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Dr. Gioacchino Failla, 1891-1961

Gioacchino Failla (1891-1961) and the Development of Radiation Biophysics

The first observation of a change in irradiated skin was the beginning of radiation biophysics, although it was many years before this subject became a respectable part of the study of natural phenomena. A satisfactory definition of biophysics is hard to formulate, but it certainly has to do with the use of physical tools to arrive at biological knowledge. One of the earliest workers in this field, and one of the greatest contributors, was Gioacchino Failla.

Gioacchino Failla was born in 1891, in a small town in Sicily, the son of a postmaster. His father died when he was a child, and his mother brought him to New York in 1906. He went through a science high school while helping out the family finances with various jobs. Things were a little easier in college, where a Pulitizer scholarship saw him through the Engineering School at Columbia University. Immediately after obtaining his E.E. degree in 1915, he went to Memorial Hospital as physicist, his main responsibility being the supervision of the radon plant and the development of new methods for use of radon in cancer therapy. In addition to this work, during the next two years he completed courses for his M.A. degree at Columbia, and also found some time to study art at Cooper Union.

In 1916 he became a United States citizen, and so when bilingual scientific aides were needed during the First World War, he was a natural choice for assistant to the scientific attache in the United States Embassy in Rome, where he served for two years.

On his return to the Memorial Hospital he began to develop a real radiation research laboratory, having been able to obtain some space, and a little money for equipment and assistants. Up to this time there had been little systematic work or thought directed toward the improvement of medical applications of radiation. Failla was truly the pioneer.

At first the investigations had mainly to do with radium—this was available, as x-rays were not—and in any case it had been for the study of radium that his group was organized. In the first four years he and his associates published eleven papers on various aspects of radium physics and radium therapy, the latter group involving close cooperation with various members of the Memorial Hospital staff. Thus, early patterns of collaboration were established by Failla; collaboration with his own associates rather than tight supervision, also collaboration with medical colleagues and with chemists and biologists.

Among these papers is the first one on dosage in radium therapy (1921). In this, Failla suggested that doses of radiation should be reckoned according to the amount of energy absorbed in the irradiated tissue. He emphasized the difference between the amount of energy available and that actually absorbed by the tissue. Physical measurements had been published showing the amount of energy emitted from 100 mc of radon, and giving some absorption coefficients for this radiation in water. From these values, and some geometrical arguments, he calculated the microcalories absorbed in one cubic centimeter of tissue, for various therapeutic procedures which had been empirically established. They averaged about four microcalories. (This is on the order of 1700 rads, a dose which would be expected to produce a definite skin reaction. Considering all the approximations involved in his calculations, the agreement with present-day data is remarkable. It took the experts thirty years after this to invent the rad and specify its use.)

In 1922, x-ray equipment became available, and extensive dosimetry studies were begun. For this purpose a water phantom was built, apparently the first one in America. This was, of course, before the days of custom-built ionization-measuring instruments. His chamber was of bakelite, connected to a gold-leaf electroscope by means of a rubber insulating cable. The electroscope leaf was projected on a ground glass screen, and for each reading it was necessary to determine the time required for a shadow to traverse a marked distance on this screen. In months of tedious work, a great deal of data was accumulated on the effects of filter, field and distance on radiation distribution in the phantom, much of which is still useful.

PARIS AND MME. CURIE

Immediately after this, Mr. Failla took a year's leave of absence to go to Paris and complete work for his degree of Doctor of Science under Mme. Curie. A year later Dr. Failla returned to the United States convinced that medical radiological research must include radiobiology. He added biologists to his staff and also insisted that the physicists associated with him should acquire some biological knowledge.

Among his early papers was one in 1925 in which he pointed out that the proper administration of radiotherapy has two parts. First the necessary combination of fields to deliver the desired dose must be worked out on paper. Second, mechanical aids must be constructed to insure that the beam directions and distances from this plan would be accurately transferred to the x-ray tube-patient set-up. The first part was to be worked out with appropriate anatomical cross-sections and isodose charts. For the second, a mechanical device was developed which was the forerunner of present-day contrivances. This whole program is, of course, today's method. Since the date of Failla's paper it has repeatedly been published as an independent idea. (It seems to happen fairly often that any idea more than 10 years old is in the limbo of forgotten things and can be rediscovered.)

In 1927, four grams of radium became available for a "telecurie" source. Compared to the great ^{60}cobalt sources of today, it was a puny effort, but it actually afforded considerable advance in radium therapy at that time, and was to play an important part in the development of radium dosimetry.

Accurate measurement of radiation quantity was always to be desired. When the Second International Congress of Radiology was planned for 1928, international correspondence indicated the importance of developing standard methods of measurements, and Dr. Failla there presented a design for a standard ionization chamber, which is essentially the one still in use.

At this meeting two sets of discussions came to fruitful conclusions in the development of the important International Commissions on Radiological Units and Standards, and on Radiological Protection. Dr. Failla was immediately involved in both, and continued to have active connections with them until his retirement, as well as with the United States National Committee on Radiation Protection (now the National Council on Radiation Protection and Measurement.)

Relative biological effectiveness of various kinds of radiation, first examined for beta and gamma rays in 1926, came to be more absorbing. With the acquisition of a 700 kv x-ray tube in 1932, a broad attack on the problem was planned. Careful ionization measurements were made in a water phantom with 200 kv and 700 kv x-rays and the gamma rays from the large radium "pack". These were the points of reference for comparison with several chemical and biological radiation effects, including clinical reactions. Fourteen collaborators were involved in this study, from all the laboratory departments of the Memorial Hospital as well as the clinical staff. As might have been expected, precise numerical results could not be obtained, but it is interesting to note that the findings were essentially in agreement with results of similar studies carried out later by much more refined methods.

In the next few years two new topics became important. The first was the matter of recovery from radiation effects, the so-called "time factor". Since the initial work at Memorial Hospital, many laboratory and clinical studies have been carried out, in various institutions, but there is still much to learn.

The second problem was the attempt to bring under a common unit, doses for x-rays, gamma-rays, and possibly other ionizing radiations. Dr. Failla suggested that the dose in tissue be based on the number of ion pairs produced per gram—essentially going back to the energy absorbed dose of 1921, but now backed up by the development of equipment to measure it. Again he was ahead of his time. It seemed to many that before such a unit as his proposed "tissue roentgen" could be accepted, it would be necessary to know how to measure gamma rays in roentgens. The story of this quest, involving many eminent physicists, its solution by Friedrich, and its final refinement by Failla, Marinelli and White, is well known.

INVENTIVE INGENUITY

Throughout his scientific career, Failla's inventive ingenuity was apparent. The mention of a new problem was enough to start ideas of design of apparatus for its solution. His solid engineering training and his ability to secure good instrument makers for his shop made possible a large number of developments.

He patented a few items, but most he made freely available to anyone. In early years, when funds were scanty, he often found ways of adapting cheap and available materials to quite unheard-of uses. Ionization chambers were built of all sorts of things from candy balls to cooking pots. But when good supplies were to be had, nobody could have been more meticulous in instrument design.

In 1939 he delivered the Janeway Lecture for the American Radium Society. His topic was "Some Aspects of the Biological Action of Ionizing Radiations" and in ensuing years he was to become more and more concerned with what might be called theoretical radiobiology. With this interest he established himself as a summer member of the staff of the Marine Biological Laboratory at Woods Hole—an activity he continued to the end of his life.

In 1943 he left the Memorial Hospital to join the staff of the College of Physicians and Surgeons of Columbia University, to organize a radiological research laboratory there. However, such organization was delayed for some years by the development of the chain-reacting pile, and the subsequent work of the Manhattan Project. As might have been expected in an enterprise of this importance, every physicist and biologist who had even a nodding acquaintance with ionizing radiations was practically drafted into the work. Since Dr. Failla had always been concerned with radiation safety, he naturally became deeply involved with the protection of personnel from radiation hazards, but he was also active in other nuclear programs. Pure radiation research had to be shelved for the duration of the war.

With the coming of peace and the unveiling of the Manhattan District as the Atomic Energy Commission, he was able to return to his laboratory, but he could never divest himself of nuclear responsibility and its associated "headaches". For the rest of his life he was consultant to various AEC installations and related agencies of government or industry.

At this time the problems of the medical radiation physicist and his allies were much broader than before. X-ray machines in the multi-million volt range appeared; tremendous quantities of radioactive nuclides were available, both for the manufacture of external "teletherapy" sources, and for internal administration, as well as for a wide range of industrial uses. Neutrons abounded around nuclear reactors. Protection problems assumed new importance, both because of the multiplication of powerful external radiation sources, and because of administration to human beings of a great variety of drugs labeled with radioactive substances. Congress, in its Atomic Energy Act, had created the Atomic Energy Commission, one of whose duties was to ensure safety in the use of all radioactive materials obtained from its facilities, and the Commission quickly seized upon experienced physicists as advisers.

Problems regarding biological effects of radiation now became the main preoccupation of many who had started out in the pure physics laboratory. In addition to somatic effects, the genetic question became urgent. Late radiation reactions, such as cancer and leukemia production, cataract formation, life shortening, needed to be investigated. Failla's radiobiological background of many years of study in this field fitted him uniquely to push forward along these lines. He was impelled to enlarge his laboratory to go into some of these problems. With the backing of the Atomic Energy Commission and the American Cancer Society, space and personnel were made available. Now he began more closely applying his vast store of practical knowledge to theoretical considerations of biological effects of radiation, of genetic and somatic mutations, and finally to developing a theory of aging based on the accumulation of somatic mutations.

OTHER ACTIVITIES

In addition to work with his own group, his extra-curricular activities were extensive. Handbook 59 of the National Committee on Radiation Protection, "Permissible Dose from External Sources of Ionizing Radiation" was almost completely his production. First issued in 1954, it has been only slightly modified since, to conform with lowered permissible doses. Many other handbooks passed through his hands during their preparation, and always he had valuable suggestions to offer.

With the initiation of the testing program for nuclear weapons, he became involved in the study of the fall-out hazard. He spent a good deal of time testifying before Congressional committees, and wrote the report published by the Advisory Committee on Biology and Medicine of the AEC, which is still the basic source of information on this topic.

He recognized the responsibility and the need for scientists trained in radiation physics and biology to aid in preparing new people for work in the field, and was largely responsible for the organization of the course at Columbia leading to a Ph.D. in Biophysics.

He proposed and was instrumental in organizing the Radiation Research Society, founded in 1952 and now having about 1000 members. Two years later, greatly aided by his interest and efforts, the journal Radiation Research was launched. The society and the journal are monuments to his vision.

HONORS AND AWARDS

His honors and awards were many. He had an honorary degree of Doctor of Science from the University of Rochester. He received the Janeway medal of the American Radium Society, the Caldwell medal of the American Roentgen Ray Society, the gold medal of the Radiological Society of North America, the medal of the American Cancer Society, the Ewing medal of the James Ewing Society, and (posthumous) the Katherine Berkan Judd award for cancer research. Just two weeks before his death the Radiological Society of North America held a special session to honor him on his reaching his 70th birthday, and made him an honorary member of the society.

He was a Fellow of the American Physical Society and of the American College of Radiology, and a member of a number of scientific or professional societies dealing with radiation or biophysical matters.

When he reached the age of statutory retirement from Columbia University he was invited by various institutions to come to them and carry on his researches. He decided to go to the Argonne National Laboratory, where he had the appointment of Senior Physicist Emeritus until his untimely death in an automobile accident in 1961.

At his retirement he was presented with a complete set of his reprints, beautifully bound, and with an illuminated foreword. There could be no more fitting termination to this biographical sketch than to quote a part of this foreword, written by one of his long-time associates:

"In an age when narrow specialization seems the only avenue to professional excellence, Gioacchino Failla has made unique contributions in a vast domain that ranges from engineering to genetics. He has not merely made his mark in his field, but more than anyone else he has made his field, and while only a fraction of his scientific achievement is commonly attributed to him, that fraction alone contains so much of importance that attempts at a mere enumeration seem futile.

Creative activity of such breadth and depth requires not only a curious, brilliant mind that increasingly explores new and farther frontiers, but also superb character and temperament. Unflinching acceptance of truth is as ingrained in Failla's approach to science as is his uncompromising justice in his human relations. Yet his rectitude is always tempered by humanitarianism, and he knows that truth is sterile without wit, and justice futile without kindness."

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