NP-2137

By:

THE JOHN CRERAR LIBRARY
Research Information Service
86 East Randolph Street
Chicago 1, Illinois

For:

Atomic Energy Commission
Washington, D. C.

Translated from the Russian by Leon Marshak

ATOMIC ENERGY AND MEDICINE
by
N. P. Krylov
Director of the Regional Clinics for Physical Therapeutic Methods, Moscow

Sovetskaya Meditsina, No. 6, pp. 19-21(1947) (in Russian).

The progress in medicine depends to a high degree on the parallel progress made in other sciences. Thus all great advances in physics have been utilized by medicine. The discovery of direct electric currents by Galvani found its first application in medical science. Induction currents, discovered by Faraday, were successfully used for the excitation and cure of paralysed muscles and nerves. High-frequency currents, found by the engineer Tesla, were studied by the physician d'Arsonval as a new physiological agent and applied to the treatment of several diseases.

The physics of rays offered new ways of therapy by high-frequency and ultra-frequent currents. As is known, Roentgen's x-rays were immediately and extensively applied in medicine. With the discovery, made by Becquerel in 1896, of the spontaneous slow radioactive decay of certain elements, a new start was given for the study and the treatment of cancer and other diseases.

These examples show how closely the progress of physics was followed by medicine for the purpose of applications of new methodologies for research and cure. The most striking example of this process is the movement connected with the recent discoveries in the field of nuclear physics.

Physicists, after having understood the structure of the atom's nucleus,

U-92-1

have learned how to destroy it and how to free its immense reserves of energy. According to Einstein, by destroying atomic nuclei contained in one gram of matter, 25 milliards kwh energy can be liberated. The present-day problem is how to apply these new energy resources for our needs, and, in particular, in medicine.

As in many other cases, the mystery of the atom was not solved by one man. The most important contributions in the study of the atomic structure were made by Bohr and Rutherford; they established that every atom has a positively charged nucleus, consisting of protons and neutrons, and an outer system of negatively charged electrons revolving around the nucleus. Very important were the works of Joliot, Curie, Fermi, and Lawrence, who created new radioactive elements by using the method of bombarding nuclei of various elements with the newly discovered neutrons.

Two facts were of decisive importance: the invention of the cyclotron for the acceleration of the bombarding particles, and the realization of the so-called chain reaction in which neutrons freed in a nuclear fission react with neighboring nuclei, fissuring them and releasing new neutrons, in an ever multiplying succession.

It was found that two recently discovered elements, uranium-235 and plutonium, show a particularly violent fission effect, due both to the instability of their nuclei and the ease with which a chain reaction is set off.

After the end of the war, scientists in many countries have concentrated their efforts on possibilities of peaceful applications of atomic energy, in the fields of industry, biology, and medicine. The prospects offered are vast and promising, and the paths of the future progress are hard to forsee, in spite of the considerable success already achieved.

The problem of the use of nuclear energy for medical purposes is not new. Soon after Becquerel's discovery of radioactive phenomena it became clear that, although too minute for industrial applications, the amounts of the liberated

energy may be sufficient for biological and curative effects.

Accordingly, rays emitted by radium and other radioactive substances were extensively used for these purposes. Actually, however, their use was limited by the small quantities of radioactive elements in nature.

The first physicians to use radioactive substances for therapeutic purposes were Danlos in France and prof. Mezernitskiĭ in Russia. Successful use of rays emitted by radium for cancer treatment caused the widespread recognition of this method in medical practice. By an appropriate selection of rays and doses, physicians have learned how to kill prolific cells of the malignant tumors without disturbing the normal tissues. It was found that the various rays emitted by radium act upon the living cells in different ways: α rays (nuclei of helium atoms), being the slowest, do not penetrate very deeply and are employed in skin diseases; and fast β rays (electrons) penetrate deeper; and γ rays (electromagnetic waves similar to x-rays) are the most penetrating of all.

Although in many cases cancer can be successfully treated only by radium, the latter's high price is prohibitive (200,000 gold rubles for one gram radium).

Recent discoveries of artificially radioactive substances permitted the substitution of radium by cheaper products. They are usually obtained by bombarding the nuclei of many of the known elements with fast neutrons; the disintegration of the latter is accompanied by emissions of rays similar to those of radium. With the aid of cyclotrons, artificially-radioactive substances have been obtained in quantities equivalent to kilograms of natural radium. Among those substances, radioactive cobalt is especially interesting on account of its prolonged γ radiation.

Radioactive elements share with ordinary elements the usual chemical properties, the faculty of emitting rays being their only distinctive feature. Advantages can be taken of this in order to trace their presence in human body. They are used as "tracers", permitting the "visualization" of many chemical processes.

By using special instruments (Geiger counters), radiations of tracer atoms are

easily detected and followed along their paths in the organism. It is easy to see the importance of these methods in diagnostics, in the study of metabolism, the genesis of diseases, and the action of poisons and drugs.

The velocity of physiological processes could be accurately measured. Radioactive phosphorus, a half-hour after its salt has been swallowed, was traced in the bones and teeth. Each tooth gets one phosphorus atom out of every 300,000 atoms received by the body. Ten minutes after an intravenous introduction, large quantities of radioactive iodine are found in the thyroid gland. The presence of sodium is discovered in blood two minutes after a grain of radioactive table salt has been swallowed. Iron ingested, as a sulfate, with food, was found present in the hemoglobin of the blood only one half-hour later. After a heavy loss of blood, the human body assimilates greater quantities of iron than it does in the normal state.

Several chemical compounds are known to physicians and biochemists as "cancerogenous". It is hoped that the tracer methods will help in the discovery of the principal cause of the terrible illness.

Advantage is taken of the specific action of radioactive elements on tissues and organs. They reach specific parts of the organism, however remote. Thus, radioactive iodine is deposited chiefly in the thyroid; accordingly, it is used in the treatment of this organ's diseases. Radioactive phosphorus is assimilated by the bone tissue and the bone marrow; the bombardment of the latter's cells by the β rays emitted by the phosphorus produces a favorable therapeutic effect in some cases of leukemia. Radioactive cobalt and nickel, which are deposited mostly in the pancreas, are used as drugs in the latter's diseases.

According to some observations, certain tumors have the same faculty of selective retention of specific radioactive substances. For example, malignant tumors of lungs retain radioactive copper. Bone tumors retain selectively phosphorus and strontium which produce favorable effects in certain diseases, such as osteo-

sarcoma and lymphogranulomatosis.

Besides peroral administrations, radioactive substances are successfully used for local applications in dermatology. Since their high radioactive power is combined with very small volumes, they can be introduced into various cavities, organs, or tumors.

One of the most valuable properties of many of the artificially-radioactive substances is the prolonged action they are able to exercise upon diseased organs: the activity of a single dose may last two weeks or longer. The lifetime of the numerous radioactive bodies obtained by the physicists from almost all the known elements, occupies a range from a fraction of a second to several months. Another important fact is the great variety of radiations emitted, one specific radiation or a set of radiations characterizing each particular substance. For example, radioactive phosphorus emits only β rays, while radioactive sodium emits both β and γ rays, the wave length of the latter being much shorter than that of the γ radiation of radium.

Sukharev studied the influence of irradiated food on human organism. He found that such food acquires peculiar properties activating several physiological functions. This can be partially explained by the fact that irradiation furthers the formation of vitamins in the food.

Many experiments showed that serious cases of anemia can be healed by irradiated preparations of dried liver. Rickets and furunculosis are cured by "radio-food". The latter is recommended during periods of heavy physical strain or prolonged marching, or for the prevention and the treatment of diseases of children. Dried milk and powdered eggs, irradiated by emanation of radium, proved especially valuable, the improvement in the metabolism being reflected in the increase of the child's weight and rate of growth. The "radio-food" retains its curative properties for about a year. Bogolubov (in Tomsk) successfully employed yeast, irradiated by emanation of radium, in cases of furunculosis. The future will certainly show many complex problems of biochemistry and pathogenesis solved by

the methods of radioactivity.

However, the applications of atomic energy in medicine are not limited to the use of radioactive substances. Another interesting problem is that of the curative properties of streams of electrons, protons, and neutrons. Fast streams of electrons were the first to be tested. The energy of electron beams, which depends on the electrons' velocity, can be very great, the highest energies being obtained in a special instrument called the betatron. Fast electron beams show strong biological effects and a penetrating power comparable to that of x-rays. Their advantage over the latter lies in the possibility of directing and concentrating them in any point of the body by using a magnetic field. The study of the therapeutic properties of electron beams started before the war, one of the problems being the treatment of malignant tumors artificially produced in mice.

The use of streams of protons and neutrons in medicine is another promising field. Little is known so far on the action of proton streams; it is established that they are strongly absorbed by the tissues, and that they are generally similar to α rays. Fast neutrons, comparable to minute penetrating bullets, are obtained with the aid of the cyclotron. Slower and less energetic neutron beams are produced by bringing together beryllium powder and emanation of radium; α rays, emitted by the emanation, dislodge slow neutrons from the beryllium nuclei.

Neutron streams, both slow and fast, will prove especially interesting in view of their high penetrating power, comparable to that of x- and γ rays. The strong biological effects they produce are probably due to their faculty to interact not only with the electronic shell of the atoms, but also with the nuclei as well. It has been found that neutron beams, like certain artificially-radioactive substances, act selectively upon various tissues. Thus, the blood-producing organs and the mucous membrane of the small intestine in mice is particularly sensitive towards irradiations with neutrons. A comparison of the sensitivities

V-92-6

of normal tissues and malignant tumors showed that cells of such neoplastic tissues as "sarcoma 180" or cancer of the breast in mice are more intensely damaged by neutrons than are the healthy cells. Furthermore, the neutron beams are more effective than x-rays in all those cases. The observations cited, and certain others, were made before the last world war; their number has considerably increased since that time, so that at present successful treatment of cancer by neutron beams is performed in the U.S.A.

John Lawrence applied this method in 119 cases of old neglected cancer with favorable results in 85 of them; all had been judged incurable by physicians. Especially good results were observed in a series of cases of cancer of the pancreas, in which 16 out of 17 patients were cured, the healing being confirmed by three years of subsequent observation of all cases.

In concluding, it can be said that medical applications of various forms of nuclear energy open very promising prospects. We have cited here only a few examples of its successful uses. The goal of the Academy of Medical Sciences and of our research institutions is to multiply the numbers of similar examples and to apply the atomic energy for the noble purpose of healing. The Soviet medicine must lead both ideologically and technically.

END

rs
2/27/50

V-92-7