval Medical Research Institute in Bethesda, Maryland, was in charge of the medical team.

EISENBUD: And I was completely discredited because it was generally known that I was sending daily reports and State Department telegrams as to the technical facts and they had every right to assume that this idea came from me. The other statement was that the Japanese were presumably inside the danger area.

Well, this, coming straight from the horse's mouth, so to speak, widely publicized, nationally televised, and presumably an authoritative statement, made it very difficult for John Morton and me to be effective any longer. I stayed on, I think, for about two weeks after that but it was obvious that very little was going to come of it.

Actually, I stayed on for the two weeks primarily so that I could see some contaminated fish. We worked out a method for monitoring which is not easy to do because there were literally hundreds of thousands of fish piled up on the docks waiting to be shipped.

FREMONT-SMITH: These were all fish from this ship?

EISENBUD: No. The fish on the Fukuryu Maru were confiscated immediately. They were buried and forgotten about.

FREMONT-SMITH: Had they been measured?

EISENBUD: No.

FREMONT-SMITH: They were never measured?

EISENBUD: No. They were dug up and. . . no, they weren't measured.

LANGHAM: I'm sorry, Merril. I can't keep quiet any longer. Again, your story sounds incredible to me. It's not that I don't believe you. I do, because I've been through a similar exercise. It is just that the public reaction to a radiation incident is incredible.

I think that we should be studying the psychology of government relations with governments. Will you please tell me why such a fuss is made over something of this nature? If a G.I. in Japan had accidentally killed two or three people with a carryall, this wouldn't have made any news at all. Why isn't it fashionable to admit a mistake when it involves radiation? Do you mean to tell me the greatest nation in the world can't say, "Okay, we made a mistake"?

FREMONT-SMITH: We can do so anywhere except in radiation. That is holy. That is part of our religion. We are the radiation people and we don't make mistakes in radiation!

LANGHAM: The Air Force every now and then hits a section of apartment houses in an airplane crash. Does that ever get the publicity that this did, and why do we have to worry so much about the American image when I think this country can afford to admit an occasional mistake and not particularly lose face? Yet, I know what Merril is saying is indeed true, and I maintain that what he went through, what the government went through, is indeed true. The question is what's the psychology behind this type of thinking? Why do we feel this much emphasis is necessary when radioactivity is involved?

FREMONT-SMITH: I'm not sure that we did very much better in Spain. We'll come to that later. Maybe there is a tradition here of making this kind of mistake between governments! [Laughter]

LANGHAM: It doesn't make sense.

FREMONT-SMITH: I think past history—and I'm afraid the future history—removes the incredible . . .

LANGHAM: How many accidents have we had in foreign countries before in which the President of the United States felt obligated to make a statement?

MILLET: It's an evidence of power in part.

FREMONT-SMITH: Yes.

LANGHAM: Why? Why is radiation unusual in this case?

MILLET: What about Vietnam?

LANGHAM: Vietnam is a different thing. Let's look at something that's comparable. Wasn't it not so long ago—well, a few years ago—a military plane on takeoff plowed through an inhabited area in Germany and killed several people?

UPTON: Chuck did mention panic developing in Japan at the time.

LANGHAM: Why panic over radiation? That I don't understand.

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EISENBUD: Wait a minute, Wright. Everybody knows that a plane can crash into an apartment house and kill people.

LANGHAM: Doesn't anybody know that it's possible that fallout can?

EISENBUD: This was never announced.

DUNHAM: It didn't come out clearly because there was no public announcement about this.

FREMONT-SMITH: At least three things are wrong, or maybe four.

UPTON: I don't think there's any need necessarily to defer discussion to Saturday if it's pertinent now. Isn't that right? This is a free-wheeling kind of a meeting.

EISENBUD: Let me finish the Japanese story.

LANGHAM: Let me clear up one thing. My saying that Merril's story is incredible doesn't mean that I think Merril is incredible! [Laughter]

FREMONT-SMITH: We think he's incredible! [Laughter]

DONALDSON: Merril, at this point may I inject a comment about the fate of the fish?

EISENBUD: Yes.

DONALDSON: The fish from the Fukuryu Maru were buried at Yaizu and subsequently were dug up and sent to various laboratories.

EISENBUD: I'm glad to know that. I was unaware of it.

DONALDSON: Pieces of these fishes have been drawn and quartered and analyzed and reanalyzed, again and again. So there is at least a great fund of evaluations by individual Japanese of the contamination of these Fukuryu Maru fish.

EISENBUD: Good. I'm glad to know that.

FREMONT-SMITH: And they were contaminated?

DONALDSON: As Merril said, some were. It was not uniform and it was the type of contamination which we had never encountered and have not encountered in all the years working in the Pacific. It was not absorbed, but adsorbed radiation, which came from dragging the fish across the deck. This external superficial contamination or surface contamination was easy to measure with the usual radiation instruments, while the internal selectively absorbed radionuclides, so characteristic in the subsequent samples of the March 1, 1954 test, were not found in the tissues of these tuna. You have two types of problems as far as radiation contamination is concerned.

TAYLOR: With these fishes?

DONALDSON: They stopped fishing and began picking up their lines. Therefore, you don't know just how much radioactivity came from contamination in the water and how much was from actual fall-out on the deck.

BUSTAD: With regard to your second statement relative to the crew being in the wrong position, in Lapp's book he states that the crew felt they had been detected by the American authorities. I assume he obtained this information from the crew, didn't he? I mean, this feeling?

EISENBUD: Yes. Well, they thought they were probably going to end up in jail again. You see, they had been in jail probably two months or so.

DUNHAM: They had been in jail in Indonesia.

EISENBUD: Yes, for poaching.

Well, what happened next? Maybe, Lauren, you have better information than I do on this. It's my recollection that the American shipping companies took the position that they would not accept any fish for transport to the United States that was not certified by the American Government as being acceptable for entry into the port when it arrived on the West Coast, and this is what caused the great tuna panic of 1954.

DONALDSON: That was part of it.

EISENBUD: Part of it? What was the other part?

DONALDSON: Well, it's a rather long story. Maybe we can come back to that later.

EISENBUD: Okay. So when that happened, the Japanese immediately needed guidance as to how they could obtain certification, and we worked out some quick screening procedures that seemed to be all right because, frankly, we didn't find any contaminated fish, at least during the period when I was there. They were, however, dumping fish. Reports were coming in that this or that boat had dumped its load of fish because it was found to be radioactive. We arranged with the Japanese Government that no more fish would be dumped until I had a chance to look at them. I had a helicopter and could go anywhere. But these reports would come in and one by one they proved to be erroneous. The only explanation that seemed credible at the time was based on a knowledge of the tuna people that a certain fraction of the Japanese boats would come in with defective refrigeration gear and the fish would be spoiled. Normally this would be a loss to the company, but now they had an out. If the refrigerator went bad, all they had to do was dump their fish and say that it was radioactive and then make a claim.

Well, this went on for several weeks. But I did not . . .

DUNHAM: Maybe at this point we ought to ask Lauren, because by this time he had been called overseas.

EISENBUD: Yes. When did you get there, Lauren?

DONALDSON: May 24th.

EISENBUD: I left May 19th. So I didn't even know you were there.

DOBSON: May I ask a question about the earlier period, please? You had said, Merril, that the Japanese did not have Geiger counters and measuring equipment. You mean that all during this time they had practically no way themselves to monitor?

EISENBUD: That's right. They had prewar equipment. I had brought with me some scintillation gear and presented it to them and this was the first time that they had actually had a scintillation counter in Japan. Of course, now they make excellent testers, as you all know. But the original measurements were made with very primitive ionization chambers by Nishiwaki and a couple of others. So I was very much surprised by the fact that our own military people had

very little equipment in Japan. This was Korean war time; 1954 was right after the Armistice, I guess, or just before it. But anyway, it was a tense period. I went to Japan on the assumption that there would be fully equipped radiochemical laboratories in our military establishment, but as near as I could find they didn't exist. So I had to send samples all the way to New York to get them analyzed.

DOBSON: So, when one looks at it from the Japanese point of view—and Japan is a busy country with many ports and a great deal of fishing—at least up until the time that you got there, Lauren, fish were coming in off of many boats in many ports and there were very, very few pieces of equipment in Japan that could be used for surveys?

EISENBUD: Yes. We provided the equipment. We had some Geiger counters.

DOBSON: But how many ports could you inspect?

EISENBUD: My recollection is that there were about 16 ports. Is that right?

DONALDSON: I really don't know, Merril.

EISENBUD: It wasn't any larger than this. It might have been 12 or 14, but it wasn't very many. It wasn't a large number of ports.

WARREN: But you couldn't be everywhere with your single equipment.

EISENBUD: No, but we trained the Japanese. We had, I think, some 30 pieces of equipment flown in and they were able to make measurements. Their plan was that when they found radioactive fish they would phone Toyko and I would fly down and take a look at it.

DUNHAM: Maybe we should ask Lauren why he was pulled over there and what he found in the wake of Eisenbud's visits in terms of public relations problems and relations with the scientists.

DONALDSON: Well, maybe we can go back to the beginning which, I guess, was March 1, 1954.

During each of these test operations our group was busy in the Pacific, studying the biological effects of the radioactivity. Quite in contrast to Merril's statement, which I'm sure he didn't mean—he

said there was no fallout—we know it just went into the ocean. This doesn't mean there isn't fallout. I'm sure you didn't mean it, Merril. It just didn't fall out on . . .

EISENBUD: Land.

DONALDSON: Yes. Just to clarify this one point.

The fallout into the ocean in this case presents an entirely different group of spectra as compared to the fallout on the land, except for the Japanese incident—and this is important: the Japanese get about 90 percent of their source of protein food out of the sea, so it doesn't make any difference whether it's tuna fish or clams or oysters or what not. The Japanese are greatly concerned about radiation in any form, that is, with respect to the contamination of any food that they get from the sea. You have this unique, almost hysterical background of the Japanese people regarding radiation from their experiences during the Hiroshima and Nagasaki bombing, and along with that, fear of airborne contamination is almost a mania with the Japanese. One always sees them with a face mask when they have a cold.

The problems of actual measurement of radiation in the sea were further complicated by the question of where it went. Also there was the resistance on the part of the Task Force to understand what we felt, to shape up to their responsibilities, to actually get busy with the measurements. It wasn't until March 26th that we got the first expedition underway, that is, 26 days after the event the first expedition went into Rongelap to actually do some rather thorough surveys. Even this attempt was hampered by Task Force orders calling the destroyer back for patrol duty while we were still on the contaminated islands.

DUNHAM: Lauren, I think you ought to get back to Japan.

DONALDSON: I will in just one minute.

DUNHAM: I don't want to steal your afternoon thunder at this point.

DONALDSON: The levels of radiation were in the order of magnitude of 100 curies per square meter on Ebeye Island on March 26th, so we're talking about appreciable amounts of radiation.

All right, now over to Japan.

EISENBUD: That's 100 curies extrapolated to March 1st.

DONALDSON: That's right. Extrapolated back to March 1st as measured on March 26th.

EISENBUD: That's right.

DONALDSON: The situation in Japan. I was sent there on two assignments. One, my direct responsibility was to help in any way possible to aid the Japanese fishing industry and the people who were responsible for the management of that industry. Two, I was to aid in any way in providing information on actual radiobiological problems. However, as it turned out, about 99 percent of my efforts were devoted to the field of public relations, as Merril has indicated. This was the real problem and one was faced with it day by day. The port of Toyko was in tremendous turmoil because there were mass demonstrations against the Americans. This was true at Nagasaki; it was true at Yaizu. There were banners, and this is a direct quote, "It doesn't take a bullet to kill a fish seller. A bit of Bikini ash will do the job." Well, this seemed a bit out of context at the moment, but in the area we're talking about I think it does make sense.

If we take tuna fish alone, during the spring of the year the Japanese eat about a million pounds of sishimi, or raw tuna fish, a day. It's a delicacy to them, and it's part of the ceremonial tradition of Japan to have sishimi in preparation for the Emperor's birthday on April 29th.

On March 17th, when the news of the Fukuryu Maru incident was publicly announced in Japan, the tuna sales dropped to practically zero throughout Japan. If we take a concrete illustration, there are over 1,000 fish markets in Tokyo alone, retail fish markets. Many of the merchants come on their bicycles, buy a tuna fish in the market and carry it to their shops. A tuna fish then cost about $35 American money. The sale of these fish represented the sole source of livelihood for the small shopkeeper. They didn't sell the tuna fish, so it decayed and they had to bury it. That was a month's pay or their livelihood. This went on for some days and thus their source of income was stopped. This situation for those people was economic disaster. Or maybe you had a boat that went out to sea and had been gone for six weeks or up to three months; you returned with a load of tuna fish that would be sold to pay off the expenses and the fishermen. But the tuna fish wouldn't sell, not because it wasn't fit to eat

but because: (1) the Japanese wouldn't eat tuna because of fear; and, (2) the United States committed an unfortunate faux pas, as Merril indicated, in saying, "We will not import this tuna fish unless it's certified." This was ridiculous on our part but our tuna fish industry was adamant and they were extremely vociferous in reiterating, "We're not going to be subject to the economic ills of Japan. That's their problem," although, of course, our nation was largely responsible for creating the environment that made this problem.

The fishing vessel owners, then, and the crews, were subjected to economic disaster.

I think we were inclined to minimize the overall sociological and emotional impact of this sort of thing upon a people whom we normally should consider our friends after the war. We did not, however, take into consideration the overall impact of this unfortunate event.

Thus, during the first few days we assumed this trauma would disappear, but there were certain other very real problems within Japan, which, I am sure, have never been documented. Merril left about the time it was becoming increasingly evident that the press—always antagonistic—was willing to grab some bit of news and immediately blow it up into a big headline. This was a great problem in Japan. Very carefully planned sessions were held with the American Embassy staff and with the Asiatic section of the Japanese Foreign Office, and very carefully laid plans were developed to handle situations as they arose; we discussed all aspects of the situation. Then there would be big headlines in the Japanese press: "The nara [kelp] is contaminated with radiation." This radiation problem was discussed at the meetings but the levels were not publicized. Surely, you could measure fallout by this time in the onshore drift. It was detected in small amounts; this had been discussed, but it would be blown up to a big headline.

So you have this weird conflict, our failure to face up to what we felt were real responsibilities, to do what Wright suggested, make a forthright statement, "This is what happened—period," which was not done. Mass hysteria spread through Japan, a country where this could happen because of the previous experience of the Japanese; in addition, there was an attempt on the part of some to discredit any move in the way of a solution or to disrupt anything which might contribute to a logical solution. All of these interacting factors tended to

prolong and prolong, indefinitely, this mass hysteria into a very real international problem

CONARD: I would like to add a postscript to what Merril was saying in regard to the examination of the fishermen.

In 1964 I was invited to go to Japan to examine the Japanese fishermen. I think this is the first time since you were there, Merril, that this invitation had been extended. When I arrived there I was surprised also, as you said, with the amount of press coverage, a large number meeting the plane. I was taken to the American Embassy and they wanted to know exactly what it was all about and what we intended to do and say, and so forth. They seemed to be satisfied that everything was all right. And so we proceeded with the examinations at Yaizu. Dr. Kumatori (Reference 6) was the Japanese physician who was in charge of the examinations.

Everything went along fine except that everywhere we went in Japan we were besieged with reporters and television people who made a big to-do over the whole thing. Certainly it was apparent that even at that time, 10 years after the accident, the Japanese were still very sensitive about anything that had to do with radiation and particularly fallout.

ROOT: I think this sensitivity, this continuing sense of outrage, persistently stimulated by the press, and exploited by political parties, stems directly from the 1954 shot and was exacerbated by our handling of it. I was in Japan in 1964. As a journalist I made contacts through fellow journalists with many officials, doctors, and scientists. They were far from reticent in our discussions. They may have been more outspoken with me because I came with their own friends or acquaintances and was not on an official mission or connected with government activity. They told me that the widespread reaction of horror crystallized into anti-American sentiment; channeled into political segments; mobilized women who had never before had any political interest; infuriated the whole country. Many called it the third U.S. atomic attack.

FREMONT-SMITH: This one?

ROOT: Yes, Bravo.

FREMONT-SMITH: More so than Hiroshima?

ROOT: Yes. This had a greater political effect because Hiroshima and Nagasaki were in the context of war—to that extent understandable. This was completely unwarranted—and the U.S. reactions seemed so callous—not even, I was told repeatedly, saying we were sorry, or taking any responsibility.

Furthermore, it played into a tense political situation. The fishermen came back two days before the Diet was to ratify MSA.

DUNHAM: What was the MSA?

ROOT: Mutual Security Agreement—after Korea. It was terribly important that Japan become a responsible member of the organization. The Yoshida cabinet was entirely favorable to the U.S. and it looked as if there would not be too much opposition. Then the fishermen arrived. Demonstrations flared up everywhere. You had the trade unions, three million strong, protesting. The cabinet tried to counteract the anti-American feeling but a tidal wave of anger inundated the country. It was just diminishing when Koboyama died. This was portrayed as a radiation death.

FREMONT-SMITH: This is the fisherman that had the transfusion and the hepatitis?

ROOT: Yes. Japanese doctors give very small blood transfusions, and Koboyama needed a great many.

Timing in Europe was unfortunate, too. At the end of January 1954 Secretary Dulles made his "massive deterrent" speech announcing a radical change in our policy; we had decided that the atomic weapon as a massive deterrent was our shortest cut to peace. In February, Vice-President Nixon stated that we were tired of being dictated to as to time and place, and were going to call our own shots from now on. The NATO countries, Great Britain and the others, were terribly concerned about this. As staging areas they expected any such momentous decisions to be the subject of consultations at least.

To cap the political confusion and dismay in March, came news of the heavy fallout from the "Bravo" Shot. And where did the press get this information? From Tokyo. As you know Tokyo is a very large city. It has representatives from the press of every major country in the world. Suddenly the whole of Europe was flooded with grim headlines—and no explanation from the United States. The first

explanations, when they came, made us look even worse. "The skin injuries might be lye burns—from the unslaked lime of the coral." Dr. Tsuzuki went on the air internationally—a 15-minute speech translated into all Western languages—to describe the injuries. He said it was ironic to tell him that radiation burns might be lye burns, when he had worked all his professional life with radiation, and had been the first to go into Hiroshima. He made a few unpalatable remarks about the ABCC, and about the Americans using the Japanese as guinea pigs.

There was much misconception about the purpose of the ABCC among the Japanese. They did not understand that the ABCC was a research organization and not allowed to treat patients, as that was against Japanese medical policy. For years resentment had been building up because radiation victims would go to the ABCC, be examined and tested for days—and then sent away without consistent treatment. The idea spread, fanned by anti-American interests, that they were being used as guinea pigs to further American science. I was told that this was one reason the fishermen and their doctors refused to permit examination by American radiation experts and doctors.

In England, Prime Minister Churchill was grilled for 7 hours by Parliament with the Members insisting he call the American Government to account, demand an explanation—and the Prime Minister protesting, "I will get only a rebuff. I think we ought to have an explanation but we can't demand it."

The image of the scientist underwent a sad change—and I think this is not simply a literary curiosity. Before 1954, the prototype was Pasteur, Einstein, dedicated men working for human good. Otherwise they were "mad scientists." Simultaneously, as if on cue, after March 1954, scientists became "sorcerer's apprentices" in every European language—English, German, French. "Mad scientists" dropped out of the literature. All scientists are now in league with the devil.

FREMONT-SMITH: They are all mad. Very interesting.

ROOT: I hope I haven't taken too much time. This may be entirely irrelevant.

UPTON: You mentioned earlier, Chuck, that there were a couple of people in the room who were at ABCC then.

DUNHAM: Yes.

UPTON: I wonder if you would like to have them offer comments?

DUNHAM: Yes. Dr. Schull!

SCHULL: I would like to make two observations which I believe are pertinent before I describe the situation in Japan in 1954 as I saw it. First, we should bear in mind that the Japanese are uncommonly health-conscious, and to an extent that some observers feel borders on hypochondria. The face mask, for example, is a ubiquitous part of the winter scene, or at least was in those years.

DUNHAM: They can't outdo us.

SCHULL: Possibly not. The second observation is that there seems to be no history of responsible journalism in Japan. The three large presses, Asahi, Yomiuri, and Mainichi are in a perpetual circulation war and they are generally prepared to take advantage of any situation which might enhance their status vis-a-vis one another. These two factors, when put together, can seriously restrict the relevance of the Japanese experience for a nation with different journalistic traditions.

As to my experiences in 1954, the story begins in the summer of 1953 when there was convened in Ann Arbor a small informal group whose function was to decide whether or not the clinical portion of the genetic studies then under way in Japan should continue. It was our task to determine whether enough additional information could be gained to warrant further investment of manpower and money. The consensus was that this was unlikely; the basis for this conclusion rested largely on the knowledge that many of the exposed individuals were reaching ages at which no further reproduction was to be expected, and hence continued study would merely increase the "control" observations which were already much more numerous than the "experimental." There seemed, therefore, no particularly strong reason to continue the clinical portion of the studies, and I had gone to Japan shortly after the first of the year in 1954 to terminate that segment of the genetics program.

Shortly after I arrived, there was held in Tokyo a review of ABCC's research activities; this meeting was attended by most of ABCC's departmental chiefs and a substantial number of Japanese scientists.

There was still manifested, I believe, some of the hostility which had arisen in certain Japanese scientific circles in the years immediately after the war. Most of the physicians with ABCC, and, in fact, most of the American physicians who went to Japan couldn't communicate effectively with their Japanese colleagues, few of whom spoke English. The language of medicine in Japan has been German, and only recently has English come to play a prominent role in the exchange of medical information. It was not easy under circumstances such as these to establish rapport. The situation with respect to genetics was quite different. This was ascribable to a number of largely fortuitous happenings. First, there was a firmer body of experimental information from which to attempt extrapolations to Hiroshima and Nagasaki, and even to the members of the crew of the Fukuryu Maru. Second, many of the Japanese geneticists of stature at that time had been trained either in the United States or in Europe, and as a consequence we often spoke a common language, namely, English. Japanese geneticists, in general, strongly supported ABCC's genetics program; whereas the endorsement that was being given to medicine, for example, was of a more qualified nature. The absence of a strong endorsement encouraged opportunists and opportunism, and the Fukuryu Maru incident was replete with both.

The emotional climate that was created in Japan when word reached there of the Fukuryu Maru was really a very strange and almost unbelievable one. Rightly or wrongly, I'm inclined to ascribe it in large part to the "devil's brew" to which I have previously referred. The newspapers seized upon the incident and began a drumfire of daily accounts which almost seemed intentionally designed to heighten anxieties, real or fancied. The Japanese government as well as our own had effectively lost control of the situation. The newspapers had "grabbed the ball and were running with it."

I can recall quite vividly some of the headlines which appeared. There was one, for example, in the Osaka English-language Mainichi; the headline said; "WBC counts of fish-eaters rise." It appeared shortly after it had been announced that radioactively contaminated fish had accidentally reached the Osaka market, and that some had been inadvertently sold. A few individuals who had presumably eaten the fish were being studied by local authorities. This headline accompanied a report of their work which, by the way, was unobjectionable. They had carefully indicated that numerous factors could produce a rise in white blood cells, including upper respiratory infections so common at that time of year; they further stated that on this account one could not conclude that the elevation was necessarily due to the

consumption of the fish. This nicety was lost on, or at least ignored by, the writer of the headline. The effect of this article and others like it was far-reaching, however. Shortly after the appearance of the one in question, ABCC was visited by a woman and her daughter who had been in Osaka when the fish were sold. The mother and her child insisted that something had to be done for them. They were really quite concerned, and were certain they had eaten the contaminated fish. We didn't have the vaguest notion, of course, what should or could be done if we assumed that they had, in fact, eaten the fish. If I remember correctly, to ease their apprehensions stool specimens were obtained and examined, and this had the desired palliative effect. At least they left with the belief that someone was interested in their health. This is but one small indication of the near hysteria engendered largely by the newspapers. I'm sure that Bob Miller can add to these experiences.

MILLER: I was too far from the scene and too inexperienced in Japan at that time to be much of a witness as to what was occurring. But I would like to point out that four years later, in 1958, Dr. Schull and I, among others, returned to Japan to make a study (Reference 7) of children who were in grammar school then and whose parents had either not been exposed to the bomb or were too far from it to have received significant exposure. In Hiroshima, of 2,200 children who were invited to come for examination, 97-1/2 percent did come. In Nagasaki, of 4,500 invited to come, 99 percent did so. So, four or five years after the Bikini incident in 1954, there was not much of a hard core of resistance as a result of that experience.

I would like to bring our attention back to Dr. Langham's question just before this discussion began: Why is radiation so evil? I think, since he asked the question, we have heard some of the answers to it. I wonder how he feels about it now, after hearing that the newspapers inflamed the public, the Japanese physicians were jockeying for position, and the governments, both U.S. and Japanese, were unprepared to handle the circumstances and made a mess of it?

LANGHAM: Well, I think this is the evil. No one respects radiation any more than I, but I don't think radiation is an insurmountable thing at all. It may be that the psychological impact created by the press and everyone else concerned is incompatible. This is exactly what I'm trying to get at. All of these affairs get blown into something that is far beyond their real importance. Now, why? Maybe some of the answers are coming now, but I don't think this means that radiation is something we can't live with at all.

DUNHAM: We can live with cranberries and pesticides, but for a while it got blown up all out of proportion, too. It just happens that radiation has created more of these situations than some of the others up until recent years.

EISENBUD: I think that this even is one of the really few important historical events in all of history. We woke up one morning and found that we had bombs that could be exploded if we knew how to use them. It threw our government into such a turmoil that they knew they had to say something but couldn't decide what to say until, when was it, Chuck, that the first real statement came out?

DUNHAM: Well, the first release containing any details came out nearly a year later, February 15th, or something like that, of 1955.

EISENBUD: It took a year for your government to formulate a position. This wasn't because they were dismissing it or that this wasn't important, but it was because they couldn't agree on what their actual position was.

UPTON: It seems to me we have here a very real concrete evidence of disaster. We have fishermen who are sick; fish that have to be thrown away and in turn, a ban against the importation of fish that aren't certified; economic disaster in Japan; newspapers which are eager to play up sensational stories; political groups who want to make capital out of this. There's certainly every element of a problem. The difficulty was assessing the magnitude of the problem soon enough.

EISENBUD: But, you see, there's one element that hasn't been brought out. That is that anyone could take that diagram and lay it on a map of Europe, let's say, by putting Bikini near some important Soviet airbase, and point the wind anywhere you choose to, and get 800 r per hour running through friendly nations. This is why I say we have bombs which we are probably no longer in a position to use; imagine the impact of this possibility militarily.

UPTON: But at the time, surely the dimensions of that zone were not known very generally, so that the Japanese couldn't really be sure how widespread the contamination of the sea might have been.

EISENBUD: Ralph Lapp, I think, published the first of these diagrams, and it seems to me it was in the Bulletin of Atomic Sciences

within a year. I think it actually preceded our official announcement, as I recall.

FREMONT-SMITH: We're not the only government that didn't know how to handle a radioactive accident. If you will all remember how the British Government fumbled the Wind Scale accident, announcing beforehand that there was no danger of any kind at all and then gradually having to admit that there was more and more, and then the milk all had to be dumped. I think that our lessons are there, but I think every government gets caught in this kind of thing or is in danger of getting caught in this kind of thing. But the first thing to do on the government's part is to deny that anything dangerous has happened, which is almost standard procedure, and then gradually it leaks out, whereas actually this is the way that people lose faith in the government. The credibility gap gets bigger and bigger, and I think certainly this is true in this country. If something happened and if we had a firm announcement from the government of this, the people of this country wouldn't have much confidence in this.

WARREN: This is true in industrial practice, too. If somebody let's loose a noxious chemical, they deny everything and then face the issue hours later or days later. The trouble is that their insurance figures are involved and the cost of paying off is involved, and they want to keep it as limited as possible. We are somewhat in the same frame of mind at the government level, aren't we?

TAYLOR: It seems to me it's a very, very important fact of life that the worldwide public has lost confidence in the official spokesmen of the governments of several nations as a result of a consistent denial . . .

FREMONT-SMITH: Of the truth.

TAYLOR: . . . of the truth by spokesmen for these governments, and that's the state of affairs that now exists.

FREMONT-SMITH: Then we are also talking about the credibility gap between the younger generation and the adult generation in any country which is part of the same thing. We have lied to the youngsters repeatedly, again and again, and the youngsters don't have any confidence in the adult world. I think it's a very broad problem we're talking about. This may be true in a good many other countries, too.

WARREN: And yet, as Wright says, the information is always there.

FREMONT-SMITH: What?

WARREN: The principles on which these decisions could be made have been there from the beginning.

FREMONT-SMITH: Right.

EISENBUD: I don't think it sinks in.

CONARD: I get impressed with the ignorance of the lay public with regard to the simple facts. When you talk to a group, it's obvious that they just don't understand the simplest things about radiation.

TAYLOR: I claim they haven't been helped by the official spokesmen, at least in the United States. They've gotten very little help at all because the very first words that were published were, "Don't worry. We know what's being done." Then followed Castle, the situation in which the natives were seriously irradiated, and yet obviously we didn't irradiate the natives on purpose. Obviously we didn't know what the hell we were doing. This has happened so many times. We deny the fact that we didn't know what we were doing, but there is no basis for confidence any more. I think that is central. I think that this central fact, that the public has, on the basis of the record, a positive lack of confidence in what they are told, is going to have a profound effect on what happens.

FREMONT-SMITH: In the future.

TAYLOR: If one or two explosions or a whole lot of explosions really start taking place in anger you will get irrational behavior which is a result of irrational behavior, namely, the way in which it's been handled by the U.S.

ROOT: We go to the other extreme in assuring the people that democracy can only exist on the basis of an informed public, that the public has a right to know. After the 1954 incident there were big headlines in London and other countries proclaiming "Ike Demands Candor. Ike says the people who are going to be subject to this and whose taxes pay for this have a right to be consulted as far as secrecy permits; that everything that can be told should be told." There was a great wait and then the British papers asked, "Where is this

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candor? The United States population is waiting for candor." We don't realize here how much is made of that abroad, or how cynically the oft-repeated "people's right to know" contrasts with the official pronouncements when they do come out.

The first acknowledgment of the fallout from Bravo was one sentence: "During a routine test, some Marshallese natives and weather officials were dusted" or some such word. The mystery of that, with no follow up, and then suddenly the Japanese thing, I think is at the root of the fact that people can't even hear the words "hydrogen bomb" without going into paroxysms. What help have they received to understand what happened? As a result of not knowing, a mystique has developed that makes the very thought paralyzing.

UPTON: How long did it take to get the tuna industry back into more or less standard operation?

FREMONT-SMITH: In Japan?

UPTON: In Japan. It was disrupted there for a time. We heard Dr. Donaldson say that.

DONALDSON: It is difficult to put an exact time limit on this problem because the fear flares up or has flared up each time there has been a subsequent test. The pulse of the people is still associated directly with any testing or any announcement of testing. The surprising thing is that the French tests and the Russian tests haven't been upsetting to the same degree.

ROOT: I was in Japan during the Chinese test. The Japanese were busy demonstrating against the arrival of an American nuclear submarine in one of the northern harbors and paid little attention—other than a kind of pleased recognition that the Chinese pulled it off. I was told that the ceremonies commemorating Hiroshima Day would probably have ceased by now because there are few enough interested in going, but the Yaizu fishermen have given it a new and bigger lease on life. An interesting insight was when the Sino-Soviet split came. They had to hold two different ceremonies and Mrs. Koboyama, widow of the man who died, finally refused to go because she was being pulled in both directions. One of the meetings climaxed in heated argument about whether the Chinese Communist Government or the Soviet Government had sent greater contributions to support this memorial. The contributions were openly acknowledged.

DUNHAM: I think it points up again that it isn't particularly right because it's radiation. This is just something simply seized on.

WARREN: This is part of the cold war.

DUNHAM: Not the government people or most of the university people or most of the scientists. The fallout they've had from some of the Chinese tests has not been played up very much in the Japanese press.

TAYLOR: I think the mystique is right here at home, typified by a comment that President Kennedy made to Jerry Wiesner when they sitting together in the White House and it was raining out. Kennedy asked Wiesner whether there was fallout in the rain that was falling on the White House lawn, and Wiesner said, "Yes, there still is." This was an intense emotional experience for the President, to see rain with fallout on the outside; nothing connected with anything in any way quantitative at all. As far as he was concerned, that rain that was falling outside was bad.

ROOT: I think it's a little dangerous to equate radiation with cranberries, though, because we know what radiation can do. There should be a legitimate and respected fear of it.

DUNHAM: I'm not saying it shouldn't be respected, but it happens in certain areas where the psychological seed has already fallen.

ROOT: I think the psychological seed germinates and flourishes because of the ultimate lethal threat.

DUNHAM: The pesticides are lethal. So is radiation.

WARREN: Not everybody buys cranberries and couldn't care less, but everybody is subjected more or less to the fallout.

DUNHAM: So is Vitamin A. It's toxic, too.

MILLET: This, I think brings up another point perhaps. We've been talking about our dissatisfaction with leaders for not giving us the information that we ought to have. I think we're getting into the area of the mystique of the leader in this country, and perhaps one of the great problems hasn't been touched upon sufficiently yet, which is that our leaders are not sufficiently well educated to know what to

think, and therefore, what to act or what to say. They are constantly changing their minds from one position to another, which is one of the problems that is due to their political needs and their careers.

It seems to me we have two ends to work on here: How to get correct information that is capable of solving problems to our leaders and how to educate the public. Now, if the general public doesn't want to be educated, this is something we've got to know, and perhaps we could do more than we've been doing in our educational system to get them to understand the environment in which they are thrust when they are born. We can only do a limited amount in getting them interested in the world in which they live. On the other hand, the leaders are certainly very interested in the world in which they live. Perhaps this is the primary goal for our efforts, to try to get the proper knowledge to our leaders.

WARREN: What you are saying is that our leaders don't have the proper father image for the community of the world at large, and in this case the father image has been tarnished if not destroyed.

ROOT: But they always talk the right father image. That aggravates the problem.

MILLET: Yes.

DUNHAM: Isn't it one of the fundamental problems that leaders, almost by definition, are amateurs? They've never faced a particular crisis until they face it.

FREMONT-SMITH: That's right.

DUNHAM: This is a dilemma that the world has been facing for a good many years and I don't know how you can just suddenly say that these people are more stupid than somebody else. It's a personal problem, as you hinted at.

FREMONT-SMITH: And the thing is partly compounded by the election every two or four years, which means leaderships change or there are desperate efforts to maintain leadership at any cost, because that's the time you'll be able to really show your responsibility, after you've been re-elected.

DUNHAM: Yes.

FREMONT-SMITH: So you've become irresponsible in terms of the election, hopefully in order to be responsible later, and the thing goes on in a vicious circle.

ROOT: I think the professionals have not demonstrated any greater aptitude than the amateurs. It was President Eisenhower who said, "We must give an accounting of this. We must let the nations know." He was sensitive about the NATO reaction and the public reaction. He wanted as much information released as possible—to help them understand. But State Department rules are rigid. Certain formulas determine our dealings and interchanges with our own people and with other countries. Those are the things that are sterile and constricting. I think if more responsibility were left to the amateur who has the confidence of the people inasmuch as they put him up there, and to the man in the affected area who knows the customs and the temper of the people concerned, there would be less suspicion and hostility in times of crisis. The sad part is that though the crisis passes, the feelings tend to persist.

WARREN: I would like your consultation and that of your confrere on your right, because this is what we're really talking about in this whole meeting. So I don't expect to get an immediate answer on this, but isn't this an opportunity?

ROOT: I know that I can get more information abroad, as Congressman Morse pointed out in the security hearings, about situations abroad, and about situations at home than I can get at home. I think that we have one of the most hysterical, panic-ridden attitudes toward releasing information of any free country.

FREMONT-SMITH: On account of security, on account of classification.

ROOT: This delusion of grandeur impedes scientific progress and destroys public confidence. . .

DUNHAM: I would like to challenge this.

ROOT: . . . because it's really going to destroy us.

DUNHAM: You mentioned the ineptitude of Wind Scale. I've seen what the British atomic authority releases, and some of the things they don't release in the way of information. And if you think we are . . .

ROOT: No. I know Wind Scale.

DUNHAM: Not Wind Scale, because it all came out. The British public never even hears about it.

ROOT: It didn't even come out about Wind Scale because, as the person who told me called it, of a failure of management. He said, "You can count on management to fail because they are protecting other values. Wind Scale has never been accurately explained, and they are doing it."

I think the British Government picked it up from us. They used to be much more open.

FREMONT-SMITH: Yes.

DUNHAM: I don't know if it's all our fault.

FREMONT-SMITH: A good share of it is our fault, a good reasonable share.

DUNHAM: The British don't publish a lot of the kinds of information on radiation exposures that we've published and things like that.

FREMONT-SMITH: Look what we've done. What is tolerable radiation dosage in industry? We've had to lower the amount year by year. Instead of coming out with a cautious statement and then finally coming out year by year and saying, "Yes, we can tolerate a little bit more," it's been in the opposite direction, hasn't it? *

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*WYCKOFF: It is of interest to document this decrease. In 1936 the Committee now called the National Council on Radiation Protection and Measurement (NCRP) recommended a provisional "tolerance dose" of 0.1 r per day, but suggested that a "generous safety factor" be applied (NBS Handbook 20). By 1949 the NCRP was recommending a "permissible dosage rate" of 0.3 r per week (NBS Handbook 41). The rationale for the reduction was contained in NCRP recommendation of 1954 (NBS Handbook 59). The differences were attributed to different types of measurement (surface dose initially and at that time to dose in the organ of interest), to a large variety of radiation sources and to a greater knowledge of the biological effects of radiation. However, it was pointed out in that document that these recommendations

DUNHAM: It has been.

FREMONT-SMITH: I think this is part of the same thing we're saying. Say they announced a kind of thing that would make everybody feel more comfortable and then they found that they were wrong?

DUNHAM: Yes, but some have gone up.

FREMONT-SMITH: Yes.

DUNHAM: Some have gone up and nobody says boo. The British do the same thing. They wait until there's an international agreement on it before these things are changed anyway.

FREMONT-SMITH: Still I think the essential feature is that I don't think one can be very proud of the way we have dealt with the public in terms of . . .

DUNHAM: I think there's a great deal of holding back, but to say that the British are so open or so frank with their people compared to us I think is a lot of nonsense because I know just how frank they are not.

FREMONT-SMITH: I'm against the British! [Laughter]

DUNHAM: I love them.

FREMONT-SMITH: I know. I'm teasing.

DE BOER: It is not a question of secrecy alone. In this week's Industrial Research, Admiral Rickover characteristically criticized the Navy and contended that the Navy had gone "downhill." He listed three things: (1) the so-called "new religion" of cost effectiveness studies; (2) the "Zero Defects Program" which he equated with "motherhood;" and (3) "the unwillingness to assume responsibility," as the

*(cont'd) excluded consideration of genetic changes manifestable in future generations. Additional information on genetic effects and possible shortening of life span obtained from animal experiments and human exposure at considerably higher doses indicated a further reduction in 1957 (Addendum to NBS Handbook 59). The exposure of a larger fraction of the population was also involved. It should be pointed out that no relatable effect has been observed for any of these levels.

cause of this phenomenon. It is particularly the third reason which has a direct tie-in with secrecy. In eleven cases before a Senate subcommittee, secrecy or security was claimed, while trying to identify the man responsible for making certain decisions. The facts were that after days and days of digging, the decision maker could not be found. Everyone was hiding behind someone else.

FREMONT-SMITH: Who are you quoting?

DE BOER: Rickover. These were eleven cases in which the responsible man was never found. In other words, something was originated, like a contract, but nobody was willing to assume the responsibility for that contract and say: "Here I am. I originated that contract and I was right in doing so because at that time, etc. . . . ." No, there was always someone who could say: "I was told to do so but I can't divulge the source." This comes close to secrecy although it is not officially labelled so.

EISENBUD: I think Chuck Dunham is correct when he says that generally throughout the Atomic Energy program there's been a candid policy. I don't think we need take the time to explore it unless you want to. I think the policy has been a candid one, but there's something different about this particular instance and it doesn't necessarily involve the Atomic Energy Commission in this respect. The fact of the matter is that when I learned that Miss Root was working on the historical implications of this matter, I referred her to a package which I had left in the New York operations office in which I pulled together all the documents that I thought would be useful to somebody someday; I left it with instructions that it shouldn't be dispersed. Most of this is pretty innocuous stuff, things like meterological reports, teletypes which give you the time when various decisions were made to do various things and a long series of telegrams of several pages a day which I sent from Japan, which was the only chronological record of what went on. I've forgotten it; I don't remember it. I forgot that they dug up the fish, which I was reminded of, and I learned yesterday that this stuff is still classified; there's no hope of getting it out. That's been sent to Washington because, on my suggestion, Miss Root asked for some of the material in that packet. It was sent to Washington for review and it's still there. How do you explain this?

FREMONT-SMITH: It will take them years to declassify it. They haven't got a staff to do it.

EISENBUD: Yes. Let me tell you something else. I thought we had access to all the information we needed at the time. I think we did, if we had asked the right questions, but sometimes you didn't seem to ask the right question. It wasn't until a few days before this shot was scheduled to go off that I actually knew that it was going to be at Bikini and not at Eniwetok. Nobody told me they were going to move to Bikini; most of my planning had been done on the assumption that it was going to be at Eniwetok and nobody told me otherwise.

DUNHAM: Yet the tower was being built all the time.

EISENBUD: Yes, but we were preparing in New York, and actually it could have been disastrous if it weren't for the fact that through a stroke of luck we had instruments at Rongerik Island. But, based upon our own meteorological projections we assumed it was going to be fired from Eniwetok, and you may say that's a dumb thing to do, but it never occurred to me as to where it was going to be fired.

FREMONT-SMITH: There's an old religious phrase of "Need to know," out of the Bible, and I'll give you an illustration: Norbert Wiener, who, as you know, invented cybernetics and who was also working in a highly classified bomb situation during the war, told me personally that during this highly classified work he ran into a discovery which he knew to be of great importance to another highly classified group. He spent two years trying to find a way in which he could tell them what he had discovered and he was never able to do it because he couldn't demonstrate the fact that they needed to know. In other words, he was never able to tell them.

I also have a hunch—and I don't expect to have it confirmed locally—that the Manhattan Project would never have been accomplished if all security had been protected. I suspect that a number of people told each other things and then discovered they had a need to know afterwards, and that's the way the thing got off the ground in several instances. But anyway, I really bring this up to point out the devastating effect—Norbert Wiener is only one example, I have several others—of this principle.

I would like to add one thing. I really do believe that, by and large, and undoubtedly there are exceptions, our own scientific advances and our own security have been set back by our security more than if we had been much more open. I think we have blocked our own advance by failure to make available to scientists a lot of information

which they could develop and then lead into new directions, and that if we were to release this information, even though it would be perhaps of use to the enemy, we would be getting ahead faster and gain more by the release than we gain by the protection. This is my personal opinion which I throw out for nobody else's use.

ROOT: I think, going back to Dr. Warren's question, that applies also to the press. You say you get "on the beach" and you have "no place to hide" and you get all these distorted reports. But what are those writers going to do? I unfortunately have a disciplined background, having been a research scientist myself, which holds me up terribly in this profession. But everything is a struggle. And journalists and writers eventually give up. There are very few instances, I think, in which, if a subject is entirely in the open, there's not great cooperation between the scientists and the writers. It couldn't be greater, and I know Dr. Langham has helped writers at great cost to his own time and energy, I'm sure. But when it impinges on an area which is not necessarily classified, but on one in which there is uncertainty as to classification, I've talked with people and quoted figures and they have stared back as though I had leprosy and could contaminate them. They hadn't known and they would say, "Where did you get that figure? It's never been published." And I would say that it had been published in such-and-such. It's just too great a task. It's a lifetime work to keep up with what is declassified and what remains classified. So, the only way for sanity is just not to say anything. But then we expect the writer to be able to communicate to the public who support the research and who really are an informed public, the strength of the democracy, and he's got nothing to say, but he's got a job to fulfill.

UPTON: I think the morning session has to be brought to a close, and I'm reminded of an amusing anecdote. We've been talking about an information problem, really, and I heard a story about the Wind Scale incident which indicates how frequently in an astonishing situation where one is caught by surprise and has one's source of information down, one has to say something and may not say the right thing.

AYRES: There's a formula called "No comment"! [Laughter]

UPTON: A group of power industry executives and engineers were being flown over the Wind Scale plant and were being briefed by a guide on the wonders of nuclear power. As they crossed the plant in the airplane and he pointed out various installations on the ground, the accident occurred and a big black plume went up out of the stack,

and everybody's eyeballs popped out and they looked at this thing in astonishment and turned to the guide and said, "What is that?" He was just as astonished and bewildered as they, and not knowing what else to say he smiled and said, "Well, you get that, you know!" [Laughter]

SESSION III

THE 1954 THERMONUCLEAR TEST
(Continued)

(Initiator: Robert A. Conard)

SESSION III
THE 1954 THERMONUCLEAR TEST
(Continued)

THE MARSHALL ISLANDS PROBLEM

BRUES: This afternoon Dr. Conard will initiate the discussion without, I guess, telling us where it may lead.

Bob!

CONARD: I have outlined on the board a few topics I thought might be worthy of a brief review and discussion. Also I put down below the main groups that were involved in the 1954 fallout accident with the numbers of people involved and the approximate dosage of radiation that they received. (See Figure 1 and Table 1.)

In discussing the case of the Marshall Islands accident, I think it's important to point out that this represents a situation on a coral atoll and it may be quite different from other fallout situations that might occur. Characteristics of a particular fallout situation depend on many factors such as whether the bomb is detonated over water, under water, over land, the geography of the terrain, the populations exposed, time of fallout arrival, length of fallout, etc. Fallout effects are somewhat different from those produced by direct effect of the bombs. In Japan, for instance, the major casualties came from blast and heat, with fewer casualties from radiation exposure, whereas with fallout it is a purely radiation exposure situation.

In Japan there were psychic trauma, physical trauma, starvation, disease and many complications; in the Marshall Islands the Marshallese people had a minimum of these factors involved. In addition, the fallout produces a more complicated type of radiation exposure in that you have not only whole body exposure but also the exposure of the skin and internal deposition of radioactive materials.

A few other points of comparison with the ABCC studies might be made. The Marshallese groups, of course, are considerably smaller than those of the ABCC studies. The vital statistics are very poor in

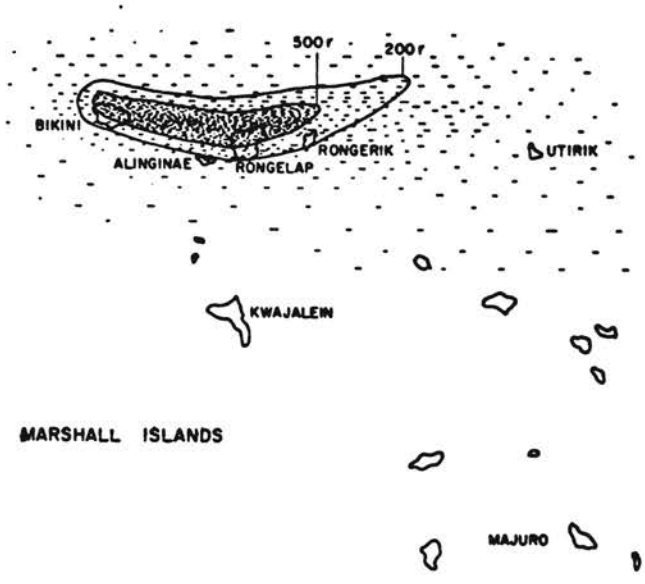

Figure 1. Map of fallout area, Marshall Islands, March 1, 1954. From R. Conard. (Courtesy Annals Int. Med.)

Table 1. Summary of fallout effects.

Group*	Composition	Fallout Observed	Estimated Gamma Dose (Rads)	Extent of Skin Lesions
Rongelap	64 Marshallese	Heavy (snow-like)	175	Extensive
Ailingnae	18 Marshallese	Moderate (mist-like)	69	Less extensive
Rongerik	28 Americans	Moderate (mist-like)	78	Slight
Utirik	157 Marshallese	None	14	No skin lesions or epilation

*Also exposed were 23 Japanese fishermen who received a sublethal dose.

the Marshallese people but the radiation dose is probably better known in their case than it is in the case of the Japanese. Documentation during the acute period was fairly complete for the Marshallese and not so complete for the Japanese. (The Marshallese findings are reviewed in References 8 and 9, the Japanese Hiroshima and Nagasaki data in numerous publications by the Atomic Bomb Casualty Commission.)

The Marshallese population under study is fairly stable.* We go back from year to year and find little attrition. We have an excellent comparison population composed of relatives of the Rongelap people who have moved back to live on the island of Rongelap. They match reasonably well for age and sex.

The Japanese fishermen studies were made difficult by the complexity of the dosimetry, the fact that on board the ship they lived part time below decks, where they were more protected, and part time above, etc. Perhaps later on Merril Eisenbud might say more about the dosimetry in that group. (The data on the Japanese fishermen are reviewed in References 6 and 10.) In addition, it was two weeks before they arrived in port where the situation could be evaluated. Another complicating factor was that during the course of treatment they were given multiple blood transfusions and many of them developed jaundice, liver disease, and one even died, probably as a result of repeated blood transfusions.

Figure 2 is a photograph of Rongelap Island taken on March 1, 1954; a typical South Sea Island village with loose palm construction.

Figure 3 is a rough sketch to show the types of radiation that people were exposed to. The wavy lines represent gamma radiation, that is whole-body penetrating type of radiation. The stippled area represents beta radiation which was largely responsible for the skin lesions that developed and also the internal deposition of the fallout material.

The spectrum of the gamma radiation from the fallout was fairly complex. There are quite a few different energy peaks as contrasted to ordinary laboratory studies in animals. The calculations of the

* The medical studies of the Marshallese are sponsored by the U.S. Atomic Energy Commission and are carried out under the direction of Brookhaven National Laboratory in conjunction with the Trust Territory of the Pacific Islands (Department of Interior).

Figure 2. Rongelap village as it was in 1954. From R. Conard.

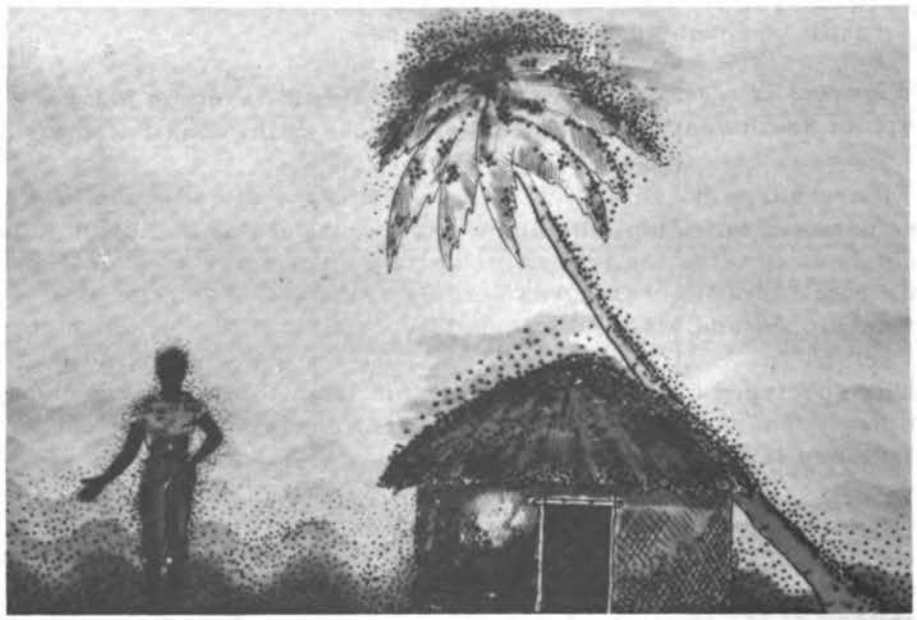

Figure 3. Rough sketch showing fallout deposition. Wavy areas represent gamma radiation, and stippling represents beta radiation. From R. Conard.

gamma dose to the Rongelap people was made on the basis of estimation of time of arrival of the fallout (which was believed to be at about four to five hours after the detonation), the length of time of fallout (which was calculated to be around 12 hours), and by the readings that were taken on the Islands at the time of the evacuation, roughly two days later. There was a telemetering device on Rongerik, as was pointed out this morning, which gave valuable information on the time of arrival there of the cloud of fallout and the 30-minute period that it required to go off scale. In addition, on Rongerik there were many film badges and the readings from these film badges afforded valuable information on the dose and agreed reasonably well with the other estimations.

In the case of the Japanese fishermen, the doses calculated were around 170 to 700 rads based on extrapolation back to Day 0.

Gamma radiation in a fallout field produces a more penetrating type of radiation than occurs with ordinary laboratory uni-directional radiation. Due to the geometry of the planar fallout field, the midline dose is increased by a factor of about 1.5.

So, this really gives a better indication of the biological effectiveness, and we might take the Rongelap dose of 175 rads of whole-body radiation and say that it actually represented possibly 260 rads or so as compared with ordinary laboratory type of radiation. In the case of the Rongerik group, from 78 to 120; the Alinginae, from 70 to 100; and Utirik, from 14 to 20.

DUNHAM: What do you mean by the ordinary type of radiation?

CONARD: I mean uni-directional type of radiation.

BRUES: The numbers you give are rads in air?

CONARD: Yes. These were based on readings three feet above the ground.

BRUES: And midline doses within the person.....

CONARD: .....were derived using the factor of 1.5. The skin dose was impossible to really calculate. As you know the beta spectrum in fallout has quite a smear of different energy components along with some soft gamma. The energy spectrum of the beta radiations

373-782 O - 70 - 8

showed about 50 to 80 percent around 100 keV and 20 to 50 percent around 600 keV. So most of it was pretty soft. There was also a beta contribution from the fallout on the ground. It was estimated that the feet got 2000 r from the ground source; at hip level about 600 and at head level, 300. The hair follicles must have gotten in the range between 400 to 700 rads in view of the fact that epilation developed but was not permanent in most cases. The internal radiation was calculated indirectly from urinalyses that were taken starting about 15 days after the exposure and thereafter on numerous occasions. It was estimated that about 75 percent of the radiation from fission products was due to the radiostrontium, radiobarium and the rare earths.

Table 2 shows the various radioelements that were calculated to be in the urine at Day 1 as compared with Day 82. Probably radioiodine is the only isotope that they absorbed that exceeded the MPC level. By 82 days you will note that these activities had diminished to practically zero. These people were able to excrete this material very rapidly.

Table 2. Estimated body burden of Rongelap people (μc).

	Activity at Day 1	Activity at Day 82
Sr^{89}	1.6 - 2.2	0.19
Ba^{140}	0.34 - 2.7	0.021
Rare Earth Group	0 - 1.2	0.03
I^{131} (in thyroid gland)	6.4 - 11.2	0.0
Ru^{103}	0 - 0.013	--
Ca^{45}	0 - 0.019	0.0
Fessile Material	0 - 0.016 (μgm)	0.0

Now I would like to take a minute or two on the thyroid dose because the thyroid situation turned out to be one of the most difficult problems we had to face in these people. The thyroid dose is usually calculated on the percent uptake of the radioiodines by the thyroid gland, the half-life in the gland, the size of the gland, and the various isotopes to which the thyroid is exposed. In the fallout we have iodine-131, 132, 133, and 135. Quite a few isotopes are involved, most of which are very short-lived — the iodine-131 having the longest half-life. The earliest direct measurements were made by Payne Harris* at Los Alamos on 15-day urine. By using this indirect approach from the urine it was calculated that at that time about one-tenth of one percent was still being excreted and this, extrapolated back, gave about 11.2 microcuries in the thyroid gland originally. This represented about 160 rads of radiation to the adult gland, plus the whole-body exposure, of course.

In the children it was a different story because of the smaller size of the glands. James at Lawrence Laboratory (Reference 11) has calculated for us that the children probably received in the range of 700 to 1400 rads to the thyroid gland. It was decided that the beta irradiation of the neck which produced "beta burns" as shown in Figure 4 did not contribute significantly to the thyroid dose in view of the superficial nature of the beta radiation.

Figure 4. "Beta burns" of neck (subject No. 39, March 1954). The area over the thyroid was a frequent site of "burns". From R. Conard.

* Harris, Payne — unpublished data.

To go on with the story, people were evacuated by destroyer, some by plane, two days after the accident and were taken down to Kwajalein Atoll where we had a large Navy base. We arrived on the scene about eight days after the accident to carry out the extensive examinations.

When they arrived they were quite contaminated, particularly their hair, and we had great difficulty in getting them decontaminated.

Figure 5 shows the people out in the lagoon at Bikini with soap and detergents, cleansing themselves. In many cases we had to cut off their hair because of the coconut oil holding in contamination. We had to take their clothes away from them, and some of the women on Kwajalein gave clothes to the Marshallese women to wear. It was quite a sight to see them walking around barefooted in Fifth Avenue types of clothing.

FREMONT-SMITH: No pictures of that?

CONARD: Unfortunately I didn't get any pictures of that.

None of them died. After the skin burns healed, etc., we moved them south to another island temporarily because Rongelap Island was too hot at that time for them to move back. The Utirik people, however, were moved back during this period since Utirik Island had a very low degree of contamination.

Figure 5. Marshallese bathing in lagoon at Kwajalein in March 1954, to decontaminate skin and hair after fallout contamination. From R. Conard.

In 1957, surveys of Rongelap showed that the Island was safe then for the return of the people even though it still had a low level of contamination. Figure 6 shows the new village that was constructed for them, which is far superior to the village they previously had.

FREMONT-SMITH: Did they like it?

CONARD: They liked it very much.

FREMONT-SMITH: This is unusual, isn't it, to have people like something that's been made for them?

CONARD: They had a hand in planning it.

FREMONT-SMITH: That makes the difference.

CONARD: Yes

Now, to go on. In regard to the lingering radioactive contamination of Rongelap, we have carried out extensive studies of the radio-ecological situation and I may say more about this tomorrow. Later I may also comment on some of the psychological reactions to receiving compensation from the U.S. Government, about $11,000 per exposed person

Figure 6. Rongelap village today. From R. Conard.

for injuries sustained. This has made them very happy, I might add.

DUNHAM: What do they buy with that money?

CONARD: Motor boats, things that they get out of the Sears-Roebuck Catalogue and other things. We're just hoping that they are going to spend it wisely. So far they haven't gone too wild with the spending.

DUNHAM: Does each one have an account?

CONARD: The Bank of America came in there and they have deposited their money there in most cases. In a few cases they wouldn't put their money in the bank, but a lot of them are living off the interest of their bank accounts.

WOLFE: When we tried to go out there with the ecological group the Commissioner was very greatly disturbed for fear we would break up their way of life. I don't know of any better way to break it up than to give each one of them $11,000 to buy motor boats and things like that.

CONARD: It was being broken up before that, though. The onslaught of Western civilization was rapidly coming into these islands, and in the other islands it's also evident—not just in Rongelap, where they have this money. You can see signs of advancing changes due to American influence all the time.

I would now like to discuss the acute effects of exposure on these people; first, the whole-body gamma penetrating radiation effects. Just to refresh your minds, you will remember that human beings respond with various syndromes of effects related to dose received. (See Figure 7.) The most acute syndrome, of course, is called the central nervous system syndrome, as depicted in the upper left-hand part, associated with doses greater than 3000 and 4000 rads. Predominantly one sees ataxia and disorientation, signs of brain involvement, and life is, indeed, very short for these people. Then with smaller exposure (above about 1000 or 1500 rads) we have the gastro-intestinal syndrome, so named because signs of nausea, vomiting, diarrhea and dehydration related to the gastro-intestinal tract dominate, and the individual usually dies within a matter of four to nine days from acute dehydration and other effects. The bone marrow syndrome

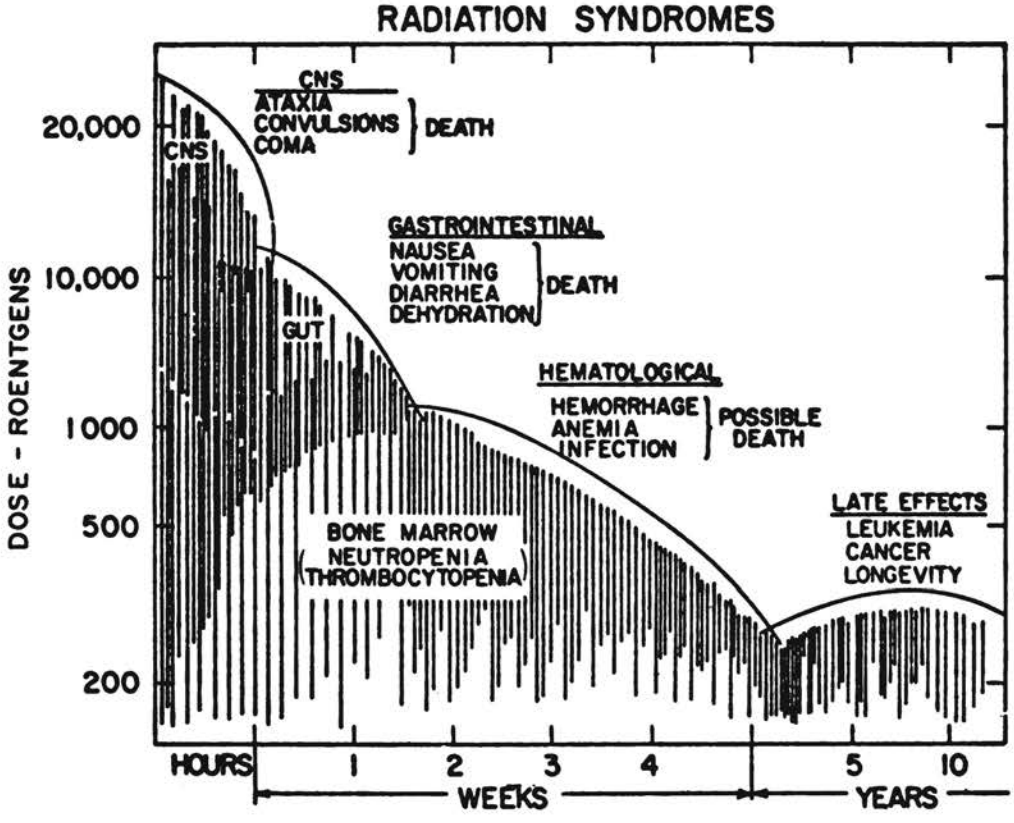

Figure 7. Radiation syndromes (schematic presentation). From R. Conard

or the hematological syndrome is that which occurs following doses in what we call the lethal range. Of course, we really don't know what the lethal range is for man, but it is guessed roughly to be between 250 and 450 rads. Owing to the effect on bone marrow, the reduction in the blood cells results in infections and the development of bleeding results from the blood platelet depression, and death may result.

Then, of course, if there is recovery from these acute effects, there is the possibility of delayed effects of radiation occurring, such as leukemia, cancer and many other possible late effects.

MILLER: I just wanted to mention that the figure makes no mention of cataracts, the intrauterine effects of radiation and the possible genetic effects.

CONARD: It isn't meant to include organ effects, only the major syndromes.

FREMONT-SMITH: It also doesn't say anything about the central nervous system effects of low level radiation which you remember the Russians had always claimed were so and which we have always denied until we recently confirmed it at the Naval Radiological Laboratory.

CONARD: All these syndromes overlap and there are many effects in each of them.

FREMONT-SMITH: I wonder whether there is anything in this group of people in terms of behavior which show that they had any of the low level radiation effects on the central nervous system, which apparently at the level of complex behavior patterns, conditioned reflexes, and so forth, are now recognized to be so?

CONARD: We did not observe any, Frank, and at that time we didn't go into sensitive means of testing this sort of thing. We had many more important considerations. We didn't know whether they were going to live or die, or whether we were going to have to request a hospital ship to take care of them and that sort of thing.

FREMONT-SMITH: Yes. And at the time we were also denying it existed.

CONARD: We weren't.

FREMONT-SMITH: I mean as a government we were.

CONARD: Yes.

Figure 8 shows the characteristics of the hematological syndrome with nausea and vomiting occurring early followed by rapid depression of blood elements resulting in a critical period at the nadir where infection and bleeding may be serious results. Hopefully, then the bone marrow will start producing sufficient blood cells to bring about survival; if not, death will ensue.

In the case of the Marshallese, they suffered from the early effects of radiation. Three-quarters of them became anorexic (lost their appetites), some of them vomited and a few had diarrhea. This occurred over the first two-day period and cleared up after that. When they arrived at Kwajalein they seemed to be perfectly healthy. The Japanese fishermen also went through an early period of fatigue, headache and anorexia, nausea and so forth.

EISENBUD: I think there's one interesting point which also seemed incredible to Wright, but the first dispatch that we got following the evacuation reported that the natives were seasick and nauseous.

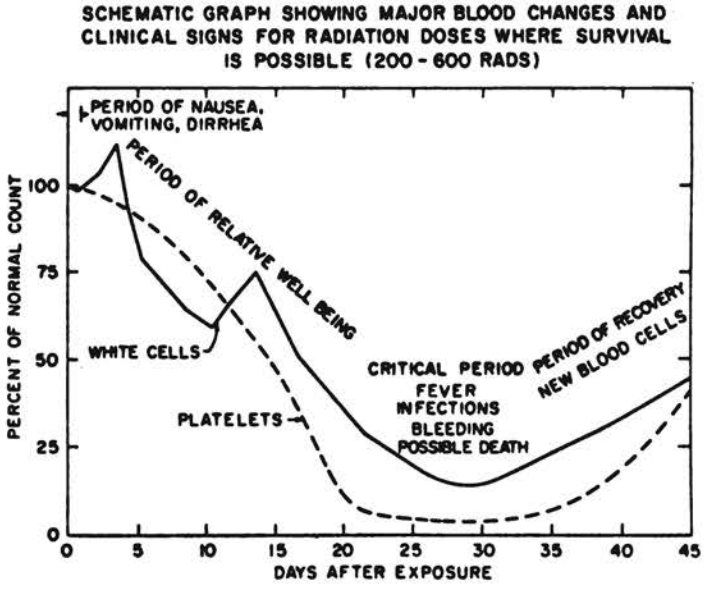

Figure 8. Schematic graph showing major blood changes and clinical signs for radiation doses where survival is possible (200–600 rads). From R. Conard.

CONARD: Were seasick?

EISENBUD: Were nauseous from seasickness.

CONARD: Yes, I think that was the original interpretation, but it soon became apparent that none of the Alinginae, the other group that received less exposure, showed the sickness and since only the heavily exposed Rongelap group showed the sickness it was apparent that it was radiation-induced. The blood elements showed considerable depression, down to one-half and more below normal levels, but, fortunately, they didn't get low enough in the Marshallese people to cause any real evidence of infection or bleeding; we used no specific treatment and none of them showed any signs of acute radiation sickness as such.

In the case of the Japanese fishermen, some of their blood elements dropped even lower than in the Marshallese, indicating perhaps a higher dose in some of them. But I would not say, looking at the blood work, that any of them received greater than 500 rad because the depression didn't seem to reach levels that would substantiate that.

EISENBUD: What allowance can you make, Bob, for the fact that they received a dose over a 14-day period?

CONARD: I agree that that certainly would moderate the effect. But most of the dose that the Marshallese and the Japanese fishermen received occurred during the first 24 hours, I would say over half of it, and so it was really more in the acute type of exposure classification.

There was a slight weight loss in quite a few of the Marshallese people and we were not sure whether that was due to their radiation exposure or to the fact that they had a change of environment and were eating different types of food, although they seemed to eat it with great relish. The Japanese, as I mentioned earlier, were given multiple transfusions over a number of days soon after they arrived in Japan, and shortly thereafter quite a few of them developed infectious hepatitis and jaundice and then, of course, one fisherman died in September. It would seem to most of us in this field that his death was most likely due to the blood transfusions that he had received.

DUNHAM: His peripheral blood picture just about returned to normal in July, before he died. The jaundice came on at about that time and he died with essentially a normal blood picture. At least the total count was in the normal range.

CONARD: Yes, that is so.

FREMONT-SMITH: That would fit.

CONARD: But the Japanese have made quite a bit over the fact that this liver disease might be radiation-induced, which is not at all agreed to.

Now, to turn to the skin lesions. The Marshallese had symptoms of itching and burning during the first 24 to 48 hours. This fallout material clung to the skin as a white frosty dust and it was very difficult to remove.

FREMONT-SMITH: Do you know why it would cling to the skin? Why was that?

CONARD: As you know, in this climate the perspiration made it cling and it got caked into the skin, I think.

Ninety percent of the people developed these so-called beta burns beginning about two weeks after exposure. These lesions were first characterized by pigmented skin, increased pigmentation, parchment-like thickening of the skin and gradual desquamation; the epithelial layer shed and a nonpigmented area was left beneath. In some people the burns were deeper, as evidenced in the next few figures.

Figure 9 shows one of the boys who wasn't wearing much in the way of clothing and had multiple superficial lesions of the skin.

EISENBUD: What's the time of this one, Bob?

CONARD: That was between two and three weeks. About three weeks, I believe.

DUNHAM: April 16th.

CONARD: That was quite a bit later. These first appeared on many about two weeks after exposure.

Figure 10 shows "beta burns" of the feet. Figure 11 shows the loss of hair, which occurred in about 90 percent of the children and 40 percent of the adults, and which was usually spotty in nature. There were usually beta burns on the scalp in the areas of the epilation.

Figure 9. Numerous superificial "beta burns" of the skin of a young boy who was wearing little clothing at the time of the exposure. From R. Conard. (Courtesy Annals Int. Med.).

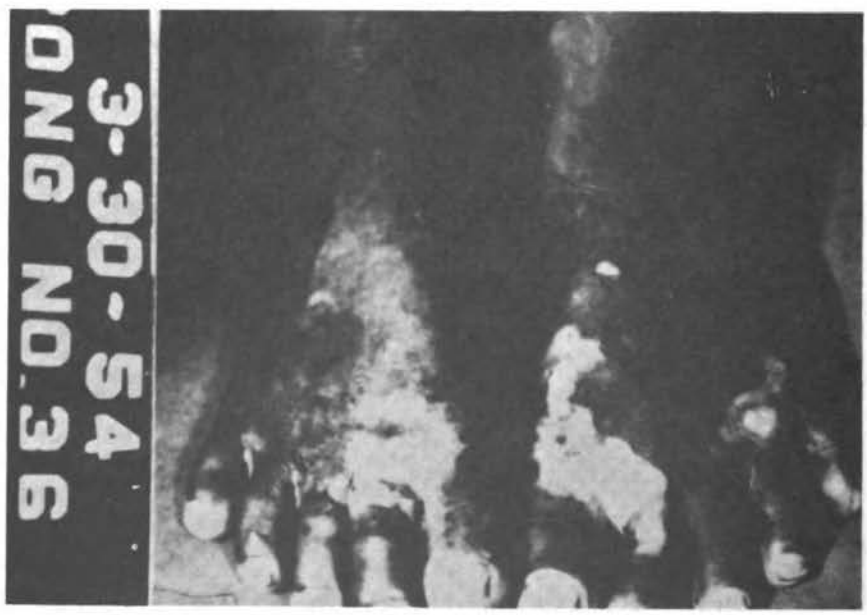

Figure 10. "Beta burns" of the feet. From R. Conard.

Figure 11. Epilation in the temporal area of the scalp of a young girl. From R. Conard. (Courtesy Annals Int. Med.)

WARREN: Is some of this because they slept on the sand without a pillow?

CONARD: Since the epilation was distributed over the head, no more so on the back of the head, I don't think that this was a factor.

DOBSON: Bob, you spoke this morning about the caustic action of the fallout. Is there any evidence that this played a significant role?

CONARD: I think that it might have aggravated the burns. It was caustic and we know that the caustic chemicals in combination with radiation will enhance the effects of radiation. So, it's entirely possible that this material did enhance the severity of the lesions.

DUNHAM: There was nothing to see for ten days at all. The skin looked perfectly good.

CONARD: Yes. We didn't see any erythema, even.

EISENBUD: Did anybody measure the pH of this material?

CONARD: Yes, I think that's been done. That's the reason it was declared to be highly alkaline. It was incinerated coral, calcium carbonate, calcium oxide.

EISENBUD: Excuse me. I didn't see how it could have helped, assuming it was calcined initially. It was in intimate contact with water quite a long while before it actually fell out. It would seem to me if it was calcined it would be hydroxide. This is an interesting speculation and it's a really interesting point which I hadn't given much credence to. I was hopeful that someone had done some work on this. It's too late.

DUNHAM: There are no notes by the medical personnel about skin lesions and for ten days after we got there we saw none.

EISENBUD: The normal humidity of the atmosphere in that part of the world I should think would result in conversion of the oxide. Apart from that, this whole fireball sucks up enormous amounts of water which eventually cool the fireball; and then there are rainfalls. It just seems incredible to me that calcium oxide could persist for four hours in that atmosphere, in this case seven hours, but this is just speculation.

BUSTAD: I think Chuck Dunham's point is quite a critical one in this case, in that a radiation burn will show up after a considerable period of time during which there may be no manifestation of injury.

CONARD: Yes. This is characteristic of radiation burns, that there's usually a lag after the burn before the lesion shows up as contrasted with thermal and chemical burns.

WARREN: A chemical burn would come within a few hours, 24 hours or so.

BUSTAD: Yes, except with radiation you may have had a transient erythema within a few hours. In comparative studies on small pigs using beta particles we observed a transient redness which disappeared within the first 24 hours.

CONARD: Yes. This was true of the Japanese fishermen, too.

BUSTAD: In the light-colored swine, injury would be manifested in 14 to 21 days.

TAYLOR: Are there any other examples of beta burns to human beings besides the Bikini ones?

CONARD: Yes, there are quite a few.

TAYLOR: Are these reactor accidents?

CONARD: "Beta burns" have been reported in persons carelessly handling fission products (Reference 12) and from exposure to other radioactive sources (References 13 and 14).

LANGHAM: There are hundreds and hundreds of examples of burns of human skin.

DUNHAM: Lowry had a case.

They have been reported by dermatologists and cancer therapists.

EISENBUD: Could I ask one question about this lye. Isn't coral calcium silicate?

DONALDSON: No. There's very little silicon.

It's calcium carbonate.

WARREN: You might have flakes of calcium oxide or hydroxide which could burn a moist skin, but a very dilute lime water has been used as a soothing solution for burns.

CONARD: There are about 15 cases in the Rongelap people that still show some residual pigmentation and scarring as a result of the burns. The Japanese fishermen had some rather severe beta burns, particularly on the hand with which they were handling the fish lines between the thumb and the index finger. One area that was heavily involved was on the crown of the head. They frequently wear a handkerchief around their head and the crown of the head was exposed. The belt line was a frequent site of involvement. (See Reference 15.)

BRUES: Dr. Tsuzuki told us that the older fishermen had more damage to the skin of the head because, in general, they didn't wash their hair as often as the younger fishermen did.

CONARD: That's interesting.

From the Marshallese experience we learned about certain factors that influence the development of "beta burns." The Americans on Rongerik recognized the danger of the fallout and immediately went indoors in their Butler buildings. They took showers and changed clothes. As a result their skin exposure and internal exposure was minimal compared to the Rongelapese. The older Rongelap people who stayed indoors and others who went wading and swimming had fewer skin burns. A single layer of cotton clothing was proved to be sufficient to protect the skin.

The internal absorption of the radioactive materials produced no acute effects that we could observe. They had three millicuries of fission products that were calculated to be in their gut but this produced no effect that we could see.

Probably the strontium and radioiodine are the most serious of the radioisotopes that are present in this acute fallout situation.

DOBSON: Excuse me, Bob. How many millicuries did you estimate they had in the gut?

CONARD: Three.

DOBSON: Three?

CONARD: Yes, three.

TAYLOR: Was that probably by inhalation?

CONARD: Mostly ingestion. The particle size of the fallout was too large for optimum absorption into the alveoli of the lungs.

UPTON: Do you wish to imply that there were not depressing effects on the marrow from internal contamination, Bob?

CONARD: Yes, I feel that's true, since I think it was calculated that the dose over the whole period of time that the Marshallese received to their bones was in the order of several rads—something of that nature.

UPTON. Surprising.

FREMONT-SMITH: Why does it surprise you?

UPTON: I've been apparently laboring under a wrong impression for many years that the internal dose to the marrow was higher than you say it is, Bob.

TAYLOR: Is that from concentration of strontium-90 in plants?

UPTON: Just total fission product intake from one source or another.

EISENBUD: Are you talking specifically in these cases or in general?

UPTON: No, the Rongelap cases.

WARREN: They weren't there right along to eat local food or get exposed internally.

CONARD: The actual body burdens of strontium-90 that had accumulated over years for the Rongelap people amount to about 5 percent of the MPC for adults and ten percent for children.

EISENBUD: The Japanese fishermen lived at sea for 14 days in very intimate contact with fallout. It's quite a remarkable thing that Koboyama had, I believe, when he died, 2 millicuries of strontium-90 per gram of calcium in his bones, which is about 20 percent of what children have today. I mean it's a small dose. I think that one of the comforting things that came out of this experience is that the human body in close contact with surface contamination apparently has better defenses than we had anticipated against absorption of at least the less soluble components.

Now, the iodine did get in, as Bob indicated.

CONARD: We felt very encouraged about the whole internal situation. To be honest with you, we were misled. We felt that the internal situation was far less of a hazard than any of the others and, of course, we still do, but we certainly did underestimate the hazard of the absorption of radioiodines, as you'll see in a few minutes when I get into that aspect of it.

WARREN; Wouldn't the radioiodine be in gaseous form and inhaled rather than ingested, and wouldn't that be why the concentration could have been higher?

373-782 O - 70 - 9

CONARD: They must have inhaled some from the cloud as it passed over but the majority of the radioiodine absorbed probably came through contaminated drinking water since it rained the night of the fallout. Moreover the people were on water rationing, everyone receiving about a pint a day including the children. So most of it was in the drinking water.

WARREN: Yes. It would be scrubbed out in the rain.

CONRAD: So, during the years the Marshallese people have remained generally in good health and we have not seen any illnesses or any deaths that we could directly relate to the radiation effects except for the thyroid situation which I will come to shortly and the one death in the case of the Japanese fishermen. They have been healthy over the years.

As far as mortality is concerned, 15 deaths have occurred among the 84 in the most heavily exposed group, which represent about 13 per thousand, and this is compared to about 8 per thousand in the Marshall Islands as a whole. So we do have some increase in mortality but whether this is significant in such small numbers it is difficult to say. We have a greater number of older people in the original Rongelap group also.

As far as malignancy is concerned, there have been two cases of cancer in the exposed group plus one case of cancer of the thyroid. So we have to keep an open mind as to whether we will eventually have an increased incidence of cancer. Again, the numbers are small.

As far as the skin is concerned, the only late effect that we have noted in the Marshallese is in the appearance of moles, benign nevi, in the areas that were more heavily irradiated.

Figure 12 shows some of the moles that have developed in the case of one woman who had fairly clear ulcerations on the side of her neck early after fallout during the acute period. Figure 13 shows residual scarring resulting from a severe "beta burn" of the ear. Figure 14 shows a case of one of the Japanese fishermen. I took this in Japan four years ago. It shows an area of permanent alopecia. The Marshallese hair all regrew except that in one case there was a slight alopecia, but in the Japanese fishermen there are two cases that still show some degree of alopecia, that is, a permanent bald area from the radiation. Some of the fishermen had "beltline" lesions with some degree of blood vessel dilatation (telangiectasia).

Figure 12. Benign nevi (moles) that developed 8 years later in area of "beta burns". From R. Conard (Courtesy Annals Int. Med.)

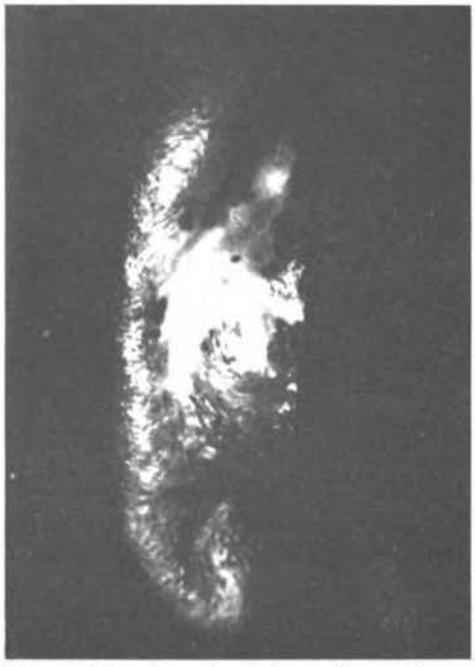

Figure 13. Scarring of ear from "beta burns". From R. Conard.

Figure 14. Permanent alopecia in Japanese fisherman. From R. Conard.

Now, a more serious finding in the Marshallese was that over the years the children, particularly the boys exposed at less than 12 years of age, have tended to be somewhat stunted in growth, have shown some lag in growth and development (Reference 16). We have carried out numerous growth measurements and x-rays for bone growth, and so forth, and this finding has become apparent.

Figure 15 shows a comparison of bone age in some of the males. The dotted line represents the exposed males compared with the unexposed males on the left, and on the right the females. The base line represents the American standard. The Marshallese tend to be somewhat smaller than American standards. Shortly, I'll have a little more to say about this lag in growth in the Rongelap children.

We have carried out blood work every year, of course, and Figure 16 shows that there's been a slight lag in complete recovery of the white count and platelet count up until about 11 years after exposure. The straight line represents the unexposed control population.

We have carried out numerous aging studies to see if we could detect any premature aging effects and we haven't seen anything along that line.

Life shortening has not been apparent in these people from this limited study.

Fertility based on birth rate has shown that about the same birth rate has existed in the exposed population as compared with the unexposed population. They've had about 70 babies and these babies on the whole appear normal. We haven't seen any greater incidence in the congenital defects in the babies of the Rongelap exposed as compared with the unexposed.

Whether there was an early sterility or not, we do not know. We did not test it, of course. It probably did occur during the early period. The Japanese fishermen showed quite a drop in sperm count which lasted for three years, but since that time they've had children repeatedly and recovered their sperm count.

During the first four years the exposed women showed some increase in miscarriages and stillbirths. About 41 percent of the births during that period ended in nonviable babies compared with only 16 percent in the unexposed group.

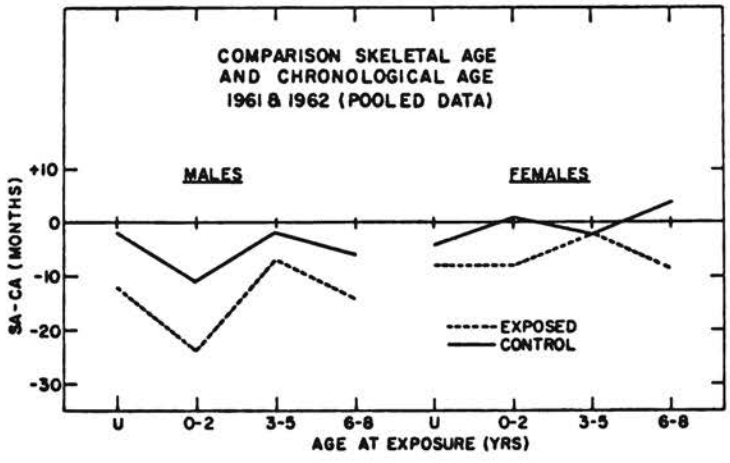

Figure 15. Comparison of skeletal age and chronological age (1961 and 1962 pooled data). From R. Conard.

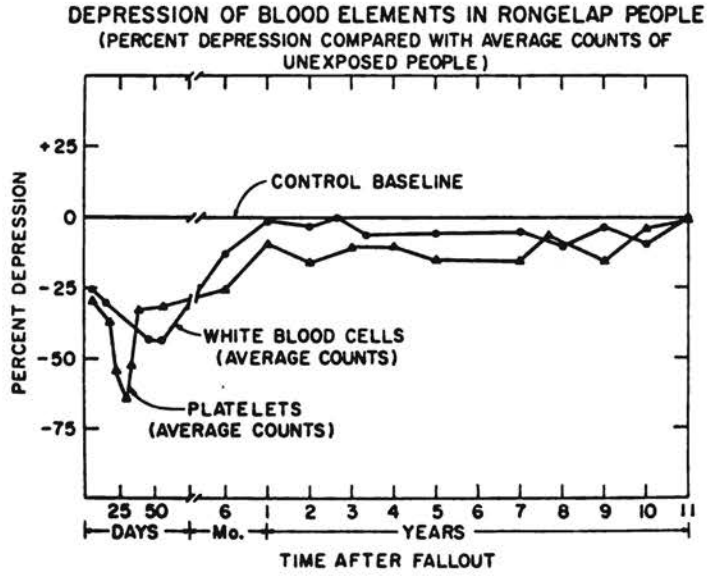

Figure 16. Depression of blood elements in Rongelap people. Percent depression compared with average counts of unexposed people. From R. Conard.

Examination of the lens for possible opacities has not revealed any evidence of radiation-induced opacities of the lens. Remember, of course, that the Marshallese didn't get neutron radiation, which has a much higher RBE for opacity than gamma radiation.

We haven't carried out any specific studies of genetic effects, particularly in view of the generally negative result of the studies of Neal and Schull (Reference 17) and others in Japan. I'm sure there must be an increase in the mutant pool of these people and we have seen evidence of chromosome damage in the peripheral blood cells. We have cultured their blood and found an increase over the normal in the number of chromosomal aberrations.

FREMONT-SMITH: Were these persistent?

CONARD: Yes. This was ten years after exposure.

FREMONT-SMITH: You don't know what they were earlier?

CONARD: We didn't test them earlier.

MILLER: More than the Hiroshima survivors?

CONARD: Yes. I was going to say that also in the Hiroshima survivors and in the Japanese fishermen there's been a persisting increased level of chromosomal aberrations. So I suppose we would have to expect that there are genetic mutations that exist in these people. Perhaps Bill might say something about that.

FREMONT-SMITH: At least in the blood cells.

CONARD: Yes.

FREMONT-SMITH: We don't know whether they are operating in the genes.

CONARD: I should imagine there would be some increase in general somatic mutations.

FREMONT-SMITH: All right. I thought you meant the genetic mutations.

CONARD: And also in the genetic.

FREMONT-SMITH: The genetic, too.

EISENBUD: What's known about consanguinity in this group?

CONARD: This is a good point. We've gone into that and it turns out that these people probably do have a somewhat greater degree of consanguinity than we do, but in the exposed group we checked the number of first-cousin marriages and second-cousin marriages and this sort of thing and found that actually they had a lower rate of consanguineous marriage than occurred in a comparison population. This also has bearing on growth and development because the children of consanguineous marriages are known to be somewhat retarded.

SCHULL: It might also have a bearing on the finding of increased percentages of abortions. If the latter reflects immunologic incompatibility between mother and fetus, fewer abortions would be expected among the pregnancies of consanguineously married individuals than among those of unrelated spouses.

EISENBUD: I don't see how they can get away from their cousins on a small island like that. I don't think they are completely inbred. Do they mix up much with the other islands?

CONARD: Yes, there's quite a bit of communication with other islands and people come in and bring in fresh blood! [Laughter]

FREMONT-SMITH: You mean small transfusions? [Laughter]

ROOT: I had heard that they had a low birth rate and that's why the custom of adopting other children into families had arisen.

CONARD: It may be true from the point of view of infant mortality which up until more recently has been quite high, but now we have brought in better medical care, and so forth, and the infant mortality is greatly reduced. But they do adopt children, too.

Now I would like to discuss the most serious finding in the Marshallese, that is the development of the thyroid abnormalities. Until 1963 we had thought that these people had normal thyroid glands. We had already detected this lag in growth and development in exposed boys and we really didn't have any explanation for it. We carried out numerous thyroid tests and so-called PBI (protein-bound iodine) tests of the blood, which are good indications of thyroid activity,

and we found them to be normal. However, since that time, as an aside, we have discovered that these people have a peculiar protein in the blood, an iodoprotein which is quite high and no doubt gave us false levels of the PBI readings earlier, and this may have thrown us off the track.

DUNHAM: It is true of all Marshall Islanders?

CONARD: Yes.

DUNHAM: I see.

CONARD: Four years ago we first noted a thyroid nodule in a 12-year-old girl and since that time there have been increasing numbers of these abnormalities until now we have 19 cases of thyroid abnormalities; 17 people with nodules and two boys with completely nonfunctioning glands, that is, a hypothyroid situation (References 9, 18, 19).

WARREN: Myxedema?

CONARD: They had signs of myxedema, yes. They were the two most dwarfed boys in the village.

FREMONT-SMITH: Were these thyroids that were destroyed or never developed?

CONARD: Presumably destroyed.

FREMONT-SMITH: How old were they?

CONARD: They were at the age of 15 to 18 months, which seems to be a critical age for children.

FREMONT-SMITH: When they were exposed?

CONARD: Yes.

MILLER: Was there any other child in that age range at the time of exposure?

CONARD: There were several in the one-to-three years of age range.

ROOT: They would be closer to the ground radiation and would get a bigger dose, wouldn't they—in addition to the fact that the organ itself is smaller? They would be at the level of the most intense radiation.

CONARD: That's true. That probably increased their whole body dose somewhat, but this would be negligible compared to the increase in the absorption of radioiodines into their glands, and that is the biggest factor by far. In other words, 700 to 1400 rad radiation came from radioiodine absorbed compared to only 175 of whole-body radiation, and if you want to assume that the children were getting a little more, you might increase it to 200 or so.

ROOT: They would be crawling around at the age of 15 months probably.

CONARD: Yes.

FREMONT-SMITH: Would their thyroids be in a stage of development where they would absorb a greater percentage from a given dose of iodine?

CONARD: I think it's assumed that their glands absorb as much as the adult, but being smaller, the same dose is distributed in a smaller gland.

FREMONT-SMITH: Right. So this means per gram of gland they were absorbing more.

CONARD: Right. They were getting a higher dose.

BRUES: Is there also a possibility that the thyroid in these children would be close enough to the skin that the beta dose would be greater, or at least would be appreciable while not as appreciable in the adult?

CONARD: We didn't feel that that was the case, Austin, because the beta radiation was so soft that it was attenuated in only less than a milliliter of the skin.

CASARETT: Bob, were these nodules appearing in relation to the onset of pubescence in most of these cases? Could the pubescence period and the endocrine disturbance associated with it be a stimulating factor in the production of nodules at the time they did appear,

which is apparently about ten years after the exposures for the first case?

CONARD: That's right. I think that's very likely to be the case, that most of these children were going into adolescence and there was a greater requirement perhaps on the thyroid due to increased metabolism and this could put a greater strain on the thyroid, and then they began showing the effects of a hypothyroid state.

Table 3 shows the distribution of cases; "R" represents Rongelap, "A" Alinginae, "U" Utirik, and "C" control. Here in the first four groups we have children less than ten years of age. You will notice that in the Rongelap exposed group there were 19 children that received a gamma dose of 175 and a thyroid dose of 714 to 1400 rads. We found on the last survey another thyroid nodule, so we have 84 percent instead of 78.9. The incidence in the Alinginae group—six children, none; Utirik—40 children, none; and the control children—61, none. In the Rongelap adults there were three nodules in the 36. The Alinginae adults had one nodule, which was not typical of the other radiation-induced cases. You can see that in the other populations there was only a small percentage of nodules and most of these were in older people which appears to be a normal incidence.

Table 3. Thyroid nodules (including hypothyroidism) in Marshallese populations.

Group	Age At Exposure	No. in Group	Gamma Dose (rads)	Estimated Thyroid Dose (I*, rads)	% Thyroid Nodules
R	< 10	19	175	700 - 1400	84.2
A	< 10	6	69	275 - 550	0.0
U	< 10	40	14	55 - 110	0.0
C	< 10	61	0	0	0.0
R	> 10	36	175	160	5.5
A	> 10	8	69	55	12.5
U	> 10	59	14	15	3.4
C	> 10	133	0	0	2.3

(R=Rongelap; A=Ailingnae; U=Utirik; C=Unexposed)

Eleven cases were operated on, nine children and two adults. Figure 17 shows the nodules at surgery. Note the hemorrhagic nodules. It turned out at surgery that practically all of these glands had multiple nodules whereas at the clinical examination we had only been able to feel one or two; at surgery in most cases the glands were pretty well shot with nodules.

FREMONT-SMITH: Does this mean that a lot of other cases where you didn't feel anything also probably had multiple invisible nodules?

CONARD: Yes, it's quite possible that we were unable to palpate minute nodules in some cases, I can't deny that.

FREMONT-SMITH: Yes.

CONARD: Figure 18 shows one of the glands in one of the children that was sliced up just to show you the consistent nature, the multiple nature, of these nodular changes in the gland.

WARREN: Is that pigment or extravasated blood?

CONARD: A lot of that is hemorrhagic blood pigment. The histological examination of these nodules showed that they were all benign; they were of the type usually seen with iodine deficiency but, of course, we know that on Rongelap there's no iodine deficiency. The iodine level in the foods is normal and the urinary excretion of iodine, checked in quite a few of these people, has been within the normal range. Furthermore, we don't know of any goitrogenic foods on the Island. The evidence seems overwhelming that this is a radiation-induced phenomenon in these people.

There was one case in a 40-year-old woman in which the nodule was malignant. Now, one can argue that this may be just a normal occurrence. A lot of people believe that cancer of the thyroid is not easily produced by radiation exposure, but certainly in a small group like this heavily-exposed one it has to be considered as a possibility anyway.

MILLER: You said that there is overwhelming evidence that this is radiation-induced. You didn't mention yet that part of this evidence is observations made in other radiation-exposed groups.

CONARD: Yes, that is certainly true.

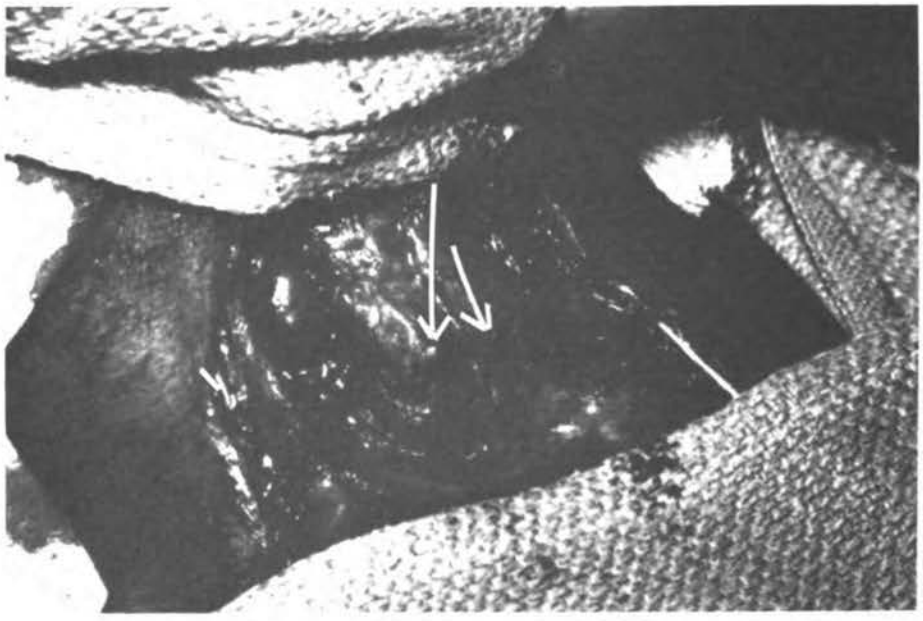

Figure 17. Benign thyroid nodules at surgery. Arrows point to nodules. From R. Conard.

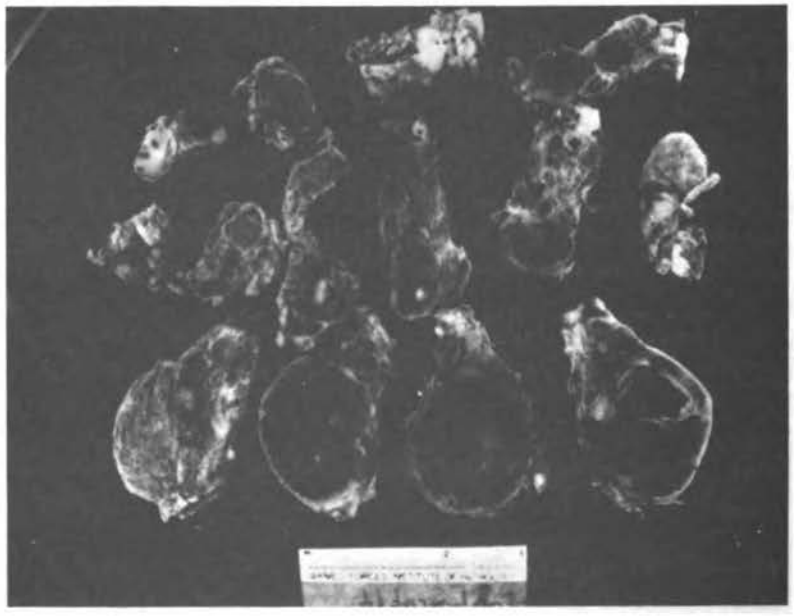

Figure 18. Sectioned thyroid gland showing multinodular, cystic and hemorrhagic nature of the gland. The nodules were benign. From R. Conard. (Courtesy New England J. Med.)

MILLER: Which others show it?

CONARD: Which other examples, you mean, from the literature?

MILLER: Right.

CONARD: Numerous animal studies have shown the causative relationship of radiation of the thyroid with later development of both nodules and malignancy (References 19 and 20). This also applies to radioiodine (References 21 and 22). Also examples in human therapy include patients, particularly children, treated with radioiodine for hyperthyroidism, which have been shown to later develop nodules (Reference 23).

MILLER: Then external radiation also has had some effect?

CONARD: External radiation certainly in children. A causal relation of irradiation of the neck region in infants and later development of thyroid cancer and nodules has been clearly demonstrated (References 24 and 25). There appears to be an increased incidence of thyroid carcinoma in inhabitants of Hiroshima and Nagasaki exposed to radiation from the atomic bomb explosions (Reference 26).

TAYLOR: Was this given for diagnostic purposes?

CONARD: Radioiodine was given for treatment of hyperthyroidism, to destroy part of the gland.

DUNHAM: Big doses.

CONARD: Yes. It takes about 10,000 rad to successfully treat hyperthyroid conditions whereas in some cases, to ablate the thyroid gland, such as in angina pectoris (heart disease) they use doses of 50,000 to 70,000 rad to the thyroid gland to destroy it.

We haven't seen any recurrence of cancer in this one Marshallese case. She's had complete surgical and radioiodine ablation of her gland.

Now, the correlation of the development of these thyroid abnormalities and the growth retardation in children has become increasingly clear. These children in recent years have shown more and more evidence of reduced activity of the gland, and, as I said, the two

dwarfed boys that were four years behind in growth and development show a definite correlation there.

So, beginning two years ago it was decided that we should treat all of these exposed people with thyroid hormone in the hope of reducing further development of nodules, to prevent cancer and hopefully, give an increased growth rate in those children that had shown the lag. Figure 19 shows the skeletal age development of the two boys that were most dwarfed. You can see that at the time of thyroid hormone therapy institution there was an almost immediate spurt in growth. We hope that in the next survey we will see increased growth rate in other children as a response to the treatment with the thyroid hormone. We are having difficulties getting these people to take their daily tablets. They just don't seem to want to do it. I was very disappointed when I returned from the last survey to find that the blood levels of the thyroid hormone in the affected children were quite low, which meant that a lot of them were not taking the drug. So we have a real problem getting them to take the drug for the rest of their lives, particularly the children.

DOBSON: Bob, in your earlier discussion of these patients, did I understand you to say that you are differentiating among different iodine-carrying proteins in the blood?

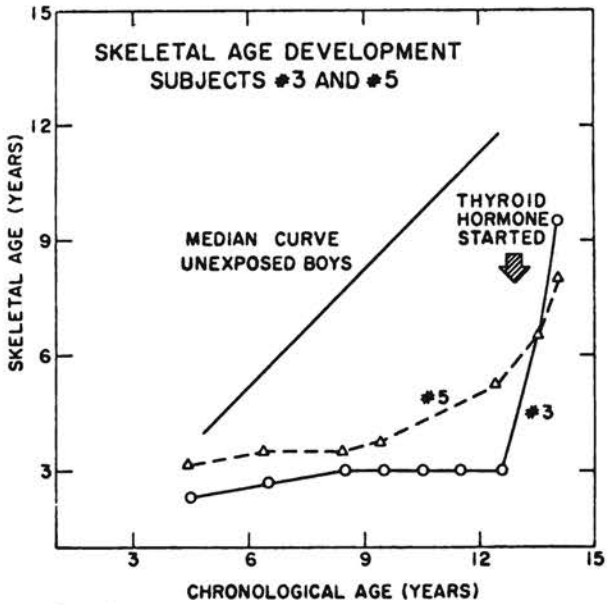

Figure 19. Skeletal age development before and after hormone therapy in two boys showing greatest growth retardation. From R. Conard (Courtesy Annals Int. Med.).

CONARD: Yes. We've done considerable work on the different protein-binding levels of the different blood proteins.

BUSTAD: On the basis of our work with radioiodine in animals and also a fairly extensive review of human data, I would not have predicted, nor can I find very many people that would predict, that you would see frank hypothyroidism with 1400 rads from radioiodine and 175 r from gamma exposure.

DUNHAM: Have you kept any animal ten years?

BUSTAD: Yes. In fact, we have fed sheep radioiodine for 11 years every day of their life.

MILLER: These were little sheep?

BUSTAD: Yes, they were exposed in utero since their mothers were fed radioiodine. In the cases of the Marshallese children, their dose was an acute one at a sensitive time, but since the calculated dose appears insufficient to cause hypothyroidism I'm wondering if there could have been two or three times the thyroid dose in some children. Maybe they drank more water or maybe a few children licked themselves and contaminated objects around them and realized significantly higher exposure. I have difficulty getting three times as much, which I would say might be the minimum exposure from radioiodine which would result in frank hyperthyroidism. I would like some reaction to this.

FREMONT-SMITH: Is this potentially a species difference?

BUSTAD: I think generally the acute ablating dose for most animals is very nearly the same. In an adult person it's reported to be about 30,000 rads, which is similar to that we have observed in sheep.

FREMONT-SMITH: Many other experiences with animals show that you do get species differences of various kinds and therefore prediction from several species of animals that you have used doesn't apply to humans.

UPTON: How about Sol Michaelson's work, George, in dogs?

CASARETT: That work (Reference 27) bears out the fact that external radiation with x rays will cause hypofunction of thyroid, myxe-

dema, with much lower radiation doses than those required from internally administered radioiodine. After 2,000 rads of x rays to thyroid the myxedema appears in about a year. With reduction of x ray dose the time taken for the myxedema to develop in dogs increases in a manner indicating a slower progression of the underlying mechanism at lower doses. There is a possibility that radiation from external sources, in addition to the internal radioiodine, may have contributed to the thyroid changes in the children in question.

BUSTAD: That was my next point. I think that 200 r or 300 r is not an insignificant amount from the standpoint of thyroid damage. These children probably received a considerably more effective dose per rad from external gamma to the thyroid than from I^{131} and there is some substantiation for this from animal data. And if I can then stretch a point and say, "Well it's five times more effective".....

UPTON: .....because of dose rate or dose distribution within the gland?

BUSTAD: Yes, I think there are at least two things that contribute to this. In order to get the same equivalent rad to the thyroid from I^{131} you have a much lower dose rate because it's extended over many days. With the total body radiation it was a sudden thing over a matter probably six or eight hours. In any case it was very acute. The other thing is that a lot more than thyroid tissue was affected following external gamma exposure. With the radioiodine, however, the periphery of the thyroid gland is probably receiving 25 percent of the dose at the center of the gland while in the case of external irradiation the entire thyroid gland is being uniformly irradiated as are the contiguous structures. I think this too is important.

The other thing that is worthy of note is that in Dr. Hempleman's studies (Reference 28), which I briefly discussed during our first meeting, he noted a high incidence group of about 268 children who were irradiated early in life anteriorly and posteriorly for total doses of 200 to 600 R or more. Of the 268, there were 20 that manifested thyroid neoplasms. Half of these were cancers. It's interesting to me to note that in your Marshallese group, Bob (Dr. Conard), the children manifested no cancer, only thyroid adenomas (Reference 29). This was also the pattern in our sheep studies. We had one fibrosarcoma and one adenosarcoma and 30 or more adenomas, and this pattern of response has characterized most of the followup studies of the children who were exposed early in life to radioiodine. That

is, there seems to be a higher proportion of cancer per total neoplasms than with the radioiodine studies, but I'll admit there isn't always comparability and many of you could then say, "But we don't know how many of these who are still walking around may have adenomas." We know that in adult populations there is a high incidence of thyroid adenomas; in fact, in those of you who are over 50 years old, if we removed your thyroid (if it isn't already removed) we would probably find adenomas in half of you. A study was done several years ago in which it was shown that half of the people over 50 had thyroid adenomas and most of them didn't know it and seemed none the worse for them. The moral of the story is if you're going to have a neoplasm, choose the thyroid.

FREMONT-SMITH: Were any primates used in the experimental animals, any monkeys which might be closer to man?

BUSTAD: The only studies in the sub-human primates that I'm familiar with are those by Pickering (Reference 30), and he was concerned mainly with the uptake in the very young—the fetal thyroid. There have been no long-term studies with radioiodine in primates to my knowledge. I think that most of the data that I've reviewed—and I think I have reviewed most of it in this field—certainly indicated to me the species that have been worked on.....

FREMONT-SMITH: But they're all lower species?

BUSTAD: Well, no. We've also looked at human cases where there was radioiodine given.

FREMONT-SMITH: Okay.

BUSTAD: The effect is similar. It will take an acute dose of 30,000 to 50,000 rads to ablate the thyroid of sheep. Dr. Goolden (Reference 31) in England, looking at a lot of human cases says it will take a comparable dose for a human adult. There's one exception to this that some of you may bring up, and that is the work of Dr. John Garner now at Colorado State Univerisity (Reference 32) who says that cattle thyroids are unusually resistant and may take over 100,000 rads. In all of these cases a lower dose will cause hypothyroidism if you wait long enough.

WARREN: The jack rabbit is susceptible, too.

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BUSTAD: Yes.

CONARD: Are you intimating that in the case of the Marshallese their gamma dose was probably significantly higher than we have calculated?

BUSTAD: I'm only trying to generate ways these children may have had more radiation than was estimated. In addition to you, I've talked to many other people who have had association with it and they will admit that maybe it could have been something over 200 (quite a bit over 200 possibly), and then we have to admit that 1400 rad as a maximum may not be a true maximum depending on what the experience of these children was during this period. I'm also worried a bit about the short-lived isotopes which can really contribute very heavily to a radiation dose, and I'm speaking of iodine 135 and 133. The fact is they may contribute up to half or more, especially in the early period.

MILLER: You keep speaking of 30,000 r to ablate the thyroid in an adult; how much is required in an animal one-month old?

BUSTAD: I feel that—and this is partially intuition—it's possible to see hypothyroidism. If you permit me to choose any animal and choose a certain dosage regimen, I could produce it with maybe 5000 or 6000 rad in an animal that's very young providing you wait the ten years or so that Dr. Dunham mentioned earlier.

MILLER: There is a need to make a study in animals that duplicates the experience of these children.

BUSTAD: Well, I've discussed this with Dr. Dunham some time ago and some of this is under way.

DUNHAM: I think the point is well taken that it is a combination of internal and external.

BUSTAD: That's right.

DUNHAM: And in the other data, it's either one or the other.

BUSTAD: That's right. And I feel strongly about this.

BRUES: Ablation of the thyroid is a different matter as regards the production of adenomas. You have to leave some tissue but remove enough so that the pituitary sees a thyroid deficiency and stimulates

the thyroid cells that remain with thyroid-stimulating hormone. So I would suppose that the adenomas would go through a maximum at some point. In addition to that, if with radioiodine, as you have said, Leo, the irradiation of the thyroid is not homogeneous so that the outer layer gets less of a dose than the internal part, there might remain a reservoir of cells on the periphery which would be stimulated by the pituitary response to hypothyroidism.

CONARD: But we had two cases, remember, with ablation and with practically no thyroid function. These glands are gone.

DUNHAM: What's your evidence that there is ablation? You said hypothyroid. How hypo were they?

CONARD: Their PBI's dropped to below 2 micrograms percent, their glands were no longer palpable, and their iodine uptake was nil. I do not see how you could account for this ablation on the basis of the increased whole-body radiation since, if the whole-body exposure had been increased by even a factor of two, we would have seen considerably lower white counts than we did.

BUSTAD: If you look back on these two boys can you really separate out the blood picture from, say, 150 r versus 250 r exposure?

CONARD: I think so. I think if they had had 250 rad we would have seen signs of infection or bleeding in these kids.

AYRES: You said a while ago that the thyroids of these young children would absorb about the same amount of iodine as an adult but the glands were smaller. Is that taken into account in the internal dosage calculation?

CONARD: Yes. This is what brings the child's dose up so much higher than the adult dose.

AYRES: I just didn't notice.

BUSTAD: A factor of ten.

BRUES: In fact, the ratio is better estimated than the absolute dose.

CONARD: Perhaps! [Laughter]

CONARD: Figure 20 shows one of the boys with greatest growth retardation (on the right) standing beside his brother who is a year younger. Shortly after this picture was taken we started the boy on thyroid hormone treatment. Figure 21 shows the same stunted boy on the left before treatment and on the right a year later.

ROOT: His features — the myxedema is gone.

CONARD: Yes. He's changed in appearance. I hardly knew him when I saw him after treatment with the hormone.

We'll go on then to the chronic exposure from residual fallout. I refer here to the period following the first few days of acute exposure. In this situation we have low dose rate whole-body irradiation, possibly some irradiation of the skin, and internal absorption of some radioactive isotopes.

We know that chronic low dose exposure such as this will increase to some extent the incidence of leukemia and cancer of the skin and has been seen by radiologists over the years. But we are in a region that we really know very little about in regard to human effects. We get down into the region in which there is controversy over whether or not there is a linear dose effect relationship and whether or not there is a dose threshold for the effect.

In the case of the Marshallese, at the time of their return to Rongelap Island there was a low level contamination consisting mainly of the radioisotopes cesium-137, strontium-90 and zinc-65. Though the body burdens were well below the MPC levels, it has afforded us a unique opportunity to study the radioecological situation in the Marshallese. Perhaps in your discussion tomorrow, Lauren, you might bring in a little bit more on this aspect of the thing.

DONALDSON: Yes.

CONARD: I find it extremely difficult to visualize what the situation will be during the aftermath of the atomic bomb. I have tried to visualize the importance of residual fallout in this situation and I just can't give it too much emphasis. To me, if one survives the acute fallout situation the economic, transportation, and psychosocial problems will far outweigh the residual fallout problem in importance.

Figure 20. At right, a 12-year old boy with greatest growth retardation; at left is his brother a year younger. From R. Conard.

Figure 21. Same boy with retarded growth as shown in Figure 20; at left, before thyroid treatment, and at right 6 months after treatment began. From R. Conard.

UPTON: Could I ask, Bob, about the dose rate at the time they were evacuated? Suppose it had been impossible to get them out promptly? Suppose one had waited a few days or a few weeks, would the situation have been vastly different in the outcome?

CONARD: There wouldn't have been as much difference as you might think. The total dose would have been, say, around several hundred rads, around 250 I believe it was, if they had stayed on there.

DUNHAM: And never left at all?

CONARD: Yes.

ROOT: Is it because of the short half-life of most of the elements that there would have been no appreciable increase with time?

CONARD: It's due to the fact that the shorter-life elements are dying out and only the longer-life ones are left, so that the radiation dose rate reduces with time and the dose rate would have been considerably less as time went on.

ROOT: Like, for instance, if you have strontium-90, does the body take up as much as it can in the initial stages so the residual strontium-90 doesn't have much effect?

CONARD: You do reach a point of equilibrium with the environment, that is provided the dietary source of strontium-90 remains constant.

UPTON: But the total dose wouldn't have been twice what it was had they remained indefinitely on the island?

CONARD: No, not the whole-body dose.

TAYLOR: Is that independent of strontium-90 concentration in the food that they eat? I thought that that didn't really come up.

CONARD: In the Marshallese the majority of the present body burden of strontium-90 is from their native dietary source after moving back to the island.

AYRES: In the first few days the concentration of strontium-90 would have been very, very tiny, whereas ten years later it would have been a significant fraction of what was left.

CONARD: Relatively greater, yes.

EISENBUD: As a general rule, as many of you know, the dose rate goes down by a factor of 10 for every sevenfold increase in time. The dose rate must have been down to about 10 percent of what it was when it started. Had they stayed on then, as you said, it would have been a smaller figure, something like 25.

AYRES: It's not true in the early hours, when you're not at ground zero, because of the delayed arrival.

UPTON: But this is simply the external radiation. This doesn't take account of continual recontamination by fission products in the environment. The internal burden would presumably continue to increase.

DUNHAM: Relatively speaking the strontium-90 is unimportant to begin with, as Dr. Ayres points out. The amount of strontium-90 that they are now living with isn't very different from what it was when they left. It was the material on the surface of the food that they might have eaten on the first two days that was important.

CONARD: I think we should seriously consider the possible psychological reactions to the residual fallout situation. It would be a great mistake if this hazard were overplayed. It could cause psychological unrest and interfere seriously with realistically facing the recovery problems. I think this point deserves serious consideration.

FREMONT-SMITH: Also, there would be a credibility lack if we made less of it than we should and it was then discovered that we had made less of it.

CONARD: Yes, that's true.

ROOT: Could I have a word about the crab that was a staple in their diet. I've heard two things: one, that the crabs ingest their own shells so they are forbidden as food; and the other, that they have disappeared entirely.

CONARD: No, they are still there. They're reduced in number. The coconut crab is quite a delicacy among the people.

DUNHAM: It's not a staple, it's a delicacy.

CONARD: They are very fond of it.

DUNHAM: They say there's a distinction between this and a staple, which is something they must have to live on—a main constituent in the diet. Crab is a delicacy when they can get one.

CONARD: These crabs have a concentration of 4000 to 5000 units of strontium-90.

FREMONT-SMITH: In their shells? In their meat and their shells?

DONALDSON: It's in their digestive gland. It's characteristic of crustaceans to build up reserves of minerals to use at the time they molt and this then is translocated into the shell from the storage house, in this case in the.....

FREMONT-SMITH: It stores minerals in its skeleton and then releases them when it's going to make a shell. When the crab makes its new shell it takes it not from the skeleton but from the digested matter.

DONALDSON: This translocation takes place in relatively short order. One distinct difference between the coconut crab and the usual crustacean is that as soon as the crab finishes the molting process and the new shell is formed, the crab eats the old shell and thus these minerals are returned to its body.

FREMONT-SMITH: They eat what?

DONALDSON: They eat the shell.

FREMONT-SMITH: The old shell?

DONALDSON: Yes.

FREMONT-SMITH: So they don't lose anything.

DONALDSON: So it preserves the materials and they go on perpetuating this process year after year. This is a particular situation peculiar to the coconut crab. It's not typical of crustaceans in general.

FREMONT-SMITH: I'm sorry. This eating the shell is what the coconut crab does?

DONALDSON: Yes.

AYRES: Perhaps I may make a further remark about the relative importance of strontium-90 in this case as opposed to, say, a nuclear war. Probably it's not important in the long run on Rongelap compared with the initial dose that people had, but it might be important in the aftermath of a large number of nuclear weapons if you're talking about the region away from direct fallout.

CONARD: You mean where it was involved immediately?

AYRES: I'm not saying that the strontium-90 would be important when compared to the damage to the area of direct fallout, but where local fallout didn't fall, strontium-90 would be one of the most important things with which to contend.

DUNHAM: Are you talking about worldwide fallout?

AYRES: Yes.

CONARD: In the situation that we're talking about, if you had a nuclear war, aren't you going to have practically everybody involved and isn't the amount of strontium going to be trivial to the problems of transportation and all of the other problems that are going to exist?

AYRES: I think probably so.

DE BOER: We don't have to talk about an all-out nuclear war.

AYRES: The point is that people tend to worry about the most important residual effect that affects them, and in some parts of the world strontium-90 might be the most important residual effect. In other parts, not.

DUNHAM: In other parts it might be something else.

AYRES: Possibly. In the areas more directly damaged it would be a relatively minor thing except very late again.

FREMONT-SMITH: If people recovered from this damage, then it would come in again.

AYRES: Yes, many years later.

FREMONT-SMITH: So the assumption is if you neglect it,you don't recover from the damage.

EISENBUD: I think we should bear in mind that through a process of testing we have disseminated around the world a very sizable fraction of the total amount that would be produced in an all-out nuclear war. Hasn't there been about 500 megatons of testing? Let's say in nuclear war you talk about 10, 000. Now you've got a good tracer experiment. You see, you're up to maybe somewhere between 1 and 10 percent of what would be released. If you increase the present level a hundredfold without creating a risk it would be significant compared to the social consequences of the bombings themselves in the immediacy.

AYRES: That's just a few hundred megatons over a decade although most of it was concentrated over 3 or 4 years.

EISENBUD: What's the difference? It's all long-lived stuff.

DUNHAM: We're talking about the late effect.

EISENBUD: It doesn't matter. It's undistributed.

AYRES: Yes, but the uptake phenomenon very much depends on the timing here.

EISENBUD: For strontium-90?

AYRES: Uptake efficiency is much smaller for strontium-90 in the soil, compared to uptake of strontium-90 from foliage. If you have a lot in the atmosphere at one time you may get quite a considerable dose and, of course, it's stored in the bone.

EISENBUD: As I say, it can increase about 100. You take the social consequences of the bombing themselves and the immediate consequences and compare that with the worldwide consequences of, let's say for the sake of argument, everybody having 500 picocuries of calcium. I would say that the late effects would be a minor thing.

TAYLOR: There's still one other case and that is when you consider strontium-90 in the region where there was heavy fallout but the people were protected, let's say, by fallout shelters. The question is, what is the remaining hazard then? Let's say people are out of their shelters after a month. I don't know. I'm really asking. Is it clear that

in such a case strontium-90 is the main source of radiation to these people?

CONARD: I think it is. It's probably the main hazard from a radiation point of view. I still contend that this small selected group of people is going to be faced with many more problems that far outweigh possible contamination from strontium-90.

AYRES: I accept that, but I wanted to bring out these points.

CONARD: The last item I have here is protection, survival, and recovery measures. I don't think I need to emphasize to this group the fact that taking shelter in either homes or basements or fallout shelters is quite protective. I think that one might want to consider such things as the use of the stable isotopes, perhaps strontium and particularly iodine, during this acute period. It only takes about three to four milligrams of iodine a day in the adult to suppress the absorption of the iodine uptake of the gland, two to three milligrams in the case of children. I don't think it would be unreasonable to have a little Lugol's solution, potassium iodine, available to add to the diet and perhaps stable strontium or calcium.

WARREN: How much are we getting now in the salt? At one time we had a lot of hypothyroidism and myxedema around the country and there was a drive to put increased iodine portions in the salt. I think the Morton Salt Company has done that, but I'm not certain.

FREMONT-SMITH: They have. In fact, you buy it in the grocery store. We do regularly.

WARREN: Yes, but is the iodine still added?

FREMONT-SMITH: So it says. You can't taste it, but it says so.

CONARD: It's a small amount, a very small amount.

BUSTAD: I would exercise caution, I think, in recommending stable strontium because I think the amounts that you would require to really affect the uptake would be toxic.

AYRES: Any stable calcium would be just about as good, wouldn't it?

CONARD: That's right.

WARREN: .....because the strontium can only join if there is a gap in the calcium. Do these people have milk? Is there calcium in the coconut milk?

CONARD: I'm not sure what the calcium content of coconut milk is but they certainly had no cow's milk and there were very few children that were nursing at that time.

WARREN: Fish bones have some, don't they, Lauren? Fish bones have some calcium.

DONALDSON: Yes.

WARREN: Don't they eat small fish total?

DONALDSON: They eat the entire fish.

WARREN: So this is one of the sources of their calcium. You don't know whether they've got a calcium deficiency, do you, so that they sop up calcium?

CONARD: We don't know that specifically.

WARREN: This could vary from day to day.

CONARD: We've done the strontium-calcium ratios in their urines, and, as I remember, the calcium was within normal limits.

DUNHAM: With all that coral dust blowing around the atolls there, they can't be deficient in calcium.

DONALDSON: There are several cyclic phenomena here. One has to realize that the atolls are made up almost exclusively of calcium compounds. There is a tremendous availability of calcium although most of it is not in soluble form. There are noticeable deficiencies of some elements in the area, particularly iron, Thus, some of the plants don't grow well because of the lack of this element. On the other hand, the natives' diets are geared to this type of environment through survival patterns, or whatever one wishes to call them.

One of the greatest sources of minerals in these diets, beside the coconut crab which is a delicacy, is the giant clam. This clam also is a great filtering mechanism for the sea. It tends to concentrate

its mineral requirements from the sea in not only the shell but particularly in the digestive gland. People eating the entire organism are thus actually being supplied with the minerals they need. The same is true if they are eating the fish; they eat the entire fish. Maybe you can say it's the Japanese influence, but as part of their diet they will eat many of the algal groups and here again they have a good source of minerals.

I think one might comment that one of the things we have feared was that a nice handout would change their food habits appreciably— they are eating rice now and canned goods to a very great extent. This new diet may have a much more specific effect upon them than some of the things we've been talking about in the context of radiation contamination.

FREMONT-SMITH: Do you think their diet might become deficient now because of the canned goods?

CONARD: I don't think so. I think they're getting more protein now. They eat canned salmon.

FREMONT-SMITH: But what about minerals?

CONARD: We haven't seen any real evidence of nutritional deficiency.

BRUES: If I may quote from your most recent monograph (Reference 9), the 1965 urine analyses showed around 100 milligrams of calcium per liter. I suspect this is a little low rather than high.

CONARD: I've forgotten exactly what it is.

MILLER: The question was raised this morning as to whether or not radiation was singled out as a special horror when, in fact, it was not special. Yet you have shown us that among the Marshallese there was no serious consequences from fallout at first, but after 10 years a high proportion of children were found to have thyroid nodules and two of the children were very markedly dwarfed. Why shouldn't there be fear, then, about radiation in particular? These people had no control over it. Exposure need not come from nuclear war; in this instance it was a nuclear accident. As Dr. de Boer said, nuclear wars or nuclear weapons now may be more limited in their effect, more limited in their areas of influence where perhaps fallout will be a serious consequence. But, even if it is not, the fear among the people may be deep and widespread.

TAYLOR: I would like to ask two questions that are related to a possible lesson from the Bikini experiences that might apply to a nuclear war situation. One can certainly visualize circumstances in which there is heavy fallout in an area and there are shelters of some kind available, but in the process of getting into the shelters people are subjected to some amount of fallout. The question is how important is it likely to be that they decontaminate themselves to get rid of any surface activitiy that is clinging to them that is gamma radioactive? Is there any estimate of what fraction of the total body dose the natives got that was due to gamma emitters that was in the white ash that stuck to their bodies and would follow them into the shelter if they had gone to one?

CONARD: It was a very small proportion. Usually they say the beta-gamma ratio is about 100 to 1, so they were getting about 100 times more beta radiation on the skin than they were from the gamma.

TAYLOR: So the necessary decontamination would be to get rid of the source of beta burns?

CONARD: Yes.

AYRES: Is this 100 to 1 ratio based on specific studies?

CONARD: I think this is just a general statement from my understanding of it.

AYRES: Well, I've heard numbers like that but the only pertinent research I am aware of was done by Steve Brown (Reference 33) at SRI about two years ago. It suggests rather smaller ratios more like 25 to 50 to 1.

CONARD: I've heard that; it's controversial, I'm sure.

AYRES: They have actually taken the fission spectrum and done detailed calculations for the first time to my knowledge.

CONARD: But, even so, that's quite a ratio.

AYRES: Yes. It's a useful number.

WARREN: I wouldn't like to leave the impression that I think it's unnecessary. I think the precaution.....

TAYLOR: Assuming it is very hard to get this stuff off, the question is how important, really, in a major disaster situation would it be to get the stuff off? I get the impression it wouldn't be terribly important—that people would get beta burns but that these really are not terribly serious anyway.

CONARD: They can be serious, but it's fairly easy to decontaminate the skin. Even with a damp cloth you can probably wipe enough fallout material off so that you won't get a burn.

BUSTAD: I wouldn't sell beta burns short. They are very irritating, at least that's what my pigs told me! Furthermore, there is a long latency for the development of skin cancers. I would also point out, although it may not be very significant, that iodine may be readily absorbed through damp skin. (The radioiodine in case of fallout originates from tellurium in the fallout.) I would recall for you that we can obtain our requirements for iodine if we just rub tincture of iodine on our skin. We'll get enough that way to satisfy our demands.

FREMONT-SMITH: You mean all over or just a little bit here and there?

BUSTAD: No, you don't have to rub it all over.

WARREN: Well, in the mass casualty situation you wouldn't want to have to supply all of the materials, ointments, and bandages to protect the skin while it was breaking down, and if you could eliminate this from the consideration, it would be worth doing.

TAYLOR: It sounds like a difficult job.

CONARD: To get it completely decontaminated. It was very difficult in the Marshallese but I'm sure they would never have developed any further skin burns if we had gotten it off completely.

FREMONT-SMITH: Baths may not be available in a disaster area for everybody. There may not be that much uncontaminated water to use.

WARREN: Some did go into the ocean and were less contaminated.

FREMONT-SMITH: But we're not all staying close to the ocean.

WARREN: I mean in their case. Of course, all the shelters will have showers.

FREMONT-SMITH: Exactly. I said there wouldn't be enough shower water.

DUNHAM: You know, the problem is a little like the flash burns in Japan. What clothing is worn makes a little difference.

WARREN: Yes.

EISENBUD: I think it's awfully hard to be adequately imaginative about these things and most of us, I think, have kind of insulated ourselves. I used to think about it more than I have in recent years and it used to impress me. Frankly, I haven't thought about it recently, but I think basically you've got to face the fact that you have a pretty high doctor-to-patient ratio. You didn't have the complications of blast; you had adequate food supplies; you had adequate water supplies; and you didn't have panic. When I think of the kinds of interacting of medical and logistic problems that would arise in the event of a real nuclear war, it seems to me that almost any type of injury would greatly lessen the chance of survival.

FREMONT-SMITH: Absolutely.

EISENBUD: It could be even a minor injury to a finger. If a man has got to dig himself out of the rubble and has a broken finger, he may not be able to get out and we haven't faced up to the fact that these things do interact in a way which is not only unpredictable but incalculable. I don't know how to apply numbers to these things.

CONARD: That's true. You may have a severe leukopenia that develops and this, in conjunction with a laceration or even with beta burns of the skin, may result in serious infections from a tiny wound. You may have a very serious situation.

FREMONT-SMITH: A small infection then could be fatal.

EISENBUD: That raises the question of what is the LD-50 in a populace exposed to mass bombing, and I don't know whether you want to get into that or not.

FREMONT-SMITH: How many assumptions do you have to make alternatively to try out that figure. There are at least 10 or 15

separate sets of assumptions you can start off with and each one leads in a different direction. I bring this out because in the very simple hypothetical situation we had in which only two counties in northern New York State were exposed to the bomb we couldn't settle down to really reach conclusions as to what we should do because there were different kinds of assumptions you could start off with which lead in different directions. I think if we had a nuclear war it would not take very long to list 50 different things which would make what you were planning to do quite different.

EISENBUD: Yes.

BRUES: You have innumerable little judgments in the case of water. If someone has a half-pint of water, how much does he drink and how much does he wash off with?

FREMONT-SMITH: Exactly.

BRUES: And does he drink contaminated water or does he wash off with it, or both?

EISENBUD: May I take a poke at the government again in connection with this. This was the first shot of that Castle series and it delayed the second shot. It proved what a lot of people had suspected; you can have massive fallout following a surface detonation of a megaton bomb. Based on early, very sketchy data collected by two or three individuals, certain isodose curves were drawn which are, at best, approximations. Those of us who have had the experience of actually measuring these fallout patterns from smaller weapons find that they are not quite so uniform, that they tend to be amoeba-like and are harder to find.

There arose out of this experience the need for an experiment which would make it possible to get better approximations of the total amount of debris that falls out; physical and chemical characteristics. This wasn't done, and as far as I know hasn't been done in any other subsequent explosions during the period when they were still testing in the Pacific. I think that, from the point of view of national security, we are without information which is badly needed.

Now, it's needed to simply answer questions. It may be totally useless in the sense that there may not be, even with the present information, a satisfactory answer to all the complications of mass fallout and the way it would interact with blast.

373-782 O - 70 - 11

DUNHAM: There were a couple of heroic efforts. One was to actually sample with rockets to find out what was coming down into the air shortly after the explosions, but the rockets all failed or something went wrong. There was also quite a lot of effort to collect stuff on barges and things. The NRDL was involved in this.

EISENBUD: When you say "heroic", what people were trying to do was slip things in. Then you remember the way we laid 400 rafts and couldn't find them afterwards. But this was all stuff that was done in a hurry trying to fit our requirements into a schedule that was already laid down and couldn't be changed.

DUNHAM: One of the big problems was simply the old business of trying to guess where the wind is going to be if you're talking about surface collecting, and they tried to get around that by a whole program of rockets. Dr. Alvin Graves of the Los Alamos Scientific Laboratory and Dr. Willard Libby, then one of the AEC Commissioners, were promoting this and it just fizzled. I don't know what happened to the rockets, but they never did get much data.

TAYLOR: I think the reason that the experiment just is not done is there's no place to do it. If what one wants is to fire a few megatons on the surface of the dry land somewhere where there isn't a lot of water involved, the question is where do you do it?

BUSTAD: You can do it in China! [Laughter]

EISENBUD: Granted. And, of course, this is an extremely important point.

AYRES: What is it that we don't know?

EISENBUD: Would you want to set national policy based on a single set of observations which yielded data which at best were just scavenged?

AYRES: Which types of data are you referring to specifically? There's much more than one set of data on this.

TAYLOR: Not a megaton.

AYRES: There's a lot of kiloton data that's very different and some megaton data (Reference 34).

DUNHAM: It's still not known whether one-third or two-thirds comes down within several hundred miles of a megaton burst.

EISENBUD: You can measure the doses and not have to reconstruct them.

AYRES: The particle size distribution, I believe, is now much better understood than it was two years ago.

DE BOER: This is an area you can't discuss very much because you get into classified information. I think you're really treading on thin ice now as far as that's concerned.

MILLER: May I ask how many casualties there were in the Marshallese?

CONARD: What do you mean by casualties?

MILLER: That's what I want you to tell me.

FREMONT-SMITH: You want to know how many there were or what do you mean by casualties?

WARREN: It's the qualitative rather than the quantitative definition. You mean some of their white counts fall and there's no other evidence and they are nauseated and some of them had beta burns and some didn't.

CONARD: Almost all of these people were affected in some way.

FREMONT-SMITH: 100 percent casualties.

MILLER: Yes, among the Marshallese. But then there were casualties in Japan. Dr. Donaldson has told us that the mother of one of his students was a casualty, and Dr. Schull has told us about a mother and daughter from Osaka whose fears caused them to seek medical advice, and who were, I suppose, psychological casualties. And there may have been many more but these were just a few we happened to hear about. I am wondering if perhaps there were not mass casualties as a result of the Bikini experience. One must think of the people around the world, especially those in Japan, who were casualties medically, economically and/or psychologically.

CONARD: Well, in this small population we were not able to observe any casualties other than those produced by the radiation effects. There was nothing that I would classify as psychological casualty. As far as their relationship with the other Marshallese people and this sort of thing is concerned, we were not able to observe anything unusual.

MILLER: No. My point was that the casualties may not be limited to the Marshall Islands.

UPTON: There has been a thyroidectomy, hasn't there?

CONARD: Eleven people have been operated on; 11 surgical cases.

FREMONT-SMITH: Do they count as casualties?

CONARD: I just don't know what definition to give.

UPTON: How did they react to their experience? Would you say this has been a source of distress? Has it been disconcerting?

CONARD: Several have come up to me in the last survey and said, "Can't you find a nodule so that I go to the United States and get operated on?" [Laughter]

FREMONT-SMITH: The mass casualties are all those who haven't been able to go to the United States!

MILLER: As I said before, my point is that the casualties may not have been limited to the area of fallout. They may have occurred in Japan, affected indirectly by the fallout, by economic troubles, by suicide, by other psychological disturbances, and by the uproar in general. That was my point—that there really may have been many more casualties than one can count in the area of the Marshall Islands.

FREMONT-SMITH: And the whole of Europe was disturbed and had a different reaction toward the U.S., and that's a major casualty.

ROOT: Yes. That's a grievous psychosocial effect.

WARREN: There's another generally insidious casualty which affects all levels of government. To mayors, supervisors, governors, and on up, Civil Defense has fallen flat on its face on the basis that it's impossible to meet the situation which we don't think is going to happen

anyway. It would cost a lot of money and trouble so we're not going to do anything about it until we have to.

FREMONT-SMITH: Yes.

WARREN: That puts us in a very vulnerable situation. There was a general participation and training up to about 1955 that could have provided a fairly competent protection in the possibility of warfare affecting the United States. But now there exists nothing that is much more than a paper organization, very poorly supported, and not well-understood or known.

FREMONT-SMITH: This was the psychological casualty, wasn't it?

WARREN: This was the psychological casualty.

FREMONT-SMITH: Of the whole country.

WARREN: There's a group of assistant professors who know nothing about World War II and still less about atomic warfare. They have a kind of vague apprehension. They would like to know more and they are beginning to work on it. Of course, there's a very small group that is willing to work on it. The rest of them think it's a horrible thing: "We must stop all war." This is a nice goal but we haven't gotten very far on that goal yet.

FREMONT-SMITH: Not quite.

WARREN: This is really where we run into trouble in the long run. How do we bring this situation to a focus and how do we deal with it? In our culture and history it seems to me to lead eventually to a war, because our people will eventually get sick and tired of the harassment and impasse of cold and hot partial wars and atomic war blackmail. Earlier, I heard this very often from audiences. A prominent businessman and other leaders in the community will stand up before four or five hundred people and say, "Well, if it's that bad, let's get it over with while we're ahead. Why are we waiting around? Let's go and do it now."

FREMONT-SMITH: You remember, Staff, the conference that we attended. We had a group of steel people from Pittsburgh, and on the first day of the conference that was their attitude.

WARREN: Yes.

FREMONT-SMITH: "If it's that bad, we'd better damm well have it quickly before everybody else can do it." We didn't end up with that mood but I think it is not an uncommon attitude and there are even some people saying this in Washington today.

BRUES: Another way of dealing with the frustration is with drugs. I wonder how much of the current drug usage is.....

FREMONT-SMITH: You mean we give drugs to Washington?

BRUES: Perhaps we should. [Laughter]

FREMONT-SMITH: Excuse me, sorry. You mean drugs to protect people?

BRUES: I mean, how much of this business is another reaction to this same frustration?

ROOT: You mean LSD?

BRUES: For instance.

ROOT: Yes. Drugs are one way to deal with frustration. I think so very strongly. You listen to the flower children talk—the bomb is coming and we've got to get out. I know one group that's really setting up a colony in the Amazon. They've got it all figured out that the Southern Hemisphere will get less fallout. Behind this kind of "there is no tomorrow" philosophy is very much the feeling that they have been betrayed, there's nothing they can trust. The only true experience is Now. In that sense we have lost a very serious war in that we are losing an increasing percentage of our youth.

FREMONT-SMITH: That's what I meant by the gap between the adult population and those who don't trust anybody over 30. Most of us are over 30 and so we can't be trusted.

BRUES: The ones over 30 have the other irrational way of dealing with it, which is to have it over with.

FREMONT-SMITH: Yes.

UPTON: Before we get too far away from the Marshall Islanders, I find it really quite intriguing that a population can be dusted, can develop burns, can be moved off their home island, can see their children stunted, can develop thyroid tumors and can accept this philosophically without great emotional upheaval.

FREMONT-SMITH: Have they really understood it?

UPTON: Yes. I would be interested in asking Bob to say a little more about how this situation was explained to them in the beginning.

FREMONT-SMITH: If ever.

UPTON: Do they really understand its implications? Do they worry about a recurrence, for instance? What do they think about it all?

CONARD: Well, it's really hard to know. They have sort of the Oriental viewpoint on things and they are a very phlegmatic type of people. Their reaction to this whole thing has been very calm and collected. They have accepted things as they have arisen. Moving them to another island to live, they took it in their stride. These people move around from island to island very readily anyway. They like to go over to Utirik or some of the islands to see other members of their families that are living there. It's nothing unusual. In the old days they used the outrigger canoes to go by family to the island and now they use the interisland cargo ship, the copra ship. They crowd on the decks of that and camp there.

FREMONT-SMITH: Have there been any anthropological studies made by Orientally-oriented anthropologists who might understand them; a Rorschach test for the Marshallese people?

CONARD: No, sir, not that I know of.

FREMONT-SMITH: I think this is the only way one could get an answer because one doesn't know what has been repressed in this so-called phlegmatic attitude. Our Negroes were also very phlegmatic and something unphlegmatic seems to be coming to the surface now.

CONARD: They certainly don't have any of the headhunting aspects that I had been led to believe existed when I went out there. I haven't seen it.

EISENBUD: I spent quite a while on various of the islands in 1956. This was two years after the event and there were tests in progress then, I guess—the Red Wing exercises. There certainly wasn't any official apprehension on the part of any of the natives. In fact, I think I spent one night on Utirik on an expedition. They were all very friendly and pleasant and somewhat excited by all that was going on.

WARREN: Historically they've had to worry about food and typhoons and drought and invasion by other peoples, not the least of which is the colonizing groups—the Japanese and now the Americans. While they probably have some radios and they hear a lot, they don't really have control over their situation and yet don't want to change it or do anything about it. I'm reminded about the time in our culture when tuberculosis and fatalities from lobar pneumonia were just accepted as being unfortunate. If the old man got kicked by a horse, had a broken leg and laid around and couldn't do the farm work, well, this was part of life. It was just tragic. It wasn't all right, but it was acceptable. We're not in this culture today nor in that frame of mind. We've got miracle drugs and we've been told about all of the advantages and the wonderful life, etc. Our young people don't see it our way. They haven't been raised in a family where members died at inopportune times nor have they lived in a general population which was close to the bare subsistence level.

Also, I think I remarked last time that our people came West with a gun and always had a gun handy and knew something about Indian fighting and predators of various sorts, human and others. We haven't had these experiences recently and a certain amount of self-reliance has now been lost.

FREMONT-SMITH: Do you mean we can't use the Marshallese experience very well to extrapolate what will happen in the Midwest after an atomic war?

WARREN: Bob has just indicated that people adjust, and I think we would adjust to whatever happens. What else is there to do? You've got to eat every day and sleep.

AYRES: It's interesting; there's a difference between our culture and the Oriental. We believe deep down that we can change our surroundings.

WARREN: Yes.

AYRES: In that we do not differ from our ancestors who went West with guns. We still believe we can change the Vietnamese, and that somehow we're going to make democrats out of them. We wouldn't be here if we didn't believe we can have some effect on our own country. But the Marshallese don't believe they can have any influence on their surroundings, and that's probably why they accept things like this. These are just Deus ex machina.

CONARD: As Staff pointed out, these people do show some of the characteristics of stoicism and the rigors of a hard previous life. They never celebrate a birthday, for instance, until a child is one year old because they're so used to them dying before they reach that age. They don't accept them as human beings before that.

WARREN: That would save them some trouble, wouldn't it?

CONARD: And the older people are all set aside. "You're old now. We'll give you some rice or something and you take care of yourself." But they love the children.

MILLER: Isn't there another feature? They are in an isolated place under American control and no one can reach them to inflame them or to pattern their thinking as in Hiroshima.

DUNHAM: People go down there from time to time and try to stir them up but they don't get very far.

CONARD: They got stirred up as far as to institute a suit against the United States Government. They tried to sue the American Government for something like $40 million. There were several lawyers that got into the case and tried to push the thing for them but that fell through.

EISENBUD: They've had several missionaries down there.

UPTON: Do they wonder why you're coming back every year?

CONARD: Yes. For a long time, for the first six or eight years, they were puzzled because we would tell them at the end of the examination, "Well, we find that everything is fine, that you're doing fine." Then they would say, "Well, why do you have to come back and take our blood and examine us again if everything is fine?" This is very difficult to explain to a naive group of people like that. But we did the best we could. We told them that we wanted to be sure that something might not develop. They accepted it gradually and over the years now

I think they look forward to our coming out. We consider them our friends.

UPTON: You speak of mobility. Have a number of them moved away? Have you lost any of the population?

CONARD: They have only moved to islands that are readily accessible to us. The "Paris" of the Marshall Islands is Ebeye, which is an island just next to Kwajalein, where a large number of Marshallese work for the government. We have a big Nike-Zeus testing station there.

AYRES: Relative to what you have been saying in the present conversation so far, of course, nothing serious has happened. They've had these nodules but they are not very obvious. What do you imagine would happen if something fairly visible occurred, let's say a skin cancer or one of these beta burn lesions, and you came out and made quite a fuss about it? Do you anticipate some very serious psychological reactions building up?

CONARD: I think they have the capacity to become emotionally upset about these things. They showed some degree of homesickness, for instance, when they were on the other island they were temporarily living on. Then the word got around, falsely, by the health aide that none of the women were going to be able to have children again, and this caused quite a bit of furor and concern until we were able to reassure them.

FREMONT-SMITH: How did they show this? Just in statements?

CONARD: I got the word indirectly. They didn't come to me with this but I heard that the health aide had told all the women that they were not going to be able to have any more children. Of course, this was a very bad state of affairs and we got all the people together and talked to them and explained that this was not the case.

FREMONT-SMITH: The crew on the destroyer I was on were all sure they were going to be impotent until I explained to them that the one thing they would not be was impotent.

IMPLICATIONS FOR DEFENSE POLICIES

TAYLOR: I would like to point out what I think is a deeply significant difference between a psychological reaction of the Marshall Islanders and people, particularly in the United States, who might become involved in even a limited sort of nuclear war. To the Marshallese apparently this was some kind of fairly important but not overwhelming catastrophe which just suddenly happened. We have conditioned ourselves as a country for twenty years now to a state of mind that says when nuclear war breaks out, all is lost. The whole idea of massive deterrence is built around the idea—it was built around the concept of making the war as bad as possible and therefore avoiding it. I think it's really clear from many things that have happened and many things that haven't happened, that it's our national policy not to accept as a working premise any kind of a nuclear war.

FREMONT-SMITH: That's right.

TAYLOR: Therefore, if it does happen, even in a limited way, it seems to me there's going to be a very deep psychological fact of life that will lead to a reaction to disaster which would be very different from the characteristic human reaction to disaster; that is, to rise to the occasion and do the best that one can. There will be a feeling of hopelessness that we have built up very carefully and thoroughly and almost studiously over many, many years.

AYRES: I could add to that. A lot of civil defense planning is predicated on the assumption that people will cooperate with agencies of the government and with its appointed representatives in an emergency. Yet privately I worry that if a nuclear war occurs, because of this conditioning that you speak of, one possible reaction is a great intensification of the kind of distrust that we've been talking about. "They really did us in this time. Now we can't believe a word they say. Lynch them, hang them from the nearest lamp-post. Don't follow directions. They're just leading us down a garden path."

MILLET: I'm interested in this apparent preoccupation with the anti-missile defense which seems to be one of the things we are struggling with Russia about most of all right now, with the possible exception of Vietnam.

If it is a true assumption that we're going ahead to increase our anti-missile defense potential, it would seem to me that any attempt to make any kind of recommendation would have to be focused around that possibility. This looks as though perhaps the tide might be turning away from this assumption of absolute disaster toward the possibility of some kind of defense and it isn't clear as far as The Times or other public media information states whether the orientation of this defense system is primarily anti-Russian or primarily anti-Chinese.

TAYLOR: Hasn't it been called primarily anti-Chinese by the Secretary of Defense? It seems to me that was fairly definitely said.

MILLET: Yes, it has been said, I think, but.....

TAYLOR: So far as the real reasons for going ahead with that decision are concerned, I think there's one interesting development that hasn't happened yet that will help reveal what was really in some people's minds in making that decision, and that is the decision with respect to fallout shelters.

MILLET: Yes.

TAYLOR: Curiously, in the recent decision to go ahead with the small ABM, whatever one wants to call it, I've seen no mention of any kind about any civil defense measures associated with that decision. It's always been coupled in the past, but this time it was not. The question is why?

MILLET: I was coming to that point in a sense. I was thinking that if we assume that this is going to be the policy, then this would seem like a great opportunity for public works possibilities for putting a lot of people to work to build appropriately distanced shelters to take care of a lot of people.

TAYLOR: The difficulty is that other few billion dollars which have not been mentioned so far as part of this decision to spend $5 billion on this active part of the defense. This would be an unpopular thing to promote.

FREMONT-SMITH: Do we have to consider the fact that we are just prior to election year? The policy is going to be influenced as much by the oncoming election as it is by national security perhaps.

TAYLOR: I'm surprised the fallout shelter issue has not been brought up again.

ROOT: Would this indicate that the distribution of anti-ballistic missiles had been worked out in a way that makes fallout shelter unnecessary?

TAYLOR: I don't see how, because no one, I think, is arguing that any ballistic missile defense system against any threat will be perfect; therefore there will be some leakage. If there really is an attack, there will be some exposures on some U.S. cities. This will simply cut down the number. There's a huge difference in the number of casualties that would result from, let's say, a single explosion; I mean, this works pretty well if there's only one explosion in one city. The difference between the casualties with some kind of a recovery plan and fallout shelters and no such plan is a factor between 10 and 100 in the number of people that would be killed.

FREMONT-SMITH: Do you think it's possible that those who are responsible for making policies are well aware of the fact that the public is not going to respond to the fallout shelter issue; that the whole thing has gone down, and that they just hesitate to propose a plan which is tied to a fallout shelter system? I think it would be very hard to get Congress to vote vigorously for fallout shelters now unless there was a much.....

AYRES: The presumption is that the Defense Department wants ABM?

ROOT: Yes. Given the credibility gap, it seems more like a trial balloon to test public reaction.

DE BOER: If one looks at the development right now, I feel that the United States and Russia, whether they have agreed in principle, both know that in an all-out attack between the two big powers they would destroy each other. Let us consider China or other potential sources and this feeling of security and certainty fades away rather fast. Our Government does consider this a threat since we are planning a defense system. But what worries me is how we will retaliate when provoked by China, or even more sinister, by an unknown source, such as was

pointed out to us by Dr. Taylor yesterday. Will there be mass hysteria if part of New York or San Francisco blows up, and will there be a cry for all-out retaliation? Retaliation in what? What are our plans under these circumstances? How much weaponry shall be used in order to retaliate against China; and if we have these plans, what is eventually coming back to us in terms of fallout?

TAYLOR: On Russia.

DE BOER: Or on ourselves as far as I'm concerned. Do we have any plans of this nature? I don't think we have. I think it's worthy of consideration in terms of an open forum, whether these plans are here officially or not officially.

AYRES: As long as you're speaking of China, a lot of people believe that the Russians are probably building their ABM system because they're worrying about China.

DE BOER: As Dr. Taylor mentioned yesterday, it does not have to be China. There are other sources quite capable. Are we ready to make up our minds as to how to proceed? Also, fallout has to be considered if China attacks Russia alone.

FREMONT-SMITH: And you put this out very effectively. How about if we don't know?

DE BOER: The question is how much of our strength is necessary to subdue the enemy? It is easily done if one knows the threat. Even in the case of Russia, we have enough weapons.

TAYLOR: Not if we don't know who did it. Who do we go and hit? Kill everybody?

DE BCER: We'll have an idea as to where it comes from—from the east or the west.

TAYLOR: All of a sudden a bomb goes off in New York. It went off because somebody put it into the basement of somebody's house.

HEMLER: I say it doesn't have to come in by ICBM to go off.

WARREN: It can come in on a ship in the harbor and go off in the harbor.

TAYLOR: Off a ship in the harbor on to a truck and wherever they want to put it.

DE BOER: Let's think about it now. This is the very point. We may even have to do something about it now.

WARREN: That was the argument.

FREMONT-SMITH: We can't possibly get a record if everybody talks at once, which is natural for us to do under the excitement.

WARREN: I wondered, when this came out, whether this wasn't part of the cold war effort by China, to have us thinking a bit more about the situation (blackmail). They have relatively few weapons and trying it, risking our uncertainties and unwillingness to really retaliate, might very well be the case. Could we stop a couple of them with our defense missiles, which might settle the matter without our getting grievous injury? We might not get involved, but they're not going to send them in clouds for a long time; they haven't got the potential yet.

AYRES: I don't see that they have any such intention. They haven't even attacked Quemoy. Yet, everyone seems to agree that China is a great threat.

TAYLOR: There's no reason that I can see that we are taking any kind of comfort in the notion that they just have two or three. They've already exploded a little stockpile.

ROOT: As far as the unknown threat is concerned, we know which nations have the capability.

TAYLOR: Ninety-six nations at least.

ROOT: Have already tested?

TAYLOR: No, no. Have the capability.

ROOT: But they won't send it over until they have tried it out and we'll know when they test. Anybody with an Atoms for Peace Program has the capability.

TAYLOR: There are 96 countries with an Atoms for Peace Program. That's what I mean.

ROOT: I would not think you could anticipate the delivery of a hydrogen bomb from a country that had not already tested. We know Great Britain is no threat to us. It would be either Russia or China.

TAYLOR: The fission bomb is a different story. That could be delivered by anybody.

ROOT: Yes.

BRUES: I think the timing is another question. It seems to me that, at least in our public statement—I don't know about our inside knowledge—we have consistently underestimated the rate at which the development would be made in other places.

FREMONT-SMITH: Yes, every time.

ROOT: The lag has always been less than we have given them.

FREMONT-SMITH: That's right.

WARREN: You can't tell whether it's a fishing expedition. They may know a good deal more but they made the charge and then see what happens when they get a rebuttal; more information comes from it. The trouble is we've got all kinds of activities at different levels that we do not know about.

FREMONT-SMITH: We don't know perhaps about each other.

UPTON: You mentioned some American personnel on an island nearby there. Are data available on relative degrees of contamination in comparison with the ground level in these groups? I myself am wondering to what extent sheltering was effective under those conditions.

CONARD: Well, they were certainly quite effective from the point of view of the skin contamination and the internal absorption of materials.

UPTON: And the thyroids were not particularly hot?

CONARD: We didn't examine the thyroids from that point of view originally. We didn't suspect that they would have any thyroid accumulations at that point. But the American servicemen definitely had

fewer skin lesions and lower body burdens of radionuclides. However, their gamma exposure was probably more in line with what you would expect from the amount of fallout that occurred on the Island.

UPTON: Let's assume hypothetically that one could have been able to predict that contamination on Rongelap and to send warning to the natives there. In absence of a shelter, could they have done anything under the circumstances?

CONARD: I can't see how they could have done anything to avoid the whole-body gamma exposure.

EISENBUD: They could have gone to sea in their canoes.

CONARD: They don't have enough boats to get the population to sea.

EISENBUD: Even if they stood in the lagoon for several hours, this would help.

DONALDSON: Yes.

DUNHAM: They came back and walked in it and got it on the backs of their feet and got the skin burns. They would have to stay there until they were removed.

EISENBUD: You would cut down the external gamma dose considerably by just going out in those outriggers.

CONARD: What are you going to tell them on the radio, "Everybody go out in the lagoon and stay there?" Or what?

FREMONT-SMITH: Exactly. "Eat fish."

EISENBUD: I don't think you could do it without advance preparation. But to answer Art's question, I think there are things that could be done.

CONARD: You mean with some advance planning.

EISENBUD: Yes.

CONARD: I thought he meant under the circumstances as they existed in the village then. If we had contact with them, is there anything that we could have told them to do to protect themselves. Is that what you mean?

373-782 O - 70 - 12

UPTON: Yes.

WARREN: How long did the white ash fall?

CONARD: About 12 hours.

WARREN: So they couldn't have been standing neck deep in the lagoon for 12 hours.

CONARD: No. They would have had to hold their breath and go under water.

UPTON: Because one may imagine that the best preparations are not likely to be made in the event of such a thing in the future, one may have to improvise in every case.

WARREN: So you have to have the knowledge to know what to improvise for.

FREMONT-SMITH: You would have to have about seven improvisation plans depending on what actually happens.

WARREN: Yes.

UPTON: We know that reactors are going to blow up from time to time. They will be localized events. What does one do in a case like that?

EISENBUD: It's an altogether different problem, Arthur. They don't blow up. This is a misconception.

UPTON: Well, take Wind Scale.

EISENBUD: Wind Scale didn't blow up. You said there was great fatality in the event. I'll let you take literary license with it. What happened was that the lighting failed and the fuel began to burn and it went out over the countryside. That's generally the type of accident you could expect. With the melt-down of fuel and the release of the volatile constituents, unless we are awfully wrong—and I don't see how we could be at this late date—the only exposure would be to the radioiodine.

BUSTAD: Possibly the cesium.

EISENBUD: Yes, and the radioiodine problem would be greatly potentiated in areas where there are crops and forage and dairy cows. This is manageable in a variety of ways. But I don't think the problem is anything like what you would have from a nuclear weapon. I've often thought that the single thing a person could do in a metropolis in the event of an attack, assuming that the weather conditions permit it, would be to get in a small boat—and the smaller the better—and get out in the middle of a lake and just stay there.

DUNHAM: With an umbrella! [Laughter]

EISENBUD: Well, you would get your beta burns in that situation and you could probably take care of that, too. If the Japanese had been on a larger boat they all probably would have died. One thing that saved the Japanese was that it was a small boat and they were not in the middle of an infinite plane. If they were, the dose could have been as much as three times higher.

DONALDSON: It rained a great deal, too.

EISENBUD: If there are not too many other boats there, of course, you might get by.

SPEAR: There are lots of ways in which you can help yourself.

WARREN: As Ralph says, there are lots of ways in which you can help yourself. You can get under a roof that is fairly high and the wooden building would get you some attenuation.

EISENBUD: We're not considering mass evacuations, blast, fire and things like that.

CONARD: I might say another word or two about the treatment aspects. Of course, we know that under the best of hospital conditions we can save a person from two or three times the LD-50 dose, perhaps, by giving him very careful attention with blood transfusions, platelet concentrations (and perhaps white cell concentrations), the use of antibiotics and by maintaining fluid balance, and so forth. But it really takes quite a hospital staff to take care of even one serious radiation casualty. So this sort of thing would be out of the question during the time of nuclear warfare.

I think the best we could hope for is to stock up on the antibiotics and perhaps plasma and have these things located at strategic areas for use.

AYRES: It's also important not to waste them on the worst cases.

CONARD: Yes.

AYRES: How do you manage that? Our normal peacetime philosophy is always to give most attention to the most serious cases.

CONARD: How are you going to get the laymen to decide whether this case is fatal or not without any blood count or any other means?

AYRES: I'm asking.

CONARD: You could go somewhat on the degree of symptoms of nausea and vomiting that occur early. If that is very severe and prolonged, then you could suspect that survival would not be likely.

AYRES: Doesn't it seem reasonable to have simple pamphlets or instructions giving a kind of range of symptons that it's worthwhile using these supplies for?

CONARD: In general, if a person survives two weeks in a fallout shelter and then gets sick, he's a pretty good candidate for antibiotic treatment.

AYRES: In other words, perhaps the first rule would be "Don't use them at all for two weeks."

CONARD: Yes.

DE BOER: I think you are ahead of the game. What you are talking about simply is not there yet. Sure, we can talk about those things around this table, but before we can reach a reasonable consensus of opinion, millions of dollars have to be spent. The points I like to make are: How do we create public interest in these matters without causing mass hysteria? And let me tell you, public interest is a must if we want support. How do we set priorities? The priorities must be not only relevant to biology and medicine, but more important, relevant to our national goals. Is it more important to have better hardware going to the Moon, Venus or Mars, or hardware for a war to be fought in the future, than to have some fundamental knowledge about what to do today in a case of emergency?

DUNHAM; These space programs are still peanuts compared to the Vietnam War. I think your Civil Defense right now is competing like everybody else with the Vietnam War. I think it's as simple as that.

DE BOER: I don't necessarily agree with you on that. The Vietnam War costs us a lot of money, true, and there may even be an argument whether it is a worthwhile cause or not. But we are selling ourselves short if we let the Vietnam conflict be the reason that stands in our way of making progress which eventually may save our skins. The entire expenditure of the DOD cannot be laid on the doorsteps of the Vietnam conflict. For a true cost of that conflict, one would need an economic analyst. The facts are: (1) We are in Vietnam; (2) We need to know more about how to defend ourselves when attacked with nuclear weapons; (3) We do not have a sound and well-thought-out priority system—a defense system based on the best this country has to offer. Indeed, we argue, we compete and work hard, but not on the real issues.

FREMONT-SMITH: Supposing that the Vietnam War was stopped tomorrow, is there any likelihood—and I think it's highly unlikely—that the money which is now being used for the Vietnam War would be used for Civil Defense? I don't think it would be at all. I think it would be used for a variety of other useful things, but I think it would take a tremendous something, a change in attitude, to get any significant use of money for Civil Defense, whether there's a Vietnam War or not.

TAYLOR: I think that change is taking place and this is independent of whether the end of the Vietnam War comes, and the change is simply a transition from a state in which we are able to rely on stable deterrents to a new world in which we can't.

FREMONT-SMITH: In which there are no deterrents that we can rely on.

TAYLOR: There's beginning to be a sort of awakening in this country.

FREMONT-SMITH: Have you seen some signs of this?

TAYLOR: Yes, by all means. More and more people are concerned about criminals using nuclear explosives for all kinds of uses in which it is not necessary for them to identify themselves to serve their purposes. The material is becoming much more available. The combination of these things is making it much more rational to imagine some kind of even very limited use of nuclear explosives for violent purposes. As soon as that begins to be a really understood threat.....

FREMONT-SMITH: Since it's been used once.

TAYLOR:.....then the whole situation will change. I think that will happen certainly within two years.

ROOT: I remember after the release of the Bravo information there was a great fear that nuclear weapons might be brought in secretly. A lot of regulations were passed for tightened inspection. The FBI issued directives about examining all luggage coming into the country and they gave specifications; a gun bore so many inches across was the tip-off. I haven't heard anything about them since.

TAYLOR: I don't think they are enforced. I've gone to some pains to try to imagine how, on this last trip, I would have brought in 6 kilograms of plutonium. What people forget is that the important part is plutonium and U^{235}, as far as what's not generally available is concerned. Depending on what it is that one is trying to put together, requirements can range from material that is available down the street to material which is very difficult to design, and there's everything in between.

WARREN: May I go back to one thing we just touched lightly on, and that is this problem of the triage. A person gets bad burns and lethal rads yet he won't die for a week, and so on. We had a big push in Civil Defense and in the Atomic Energy Commission for dosimeters. I can remember a very serious conference on this in which people began to really face the situation and it was agreed that you couldn't do this. After that there was a general let down on these dosimeters all around. There are good ones; there are stable ones.

FREMONT-SMITH: It would be too disturbing for people to know about that or for anybody else to know that they were already dead.

WARREN: That's right. This psychological factor is something that you have to deal with.

FREMONT-SMITH: It's somewhat the same thing if you are in a shelter and your neighbors come and want to get in and there isn't room for them, which ones do you shoot? I mean only the ones that are over 65?

WARREN: Yes. It would be a good idea to re-examine the situation.

EISENBUD: One of the things that bothers me, having lived through this almost as long as you—I guess Stafford Warren has got two more years than I have, and after 25 years that doesn't seem important because these were exciting years—but I got into this field when we were thinking of one or two bombs, air-delivered because you had to consider their effect on blast, and so forth. That was 1945, when we were talking about 20 kilotons delivered by a propeller aircraft. In 1955 we were already talking about 20 megaton bombs delivered by jet aircraft. By 1965 the ICBM systems on both sides were pretty well dispersed, presumably by the hundreds, maybe by the thousands; I don't know. Now we're talking about 1975 when we expect to have an anti-missile system employed, and the impressive thing about this is that the technology has gotten to the point where you can even think of knocking a missile out of the air on about 10 minutes' notice or whatever it is. It may be less, and if the technology is that advanced, then what are the delivery systems going to be like? If the defense system has advanced to this point, what are the delivery systems going to be like in 1975 when we see what has happened in the last 20 years?

ROOT: Probably they'll all be obsolete. We'll be using lasers.