OF SNARKS AND QUARKS AND MEDICAL ULTRASOUND

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ABSTRACT

In which the speaker recounts some of the early history of the Bioacoustics Research Laboratory.

Mr. President, members of the Institute, and guests.

It is with a great deal of pleasure and humbleness that I accepted the invitation to come before you to discuss the beginning and early events of our Laboratory. And there are two reasons for my feeling this way.

Firstly, I am a native of Kansas City, MO. I was born, raised, and educated beyond high school here. I left to participate in the events of World War II and, when it was over, I went to the University of Illinois to do my undergraduate and graduate studies, and to begin a career. I well remember this structure, the Municipal Auditorium, when we, for example, had many Boy Scout activies here and often our high school indoor competitive althletic events, and the like, were also held here. In fact, wrongly or not, I remember this as the premier cultural center of Kansas City. While I have returned numerous times, during these nearly 40 years, to visit my family who, continue to reside in the Kansas City area, this is the first occasion that I have had to be in Kansas City for professional purposes.

Secondly, the late William J. Fry was my graduate thesis advisor, my most esteemed professional colleague, and a very close personal friend. We shared not only interests of biological

and medical ultrasound but also interests in modern literature and modern art.

Bill, as he was known with affection by colleagues and friends alike, was studying physics at Penn State University when World War II broke out and he soon found himself during the war years at the Naval Research Laboratory in Washington, DC developing principles for SONAR system design and development. You will recall that the French physicist Langevin had experimented with ultrasound as a means of detecting submarines when they appeared in World War I, but none had ever been detected during hostilities prior to World War II. Thus, as instruments designed between the wars were found lacking in many respects, the creation of more adequate design principles and useful instruments was crucial. Bill co-authored a book on these topics during this period that may still be referred to for analysis, etc.

Immediately after the war, many such as Bill, who were part of the scientific and engineering war effort, found themselves in the position of wanting to conduct research activities of their own choosing in the freer university atmosphere. Universty faculties and facilities were expanding rather rapidly at that time due to the fact that much stagnation in growth had occurred during the depression and war years and because returning

military service personnel were flocking to campuses for higher education. At the University of Illinois, William L. Everitt, an already renowned communications engineer, was in the process of building up the Electrical Engineering Department and he had induced Lloyd DeVore, who had been a professor of theoretical physics at Penn State, and Bill Fry's teacher, and who had spent the war years at Wright Field in Ohio directing electronics research projects, to become a member of the EE Department and to promote and develope a research program. It must be understood that prior to World War II, research was not an important undertaking of EE faculty members. If they conducted any scholarly activities at all, it was in the form of consulting. Lloyd DeVore knew Bill Fry to be an unusually clever, independent, and ingenious solver of theoretical physics problems, as they were treated in graduate course work. Bill came to the University of Illinois in late 1946 and immediately endeared himself to many of the old-time, nonresearch oriented, EE faculty by removing, for trash disposal, their numerous cherished World War I electrical instruments in order to make room for the only space that could be found for him which was in a tunnel under the then EE building (later to become the EERL).

Bill Fry wanted to study the central nervous

system with sufficient comprehensiveness to begin to understand intimate details of structure and function. The methods employed up that time had been rather crude, requiring invasion of the brain tissues by physically rigid electrodes and the consequent production of unreasonably large lesions. Such methods were employed with the hope of identifying those structures which might involve particular types of neural activity. Bill had invisioned that ultrasound, which he knew could be focused to very small volumes would comprise a vastly superior tool, by providing for noninvasive alteration of brain tissues. He set out to deal with two related topics: firstly, to develop ultrasonic surgical procedures for affecting the mammalian brain, both reversibly and irreversibly, which would provide for animal experiments and clinical surgical procedures and secondly, to study the detailed neuroanatomy of the mammailian central nervous system, if you will, to determine a complete "circuit diagram" of the neural components. The first of these was accomplished with extreme success and by the late 1950s had been well demonstrated in animal experiments and was being utilized in medical practice in a cooperative program at the University of Iowa. Numerous patients were treated for hyperkinetic and dystonic disorders, including Parkinson's Diease and

intractable pain. The procedures, though extremely complex, were successful and Time Magazine discussed these in the December 2, 1957 issue.

The project dealing with determination of the "wiring" diagram of the central nervous system also achieved significant success, though because of the enormous complexity of the media being studied, and many attending difficulties, only details of small sections of the cat brain were achieved. Nevertheless the methodology was well demonstrated.

Throughout the approximately 20 year period from the mid-40s to the mid-60s, and in order to reach these goals, instruments were invented and developed for generating, detecting, and measuring ultrasound; crucial details regarding how ultrasound propagates in biological media were discovered; the propagation properties important for diagnostic, as well as therapeutic and surgical ultrasound, such as speed of sound, absorption, attenuation, scattering, and impedance, were determined; the physical mechanisms of interaction of ultrasound was studied in some detail and phenomenological theories were developed; toxicity and dosimetry were treated in some detail; and nonlinear acoustic properties were begun to be studied. Measuring methods and as well as instruments were invented and developed to their full usable potential that are still employed

throughout the world. Technicians were trained, graduate students were educated, and approximately 100 papers were published in high level peer-reviewed journals describing all of these scientific and technological developments

Additional research topics were also undertaken. The 1957 meeting of the AIUM was held in Los Angeles, probably in early September, and we drove there and returned with Dr. Oka, of Osaka, who spent about a month learning our neurosonic surgery methodologies.

During the several day automobile trip back to Illinois, Bill developed the view that it was time to initiate a program to develop an artifical heart. We discussed this to some degree while traveling, and by the time we arrived in Illinois, Bill had worked-out a piezoelectric device which, though it seemed promising in the car, turned-out to be very inefficient when detailed calculations were made in the comfort of the Laboratory. Nevertheless, less dramatic, or more conventional, ideas were employed and devices capable of sustaining animals for extensive periods were developed and patented.

The ultraconservative attitude of the University of Illinois, at this time, toward the promotion by faculty of their innovations, prompted Bill to organize the Interscience Research

Institute to exploit these heart devices and they were no longer treated in BRL.

Other topics that were undertaken in the Laboartory, largely at Bill Fry's design, were studies of excitable tissue, with and without ultrasonic stimulation; investigations of the organ of Corti; and studies of the modification of animal behavior produced by neurosonic surgical methods.

Thus the Laboratory emerged as pre-eminent in this area and Bill, recognizing the necessity for supporting all those working in this field, created what has come to known as the Allerton Conferences--closed, invited-only to participation--held at an estate owned by the University, approximately 25 miles from the campus. Thus the acknowledged world leaders in the field were able to convene and discuss in detail, in isolated, pleasant surroundings, the then important problems of investigation. These continue!

It would, however, be intirely wrong to have the view that this was only a very narrowly focused bioultrasonics laboratory of inquiry. Such a view would belie the character of Bill Fry who was, in actual fact, a most extraordinarily well read, highly cultured, near Renaissance individual.

As a matter of example, you will recall that physicists some years prior to WW II a had begun to investigate the contents and structure of the

atomic nucleus, but some difficulties had arisen. For example, in beta decay, electrons were found to be emitted with a spectrum of energies. This was very mysterious since, as there are only two particles in the process, viz., the nucleus and the emitted electron, there should be only one way the available energy can be shared. The recoil velocity of the massive nucleus should be very low, thus it would carry very little kinetic energy. The electron should carry away essentially all the energy in the form of kinetic energy. However, as electrons were found to be emitted in a spectrum of energies, some would carry away less energy than the mass difference showed should be released in the process, i.e., some energy vanished. To account for this, without having to give up conservation of energy, the physicist Wolfgang Pauli proposed in 1931 that all could be accounted for if another particle was also emitted along with the electron; the neutrino. The neurtino was to be a small particle that was to have no rest mass and no charge, but was to have a spin angular momentum quantum number s = 1/2. However, by the mid-1950s the neutrino had not as yet been detected, though there had been numerous experimental schemes set up to do so. You must recognize that since it was to have a very small mass and had no charge, it did not readily interact with matter and estimates at

that time gave it a mean-free-path through dense matter of light years. Under Bill's guidance, stimulation, and encouragement, several of us in the Laboratory, including Bill, often discussed this and it emerged from our discussions that we were able to put forth a postulate which could provide for the missing mass and energy, viz., we postulated that the neutrino was simply a manifestation of space and that an energy-space equivalence existed, similar in concept to the mass-energy equivalence in the relativity theory of Einstein. You will recall that this was a time when both the big bang and the continuous creation hypotheses were competing for acceptance as descriptions of creation of the universe. A scheme which provided for both expansion of the universe, by creation of space, and an explanation of the vanishing energy in beta-decay, would have been no mean feat of accomplishment. Unhappily for us of the Bioacoustics Research Laboratory, though certainly not so for the field of physics, the neutrino was indeed detected in 1956.

Now the neutrino belongs to a class of small particles known as leptons, which includes electrons and muons and which experience only weak interactions. These are distinct from the larger heavier strong interacting particles known as hadrons. A particular constituent of the hadrons

fall in the class of particles known as quarks, this name being introduced by the physicist M. Gell-Mann in 1964, as a possible nonsensical entity, taken as it was from James Joyce's Finnegans Wake in which "quark" was seemingly used as a neologism without reference to any meaning. The quark has 1/3 or 2/3 of the electron charge and comes in the six categories; up, down, strange, charm, top, and bottom. I thought "quark" to be a bit more poetic than lepton in the title of the talk.

Another example of our Laboratory undertakings under Bill Fry's direction, and suggesting its scope of activity, was to be found in another strangeness of the time. Unusal objects called "flying saucers" were being sighted, and unusual abilities embodied in the term ESP (extra sensory perception) were being promoted with seriousness for contention with the established sciences. Rhyne had established a laboratory at Duke University for the investigation of some of these unusal abilities. The military were of course not unaware of these goings on, but completely unprepared in anyway to evaluate them. Thus Bill was asked if he would consider investigating persons, or groups of persons, alleged to have rather special abilities, for example, the ability to see through dense media. Such an ability were

of interest to the military who were ever on the look-out for providing personnel the possibility of "seeing" in night darkness. Examining such persons provided curious diversions as people came to the Laboratory to be examined and members of the Laboratory traveled to other places to conduct tests, etc.

You see before you three such Laboratory investigators who were convened for the purpose of examining an idividual alleged to be able to float very high in water, in violation of Newton's law of gravity. In this particular instance, a swimming pool at the University of Illinois was engaged for the test, during which it was found that the skinniest of the investigators probably floated as high in the water as did the protagonist, his wife doing even better.

In all approximately a half dozen individuals were examined. Of course, all were found to be either extraordinarily clever performers or frauds. This fruitless activity, though often a great deal of fun, was rather reminiscent of the pronouncements and actions of the Bellman, the Baker, the Beaver, the Barrister, and the Banker in Lewis Carroll's nonsense poem, "The Hunting of the Snark."

The AIUM has benefited well from the existence of our Laboratory. Early on when Bill Fry took an

active interest in Institute's affairs and during his tenure as President, he nurtured it through a very traumatic transition period, when it seemed on the verge of self-destruction.

Since that time, second generation lab members have become National Academy members and Fellows of the Institue, third generation lab members are serving as administrative officers, as well as being intimately involved in scientific affairs, and some of our graduate students are presenting reports of their studies this week here at the Kansas City meeting.

Well, in these past few minutes I hope I have been able to convey to you some feeling of what it meant to work in the laboratory Bill Fry founded and led. I hope, too, that you've been able to glean some of the excitment that we experienced during those days when he was actively driving and creating science in our Laboratory. As you know, Bill Fry suffered a rather serious heart attack in 1965 and he used the few years following this to prepare himself for a Ph.D. degree, which he had never had the opportunity to pursue because of the war interrupting his graduate education at Penn State, and the great demands he put upon himself thereafter. He was to receive the Ph.D. degree at the University of Texas in early 1969 though, as you know, he died in July, 1968.

It has been most interesting for me to reflect on those earlier times, in preparing this talk, and to speculate on what might have occurred had Bill and some of the other giants of our field continued to live beyond their life times on into the present era. You may not know, but at the present, discussions are occurring, in various parts of the world, regarding a Nobel prize to recognize the contribution of ultrasound in medicine. With that, I leave you to ponder this last thought, and I thank you very much for attending.