

APPENDIX II — SCIENTIFIC SECRETARIES' REPORTS ON TECHNICAL SECTIONS OF CONFERENCE

Section 6 — Health and Safety Aspects of Nuclear Energy by

Robert J. Hasterlik and U. M. Staebler

Under the chairmanship of W. B. Lewis (Canada), Section 6 of the United Nations International Conference on the Peaceful Uses of Atomic Energy was divided into two parts, the first dealing with "Biological Effects of Radiation", the second with "Reactor Safety and Location of Power Reactors."

The first speaker was J. F. Loutit (UK) who delivered paper No. 392 on "The Experimental Animal for Study of the Biological Effects of Radiation". Loutit stated that it was to be expected the higher animals, including man, would be more sensitive to ionizing radiations than would lower forms. In order to collect data and set reasonable levels for radiation exposure to man, the International Commission on Radiation Protection had been organized. It was necessary to collect all available data concerning deleterious effects in the human which fall, in general, into four categories.

1. Superficial injury, such as the radiation burns suffered by the early radiologists.
2. General effects, such as the production of aplastic anemias following prolonged exposure to radiation.
3. Induction of tumors, such as have appeared on the skin after a latent period of 20 to 30 years following irradiation of the skin in a child at levels of 1500 roentgens. Presented studies on skin carcinogenesis in the hairless mouse.
4. Other deleterious effects such as the production of cataracts, genetic effects, etc.

Future progress was to be expected on the basis of study using the experimental animal.

Certain studies of great importance have been going on in several countries concerning factors affecting recovery of the hemopoietic systems from irradiation. These include studies on parabiosis; shielding of tissue such as spleen, liver, head; and the injection of bone marrow.

Loutit believed that periodic blood counts were not a sufficiently sensitive indicator of the occurrence of irradiation damage and recommended that the periodic blood count be replaced by physical methods of monitoring. During the course of his presentation, Loutit suggested that natural levels of radiation probably play little part in the natural mutation rate except in long-lived animals such as man.

The second paper, No. 616, "The Influence of the Ionizing Radiations on Animal Organisms," was presented by Prof. A. V. Lebedinsky (USSR) who stressed the importance of the therapeutic use of ionizing radiation but

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pointed out the limitations imposed by the development of "radiation sickness". USSR studies have for the most part been directed toward the effects of radiation on the nervous system.

A first approach has been by means of histological study of nervous tissue after irradiation. Nemenov has studied the effects of 2,500-3,500 r on conditioned reflexes in dogs. Nemenov's data demonstrated that, after radiation, there was a marked decrease in the latent period between the stimulus and appearance of the conditioned reflex, salivation, which was in larger volume than normal. After a lapse of time, a reverse effect was noted.

Gorizontov has irradiated rats with 600 r. He has found a fall in "internal inhibition" of the central nervous system, followed by a "depression of cortical activity", followed by a disappearance of reflexes, followed by their return.

Livanov and Anyanov have studied the changes in electroencephalographic changes in rabbits following 500-1000 r. They found a general depression of wave activity following irradiation up to 18 hours.

Lebedinsky reported studies on electroencephalographic studies done on six hours being irradiated for therapeutic purposes. He stated that caffeine administered before irradiation yielded an increase or no change in cerebral cortical electrical activity. After irradiation caffeine plus stimulation resulted in a decrease in cortical activity. He postulated that "overstrained" cortical cells respond to stimulation by inhibition. He also had no doubt that these effects occurred immediately following irradiation.

As a further example of the nervous system effects, Lebedinsky stated that the injection of acetyl choline causes a rise in blood pressure. Two days following irradiation the rise do not occur on injection of the drug, at three days there occurs a heightened blood pressure response, followed by four days with a normal response.

The third paper, No. 478, by R. J. Masterlik and L. D. Marinelli (US) on "Physical Dosimetry and Clinical Observances on Four Human Beings Involved in an Accidental Critical Assembly Excursion", was presented by Hasterlik.

On June 2, 1952, three men and one woman were exposed to gamma rays and slow neutrons in an accident at the Argonne National Laboratory. The doses were respectively 190 rem, 160 rem, 70 rem, and 12 rem. The fast neutron energy component was approximately 2% of the total rads and the slow neutron component, approximately 0.5%. Detailed studies on the dosimetry, including a rerun of the reconstructed assembly at known power levels established the validity of the radiation doses.

Marked amino-aciduria was a prominent finding in all individuals. One patient excreted as much as 5500 mg. in one day. An increased level of urinary amino acids persisted in one individual until four months following exposure.

Complete data on the hematologic findings were presented. Studies indicated that the sperm counts had returned to normal levels in the male patients at 20 months.

The last paper of the session, No. 617, "Two Cases of Acute Radiation Sickness in Man", by A. K. Guskova and G. D. Baisogolov (USSR) was presented by M. D. Domshlak.

Two individuals were exposed in an "experimental reactor" accident to 450 r and 300 r. No details were given concerning the type of reactor or the details of dosimetry. It was reported that the individuals have been studied for 18 months following the exposure.

The authors stressed the changes occurring in "cortical activity" on the central nervous system and described the marked changes in chronaxie which they observed during the course of the radiation sickness and recovery.

Both individuals appeared clinically "well" until the 24th day, at which time their clinical condition deteriorated. Marked bleeding tendencies were seen and the patient exposed to 450 r developed a severe ulcerative pharyngitis and tonsillitis. The patients were treated with penicillin, neucleotides, frequent 200 cc blood transfusions, caffeine, cardiazol, oxygen, and bromides. Both recovered.

Question: Tatsuke (Japan) asked Domshlak (1) what he believed to be the effect of neutrons on the bone marrow, and (2) would he estimate the importance of the therapeutic effect of blood transfusions? Answer: Domshlak stated (1) the authors did not deal with the question of neutrons and the bone marrow, and, in answering (2) stressed the importance of early prophylactic effect of blood transfusion.

Question: Farr (US) asked what specific therapy could be used for the reported effects of radiation on the central nervous system? Answer: Domshlak (USSR) said bromides could be used in the stage of excitation and caffeine in the stage of nervous activity depression.

Question: Pearson (US) asked what were the relative proportion of neutrons and gamma rays in the exposures. Answer: Domshlak said the authors did not give the exact figures but believed the greatest

amount was gamma rays, not much neutrons.

Question: Loutit (UK) asked whether Domshlak believed the effect on the central nervous system was primary or secondary?

Answer: Domshlak (USSR) said this has been clarified by Lebedinsky in his paper, since alterations in the nervous system arise immediately.

Question: Mitchell (UK) asked (1) was there any evidence for the distribution of the radiation dosage to the body of the two patients, and was it uniform; and (2) what was the evidence for the value of pentoneucleotides or other nucleic acids in the treatment of the patients? Answer: Domshlak replied that the authors did not state the distribution of radiation, and (2) that the drugs mentioned had not administered and studies were not made.

Question: Gamble (Turkey) asked Loutit whether he believed the mechanism of carcinogenesis in the hairless mouse to be the same as in other mice? Answer: Loutit (UK) said the hairless mouse differed from the normal mouse only in having a hereditary absence of hair follicles, that sebaceous glands were present, and he believed the mechanism to be the same.

Question: Cipriani (Canada) commented that animal data were not always applicable to man and asked how could these difficulties be obviated? Answer: Loutit said it was necessary to study effects in several species and pointed out that data on humans could be obtained from radiotherapeutic irradiations, and accidental human exposures. He stressed the extreme value of a "world clearing-house" for the assembly of all human data.

Question: Roche (Venezuela) asked whether a nitrogen balance study was carried out and, if so, what were roughly the data? Answer: Hasterlik (US) said nitrogen balance studies were not carried out.

Shields Warren (US) presenting the first paper in the second part of the section (No. 309, US, "Radioisotopes in Medicine") pointed out that the uses of isotopes may be placed in two general categories, namely, (1) tracer techniques and labeling, and (2) radiation effects, involving therapy, sterilization, food preservation and gene changes. He gave several examples of how isotope tracer techniques may be used to advantage. Thus, (1) from tracer studies it has been learned that there is much greater mobility and change of substances in the organism than has previously been appreciated; (2) by assaying with isotopes, many tedious chemical methods of analysis have been greatly lightened, and frequently without disturbing the organism itself; (3) the ability of an organism to form a substance can be measured directly by the isotope technique, without calculating the total net gain from adding and subtracting materials of both constructive and destructive metabolism; (4) enzyme patterns can be followed in both plants and animals. Standards of operation have been established for work with tracers. The technique is of greatest importance and extremely promising.

Warren described therapeutic use of radioisotopes as both (1) external, and (2) internal. The ability to concentrate isotopes in certain tissues makes interior treatment far superior to external treatment. The advantages of low-cost, low-level reactors close to the source of use are many, and should receive careful consideration.

Question: Cambel (Turkey) asked whether cesium-teletherapy could be cheaper and superior to cobalt-teletherapy? Answer: Warren said that the chief saving for cesium would be that its softer radiation required less shielding, but since its rays are less penetrating, its use would be limited.

Question: Milcou (Romania) asked whether synthesized radioactive hormones been used in therapy? Answer: Warren said their radioactivity was so slight as not to be helpful in therapy, but that as tracers they helped understanding of metabolism.

A. L. Kursanov (Paper No. 618, "The Utilization of Radioactive Isotopes in Biology and Agriculture in the USSR") said Russian scientists have used tagged atoms rather extensively in research. They have done considerable work on roots where activity is fairly easily followed. P-32 is being used by field stations in dozens of locations in the USSR.

Among reported findings was that a much higher percentage of applied fertilizer was used by the plant than had been previously supposed. For example, 40 to 60 percent of the phosphorus used by a plant might come from applied fertilizer instead of the 10 to 12 percent as frequently suggested.

By the isotope technique, a more rational distribution of fertilizer could be made in the soil. For example, it had been found that the "efficiency" of a root could be greatly increased by being in contact with the fertilizer. Thus, using P-32 it had been shown that as little as 4 to 5 percent of the root system of some plants could take up the phosphorus requirements of the entire plant, meaning an increase in "efficiency" of 20 times.

Kursanov said it had been possible to follow the production of materials by micro-organisms and to ascertain the uptake and utilization of these materials by the plant. A study of the disintegration of humus had shown that CO<sub>2</sub> might be picked up by the roots from the soil, transported to the leaves, and there used in photosynthesis fully as effectively as CO<sub>2</sub> from the air.

He said that the discovery of some steps in photosynthesis, in vitro had been made simultaneously with a similar discovery made by US investigators.

It had been shown that both proteins and carbohydrates might be synthesized in the leaf in the presence of light. Further, the red-green portions of the spectrum was used in carbohydrate synthesis, and the blue portion in protein synthesis.

It had been found that the speed of movement of materials, and the buildup and breakdown of materials in the plant was very great. He pictured a dynamic system of great change and mobility.

The USSR scientists had studied the "non-root" intake (foliage intake) of plants. Following these studies many thousands of acres of plants had been given foliar feeding, mostly sugar beets, in cool areas, and under conditions where nutrients were not readily available at critical times.

It had been shown that sucrose was manufactured in the leaves of beets, and then moved to the roots. Because of this, greater attention was now being paid to leaves. In studies with fruits (poppy) it had been found that CO<sub>2</sub> might be evolved in the center of the fruit, and that the CO<sub>2</sub> might then diffuse to the periphery where it might be used in photo-synthetic processes. There was a mechanism for maintaining the O<sub>2</sub> and the CO<sub>2</sub> levels at proper concentrations in different parts of the seed and the fruit.

Studies of latex synthesis had revealed some processes involved, notably that latex appeared very suddenly in some plants.

Questions: Mitsui (Japan) asked about isotopes in soil erosion studies. Spinks (Canada) asked whether universities participated in the program and was assured that they did. Reifer (Poland) asked for more information on synthesis of alkaloids.

S. A. Silow (FAO) in Paper No. 780, "The Uses of Atomic Energy in Food and Agriculture", stated that the world supply of food could be increased by (1) reducing the heavy losses that now occur in storage, transport and handling; (2) increasing the productive areas of the world; and (3) opening up new areas to production. Atomic energy could help eventually through producing cheaper power so as to remove salinity from water and provide better drainage, and through the use of isotopes.

Isotope studies might not stimulate production directly, so far as was known, but atomic energy radiations could induce mutations, sterilize foodstuffs, provide better knowledge of insect and disease control, show how fertilizers could be most economically applied, discover fishery sources and hence promote better production of fish and help determine adequate balance of diet.

Silow made a statement that only 1% of sunlight was used by plants. Wassink (Netherlands) pointed out that this might be so for an entire year but was not true for certain short phases of plant development and in low light intensities.

"C" SECTIONS - BIOLOGICAL AND MEDICAL

SECTION 8C - Radioactive Isotopes and Nuclear Radiations in Medicine: Therapy

By A. M. Bruce

The Chairman, F. Leborgne (Uruguay), introduced the Section briefly, indicating that the powerful effectiveness of isotopes in medicine was limited by physiological and topographic considerations -- the location of lesions.

Dr. A. V. Kozlova's paper (No. 685; "Medical Application of Some Radioactive Isotopes") was presented by M. N. Fateieva (USSR). The chief isotopes used have been Co-60, Au-198, P-32 and I-131, and Fateieva stated that free medical service makes large-scale medical observations possible. Comparing Co-60 and radium, as external agents, she said the former caused slighter injury to normal tissues and so made repeated therapy easier. 160 oncological establishments have received tubes and needles of 0.5 to 35 mgms. radium equivalent. A few clinics have 400 curie packs, used at 35 or 60 cm. skin distance, and 20 curies used at 6 cm.

Various data were presented indicating that therapeutic results ("recovery") have been better since the use of cobalt. The improvement in per cent actually was modest and might represent improvement in techniques and perhaps an enthusiastic outlook. In one type (esophageal carcinoma) where greatest improvement appeared, teletherapy was combined with intracavitary treatment.

Fateieva also mentioned use of gold and chromic phosphate colloids locally in 11 melanomas with metastases, and said 8 showed no spread in 2 years. Cobalt was being used for cavernous angioma, and P32 for angioma, neutodermatitis, precancerous skin conditions, eczema, psoriasis and red lichen. P32 was injected for erythremia, preceded by venesection and introduction of plasma; 4 mc. is the maximum given in course of treatment. Other modes of therapy were detailed in the paper. Some slides were shown of 7-year cures of several neoplasms.

In paper No. 446, J. S. Mitchell (UK) discussed "Some Problems of Radio-therapeutics," mentioning the possible usefulness of I 124 and P 33 as substitutes for I 131 and P 32 because physical characteristics were probably more favorable. He brought out the use of Cs 137 as a gamma source and Ce 144 as a hard-beta source. He also emphasized conservatism in the use of I 131 in nonmalignant states, pointing out that if the mortality from delayed carcinogenesis were as little as 2%, surgery still would be preferable.

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Question (Brucer, US): What was the meaning of "recovery" and were all cases histologically proved? Answer (Fateieva): Recovery meant the tumor was gone at the end of treatment; biopsy and histology were done in nearly all cases.

Question (Aebersold US): Was cobalt used in teletherapy or in needles; how many years' experience had they had with teletherapy? Answer (Fateieva): Depending on circumstances; needles and teletherapy were used in conjunction in bladder cases, for example; 160 institutions were supplied with cobalt and results from all of them summarized in the central organization.

Question, (Netherlands) asked about germanium dosimeters, which he had not found useful. Answer: Fateieva stated USSR workers were not yet ready to draw conclusions.

In Paper No. 179, "Teletherapy Devices with Radioactive Isotopes", M. Brucer discussed teletherapy devices using cobalt-60 and cesium-137, and presented tables for calculating shielding. He appeared to favor using cesium when available, shielded with tungsten alloy. He believed the enthusiasm for sources over 1000 curies was decreasing.

Question: Lebedinsky, (USSR) asked whether hectocuries or kilocuries would eventually be used in packs. Answer: Brucer stated most people used 200 to 400 curies and, of those using 1000, about half would use more the next time and the other half less.

Question: Bora (India) asked for the evidence that 5 roentgens/hour/meter was an inadequate dose rate. Answer: This was arbitrary but generally accepted.

Question: Khanolker, (India) asked how the tumor dose was determined. Answer: Brucer said the policy was, in general, similar to that used with 250 KV x-ray. With the larger machines some radiologists tended to give higher doses.

J. H. Muller (Switzerland) in presenting paper No. 925, "Internal Radioactive Isotope Therapy of Neoplastic Diseases by Means of Radioactive Suspensions," discussed intravenous colloidal suspensions, intracavitary, and tumor infiltration, and mentioned the escape of colloid into lymphatic drainage areas as an advantage of the latter.

A. Chevallier (France), Paper No. 367, "Utilization of Colloidal Chromium Radiophosphate in Malignant Tumor Therapy" by Chevallier and C. Burg, discussed very fine (100-150Å) chromic phosphate colloid, implanted in gelatin, which seemed to promote infiltration via the lymphatics. This was demonstrated by autoradiographs.

Question: Mitchell (UK) asked Muller about dosage in interstitial treatment; for example, 50,000 rps are often needed in the case of beta emitters. Answer: One mc/ml was about enough, but in large volumes, one must reduce this.

Question: Siwarbessy (Indonesia) asked what was the effect of colloidal gold, used locally, on the liver and spleen, and had Muller had any experience with cancer of liver? Answer: Muller replied that the dosage to liver and spleen was not high; perhaps the stimulation of the reticuloendothelial system from the lower doses might be protective. He had no wide experience with liver but thought gold would be only palliative.

Question: Ross (US) asked whether or not lymphatic drainage was blocked when there were metastases, and why gold was better than P 32 because of the gamma radiation? Answer: Muller said local injections might reach very early metastases before blockage of lymphatic drainage occurred; or after removal of metastatic masses. Many factors were involved, he said, in the preference for gold.

J. H. Lawrence (US), paper No. 183, "Radioactive Isotopes in Hematologic Therapy" gave a historical account of treatment with isotopes, primarily P 32. Best results were obtained in the case of polycythemia vera (erythremia), with relative success in the leukemias (particularly chronic forms) and some of the lymphoblastomas. Colloids also have been used (chromic phosphate, or some of the rare earths) but were not considered superior to the administration of soluble phosphate.

V. H. France (Portugal), paper No. 970, "An Accurate Method for Treatment of Hyperthyroidism with I 131" described a method for outlining the thyroid gland by circuminjection of air and showed x-rays. In only three cases was this technique unsuccessful and two of these were post-operative. He also used small repeated doses of I 131 to avoid myxedema. In injecting air, the patient was placed on the left side and negative pressure was used as a test to avoid embolism; a 0.7 mm. needle was used; the size of the gland was calculated from radiographs as 2 ellipsoids with the axes as measured from pictures.

L. E. Farr (US), paper No. 177, "Use of the Nuclear Reactor for Neutron Capture Therapy of Cancer" reporting using a flux of  $2 \times 10^9$  and  $3 \times 10^9$  slow neutrons per  $\text{cm}^2/\text{sec}$ . with boron 10 injections, and gave data. For good results, 30 times the higher flux was necessary about  $10^{11}$ . He described a special reactor for medical purposes only which would accomplish this, as well as provide for animal experiments and the production of very short-lived isotopes for immediate use.

The only elements other than boron 10 that might be injected

would be lithium-6 and uranium-235. Boron 10 was used because of availability and the probability that its tissue distribution with time after injection is favorable. Treatment was now being given between 10 and 50 minutes after intravenous injection of borax. This was the time interval during which the difference in boron concentration between brain and tumor tissue was greatest.

Question: Ross asked Franco (1) what about varying the dose of I 131 along with the severity of the disease; (2) what about the hazards of interstitial air here, as in the case of adrenal radiography; (3) how did his size estimates agree with those made by scintillation scanning or palpation? Answer: Franco said (1) that it was known that different doses were required, but in this study all were given equivalent doses since it was experimental; in the care of 4 nodular goiters function was only reduced somewhat and then surgery was done; (2) that he had had no accidents with 50 insufflations; (3) that comparison with other methods of measurement was not made.

SECTION 9C - Radioactive Isotopes and Nuclear Radiations in Medicine:  
Diagnosis and Studies of Disease

by Marshall Brucer

The Chairman, V. R. Khanolkhar (India) opened the section, pointing out that radioactive isotopes were helping to reshape the diagnostic art.

W. V. Mayneord (UK) presented paper No. 768, "The Use of Radioactive Isotopes in Diagnostic Procedures," a general summary of material he had previously written up in the British Medical Bulletin (1952). Mayneord's work included use of various kinds of instrumentation for measuring beta and gamma emitters under clinical conditions, and the possible uses of many different isotopes. He described studies of total thyroid uptake, measurements of protein-bound iodine, using roughly collimated counters and methods of blood iodine measurement. Mayneord described some problems in Fe 59 and Cr 51 work and indicated their fundamental similarity to the I 131 problems.

Much of Mayneord's time was spent describing his radiographic devices. He concluded that there was a reasonable possibility that radiography might be successful with isotopes in the future.

8 M. N. Fateieva (USSR) in her paper, No. 684, "Experience in Clinical and Diagnostic Application of Some Radioactive Isotopes in the USSR," reported using 2 microcuric doses for standard 2- to 24-hour uptake measurements. She reported mass-scale examinations of population in endemic goitre districts. Fateieva described simple uptake and dynamic studies with I131 in rheumatic and hypertensive heart disease. Work was also presented on Na<sup>24</sup> measurements on hypertensive patients and blood flow studies in heart disease.

B. G. Ziedses des Plantes (Netherlands) showed 3 slides on his electrical stylus method of correlating the scanning image with a true body image on a scintiscan of the thyroid.

Marcel Roche (Venezuela) described a mass population study of thyroid uptake in the lowlands of Venezuela and high in the Andes, showing 2 slides. At very high altitudes there was a uniformly higher thyroid radioiodine uptake.

Questions: W. H. Sweet (US) asked about the ratios of activities of isotopes in normal and in brain tumor tissue. Bacq (Belgium) asked in what form the iodine circulates in the blood. Lawrence (US) asked how sensitive the scanning device was. Answer: Mayneord was not conversant on the first two questions. He stated that the average scanning dose was one millicurie and that theoretical studies had indicated it would be

impossible to outline the shape of a mass with less than 10 to 20 microcuries.

Fateieva enlarged her description of the mass population surveys: one in the Urals, and two in the Ukraine. One Ukraine area was in an endemic area of hyperthyroid patients. The thyroid uptakes were high and the urine counts low in the hyperthyroid endemic area and the opposite was true in another area where euthyroidism was prevalent.

W. H. Sweet presented the work of G. L. Brownell and Sweet (US) in paper No. 181, "Scanning of Positron-Emitting Isotopes in Diagnosis of Intracranial and Other Lesions" on the methods of visualization of isotope distribution in the body by automatic scanning with scintillation detection. He remarked that they had been able to detect verified tumors of the cerebral hemispheres outlined with radioarsenic in nearly 80% of patients. In meningiomas the results were over 95%. Mention was made of the extension of this work to other areas of the body.

J. F. Ross (US) emphasized work on dynamic studies of hematopoietic tissues and in erythropoiesis in paper No. 754, "The Dynamic Aspects of Erythropoiesis in Normal and Pathologic States as Indicated with the Radioactive Isotope Tracer Technique," by Ross and A. Miller. With isotopes, hematologists were able to prepare a comprehensive outline of the entire red-blood-cell cycle. Ross described some of the mechanics of the measurement techniques and presented examples of the work done in Boston.

In the discussion, Kunkei (West Germany) described similar work using a simple coincidence counter system measuring gamma rays. He indicated that the use of positron-emitters was unnecessary.

Question: Bale (US) asked about the relative efficiency of single channel and coincidence systems. Answer: Brownell (US) said studies showed that the coincidence system demanded only one-tenth the activity of a single channel system.

E. E. Pochin (UK), presenting paper No. 769, "The Speed of Iodine Metabolism," described in some detail the advantages of the neck/thigh ratio and the equipment he used to make the measurements. Pochin used I 132, particularly in pregnant women where he indicated a six-microcurie dose. Pochin then outlined his work on metabolic pathways of iodine and described a linear scan of the vertical plane of the body to get an index of the discharge rate of iodine.

C. H. Jaimet (Canada) in presenting paper No. 9, "Further Clinical Studies of Thyroid and Salivary Gland Function with Radioiodine" by

Jaimet and H. G. Thode, discussed the metabolism of I 131 in the salivary gland and his development of the salivary iodine test.

Michel Berger (France) presented a summary of paper No. 365, "The Role of Genetic Factors in the Development of Congenital Myxedema," the genetic history of 21 cases prepared by M. Bernheim, et al. (France). He stated that in most of the families of the patients, he found evidence of thyroid abnormality. In the cases of nine patients, both parents showed abnormal thyroids, there being usually a high thyroid iodine fixation in the male parent. Berger discussed the genetic possibilities of his studies and proposed a hypothesis of genetic transfer of the diseases.

Paper No. 1097 by Stefan Miledu et al. (Romania) "Influence of the Dynamics of the Central Nervous System on Iodine Fixation in the Thyroid" stated Romania had just begun to receive isotopes and hoped for more assistance in the near future. Romanian scientists have studied the effects of estrodiol on iodine metabolism in rats and have concluded that there was a thyroid block with high doses of estrodiol and a thyroid stimulation with low doses.

Opening the discussion, Joyet (Switzerland) presented a short extra paper which emphasized that the major movements of I 131 could not be explained mathematically unless the three factors of thyroid, blood, and urine, were taken into account. He described some complex mathematical formulations of what appeared to be averaged blood, urine, and thyroid counts on many patients in order to arrive at definitions of hyper, hypo, and euthyroidism.

Questions: Pochin (UK) was asked a number of questions on handling of post surgery patients, carcinoma of the thyroid patients and the use of chromatography. His answers emphasized the necessity for iodine turnover or clearance studies.

Vetter (Austria) commenting on Jaimet's paper, said that they had tried the saliva tests in Vienna, and had attempted to work out a parotid clearance test. They found the clearance through saliva was independent of thyroid clearance rates. The conclusion was that the salivary tests were not better, and might be much less reliable, than other tests.

Berger was asked about living conditions of the families studied for genetic factors. Berger said there were no abnormal conditions apparent. He was asked about the possibility of hyperthyroid mothers, but thought that this could not explain the transmission through the male parent. He was asked his definition of the words

"biochemical hyperactivity" and indicated that this meant a sub-clinical hyperthyroidism.

W. F. Bale (US) presented his and I. L. Spar's work in paper No. 199, "Tissue Specific Antibodies as Carriers of Radioactive Materials for the Treatment of Cancer."

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FOR ARCHIVES

SECTION 10C -- RADIOACTIVE ISOTOPES AND NUCLEAR  
RADIATIONS IN MEDICINE:  
DIAGNOSIS AND STUDIES OF DISEASE

by

Paul B. Pearson

M. Tsuzuki (Japan) presided as chairman.

A. Baird Hastings (US) discussed paper No. 178, "The Use of Isotopes in Biochemical and Medical Research" and then read the paper by DeWitt Stetten (US) No. 840 on "The Use of Isotopes in Analysis of Metabolic Disorders". These were general review papers with a historical background on isotopes as a research tool in biology and medicine. The following areas were covered: total body water, plasma and red blood cells, intracellular fluids, bones and teeth, proteins, nucleic acids, lipides and carbohydrate metabolism.

The paper by B. A. Burrows and J. F. Ross (US), No. 180, "The Use of Radiosodium and Radiopotassium Tracer Studies in Man", was concerned with the metabolism of sodium, potassium, and sulfate distribution in body fluids in both pre- and post-operative patients. Using radioisotopes, studies were made on the distribution of sodium and potassium between extracellular and non-extracellular phases by serum sampling at appropriate intervals following intravenous administration of a tracer dose of the isotope. Simultaneously, isotope dilution measurements of the body potassium, chiefly intracellular, have been made to determine changes in the ratio of body sodium to body potassium as well as changes in body potassium alone.

There were no questions or discussions of these three papers. "The Absorption of Vitamin B<sub>12</sub> and the Pathogenesis of Vitamin B<sub>12</sub> Deficiency", paper No. 447, by D. L. Mollin and E. Lester-Smith (UK), was presented by Lester-Smith. In these studies Vitamin B<sub>12</sub> containing radioactive Co 58 was used. Co 58 has a half life of 270 days and had been used with safety in amounts up to 5 microcuries. The labeled vitamins were made biosynthetically by small scale fermentations in an almost cobalt-free medium. Patients suffering from various types of anemias were given labeled vitamin B<sub>12</sub> and its absorption and utilization studied.

Paper No. 711 by D. L. Ferdman (Ukr.SSR) presented by R. E. Kavetsky, discussed "The Application of Radioactive Isotopes to the Study of the Biochemistry of Muscles". Studies were made using rabbits

chiefly as the experimental animal. Data were presented on the following: the biochemistry of muscles in the vitamin E - renewal rate of proteins in hyperthreosis; the renewal rate of proteins and phosphoric compounds in tomised muscles; and the renewal rate of proteins in denervated muscles.

P. Saraiya presented paper No. 921 by Saraiya, V. R. Khanolkar and A. R. Gopal-Ayinger (India) on the "Synthesis of 4:4' - Diaminodiphenyl Sulphone - S<sup>35</sup> and Its Use in Leprosy Research". The procedure for synthesizing the compound labeled with sulfur 35 was given. The labeled drug was administered orally to leprosy patients. Radioautographic techniques were used to measure the uptake of the drug by the lepromatous tissue. The radioautographs did not suggest that there had been a preferential incorporation by particular tissue systems. There was indication of a more or less generalized distribution of the radioactive material throughout the tissues.

"Utilization of Nuclear Energy in Public Health Problems on the Epidemiology of Communicable Diseases", paper No. 224, was discussed by Dale W. Jenkins (US). This was a general review paper covering disease transmission by vectors; relation of animal hosts and parasites; insecticide and natural control of vectors; radiation control of vectors and diseases; and air-borne and water-borne diseases. Jenkins said that the use of nuclear energy in studying the epidemiology of communicable diseases offers an extremely promising and fertile field to epidemiologists and other investigators. Additional discoveries of major importance in the field of health were to be expected.

Question: Clark (US) asked Lester-Smith (No. 447) if he would define "loop syndromes". Answer: Lester-Smith replied that he was not the medical partner of the team, but he understood a loop syndrome to be a fluid intestinal diversion or loop.

Question: Cheoskul (Thailand) asked Lester-Smith whether or not they had measured concurrently the Co<sup>58</sup> and biological activity of B<sub>12</sub> in the feces so as to determine whether or not the labeled B<sub>12</sub> had undergone metabolic change. Answer: Lester-Smith pointed out that it was not easy to measure this, B<sub>12</sub> being synthesized in the gastrointestinal tract. Using B<sub>12</sub> labeled with both Co 58 and P 32 they found evidence that B<sub>12</sub> was not degraded to any extent in the digestive tract.

Question: Ross (US) asked Lester-Smith if they had made any studies on the absorption of vitamin B<sub>12</sub> across the respiratory epithelium. Answer: Lester-Smith said they had not made such experiments, but that it would not be unreasonable to expect the vitamin to be adsorbed by this pathway.

A paper by Marino B. Aragao et al., (No. 140), presented by J. Costa-Ribeiro (Brazil), discussed "A New Radioactive Method for Marking Mosquitoes and Its Application". The methods used a nuclear emulsion and had a much higher sensitivity than other methods previously used. In this methods long-lived radioactive elements like thorium and uranium had been used for marking mosquitoes.

Question: Bugher (US) asked Jenkins to comment on applying these methods to tsetse fly control for hypanosomiasis, and anopheles control for malaria. Answer: Jenkins pointed out there were several ways of using radioisotopes for studying tsetse fly control.

Question: Troitsky (USSR) asked about the possibility of labeling bacteria and how such labeled bacteria could be used to solve epidemiological problems. Answer: Jenkins said bacteria had been labeled and pointed out a number of ways labeled bacteria have been used in epidemiological studies.

Question: Gopal-Ayengar (India) asked Jenkins if isotope work had been done (1) on the spread of allergens by using radioisotopes, (2) on the metabolism of tubercle bacillus. Answer: Jenkins said some work has been done following the spread of pollen from plants that had been fed radioisotopes, and referred to some papers cited in his manuscript in reply to other questions.

Question: Jenkins asked Costa-Ribeiro about plans for continuing the disposal of anopheles mosquitoes. Answer: Costa-Ribeiro said he was not working on this problem, but did outline some work using thorium nitrate on Shaga's disease.

SECTION 11C - BIOLOGICAL EFFECTS OF RADIATION:  
MODES OF RADIATION INJURY AND  
RADIATION HAZARDS

by

C. L. Comar

R. Lataiet (France) was Chairman.

A. M. Brues (US) presented paper No. 82, "Commentary on the Modes of Radiation Injury", in which he emphasized that information was needed to establish firm values of permissible dosage, and also to find means of protection against, and treatment for, radiation injury. He reviewed the various modes of radiation injury: bone marrow effect; lymphocyte and immunological function; gastrointestinal tract effects; sterility; loss of hair; secondary metabolic changes; genetic effects; localized responses and others. He concluded that permissible levels now employed for total body irradiation were justified but values where only a part of the body was involved might be too conservative.

E. Rock Carling (UK) next presented paper No. 450, "Modes of Radiation Injury--Medical Aspects", giving a general description of information requirements and the philosophy of the physician who must treat patients exposed to radiation injury. Education and apparatus design could do much to minimize exposure, but accidents did occur. The safety record in nuclear establishments had been better than in comparable industrial establishments.

Rock Carling said, "To the non-geneticists it appears that for the benefit of the race as a whole in the future, one mutation which results in an Aristotle, a Leonardo, a Newton, a Gauss, a Pasteur, an Einstein, might well outweigh ninety-nine that led to mental defectives."

V. L. Troitsky (USSR) presented paper No. 692 by L. A. Pigalyev (Some Aspects of the Immunity of the Organism Exposed to Action of Ionizing Radiation") saying that since radiation sickness was often complicated by infection, it was important to study the immunity of an organism exposed to radiation and infected with germs. In general, x-irradiation produced a decline in natural resistance to infections.

In a study of relationships between administered tetanus toxin and polonium it was demonstrated that the response to polonium was increased whereas the tetanus symptoms were decreased. Studies were reported on comparative effects of radiation on fully formed immunity and on immunogenesis. In general, immunogenesis was inhibited while there was little or no effect on fully formed immunity. Internal radiation from polonium

or radio-thorium gave the same results as did external irradiation.

Discussion: Gustaffson (Sweden) objected to Rock-Carling's statement on genius vs. mental defectives. Detrimental results were easily brought about; to produce genius required much more: a summation of good effects. He stated there was great difference between these two. Russell (US) stated it is not necessarily beneficial to man to increase the mutation rate. Answer: Rock-Carling replied he had wanted and was glad to have on the record these statements by geneticists.

Question: Brues (US) asked whether combined treatment produced the pathology of the toxin or of the radioelement. Answer: Troitsky replied that there was radiation sickness due to polonium, but tetanus symptoms were observed later than in the control animal. Guinea pigs died earlier on account of the toxin; those with toxin alone survived, whereas those getting toxin plus polonium died.

Question: Cambel (Turkey) asked what enzymes besides sulfhydryl were affected by radiation and inquired about alkaline phosphatase. Answer: Brues replied that since radiation affected proteins, we should expect enzyme to be affected. Alkaline phosphatase appeared to be less sensitive to radiation than other enzymes.

Question: Costachel (Romania) stated that the nervous system was important in radiation response, and that narcosis would reduce biological effects. This might be a way of increasing doses used in radiotherapy.

W. F. Neumann (US) presented paper No. 847, "The Use of Isotopes in Study of Skeletal Physiology and Metabolism," which described the nature of bone with emphasis on the processes by which bone-seeking isotopes became deposited in the skeleton. The physical processes were exchange, diffusion, and recrystallization, while the biological processes were bone growth, resorption, and remodeling of Haversian systems. Exchange and diffusion were reversible whereas the others were irreversible. The difficulties in removing skeletally deposited radioisotopes were caused by the irreversibility of these processes.

F. E. Hoecker (US) presented his paper No. 88 "The Deposition of Radioactive Substances in Bone." A new technique for dating radioactive deposits in bone by concurrent injections of radioactive substance and alizarin red was described; it was thereby shown that these substances were found only in bone being formed at the time of entry of these substances. In general, the higher the atomic number of the alkali earth, the smaller the placental transfer. Lactation studies indicated that a negative calcium balance induced before or shortly after deposition could reduce the retention of the bone-seeker.

D. E. Clark (US) presented paper No. 242, "The Association of Irradiation with Cancer of the Thyroid in Children and Adolescents." Fifteen cases of thyroid carcinoma in children up to 15 years of age were reported. Each case had received x-irradiation in infancy or early childhood. The total dose ranged from 200 to 725 r and the period between irradiation and diagnosis averaged 6 to 9 years. Statistics showed that thyroid carcinoma was increasing and this appeared to be correlated with prior X-ray treatment for such conditions as enlarged thymus, enlarged tonsils and adenoids, cervical adenitis and benign pulmonary conditions.

Question: Loutit (UK) asked if there were any hope of either preventing skeletally deposited radioactivity or causing removal.

Answer: Neumann replied there might be hope if it were possible to stop the growth processes, but this seemed unlikely. To prevent deposition and to cause removal very quick action would be needed.

Question: Bacq (Belgium) asked if Neumann could explain chemical analyses of bone which showed a higher Ca/p ratio than theoretically expected. Answer: Neumann replied that lattice was capable of wide variations in composition due to defects and surface adsorption.

Question: Copp (Canada) stated that studies indicated that isotopes were deposited in bone as quickly as brought there and that work in which he was associated had not been able to bring about removal by a negative calcium balance. Answer: Hoecker agreed in regard to old deposits, but said that negative calcium balance, induced shortly after acquisition, could accomplish removal.

Question: Ara (Cuba) said that it was desirable to know more about the metabolism of calcium and other radioisotopes in humans and asked whether serial biopsies and autoradiograms would be useful. Answer: Hoecker said human data were from old specimens from Martland. There was always the problem of how to extrapolate from animal experiments to humans.

Question: Tubiana (France) asked about the relation between thyroid carcinoma in adults and previous irradiation. Answer: Clark answered that these studies were not yet complete and that it was difficult to get early histories for adults.

Question: Stanley (Australia) asked if he had any figures for uptake of  $I^{131}$  by the carcinoma? Answer: Clark replied that they used a biopsy technique and if there were good localization, they treated with  $I^{131}$ .

Liane B. Russell (US) presented her paper No. 77, "Hazards to the Embryo and Fetus from Ionizing Radiation." Experiments with mice indicated that the potential radiation hazard was greatest during the period of major organogenesis. In applying these findings to the human, it was recommended that pelvic irradiation of women of child-bearing age should be restricted to the 2 weeks following the menses, when there was little chance of an unsuspected pregnancy. The present permissible weekly dose did not appear to constitute a measurable hazard at any stage in pregnancy.

G. W. Casarett presented his paper, No. 257, "Effects of Daily Low Doses of X-rays on Spermatogenesis in Dogs." He found that in general 0.6 r/day of X-rays produced in dogs a progressive decline in absolute sperm count after the 20th to 30th weeks of exposure. Most of the dogs have proven infertile in testmating. No effects have been demonstrated as yet in the 0.3 r/week and 0.6 r/week dogs after radiation exposures of from 20 to 4 years.

H. Fritz-Niggli, Switzerland, presented her paper, No. 1070, "Dominant Lethal Factors and Embryonic Mortality After Irradiation at 180 Kev and 31 Mev." Drosophila were used to study the effect of 3000 r on spermatogenesis. Hatchability was definitely decreased, with 180 Kev radiation more effective. The greatest decrease was observed in the second brood period (5-7 days). The maturing spermatids appeared to be the most sensitive.

Question: Cambel (Turkey) stated that in general she had seen the same results as Russell, but in the same litters had had some normal and some abnormal offspring. She also had one patient in which no effect on offspring were observed, although the mother received radiation during pregnancy. Answer: Russell stated there was not always 100% incidence either within litters or between litters. This might be due to probability relations and also to slight difference in developmental age.

Question: Somerwil (Netherlands) asked whether studies on the recovery of fertility in dogs had been done. Answer: Casarett stated that in the reported experiment the dogs would be irradiated throughout life. Other experiments were under way for recovery data, but results were not yet available.

Section 12C - Biological Effects of Radiation (continued) -  
Mechanisms of Radiation Injury; Protection and  
Recovery

by A. Hollaender

Z. Bacq (Belgium) was Chairman.

The first paper, No. 899, "Biological Damage Resulting from Exposure to Ionizing Radiations" by L. H. Gray (UK) discussed radiation damage mainly from the physical point of view.

Gray reviewed the mechanism of the use of isotopes in biological research and discussed the effect of density of ionization on the biological effectiveness of different types of radiation. He emphasized variation among the different biological mechanisms upset by radiation, with special emphasis on the different stages of mitosis, the function of respiration, and the synthesis of nucleic acids. He brought out that the actual step from the changes produced by radiation in water to the biological response was poorly understood, and finally he discussed certain of these aspects in relation to the oxygen effect.

Alexander Haddow (UK), paper No. 898, "Comparative Studies of the Biological Effects of Radiation and of Radiomimetic Chemical Agents, compared the biological effects of ionizing radiation with the radiomimetic chemical agents. He related the structure of these compounds to their biological effectiveness and showed that certain groups were necessary for the effectiveness of these compounds. He illustrated the function of the compounds and the effect on hair pigmentation, inhibition of growth, carcinogenesis, mutation production, cytological changes and their action on natural and synthetic macromolecules. He discussed the cytological effects in greater detail on the basis of work done at the Chester Beatty Institute.

Paper No. 904, "Cytological and Cytochemical Effects of Radiation in Actively Proliferating Biological Systems" was presented by A. Gopal-Ayengar (India). He illustrated his talk with many slides showing differences in the chromosomes of ascites tumors, bean roots, and related materials.

N. M. Sissakian (USSR), presenting his paper No. 691, "On the Nature of Changes in Metabolism Under Irradiation Effects", discussed the nature of the basic changes of the biological materials and the effects of ionizing radiation. Whereas individual enzyme systems in vitro were very resistant to radiation, the mechanism of synthesizing the enzymes which were responsible for saccharose, proteins and nuclei

production was much less resistant. The nucleic acid production was changed by 5000 r, proteins by 20,000 r and saccharose by 30,000 r. When plants grew older they became much more resistant to radiation. Sissakian believed that the alterations in nucleic acid synthesis were easily reversible. He emphasized the great importance of metabolism and the interaction among different synthesizing systems which could be easily upset by radiation.

Sissakian also read a paper, No. 690 by M. N. Meissel (USSR) on the "Biological Effects of Ionizing Radiation on Micro-Organisms".

R. Latarjet (France) discussed paper No. 371, "The Problem of the Biological Action of Low Doses of Ionizing Radiation" by H. Markovich, his co-worker, on various effects of low dosage of ionizing radiation on lysogenic bacteria. He found the lysogenic process extremely sensitive to radiation and one roentgen or possibly less will initiate the process. Since the process was so extremely sensitive he thought he might be able to detect the different levels of cosmic radiation at sea level and at high altitude; for this reason he had carried several flasks of lysogenic bacteria to the top of Mont Blanc which he would collect again next summer.

Question: Caldecott (US) asked Sissakian why the concentration of S-H<sub>2</sub> groups was so high after exposure to radiation. Answer: Sissakian pointed out that insects were extremely resistant to radiation. If the same mechanism of radiation damage were involved in all the different kinds of organisms, why did such tremendous variation exist in sensitivity?

The next paper, No. 78, "Studies on Protection by Treatment Before and After Exposure to X- and Gamma Radiation", by A. Hollaender and G. E. Stapleton, was given by Hollaender (US), based on work on the mechanism of protection against radiation damage. After a review of protection of bacteria by chemical compounds and the support of the recovery of nutrilites, the action of the four compounds was compared: cysteine, B-Mercaptoethylamine, S-B Aminoethylisothiuronium, and Tyramine.

It was typical for all these four compounds that they had the NH<sub>2</sub> group. The most successful ones were cysteamine and thiuronium. The latter seemed to be of considerable promise since it was quite stable in air and had relatively low toxicity. The last part of the paper reported the observation that in bacteria the mutation rates produced by radiation were not necessarily proportional to the amount of radiation absorbed, but rather inverse in proportion to the survival ration. The possible implication of this finding was discussed.

J. Maisin (Belgium) discussed protective action of cysteamine on mammals in his paper, No. 940, "Tissue and Cell Damage Due to Radiation; Their Consequences and Their Repair". He reviewed the work of his group and the protection produced by shielding the liver against radiation in his more clinical approaches to this problem.

Several questions were asked about why the oxidized as well as the unoxidized form of cysteamine protected under certain circumstances. Gray explained that the cysteamine could be reduced in the animal body and did become protective. Since bacteria were not able to reduce this compound, cysteamine gave them little protection.

Fritz-Niggli (Switzerland), in commenting on Sissakian's paper, reported the detection of changes in enzymes by direct observation of the oxygen consumption in tissues. She believed she was able to recognize changes in the citric acid cycle.

A scheduled paper, No. 932, "The Scope of Chemical Protection against Ionizing Radiation in Mammals" by D. W. Van Bekkum and J. A. Cohen (Netherlands) was not presented.

SECTION 13C - Biological Effects of Radiation: Genetic Effects;  
Human Implications Radioactive Isotopes and Ionizing  
Radiations in Agriculture--Radiation-induced  
Genetic Changes and Crop Improvement

by

B. Wallace, and Richard S. Caldecott

Section 13 of the Conference was divided into two parts, the first dealing with human genetics, chaired by T. Kemp (Denmark), the second with crop improvements through radiation-induced genetic changes, chaired by A. Gustafsson (Sweden).

In presenting paper No. 238, "The Genetic Structure of Mendelian Populations and its Bearing on Radiation Problems", B. Wallace (US) emphasized the importance of heterosis and polymorphism, rather than the highly uniform genetic structure generally ascribed to species, and the large proportion of homozygous individuals resulting from such a structure. Starting with the idea that a species could be equated with the museum type-specimen, Wallace followed the breakdown of "typical" thinking to the term "allels" itself. Supposedly identical "wild-type" alleles have upon closer analysis been shown to be different (iso-alleles). Polymorphism has been found to be extremely common in many groups. Wallace summarized the evidence that supported the thesis that polymorphism was the rule -- not the exception -- and that wild type individuals were largely heterozygous. The implication of this concept for radiation problems was that genes were acted upon by selection in heterozygous individuals to a greater than was generally recognized. If a gene were deleterious in the heterozygous condition, it would be eliminated from a population rather rapidly; if it were beneficial, no matter how rare, it would be favored by selection.

This concept was not contrary to the humanitarian view that needless irradiation should be kept to an absolute minimum, Wallace said. In the process of elimination of deleterious genes, harm occurred to some individuals. In fairness to these individuals, the numbers of deleterious genes must be kept as low as possible.

In paper No. 235, "Genetics Effects of Radiation in Mice and Their Bearing on Estimation of Human Hazards", W. L. Russell (US) discussed investigations into mutation rates in mice and the harm resulting from these mutations. Russell reported a lower mutation rate of irradiated spermatogonial cells as compared to the mature sperm. From this observation it was recommended that males exposed accidentally to

high doses of irradiation should refrain from procreation for five weeks after exposure so that exposed sperm would become eliminated and new sperm would have formed from irradiated spermatogonia. Not all mutations could be eliminated by this technique; Russell emphasized that further elimination through intercellular selection seemed to be absent.

Russell pointed out that mice irradiated with 300 r produced, on the average, 3% to 4% fewer offspring than unirradiated males. This might indicate the effect of slightly deleterious genes and, hence, reflected a not inconsiderable drop in overall viability of first generation individuals.

In paper No. 449 "The Genetic Problem of Irradiated Human Populations", T. C. Carter (UK) introduced the concept that human societies accepted harm to a few or a slight harm to many, if these resulted from some activity that conferred good to the multitude. He pointed out that the great concern over radiation effects stemmed from our inability to predict the amount of harm and, hence, to weigh the harm against the good. He pointed out that more research was needed in population genetics to test the models developed on theoretical grounds. He stated that more research on mutations was necessary -- especially research dealing with low levels of irradiation. He believed that the populations of areas rich in granite-bearing rock which had higher radioactivity could be contrasted with those of areas deficient in this type of material to discover differences in mutation rates.

Question: Ehrenberg (Sweden) stated that barley had been exposed to chronic irradiation in Sweden and certain mutation rates found. Were these data comparable to the information in mice? Answer: Russell said in general yes, but that he did not really have comparable treatments.

Question: Wallace (US) stated that Russell had mentioned a lack of elimination of mutations as irradiated males aged. He asked for the rate of elimination still consistent with the data. Answer: Russell said that the analyses were not yet far enough along to say.

Question: Bacq (Belgium) asked if there were evidence of a genetic recovery. Answer: Russell replied that there was not.

Gustafsson, as chairman, opened the second part of the section with a statement emphasizing that 99% of all mutations obtained by irradiating plant material were deleterious. With plant populations this was no particular problem because there was no remorse over "mass-killing" of an experimental field to obtain one beneficial mutant.

The first paper was No. 110, "The Contribution of Radiation Genetics to Crop Improvement" by W. R. Singleton et al. (US). The significant researches of Swedish scientists were referred to as it was mentioned that they had been able to increase yields of agricultural crops in addition to obtaining stiffer straw and earlier ripening cereals. Gregory (North Carolina) had been able to induce disease resistance in peanuts. At Brookhaven Laboratory, Konzak had induced resistance to stem rust and *Helminthosporium* in some of his oat material.

Singleton showed that proper utilization of a  $\text{Co}^{60}$  source could augment the production of mutations in *Zea mays*. This could be a very significant contribution if the beneficial mutations occurred often enough to be worked with by practical breeders. There was every reason to think this would be the case.

In the second paper, No. 890, "Studies on Genetic Effects in Plants of Chronic Gamma-Radiation", Mikaelson (Norway) mentioned that  $\text{Ir}^{192}$  and  $\text{Co}^{60}$  had been installed in a field for irradiating plant material. He conducted some important studies on the frequency of chromosome aberrations resulting from chronic irradiation of *Tradescantia* and showed that, per r unit, chronic radiation was more effective at breaking chromosomes than acute irradiation. Relatively small doses of chronic radiation produced a high frequency of chronic radiation produced a high frequency of chlorophyll mutations in barley. A rather high frequency of variability in flower characters and abnormal development of flower parts was another manifestation of chronic radiation of *Tradescantia*. There was every reason to believe that promising new horticultural species might be developed using this method.

In presenting paper, No. 793, "The Production of Beneficial New Hereditary Traits by Means of Ionizing Radiation", by L. Ehrenberg et al., (Sweden) Ehrenberg stated that recent studies in Sweden had again emphasized that induced mutations were an important tool in plant breeding. It was shown that mutations of a beneficial nature might accompany chromosome anomalies, and Ehrenberg expressed a view that a complete modification of species, as to type, would be possible. Some mutants produced had greater ecological ranges than conventionally derived varieties, and it was noteworthy that mutants of the "bright-green" barley required less nitrogen fertilizer than did normal colored varieties. In addition, the bright green mutations evidenced a greater resistance toward certain fungi than did the mother strain. The variety of sweet lupine now cultivated in Sweden arose from a radiation-induced mutation.

A radiation-induced mutant of white mustard, released in Sweden, had a higher grain and oil yield than the original strain, and was now the principal commercial strain grown in Sweden. In addition to those mentioned numerous other mutants in barley, wheat, peas, and lupine were being tested in large scale experiments.

In one institute in Sweden, techniques had been worked out to help increase the frequency in which bud sports were induced in fruit trees.

In the fourth paper, No. 101, "Ionizing Radiations as a Tool for Plant Breeders", R. S. Caldecott (US) placed some emphasis on the need for increasing our knowledge of the action of ionizing radiations in seeds and other plant organs. He discussed a number of studies in which an attempt was made to modify their radiosensitivity. The sensitivity of seeds to x-rays could be strikingly modified by hydration and oxygenation but this had not been demonstrated with neutrons.

The studies showed that more mutations and chromosomal aberrations per unit survival could be induced with densely ionizing radiations than with sparsely ionizing radiations. In addition, plants from seeds subjected to neutrons were more uniformly injured. Caldecott particularly emphasized the need for strong support of basic research programs in agricultural institutions to provide the plant breeder with maximum numbers of induced beneficial mutations.

Question: Savalescu (Romania) asked whether or not the disease resistant plants reported by Singleton had been examined morphologically for characteristics of biological significance which were modified by the radiation. Answer: Singleton said that such studies had been undertaken but that they were anticipated.

Question: Bonet-Maury (France) was particularly interested in ion density and the mutations induced from densely ionizing radiations. He asked Whrenberg about the mechanism of such radiation. Answer: Ehrenberg replied that it was a most important question but not too much could be said about it at this time.

Question: Lester-Smith (UK) asked how useful isotopes might be in a plant breeding program. Answer: Singleton indicated that the only studies he was familiar with were in Neurospora but that the subject should be further investigated.

Question: Roche (Venezuela) asked whether or not there was information on the electrolytic content of hydrated seeds. Answer: Caldecott said he had no data.

SECTION 14C - Radioactive Isotopes and Ionizing  
Radiations in Agriculture -  
Tracer Studies in Agriculture

by

E. Epstein

The Chairman, V. F. Kuprevich, (Bye. SSR) spoke briefly on the utility of the tracer tracer technique for elucidating many kinds of problems in agriculture and biology.

Paper, No. 10, "Studies of Special Problems in Agriculture and Silviculture by the Use of Radioisotopes," by J. W. T. Spinks (Canada), surveyed Canadian experience. After briefly reviewing general principals and questions of methodology, Spinks described typical results of tracer fertilizer experiments. The stage of growth of the crop, its type and variety, the type of soil, placement of the fertilizer, the type of fertilizer and its rate of application, were factors which influenced the uptake of the fertilizer by the crop. He said radiation damage seemed slight at the levels of radioactivity commonly applied.

The available soil phosphorus (A) could be measured by comparing the percentage of P from the soil with that from (tagged) fertilizer, using the Fried and Dean equation

$$A = \left( \frac{\text{rate of application of fertilizer X} \left( \frac{\% \text{ P from soil}}{\% \text{ P from fertilizer}} \right)}{\left( \frac{\% \text{ P from soil}}{\% \text{ P from fertilizer}} \right)} \right)$$

Spinks next discussed diffusion of ions in the soil, saying that tagging provided the only means of determining the path of fertilizer phosphorus. Measurement of soil moisture by means of a neutron flux provided an alternative to conventional methods.

Spinks concluded by discussing radioactive tagging of insects and pests, and the gross movement of nutrients in trees.

S. Mitsui (Japan) presented paper No. 1049, "Studies on Plant Nutrition, Fertilizers and Soil by Use of Radioactive Isotopes." He found little loss of P<sup>32</sup> from rice plants under normal conditions, but hydrogen sulfide severely interfered with normal phosphorus movement and retention. Foliar absorption of P<sup>32</sup> by rice and other crops was demonstrated. Field studies on a moderate scale, using P<sup>32</sup>, have been conducted, demonstrating very limited movement of the applied P<sup>32</sup> in the soil. Mitsui concluded with a consideration of various technical and methodological problems.

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E. Epstein (US) presented paper No. 112 by Epstein and Hendricks, "Uptake and Transport of Mineral Nutrients in Plant Root." Using excised barley roots and various radioactively tagged inorganic ions, they demonstrated three modes of uptake; ion exchange, diffusion, and active transport. Of these, the first two were passive, and reversible, whereas the third involved metabolic activity on the part of the tissue. A hypothesis was advanced, and evidence presented, that this active transport involved the attachment of the ions to metabolically generated "carriers." Active transport was shown to be specific in regard to the ions taken up and their mutual interference.

R. Scott Russell (UK) presented paper (No. 460) by Russell et al., on "Factors Affecting the Availability to Plants of Soil Phosphates." Russell described two methods for estimating labile soil phosphate by means of P 32: isotopically exchangeable soil phosphate referred to as the "E" value, and the "A" value already described by Spinks. Russell took issue with the interpretation of the latter value as the "available" soil phosphorus, and referred to this value as the "L" (Larsen) value. For each soil used, absorption of phosphorus by plants increased approximately linearly with both the "E" and "L" values, when aliquots of a soil to which different quantities of phosphate had been added were compared. This relationship did not, however, hold when different soils were compared.

Because of the greater ease of determining the "E" as compared with the "L" value, Russell expressed a preference for the former.

V. M. Kletchkovak (USSR) presented paper No. 694 on "The Use of Tracer Atoms in Studying the Application of Fertilizers." Kletchkovak stressed the possibility of distinguishing by labeling between applied and soil fertilizer elements. He stated that densely spaced grains of superphosphate resulted in optimal utilization of the applied phosphate by young plants whose root systems were as yet poorly developed. At later stages, better results were obtained from larger, more widely spaced granules because under those conditions, fixation of the added phosphate by the soil was minimized.

Depth of application in the soil was an important factor. Best results were obtained by a combination of two types of placement: one at slight depth before sowing to give the young seedlings a source of nutrients at an early stage of development; another more massive application plowed under, to supply the plant during the remainder of its growth.

Kletchkovsky concluded with a brief consideration of experiments on foliar application of fertilizers.

A. V. Sokolov (USSR) in paper No. 695, "Determination of the Assimilation Capacity of Soil Phosphates and Fertilizers with the Aid of Radioactive Isotopes of Phosphorus" stated phosphatic fertilizers might give different results depending on the type of soil, and that addition of phosphatic fertilizer might substantially reduce the relative uptake of native soil phosphate.

Sokolov discussed the use and limitations of the value described earlier in the session as the "A" (Spinks) or "L" (Russell) value. He also considered the equilibrium between solid phase and liquid phase phosphorus, which could be studied by adding amounts of  $P^{32}$  so small as not to disturb the ratio between the two quantities.

O. K. Kedrov-Zikhman (Bye. SSR) presented a paper (No. 716) on " $Co^{60}$  in the Study of the Role of Cobalt as a Micro-Element in Plant Nutrition." He stated that there was an erroneous opinion in the world literature that cobalt fertilizers had no significance for agriculture, but that this opinion had been refuted in the Bye. SSR. He reported various agricultural crops were observed. The effects depended on the quantity of lime applied, Cobalt being positive in the presence of lime, and negative in its absence. He also claimed positive effects due to the radiation from  $Co^{60}$ .

H. B. Tukey (US) in presenting paper No. 106, "Utilization of Radioactive Isotopes in Resolving the Effectiveness of Foliar Absorption of Plant Nutrients" described studies which he and several collaborators made by means of radioactive isotopes. Radioactive mineral nutrients were readily absorbed where applied to leaf, stem, and fruit surfaces, and even through the bark of dormant trees. The leaf, however, was the most important organ for entry of nutrients. Movement of mobile elements, such as nitrogen, phosphorus, potassium, and rubidium, after the application of their radioisotopes to the leaves, was comparable in rate to the movement of the same elements absorbed through the roots. Calcium, on the other hand, did not move in the direction of the root (basipetally).

Not only trees, but herbaceous plants as well could absorb and translocate nutrients in this manner.

Tukey discussed a number of factors which affected foliar absorption of nutrients - temperature, light, pH, and carrier of the solutions used, as well as various characteristics of the plant treated. Tukey finally discussed foliar applications of  $C^{14}$  urea and the loss of nutrients from the leaves through leaching.

A. J. Riker (US) presented paper No. 105, "The Use of Radioactive Isotopes to Ascertain the Role of Root-Grafting in the Translocation of Water, Nutrients and Disease Inducing Organisms Among

Forest Trees" embodying work by J. E. Kuntz, Riker and others. Radioactive isotopes were used to trace the movement of materials in the sap streams within and among trees. The experiments and observations indicated, for some species, a widespread occurrence of root grafts by which the vascular systems of many trees were connected. These findings have interesting implications for the study of disease susceptibility, mineral nutrition, and other aspects of tree growth. Movement of substances within individual trees was studied also, and marked differences were observed between species.

Question: Tukey (US) asked about the scope of foliar nutrient studies. Answer: Kelchkovski (USSR) said foliar application of nutrients was being used on thousands of hectares. It was particularly valuable for plants on poorer types of soil. Klechkovski answering a question by Schuffelen (Netherlands) said the amounts and distribution of rainfall were important considerations in the placement of fertilizers.

Question: Epstein (US) asked whether positive effects on crops from the application of cobalt to the soil were considered adequate evidence for classifying cobalt as an essential plant nutrient. Answer: Kedrov-Zikhman (ByeSSR) answered in the affirmative for those cases where the responses were specific to cobalt.

SECTION 15C - Radioactive Isotopes in Physiology and Biochemistry: Animal  
Physiology and Plant Biochemistry.

by C. L. Comar and M. Calvin

Section 15C of the Conference was divided into two parts, the first, dealing with animal studies, chaired by A. V. Palledin (U.S.S.R.); the second, dealing with plants, presided over by the Vice-Chairman, E. C. Wassink (Netherlands).

C. L. Comar opened the first part with his paper, No. 90, "Radioisotopes in Animal Physiology and Nutrition-Mineral Metabolism" in which an overall mechanism for calcium ion movement in the body was presented. The data explained the rapid deposition of such bone-seekers as calcium, radium and strontium in the skeleton and the difficulties in their subsequent removal. The importance of the endogenous fecal loss was presented both from the viewpoint of removal of bone-seekers and utilization in nutritional studies. As an example of nutritional application it was shown that cattle adapted to a sub-optimum calcium diet by a reduction in the fecal endogenous loss. Also, it was demonstrated that milk was greatly superior to hay and grain as a source of calcium for calves.

Methods were described for the simultaneous estimation of fecal endogenous calcium and phosphorus as well as total digestive juice calcium and phosphorus.

H. H. Ussing (Denmark) presented paper No. 908 "Use of Isotopes in Permeability Studies." Methods were described for measuring the transport of radioisotopes such as  $\text{Na}^{22}$  and  $\text{Na}^{24}$  through frog skin and, at the same time, measuring potential differences and electric currents. There was an identity between active Na transport and electric current output which indicated that the active Na transport was the sole source of electric asymmetry. It was concluded that the operating force was of chemical nature. In studying the effects of neurohypophyseal it was shown that (a) osmosis through a living membrane could be of the type of bulk flow, (b) the layer acted upon by the hormone was provided with pores, (c) the hormone acted by increasing the pore size.

Question: Pora (Romania) asked if Comar had taken into account such variables as Vitamin D and parathormone, and had radioisotopes been used to study the effects of these substances on mineral metabolism.

Answer: Comar replied that all the studies described were carried out with animals on normal diets with respect to Vitamin D and hormones. Radioisotopes had been widely used to study these substances. For example, the effects of parathormone in removing calcium and phosphorus from bone, in causing increased urinary phosphorus excretion, and in causing accumulation of calcium in the kidney had been clearly demonstrated by use of the isotope.

Question: Hastings (US) asked what the effect was of pH, K and Ca on the drag force? Answer: Ussing remarked that these had not been studied in detail. However, the hormone was optimally effective between pH 7 and 9.

Question: Bergmann (Israel) asked if the influence of glyceric acid on ion transport had been studied. Answer: Ussing replied in the negative, but that it was a good idea.

C. Blincoc (US) then presented paper No. 275 "Use of  $I^{131}$  in Study of the Influence of Climatic Factors on Thyroid Activity and Productivity of Livestock," prepared by Blincoc and S. Brody. Methods were described for measuring thyroid activity as follows: (a) maximum thyroidal uptake of  $I^{131}$ , (b) rate of thyroidal uptake of  $I^{131}$ , (c) rate of thyroidal release of  $I^{131}$  and (d) time changes in thyroxine  $I^{131}$  in plasma.

The larger the animal and the higher the production level, the greater was the decrease with rising temperature in thyroid activity, heat production, and milk production. India-evolved cows showed less thyroid changes at high temperature than did Europe-evolved cows.

A. Jentzer (Switzerland) then presented an unscheduled paper No. 119, "Problems Related to the Posterior Hypophysis Studied by Radioactivity." It was demonstrated that the posterior hypophysis would accumulate thyroxine  $I^{131}$  and that this accumulation was markedly affected by induction of hibernation or anesthesia.

G. Mitsui (Japan) presented paper No. 1047 by R. Sasaki, "Studies on the Metabolism of Calcium and Phosphorus in the Laying Hen," describing detailed experiments in which  $Ca^{45}$  or  $p^{32}$  were administered to hens or eggs and the movement followed into the various compartments. Most of the calcium required for egg formation was derived from the feed. The calcium required for the developing embryo comes from the yolk but to a greater extent from the shell.

Paper No. 697 "Tracer Atoms Used to Study the Products of Photosynthesis Depending on the Conditions Under which the Process Takes Place" by A. A. Nichiporovich (USSR), presented by A. M. Kuniz, consisted of an empirical extension of the observation that amino-acids and proteins were products of the transformation of the very earliest primary products of photosynthesis. Kuniz reported that blue light promoted amino-acid and protein synthesis, as contrasted to red light which was supposed to favor carbohydrate formation. The explanation offered was based upon the photosynthetic cycle which was described in the next paper No. 259, "The Photosynthetic Cycle" by M. Calvin and J. A. Bassham, published in its entirety in 1953 (UCRL) and in JACS 76 - 1760 (1954).

Question: Calvin, (US) asked if the suggestion were made that there might exist a major port of entry of carbon (in substantial non-catalytic amounts) into the reduced material of the plant other than the carboxylation of RuDP to PGA, as was suggested in the text; if so, what was it and under what conditions did it function. Answer: Kuzin answered that no other point of entry was proposed other than that given in the "photosynthetic cycle."

Question: Calvin (US) remarked that in view of the known dependence of the nature of the secondary products formed (protein, fat, carbohydrate) upon the overall light intensity, had the comparison between the effects of blue light (filtered Hg arc) and red light (incandescent lamp) been made at the same incident quantum rate? Answer: Kuzin replied: Yes.

Paper No. 715, "C-14 in the Study of the Biosynthesis of Chlorophyll" by T. I. Godnev and A. A. Shlyk (Bye.SSR) reported a set of experiments in which plants were fed both C<sup>14</sup>O<sub>2</sub> and C<sup>14</sup> acetate.

Question: G. Burr (US) questioned the quantitative significance of the 19-day life of the chlorophyll molecule reported by Godnev in view of the known and expected dependence of the turnover rates of such molecules upon environmental conditions such as light, which were not reported. Answer: Godnev stated that he recognized such control by environmental conditions and indicated some observations of different turnover rates under different field conditions. Details were not given.

Paper, No. 459, "Some Aspects of Sucrose Metabolism in Plants" by H. K. Porter and J. Edelman (UK) reported using sucrose labelled selectively in either half (glucose or fructose) of the molecule, the relationship between this disacharride and the free hexoses, oligosacharrides and starch had been studied, as they were interconverted by various enzymes. He reported that sucrose acted by a trans-fructosidation mechanism and not through the free hexoses.

SECTION 16C - Radioactive Isotopes in Physiology  
and Biochemistry: - General  
Biochemistry

by

D. E. Koshland, Jr.

The section was called to order by Chairman Hans Ussing (Denmark).

Paper, No. 456, "Some Recent Applications of Tritium in Biological Research", by R. F. Glascock (UK), described a new method of tritium analysis in which the tritiated water was reacted with butyl magnesium bromide to produce butane. The method, particularly valuable for multiple labeling experiments, was applied to studies of fatty acid synthesis. It was shown that, in agreement with theory, the isotopic ratio, tritium to deuterium, was different at a site of net synthesis than at a site at which only turnover was occurring. Double labeling experiments were also used to show that insulin and glycerol stimulate fatty acid synthesis by independent mechanisms.

The next paper, No. 710, presented by A. V. Palladin (Ukr. SSR) and titled "Use of Radioactive Isotopes in the Study of the Functional Biochemistry of the Brain" by Palladin and G. E. Vladimirov, reviewed the work of many institutes on turnover studies in brain tissue. Using radioactive carbon and phosphorus, experiments found that turnover of protein proceeded more rapidly in the functionally complex and phylogenetically young sections of the central nervous system than in the older and simpler parts. Another conclusion was that excitation increased incorporation of  $P^{32}$  into ribonucleic acid, phospholipides, etc., whereas narcosis caused a decrease in this incorporation.

Next, D. E. Koshland, Jr. (US) presented paper No. 262, "Use of Isotopes in the Study of Enzyme Mechanisms", which described two general types of isotopic use in this field: (a) the use of a labeled atom to delineate the type of enzyme-substrate intermediate in a complex enzymatic reaction and (b) the use of isotopes to substantiate a theory on the nature of enzyme catalysis. The first application was to the problem of peptide bond formation and established that in the synthesis of glutamine a phosphorylated intermediate must be involved. The second application was to a theoretical prediction of bond-splitting which was supported by isotopic experiments with invertase and beta glucosidase. The theory thus supported was that the orientation of the catalytic groups was a major factor in enzyme catalysis.

A paper by F. J. Dixon (US), "The Role of Radioactive Isotopes in Immunological Investigation", described the application of  $S^{35}$  and  $I^{131}$  to studies on immunity. The tracer studies showed that antibody synthesis in the primary response was maximum near the end of the period when antigens could be detected in the host, and this rate decreased precipitously to negligible levels shortly after the antigen could no longer be detected. In contrast, during the secondary response antibody synthesis was demonstrable for long after the elimination of the antigen.

E. D. Bergman (Israel) presented the next paper, No. 776 for B. Shapiro and G. Rose, "Application of  $C^{14}$ -Labelled Substances in the Study of Adipose Tissue Metabolism". Bergman described the use of radioactive substrates which showed that lower fatty acids were activated at a considerably slower rate than the higher fatty acids. Starved rate increased glycogen synthesis due to a block in the catabolism of glucose beyond the glucose phosphate stage, and a diversion to glycogen synthesis.

P. Fromageot (France) presented paper No. 377, "Utilization of Sulphites by Higher Animals", by Fromageot and F. Cahpeville. Reactions paralleling the carbon dioxide fixation and transamination reactions were observed for  $SO_2$  and sulphur compounds. In accordance with deductions by analogy it was possible to isolate cysteinesulfinic acid formed by transamination from sulfinylpyruvic acid.

Paper No. 686, "Investigation of the Incorporation of Amino Acids into Proteins In Vivo and In vitro", by V. N. Orekhovich, presented by A. M. Kuzin (USSR), described the incorporation of labeled amino acids into proteins. In chicken eggs the tracer studies showed that the proteins of the yolk and the white of the egg did not incorporate radioactive carbon, whereas the embryo proteins did. In guinea pigs it was shown that healthy pigs incorporated the  $C^{14}$  of labeled glycine into their collagen and procollagen, whereas scorbutic animals did not. The authors concluded that incorporation of amine acids occurred only in the course of synthesis of the proteins and not as a result of renewal.

Paper No. 260, presented by G. B. Brown, "Pathways of Biosynthesis of Nucleic Acids", described using two or three isotopes and determining that the purine ring remained intact during certain metabolic transformations. Likewise the pyrimidine-riboside moiety was transferred intact, but the phosphate was metabolized independently. Direct conversion of ribosyl to deoxyriboxyl derivatives was indicated by comparison of isotopic ratios.

The final paper, No. 457, "Studies on the Incorporation of Radioactive Precursors Into the Nucleic Acids and Related Compounds of Living Cells", by R. M. S. Smellie and J. N. Davidson, was presented by Smellie (UK). The paper described improved analytic procedures for analyzing the isotopic contents of nucleotides. Applying these to the problems of nucleic acid synthesis in living systems, the author found that nuclear RNA turnover was greater than that of DNA or cytoplasmic RNA, while DNA exceeded cytoplasmic RNA only in the appendix and bone marrow.

## SECTION 23 C - Fission Products and Their Applications

by Bernard Manowitz, B. E. Proctor and Edward Epremian

Section 23, the closing "C" Section, was divided into three parts, each of which considered a particular peaceful application of fission products, essentially the wastes from atomic reactors. In the first, radiation-induced polymerization was discussed; in the second, the use of radiation to sterilize food; in the third, conversion of radiation directly into electricity. J. Gueron (France) chaired all three parts of the section.

Paper No. 168, presented by J. J. Martin (US), "The Effect of Gamma Radiation on Some Chemical Reactions of Possible Industrial Importance", by B. G. Bray et al reported on radiation-induced polymerizations and halogenations. Data were given on polymerization of ethylene in a radiation field; including yield data and physical properties.

Of chlorination of benzene and other hydrocarbons, Martin said additional compounds seemed to be favored with the production of different products than by the standard method. Cost estimates were given for benzene hexachloride production.

Paper No. 465, by A. Charlesby (US) "Recent Developments in the Irradiation of Long-Chain Polymers" discussed the mechanism of cross-linking and chain-cleavage. Gel formation in dilute solutions provided a technique for the study of the direct and indirect effects of ionization.

Question: Magat (France) commented that to achieve rapid utilization of fission products it would be necessary to experiment with appreciable quantities so that the effect of intensity on reaction rate and on reaction products could be determined. He pointed out that weak sources would spread out evenly so that there were homogeneous fields and this might turn out to be more useful than very intense sources. The answer was required soon. As an example, in the polymerization of methyl methacrylate 100 curies at one intensity could produce 20 to 25 tons a year. By increasing the intensity fourfold, the yield was increased by a factor of less than two. G values should be given as a function of dose rate. The yield of primary radicals was a better way of describing radiation processes.

Answer: Martin remarked that the comments were well made on intensity effect. The University of Michigan's calculations assumed a linear effect because it gave a conservative cost estimate. Experiments in the benzene hexachloride system indicated that the yield was independent of dose rate.

Question: Leveque (France) asked for an explanation for the differences in polyethylene yield. Tests at the same temperature and pressure, according to the data given, gave different results by a factor of 3. Answer: Martin replied that a variation in polyethylene yield was found. Inhibitor studies ( $O_2$ ) were carried out to find the reason for the variation, and very pure ethylene was used. The yield for pure ethylene was four times greater. The variation probably was due to an inhibitor and very pure chemicals would give higher yields. The same effect was observed in hydrocarbon halogenation. A new purification technique was being worked out involving a short radiation exposure, then a distillation. The distillate was used in the experiments and gave a higher yield.

Question: Drimus (Rumania) reported exploring several methods for making benzene hexachloride including UV, free radicals (without light), liquid  $Cl_2$  (without light). All methods gave the same yield. Drimus believed that gamma radiation would be superior because it would give a greater output. Answer: Martin said the problem of increasing the per cent of gamma isomer was being worked on and results indicated that the yield depended on temperature rather than intensity. Temperatures of  $0^\circ C$  and lower were now being investigated with a hope of increasing gamma isomer yield.

Question: J. Gueron (France) asked if Martin could compare the polyethylene prepared or modified through radiation with the German polyethylene polymer recently produced. Answer: Martin replied that Ziegler process material was not available so no direct comparison could be made, but probably the radiation polymer was more highly cross-linked. Charlesby (US) remarked that densities could be compared. Both Ziegler and radiation polymers were more crystalline than the standard polyethylene.

Magat (France) stated that Charlesby mentioned an  $O_2$  effect. Magat noted that  $O_2$  played an important part in this work. The Russians and the French had shown through infra-red spectroscopy that  $O_2$  created intramolecular bridges. Some of these broke at  $80^\circ C$  to  $150^\circ C$  -- possibly the peroxide groups. Magat said that in France they added acrylonitrile to air irradiated polyethylene heated at  $120^\circ C$ . The polyethylene was swelled and prompt polymerization occurred. The polyacrylonitrile was fixed in P. E. chains to form a grafted copolymer. This offered a new way of making a material difficult to prepare by other techniques. In the graft operation, moreover, the form of the material was retained.

Graft copolymers offered a rapid application of radiation since techniques were simple and the dose requirements were low.

In presenting Paper No. 172, "Progress and Problems in the

Development of Cold Sterilization in Foods" by B. E. Proctor and S. A. Goldblith (US), Proctor gave a concise review of 11 years' endeavor in the field of radiation sterilization at Massachusetts Institute of Technology.

He reported that their data related to various types of micro-organisms and their sensitivity to radiation, the considerations necessary when determining the magnitude of the sterilizing dose, the effect of radiation changes on food components and the factors which influenced such change. He further reported the protective action which may have resulted from combining one radio-sensitive chemical compound with another which changed the sensitivity of the two components. This phenomenon might be used to advantage in some food radiation sterilization processes by using some compounds to protect others.

He emphasized that some food enzymes required 10 to 20 times the normal food sterilization dose, which was approximately 2 million rep. for their inactivation. This indicated that some other means of enzyme inactivation might be required. One suggested possibility was high-frequency heating by electricity.

The problems in food sterilization by radiation today related primarily to changes in flavor, color and texture which might and frequently did occur at sterilization levels. These changes might be alleviated by irradiation of food in the frozen state, irradiation in inert atmospheres, or addition of free radical acceptors such as ascorbic acid. Much study was being given to these and alternate means of controlling changes.

Complete answers for permanent preservation with no detectable changes were being sought by many scientists. Speculation had been raised concerning whether any compounds of toxic nature might be formed by irradiating foods and numerous tests were currently under way to determine these facts. Limited published reports indicated no toxic factors, but some loss of nutritive values such as also occurred in commercial thermal food processing.

That foods, pharmaceuticals and tissues might be adequately sterilized by ionizing radiation was now an established fact, and the levels and types of radiation that might accomplish this sterilization were known, in any type of container currently used for processed foods.

Question: Comar (US) wanted to know what time and effort were necessary to determine by laboratory tests whether foods subjected to radiation sterilization might not produce changes undesirable from a health standpoint, when the food was ingested. Answer: Proctor answered that the type and extent of tests outlined by the U. S. Food and Drug

Administration required the feeding of large numbers of laboratory animals through several generations for growth and reproduction evaluation, and the feeding of a larger animal type, such as dogs, for a period of a year. Tests might require two years for the consideration of any specific food.

Paper No. 225, "Health Protection Against Food-Borne Parasitic Diseases with Particular Reference to Control of Trichinosis" by H. J. Gomberg and S. E. Gould was presented by Gomberg, who told of several years' study of the destruction by radiation of larvae encysted in meat. He said the results suggested that ionizing radiation might also be used to control such food-borne parasites as beef or pork tapeworm, pork cysticercosis, and hydatid; fish tapeworm infection, Chinese liver fluke, intestinal fluke, and ascariasis.

Gomberg described the typical cycle of trichina larvae in man and animals, and said the larvae could be killed in meat by exposures of about 1 million rep of 250 kv x-rays or Co 60 gamma rays which, however, made the flavor of the pork rancid and sour. About 18,000 rep of Co 60 or Cs 137 gamma rays, or 15,000 rep of 250 kv x-rays would inhibit development of the larvae, and produced no detectable changes in flavor, texture, or appearance of the pork. Sterilization of female larvae could be accomplished by 15,000 rep of Co 60, or Cs 137 gammas, or 5,000 rep of 250 kv x-rays. These results indicated that 30,000 rep of Co 60 or Cs 137 gammas, or its equivalent, delivered to pork would prevent and eradicate trichinosis. There was no indication of deleterious side effects which would contraindicate on medical or biological grounds the use of radiation as a means of trichinosis control. Gomberg gave detailed data on methods of using radiation, testing the dosage, and the analysis of results when laboratory animals were fed with irradiated and non-irradiated infested meat.

Gomberg showed a slide of a designed plant which could handle 2,000 hogs a day, and said smaller mobile units could be built; that semi-skilled personnel could handle the operation, and that only routine materials were needed for the structures. He reported that initial contacts with the World Health Organization indicated WHO was willing to act as a coordinating agency for bringing together research workers in various parts of the world to study the problem of constructing pilot plants.

Question: Comar (US) asked if there were any specific tests being made on diseases other than trichinosis at this time? Answer: Gomberg answered that tests on ascariasis lumbar certis had just started and tests on tapeworm were planned. Gomberg showed some slides on ascariasis eggs, and described their cycle. His tests currently were

directed at determining the sensitive points in the cycle. To a question from Leborgne (Uruguay) about hydatid, Gomberg urged that this problem be studied in South America where hydatid was most prevalent.

In presenting Paper No. 175, "Sterilization of Medical Supplies with Gamma Radiation", by L. E. Brownell and J. J. Blumer, Brownell indicated medical dressings, cotton gauze, instruments and special items such as human bone might be sterilized by the use of gamma radiation, as might pharmaceuticals and antibiotics.

Bulk medical supplies could be sterilized in the final packages with possible savings in packaging costs. He advocated gamma radiation because of its great depth of penetrations, and found the dosage for complete sterilization was 2 million rep.

Tentative specifications for an installation were given, together with calculations for a preliminary design which could be used to irradiate bulk medical supplies in packages (4"x4"x4") using cooling reactor fuel elements as a source of radiation.

The third part of the section, concerned with conversion of radiation directly into electricity, was opened by E. Haeffner (Sweden) who gave Paper No. 794, "Study on the Properties of an Electrolytic Cell Consisting of an Electrode System in a Chloroform Alcohol Solution Under Gamma Irradiation", by C. G. Osterlundh and Haeffner. Haeffner described a cell consisting of graphite and lead electrodes with a chloroform-alcohol electrolyte. Details were given for the behavior with various compositions of electrolyte, various irradiation exposures, etc. The efficiency of the cell in converting gamma radiation to electricity was 0.9%.

E. G. Linder (US) presented Paper No. 169, "The Direct Conversion of Radiation into Electricity" for himself and his co-workers. Linder discussed the present role, limitations, and potentialities of the direct conversion: (1) direct charging methods utilizing charged radiation and involving the simple collection of charged particles by an electrode to create a voltage; (2) contact potential methods which might utilize both types of radiation and use contact potential fields to separate charges and produce currents; (3) thermo-couple methods whereby irradiation was used to create heat by absorption which was converted to electricity; and (4) semi-conductor junction methods where carriers were formed within the semi-conductor by either type of radiation and separated by the internal junction field.

The last method now had an efficiency of 3%. At higher power levels it was estimated this could reach 7%. Other problems yet to be

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solved in the use of these devices were radiation damage, radiation shielding, and the high cost of radioactive material.

Question: Turkevich (US) asked whether there was any hope of improving the efficiency of the cell described by Haeffner and, if so, by what means. Answer: Haeffner said that exclusion of oxygen from the solution gave a five-fold increase in current; other means might come from further research.

Question: Gueron (France) asked what part of the output came from absorption of radiation and what from chemical reaction. Answer: Haeffner was unable to say but welcomed a suggestion by Gueron that tracers be used to investigate this point.

Question: Haeffner asked about the probability of low-cost isotopes in the future so that an atomic battery could be operated at higher power and hence higher efficiency. Answer: Rupp (US) mentioned the new facilities for isotope production and expressed a hope that the cost of isotopes would be greatly reduced in the near future.

Question: Epreman (US) noted that there were certain similarities between the semi-conductor atomic battery and the device for conversion of solar energy to electricity and asked Linder to discuss the similarities and differences between these devices. Answer: Linder pointed out that both the atomic and solar batteries use Si and p-n junctions, but, of course, the radiation used differed, and the atomic device would work with charged particles. Another difference was that visible radiation affected only the surface of the component in the solar device while penetration occurred with the other; thus, there was a difference in geometry. With regard to efficiencies, the solar battery had a value of 6 to 10%, and the atomic battery now had a 3% value. This difference was largely due to the difference in input energies.