ATOMS FOR PEACE + 50
Nuclear Energy & Science for the 21st Century

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Afternoon Keynote Address
Nuclear Science: Implications for Medicine

DR. ROBERT L. PFALTZGRAFF, JR.: It is very seldom in the annals of conference development and participation that things run on time and we have established, indeed, a precedent by having something begin ahead of time because I thought that it would be better to allow ourselves some extra time for one of the most important topics that we have on our agenda and that is nuclear medicine. We have talked this morning about Atoms for Peace. We have coined the term Atoms for Prosperity. And as Dr. Wagner said to me just a few moments ago, perhaps we ought to add to the perhaps yet another term, which is Atoms for Health.

It seems to me that Atoms for Health would be the appropriate title, if not subtitle of what Dr. Wagner will be talking to us about this afternoon. I would like to make just a few comments about our speaker and to say that he was present at the origins of nuclear medicine as a defined sector of medicine. In other words he was, as Dean Acheson put it in one of his books in his memoirs, present at the creation. Dr. Wagner has sustained the momentum of discovery that began in the 1950s and continued to the present day, certainly continued into the sixties and then into the 21st century.

He has promoted nuclear medicine at key U.S. teaching and research centers not only here but also elsewhere in the world, centers in the United States but also elsewhere in the world. And then, of course, at his own Johns Hopkins School Medicine, where for many, many years, he was professor and told me that he is now working what he called ‘24/7’. And I said, “Well”-- And he said, “Do you know what that means?” And I said, “ I thought I did.” And he said, “That means 24 hours/WEEK, seven months a year.” So we’ve had quite a spirited conversation at lunch here and I thought I would really want to share him with you more than with myself at this time.

As measured by the extent of his personal influence, Dr. Wagner has had an enormous impact on the field of nuclear medicine. He has been, for 40 years, in charge of the University nuclear medicine program at Johns Hopkins and he has, in that program, trained many, many nuclear medicine physicians and physicists and pharmacists and technologists and so many other specialists in the medical field who are now practicing around the world beginning in the 1960s and continuing. His influence continues and will continue for many, many years to come.

So I would like at this point to introduce Dr. Wagner as one of the founders and pioneers of this very important area, nuclear medicine, that came out of Atoms for Peace and we now have something that we can add to our lexicon called Atoms for Health. So, Dr. Wagner, welcome to this conference.

[applause]

DR. HENRY N. WAGNER, JR.: Thank you, Dr. Pfaltzgraff. Colleagues and friends, once someone introduced my by saying, “We frequently have speakers who need no introduction. Unfortunately this is not one of those times.” Another time, in fact fairly recently, someone introduced my by saying that, “Henry Wagner used to date Marie Curie,” (Laughter), which is not true.

What you’ve heard this morning is a clear example of how important it is to have political leaders become involved in what science produces in terms of technology and ideas. And on December 8, 1953, science and politics met when Dwight Eisenhower made his famous “Atoms for Peace” speech. He said: “The governments principally involved, should now begin to make joint contributions from their stockpiles of uranium and fissionable materials to an international atomic energy agency.”

“We would expect that such an agency would be set up under the aegis of the United Nations.” And the IEA was established, was opened, six years later and since that time has played a major role in nuclear medicine worldwide. As I’ll show you in a minute, nuclear medicine technology had been developed and expanded before World War II with the work of Ernest Lawrence and John Lawrence in Berkeley and then, after World War II with the invention of the nuclear reactor.

In June of 1946, the first shipment of Carbon 14 tracer was sent to the Bernard Skin and Cancer Hospital in St. Louis. And, as you all know, Carbon 14, P-32 and tritium are the foundations of biochemistry. It was this talk, the “Atoms for Peace” talk that translated the scientific applications of these radioactive tracers to human health studies. Dag Hammarskjold, the late Dag Hammarskjold, Secretary General of the United Nations said that, “Only he who keeps his eye fixed on the far horizon, will find his right road.”

Now, what was the road that lay ahead 50 years ago? Science is made by scientists. And earlier that year, Dr. Jeff Holter, who had returned home from Montana from the atomic bomb tests at Bikini, held a meeting at the Hotel Davenport in Spokane others and with 11 others decided to create a new medical society based on the use of radioactive tracers. Thus, this year, is also the

50th anniversary of the forming of The Society for Nuclear Medicine. The first public meeting was held on Saturday, May 29th, at the Benjamin Franklin Hotel in Seattle, Washington.

What lay ahead and what have we accomplished over half a century? A term that is being widely today is molecular nuclear medicine. Medicine is moving from an orientation primarily toward organs and cells, to molecules. In other words, chemistry, together with physics, is dominating molecular nuclear medicine today. Using the photons coming from inside the body to outside detectors, we can relate regional molecular processes to disease, from organs to cells to molecules.

Thermodynamics is another very important area where the application of radioisotope technology is being applied more and more in biomedical research and clinical medicine. It assesses the regional energy supply of organs and lesions. Kinetics is an important part of nuclear medicine. We routinely carry out studies in three dimensions in space and one dimension in time, measuring the rates of regional molecular processes. These regional molecular processes are used to develop new definitions of diseases. Another area of nuclear medicine is concerned with information transfer, that is, communication among molecules and cells.

We know now that molecules are continually circulating through the body where they bump into receptor sites, stick there and bring about a biological process. In addition to the founding of the Society of Nuclear Medicine in the U.S. the year 1953 was when the structure of DNA was published in Nature by James Watson, who at the time was 25 years old, and Francis Crick, who was 35 years old. They published their classic article on May 30, 1953 and pointed out the genetic implications of the elucidation of the structure of DNA. Subsequently, the Department of Energy played a major role in the human genome project. Nuclear medicine and the human genome projects are now coming together more and more to their mutual benefit.

On September 19, 1983 in a talk I gave at Oak Ridge, I said, “The field of nuclear medicine has been and will continue to be dependent on the Department of Energy. No force in the country or in the world has done more to develop nuclear medicine than the DOE.” Many immediately think of the National Institutes of Health when you think about government involvement in biomedical science in the United States. It is the combination of the orientation of the national laboratories and the research that is sponsored by the DOE that makes it possible for much of the research that goes on at the National Institutes of Health. I look at the NIH and the Department of Energy as two hands that will together help advance the use of radioactive tracers, that is, nuclear medicine technology in biomedical science and in clinical medicine.

Here are some examples of projects that the AEC/DOE has supported and have spread into modern clinical medicine. At that meeting in 1954 of the Society of Nuclear medicine, the invention of the rectilinear scanner by Benedict Cassen from UCLA was presented. This was a motor driven radiation detector that moves back and forth across the body detecting the photons being emitted and producing images such as the distribution of radioactive iodine within the thyroid gland.

Although the technology has improved enormously, the basic principles of nuclear imaging to examine regional biochemistry in the living human body and in experimental animals have remained the same. When I first entered the field of nuclear medicine, in the late 1950s, we injected patients with Iodine 131, which accumulated in the thyroid gland, and used a Geiger-Mueller tube positioned at the various points over the patient's neck to record the accumulated radioactivity. .

The regional counts were used to produce what we called iso-count lines. For example, a mass in the neck could be identifies as a thyroid tumor. The fact that it was not accumulating radioactive iodine meant that it was undifferentiated, that is, it was a primitive type of cell, probably a tumor. This was an early example of what we still do for all organs of the body, that is, use the photons emitted from injected radiopharmaceuticals to study bio-molecular processes. .

At Johns Hopkins in 1958, we build a modification of the Cassen rectilinear scanner, which moved a radiation back and forth over the patient's body. Today we do not use moving radiation detectors, and routinely combine the regional biochemical information with anatomic information from a computed tomography (CT) instrument..

As long ago as 1961, we combined the nuclear medicine images of regional chemistry and function with x-rays on which the nuclear medicine images were superimposed. Thus, even then, clinical decisions were based on the combining of anatomical and biochemical images. .

The 1940s and 1950s marked the birth of regional biochemistry in clinical medicine to examine various organs of the living human body and experimental animals. For example, on May 26, 1946 Hertz and Roberts at MIT showed that radioactive iodine could be used in the study of thyroid physiology and define deseases of increased or decreased function of the thyroid, based on measurement of the metabolic activity of the gland. A regional biochemical process defined the disease. If the thyroid was hyperactive, the patient is given a higher dose of the radioactive iodine to diminish its abnormally increased function. The same paradigm is used today and is expanding into many organs and lesions of the body.

The same agents used to identify regional chemical processes can be used in higher radiation doses for treatment. In December 7, 1947, a publication by Seidlin and his colleagues in New York cause a tremendous interest on the part of the press, when they described the use of radioactive iodine treatment in treating functional metastases of carcinoma of the thyroid.

The field of nuclear medicine is based on the "tracer principle", invented by Georg Hevesy, to whom the Nobel Prize was awarded in 1943. His Nobel lecture was entitled, "Some Application of Isotopic Indicators." Rosalyn Yalow was awarded the Nobel Prize in 1977 for developing the technique of radioimmunoassay, which made possible detection of molecules present in the blood in extremely low concentrations.

Yalow shared the Nobel Prize with Schally and Guillemin who discovered a hormone called somatostatin, an example of a chemical messenger involved in bioenergetics or information transfer. Also in the 1970's we saw the introduction of minicomputers into nuclear medicine, to improve and quantify the data from nuclear imaging of the body. Today's biochemical and anatomical imaging would be impossible without the invention of computers.
One of the major fields to benefit from nuclear medicine is pharmacology. As early as the

1960's, imaging of the blood flow to regions of the lung was used to examine the effectiveness of a drug called, Urokinase, that dissolved blood clots in the lung, a disease that is often fatal. A series of lung scans showing the distribution of blood flow to the lung was examined to provide objective evidence of whether the drug was or was not effective.

An example today is in the assessment of drugs for the treatment of Alzheimer's disease. In addition to assessing the symptomatic or psychological testing of the patient's response to the candidate drug therapy, it is of great value to have an objective, quantifiable, regional biochemical signal.
The 1970s saw the birth of nuclear cardiology, which today has become a routine, dominant part of cardiology, another achievement that can be traced back to the "Atoms for Peace" talk by President Eisenhower. The field is based on an invention by Hal Anger working at UC Berkeley, work sponsored by the DOE . His first scintillation camera was shown at the 1958 of the Society of Nuclear Medicine. It measured the photons coming from the body by means of a large stationary scintillation camera . He replaced the Cassen type of scanner in which a detector moved back and forth over the regions of interest, with a large detector that could measure the radioactivity coming from large areas of the body simultaneously. This made possible introduction of a time domain into the examination of the spatial distribution of the tracer.

Technetium-99m, introduced by the Brookhaven National Laboratory, provided the large numbers of photons needed to produce interpretable images of radioactive tracers in the heart. Its physical properties made possible administration of large doses safely to the patients. In 1960, the cover of the catalogue of the Brookhaven National Laboratory advertised technetium-99m generators, at a time when nobody had any idea what it would be used for. Only three years later, Paul Harper, at the University of Chicago, realized that the physical characteristics of technetium-99m were perfect for nuclear imaging. It was metastable, that is, it did not emit particles in the process of radioactive decay, which meant the radiation dose was very low. It emitted photons of the right energy range so that the information could get from the inside to the outside of the body. The combination of the Anger camera and technetium-99m from the National Laboratories made possible the development of nuclear cardiology.

One can obtain images of a radioactive tracer moving into the right side of the heart, then into the lungs, and then into the left side of the heart, and obtain quantitative time/activity curves as the tracer passes from the lungs into the blood vessels. If the patient has an abnormal connection or a shunt between the right and the left ventricle, characteristic time/activity curves are obtained. Today, positron-emitting photons, such as fluorine-18 deoxyglucose, oxygen-15, and nitrogen-13 ammonia are widely used in clinical cardiology and research. For example, one can examine the effect of gene therapy of coronary artery disease in experimental animals in an effort to improve the circulation. Here you can see the combined image at the bottom.

In addition to cardiology, an important use of nuclear medicine techniques today is in the study of the brain. Again, the early studies go back 50 years, when George Moore of the University of Minnesota, using a Geiger-Mueller tube in the operating room to locate deep-seated brain tumors that could not be seen visually. .

Today, throughout the world, hand-held imaging detectors are used during operations to identify cancerous tissue from non-cancerous tissue. In the brain, as in other organs, the fusing of biochemical (molecular) imaging with structural imaging also goes back to the 1960s. The rectilinear scans of the brain of a patient with a brain tumor were superimposed over an X-Ray of the skull obtained at the same time.
Another example of the use of nuclear medicine in therapeutic drug design and development is I patients with Alzheimer's disease. Nuclear imaging is used to make accurate diagnoses prior to treatment, and then is used to assess the effectiveness of treatment in serial studies. Recently, at UCLA and the University of Pennsylvania, radiotracers are being developed that accumulate in the pathological lesions believed to cause Alzheimer's disease.

On May 25, , of 1983, we were able to carry out the first imaging of a neuroreceptor in the brain of a living human being. Neuroreceptors are involved in the transfer of information from one neuron to another. We were subsequently able to show that the dopamine receptor decreased markedly with age in normal persons, and that so-called pre-synaptic receptors, called "transporters", were characteristic of Parkinson's Disease. One could objectively differentiate normal persons from patients with various types of Parkinson's disease.

Another major domain of nuclear medicine is oncology, based largely on the findings with positron emission tomography (PET) and an analogue of sugar, fluorine-18 deoxyglucose. Again, returning to 1953, the American Cancer Society wrote, "The number of cancer patients who would have been cured last year could have been doubled by early diagnosis and prompt treatment." In the early stages most cancer cause no symptoms. Today, cancer is being detected before symptoms occur, often in persons identified as being at high risk of developing cancer.

Clinical examination, anatomical imaging, and histopathology play a major role in medicine today, histopathology can only examine small samples of tissue, tha must be removed by biopsy or surgery. Molecular images with techniques, such as PET, and examine the entire human body, examining a variety of molecular processes For example, in patients suspected of cancer one can detect the increased utilization of sugar by the tumors throughout the body; then, one can examine the degree of oxygen-supply to the tumors, or their rate of cell division. All this information can be translated in improved treatment, and monitoring of its effectiveness.

What about the 1990s and the future? One challenge is to increase productivity. Today it rakes about an hour for a PET study. Many are trying to reduce the examination time to 10 minutes.

Persons are now being identified as being at high risk of developing cancer. Approaches now being developed are to screen millions of persons, identify those at special risk, and then, together with tumor markers, examine those persons who are at very high risk with PET scans so that the foci of disease can be identified at a very early, treatable phase. The goal is to move more earlier and earlier into the diagnostic process.

Nuclear medicine, so very much affected by President Eisenhower's "Atoms For Peace" has reached the prominence and importance in biomedicine that it has today is based on the collaboration between government, academia and the community hospitals, using chemistry and cyclotrons as well as reactors to produce radioactive tracers today, and fluorescent tracers tomorrow. Whole body molecular and structural imaging are now part of the health care systems throughout the world.

Another child of the DOE is the human genome program, which provides maps, or the ingredients, if you like, indicating a high risk of present or future disease in an individual. Radiotracers help identify the phenotypic expression of these genetic maps. Nuclear medicine, particularly what is now called molecular nuclear medicine, provides incisive, in vivo chemistry and physiology. It rests on an infrastructure of physics and chemistry, and is an effective partner with genetics and pharmacology.

Nuclear medicine provides molecular markers for gene hunts. Instead of using symptoms, such as forgetfulness of impaired movement, one can use molecular markers in genetic studies. We can identify asymptomatic persons at high risk for subsequent disease, such as breast cancer. We can monitor the effectiveness of gene therapy, with reporter genes, that can be administered with therapeutic genes to be able tell whether the therapeutic gene has been successfully transfected.

Nuclear medicine connects genes, proteins and disease processes, for example, the sickle cell gene that results in an abnormal hemoglobin, which results in an abnormal destruction of red blood cells. It can target therapy. The studies that we started in 1983 of dopamine, serotonin and other receptors, and transporters, provide targets for drug therapy. If the physician is going to treat the patient with chemicals, he or she should characterize the disease as an abnormal chemical processes. .

The trunk of the tree of molecular nuclear medicine, regional physiology and regional biochemistry, based on technology and ideas that began with Dwight Eisenhower's "Atoms for Peace" talk. The branches extend out into other medical specialties, including cardiology, neurosciences, and more recently to oncology.

The challenges. There are hundreds of potentially useful radioactive tracers that have been shown in experimental animals to be very, very useful. Yet it still takes between five and ten years to get an diagnostic, let alone a therapeutic, agent through regulatory agencies, and, subsequently, approval by insurance.
An economic problem is that diagnostic agents do not provide the economic benefit for the pharmaceutical industries that therapeutic agents have. This results in their being hesitant to make the investment needed to meet the requirements of FDA and Medicare. We need to try to simplify regulatory requirements for the approval of diagnostic radiotracers. To validate and show the safety of a procedure that is only given to a patient only once or twice, should be simpler than what is needed for a therapeutic drug that is going to be taken for the rest of the patient's life. The challenges are to continue to support the basic and clinical research with collaborative efforts, particularly between the DOE and the NIH. And finally, to form teams in government labs, academia, and industry, working together to solve problems. Thank you very much.

[applause]

PFALTZGRAFF: Well, we now have an opportunity for some questions for Dr. Wagner. We have a few more minutes. Who would like to open the discussion? This is your opportunity to get free medical advice as well so you might want to think of it that way, too. So who would like to be the first? Right over here, yes. And wait-- Excuse me, over here, because there is the microphone for you and then the second will be here.

TOM: I'm Tom, ten-forty(?) National Council on Radiation Protection-- Dr. Wagner I think it's been recognized for a number of years that one of the problems in nuclear medicine is the lack of availability domestically of many of the isotopes that are needed and especially research isotopes, not just moly-99 that we get from Canada and Europe. Could you comment on this problem and perhaps discuss some paths forward in terms of improving the national program?

WAGNER: The first point to make is that the two areas in which tracers are used are the positron tracers such as flourid-18 dioxyglucose, which is produced by a cyclotron and the cyclotrons are usually located locally. But to decrease the complexity and cost it's very helpful if these can be translated into single photon emitting tracers that have a longer half-life. An example of the latter is Iodine 123. Iodine 123 has a 14-hour half-life so it can be shipped to distant sites.

I mentioned earlier that there is a hesitancy on the part of industry to put in to get these agents approved frequently because the profit from the use of these agents is much less than from therapeutic agents. And so that's why you really have to have continual participation of government support in getting these things started. As you mentioned earlier, most of the tracers come from Nordian(?), which is in Canada and they are really are no really good producers of these longer lived single photon agents in the United States.

So I think this not only limits research but it also limits clinical applications, too. I think the DOE has played an important role and I think those of us who work in the nuclear medicine field have got to continually try to get the DOE to focus to some degree on the biological and medical applications as well as the areas that you heard about such as nuclear energy or non-proliferation. So I think it requires the continued activities of both the NIH and the DOE and I think now the NIH fully recognizes the importance of the tracers. So I think that efforts that you're carrying out to get the support of both the DOE and National Laboratories in association of the pharmaceutical industry working together.

PFALTZGRAFF: I think we have another question from over here. Wait for the microphone. And then, please identify yourself as well.

BEN: Ben ...(inaudible) from Los Alamos. Do you see any future for neutron boron therapy?

WAGNER: The question is about neutron boron, neutron capture therapy, which for those of you who are not familiar with it, it's using boron, non-radioactive boron as a tracer being attached to a particular chemical that has the desired chemical properties and then activating the boron with neutrons. I think it's conceivable that the advances that are being made in chemistry, that is, in the development of improved tracer development technology, biochemistry, organic chemistry, it's conceivable that boron neutron capture therapy might, let's just say, have a renaissance because of the improved chemistry. But at the present time I think it's got a lot of hurdles to overcome.

PFALTZGRAFF: Can we take another question from over here perhaps? Or who else would like to intervene at this time with a question? Yes, over here?

WALTER: Alan Walter, Pacific Northwest National Lab. You indicated, Dr. Wagner, that a lot of the previous work has been on diagnostics and now there is more attention on therapeutics. I think you mentioned indirectly itreum-90 on non-Hodgkin's lymphoma and what not. Could you comment a bit on what you see for the future of alpha-emitters both from the stand-- Is there a cart, a chicken and egg. Do we have to have the source in order to underwrite the clinical work that needs to be done? But it seems to have potential. Could you comment on that?

WAGNER: The desirability of the radiation effect varies with the particular type of cancer. If you want to have a very short range you can use an alpha-emitter or Iodine 125 or something like that. So you really have to look at the range that you want to irradiate, that you want to kill the cells over a certain range. It is what is called a cross-talk effect, where the tracer's in one cell but you want it to irradiate a larger area. So there's room for all of these tracers. The tracers are widely available. The nuclides are clearly not available in terms that you could buy them but I mean from a scientific standpoint they exist and people have carried out studies.

So I do see a role for alpha-emitters, absolutely, particularly if you're interested in affecting the DNA or RNA where you don't really want to get it outside of the particular cell. So there is a role for all of these different types of emitters depending on the range that you want to irradiate. Now to make it crystal clear, the reason that this is different from external radiation therapy is that you're using chemistry to get the tracer where you want it to go. It is not like external radiation, to make sure that that's clear.

This area I think-- It's called radionuclide therapy is a major area of advance. At the present time, the drug that you mentioned, the itreum-90 tracer is used in patients with non-Hodgkin's lymphoma, which is a very common type of disease, type of cancer. It is used where the non-radioactive type of compound has not been successful or it's been successful for a certain period of time, but then the disease recurs. So at the present time, when that fails, itreum-90 is added to the molecule, which damages the cells and has another affect on the patient's tumor.

PFALTZGRAFF: We have time for one of two more. Yes, please.

GERKY: Bob Gerky from the Idaho National Engineering Environmental Laboratory. Alan asked the question about alpha emitters. I have not heard much about X-Ray emitters from radioisotopes that are very low in energy, can be anywhere from 6 kilovolts up to whatever, you know, 70 kilovolts. Is there an application for such low energy X-Ray emitters?

WAGNER: A lot of work has been done and is being done at Harvard by James Adelstein and his colleague Dr. Cacese(?) on using I-125 and acetane. There is definitely is a role for doing that. I-125, which is very low energy photon emitter, was compared with I-131 decades ago and it was found that I-125 was, in that particular disease was not as good as I-131, presumably because you wanted to have this cross-talk affect. In other words, the range was too short. But there are certain diseases and they are being identified and characterized by the Harvard group where--

Look up James Adelstein, A-d-e-l-s-t-e-I-n, and you'll see a whole bunch of work on X-Ray emitters ...(inaudible) nuclides.

PFALTZGRAFF: Another question, perhaps from over here. All of the questions are coming from this side, isn't there anyone here who would like to ask a question?

WAGNER: Can I mention one thing that I forgot to mention?

PFALTZGRAFF: Please.

WAGNER: I think it is very, very important and that is one of the things that came out of the sessions this morning is the need for education and I think that most people today really do know what nuclear medicine is and they know that it involves radiation. And I think that familiarizing the nuclear medicine community with the problems of educating the patients in these other areas such as in nuclear energy is a very important source of an educational process, better than ads.

I mean people-- In my experience, patients have not really hesitated to have any kind of diagnostic study based on a radioactive tracer technique because they accept the fact that if it is really personally benefiting to them, they are willing to learn about it and do it. So I think that the educational benefit of nuclear medicine should be recognized as a means of familiarizing human beings about radiation and its usefulness.

We have had to face the fear. We have had to face the fear that you in nuclear energy have had to face but it's a lesser problem for us because it's an immediate benefit to them. It is not as if somebody out there is irradiating their neighborhood. But on the other hand, they could be-- You could get them-- There are at least seven thousand nuclear medicine physicians in the United States alone and I think to have them be involved in education of the public about radiation is a very important role for nuclear medicine and why there should be this Atoms for Health and Education as well as Atoms for Prosperity and Atoms for Peace.

__: Dr. Wagner, in one bios that I was reading about you, you said the following, this was a quote attributed to you, "Nuclear medicine is a primary specialty field whose increasing obvious worth would lead many bright young people into the field." I wonder if you could tell us something about what percentage of young people going into the field of medicine are going into nuclear medicine and what impact you think they will have in the years ahead. How is that shaking out (simultaneous conversations)

WAGNER: Nuclear medicine has always been, in the past, in the distant past, it has always been somewhat of a Cinderella to radiology because the images were definitely not as appealing as X-Ray images. But now a very important thing has happened and that is the, because of the success of techniques, such as positron tomography and other techniques, the radiology community, organized radiology if you like, now recognizes the value of nuclear medicine and they are getting involved in it all the time.

So bright young people are being very attracted to this field of radiology which includes nuclear medicine, not restricted to radiology but it now includes radiology. And among the most popular fields for physicians particularly are fields such as ophthalmology, radiology and less popular fields, unfortunately are internal medicine and pediatrics, which requires a lot of interpersonal contact. So it is too technologically oriented but it does attract-- The advances in the technology are so great that young people have become very interested in the field.

PFALTZGRAFF: We have time for one or two more questions. Yes, please, from over here.

DOWNEY: Jim Downey. Harvard University and I just want to ask a follow-up on that, the growth of jobs because this morning there was some question about the nuclear industry in general and not necessarily people going in as doctors but what about a nuclear engineer or perhaps an undergraduate physics major that might want to pursue the field. Do you see growth in the discipline that would support that?

WAGNER: There is a big shortage. It is somewhat different in the fact-- Nuclear engineers have a problem in that nuclear energy facilities are not being developed very much. There is a big shortage today in chemists that are involved in this technique. And the DOE and others that this is a very good opportunity for chemists and, in fact, some chemistry departments, not enough, unfortunately-- Chemistry departments in universities are getting more and more interested in this, too.

So the opportunities are tremendous and it’s really primarily a recruitment and an educational problem. There’s a big shortage of nuclear physicists in nuclear medicine and nuclear chemists, of people but not positions.

PFALTZGRAFF: One or two more questions before we move on. Who would like to be next? This is your opportunity.

WAGNER: If you have other-- My email address is hwagner@jhsph.edu which stands for Johns Hopkins School of Public Health, dot edu and I would be glad to answer any other questions that you have.

PFALTZGRAFF: You may be sorry that you gave that out now, but there it is. Are there any more questions? Well, if not I would like on our collective behalf to express thanks to you Dr. Wagner for being with us. And I can only say that having listened to you for the last hour or so, I can readily see why nuclear medicine would be a very popular field for medical students at Johns Hopkins Medical School. So I really commend you for all that you have done in this very important arena and for bringing so much to us in such a short time this afternoon. Thank you again, very much for being with us.

[applause]

END OF AFTERNOON ADDRESS